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SOIL EROSION CONTROL STRUCTURES ON SKIDTRAILS

By

W. J. KIDD, Jr.

Division of Watershed Management Research

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
OGDEN, UTAH
JOSEPH F. PECHANEC, DIRECTOR

PLEASE NOTE

This is the first of a new series of reports to be issued by the Intermountain Forest and Range Experiment Station. These reports will be designated "U.S. Forest Service Research Paper INT- --." They replace the Research Paper series, the last one of which was Research Paper 71.

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THE PROBLEM

A common practice in Idaho and other western states is to log steep slopes using a jammer and crawler tractor conjunctively. Jammer logging requires a closely spaced road net where roads are commonly 100 to 400 feet apart. The jammer, used for skidding uphill, and the tractor,[1] for skidding downhill, create bare skidways which in turn may become important sources of sediment in streams. Although the use of high-lead systems of cable logging is increasing, such equipment also leaves occasional skidtrails on steep, cutover slopes.

Proper treatment of bared skidtrails after logging reduces the hazard of potential erosion. Commonly, treatment consists of constructing retention structures from logging debris or diversions by using hand shovel or bulldozer. Objectives of this study were: (1) to determine the optimum spacing distances between manmade structures for preventing excessive rilling, and (2) to determine which of several structures or diversions provides the most effective controlled disposal of sediment-laden water that originates on skidtrails.

[1] Haupt, H. F. 1960. Variation in areal disturbance produced by harvesting methods in ponderosa pine. Jour. Forestry 58: 634-639.

ESTABLISHMENT OF STUDY AREAS

During the summers of 1953, 1954, and 1955, 86 skidtrails on four National Forest timber sale areas (see map, fig. 1) were treated by building either slash dams (fig. 2), or diagonal log water bars (fig. 3).[2] Seventy skidtrails were selected on soil derived from granite of the Idaho batholith; 16 were on soil derived from Columbia River basalt. An additional 14 skidtrails were treated by lopping and scattering slash on the skidtrail surface; of these, 10 were on granitic soil and four on basaltic soil. Five other skidtrails on basaltic soil were treated with cross ditches dug by a D-4 type bulldozer and hand shovel.

[2] Acknowledgment is made to the erosion control crews of the Boise and Payette National Forests for building the structures under the guidance of Paul E. Packer and Harold F. Haupt of Intermountain Forest and Range Experiment Station.

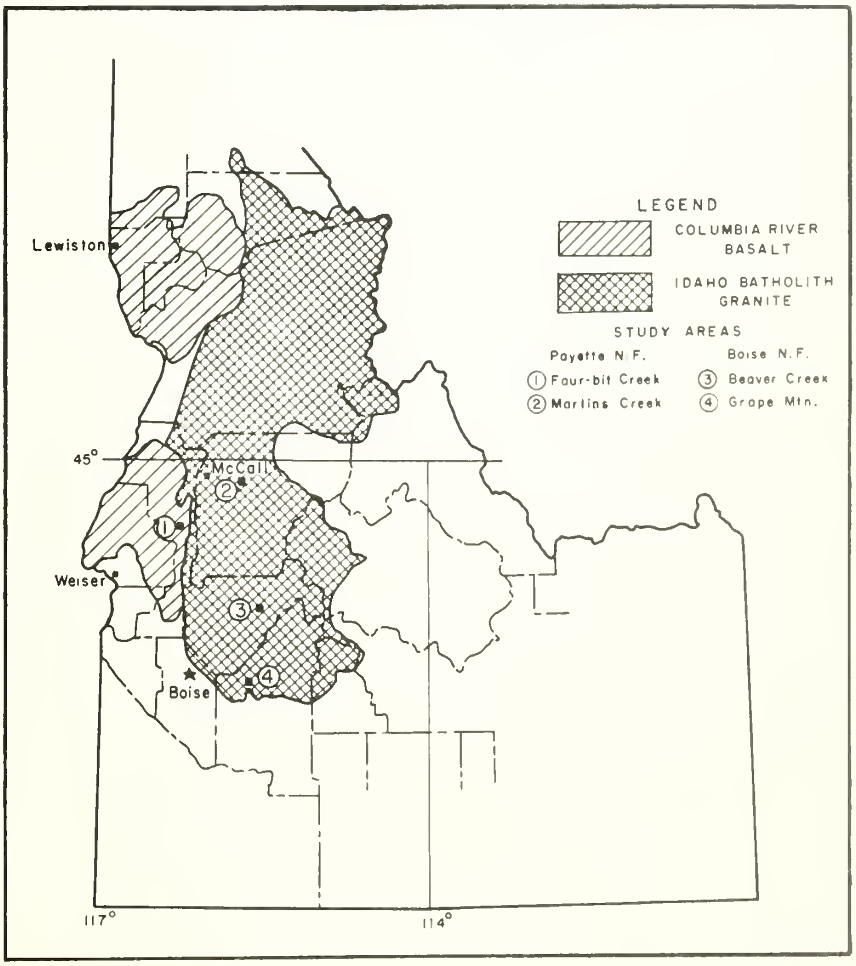

Figure 1.--Location of study areas on soils derived from granite and basalt in west-central Idaho.

Figure 2.--Completed slash dams on Martins Creek sale area, Payette National Forest.

Figure 3.--Completed log water bar on Grape Mountain sale area, Boise National Forest.

Spacing of the structures--10, 25, 50, and 75 feet--was based upon Packer's[3] observations in 1952 of erosion on logging haul roads and skidtrails. He measured the distance from a control structure to the head of the nearest active erosion gully or rill immediately below, then computed the average distance from structure to the point of active erosion for three slope classes: less than 20 percent, 20 to 40 percent, and 40 to 60 percent. The above spacings were then derived by subtracting three times the standard error of estimate from the average distance to erosive cutting. As part of this new study, Packer's recommended spacings were field tested on skidtrail slopes ranging from 20 to 90 percent.

[3] Packer, Paul E. Criteria for reducing erosion from logging on granite soils. 1954. (Unpublished report on file at Intermountain Forest and Range Expt. Sta., U.S. Forest Serv., Ogden, Utah.)

Following installation of the water-control structures, the skidtrails were broadcast seeded to the following plants:

Yellow sweetclover	Melilotus officinalis
Timothy	Phleum pratense
Tall oatgrass	Arrhenatherum elatius
Orchardgrass	Dactylis glomerata
Bulbous bluegrass	Poa bulbosa
Crested wheatgrass	Agropyron cristatum
Intermediate wheatgrass	A. intermedium
Winter rye	Secale cereale

STORMS

When erosion results from overland flow but only the effects are measured, it is highly desirable to know something of the timing and severity of the storms that produce the overland flow. Unfortunately, yearlong rainfall and snowmelt data are unavailable for the four study areas because of their remoteness. However, available data from U.S. Weather Bureau stations nearby provide a basis for several extrapolations for the period 1954 to 1957.

1. The number of high-intensity summer storms on the study areas, was below the average.

2. In December 1955, a medium-intensity rain fell on a shallow snowpack and caused above-normal runoff for that time of year. The rain was general over all four areas; the Martins Creek area was heavily damaged by erosion.

3. Rainfall and temperatures in January 1956 were above normal. The abnormally high rainfall probably caused additional damage to the study areas.

4. Heavy rains on snow in February 1957 probably yielded above-normal runoff from all study areas.

It may be presumed that overland flow was greater during the cool seasons of the year than that normally expected; however, only a few of the treated skidtrails were exposed to repeated surges of overland flow caused by high-intensity summer storms that are common in the mountains of central Idaho.[4] Thus, the overall weather potential for erosion was probably moderate rather than exceptionally high.

FIELD OBSERVATIONS

Field observations were made in 1955 and 1957. In 1955, 105 skidtrails (excluding a few untreated ones on Grape Mountain) were inspected, and quantitative measurements of erosion were made. Rills and gullies were measured to ascertain the cubic-foot volume of soil displaced by overland flow; also, the volume of sediment trapped behind individual skidtrail structures was determined. Deep erosion was noted on 27 of the 80 skidtrails on granitic soil, and on 11 of 25 treated skidtrails on basaltic soil. The remainder of the trails had no measurable rills or gullies, but wherever evidence showed sheet erosion or soil creep, it was noted.

[4] Kidd, W. J., Jr. 1961. High-intensity rainstorms on the Boise and Payette National Forests. U.S. Dept. Agr., Forest Serv., Intermountain Forest and Range Expt. Sta. Res. Note 81, 4 pp.

The four study areas were reexamined in 1957 and the various control structures rated qualitatively by using the numerical point system outlined in the Appendix. Each skidtrail interval, 569 altogether, was assigned a rating of points for five conditions; an average score was then calculated for each skidtrail. A low score meant that the structures were acceptably controlling erosion, and that the interstructure skidtrail surface was in good condition. An average of 1.0 represented complete protection; an average of 4.8 meant that all control structures were washed out and that the skidtrail surface was eroded severely.

RESULTS

1955 QUANTITATIVE DATA

Table 1 shows the number of skidtrail intervals by study area and treatment and the percentage of each on which erosion was measured in 1955 and 1957. More skidtrail intervals, percentagewise, were eroded on Grape Mountain and Martins Creek than on Beaver Creek and Four-bit Creek because most of them were located on south, southeast, and southwest aspects, which supported correspondingly less reseeded vegetation than did the northerly aspects of Beaver Creek and Four-bit Creek areas.

Table 1.--Type of erosion by number of skidtrail intervals [1]

Area	Treatment	No erosion				Trace or sheet erosion				Rill erosion				Gully erosion			
		1955		1957		1955		1957		1955		1957		1955		1957	
		No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Beaver Creek (granitic soil)	Slash dam	57	73	37	48	15	19	11	14	2	3	14	18	4	5	15	19
	Log water bar	52	66	37	52	14	18	13	18	7	9	21	30	6	7	0	0
	Lop-and-scatter	3	75	3	70	--	--	--	--	[2] 2	25	[3] 2	30	--	--	--	--
Grape Mountain (granitic soil)	Slash dam	5	19	[4] 14	30	6	23	4	9	11	42	5	11	4	16	23	50
	Log water bar	16	27	[4] 78	78	21	35	13	13	15	25	9	9	8	13	0	0
	Lop-and-scatter	0	0	0	0	--	--	1	100	--	--	--	--	--	--	--	--
Martins Creek (granitic soil)	Slash dam	52	57	40	47	23	25	8	9	14	16	19	22	2	2	19	22
	Log water bar	13	25	31	49	15	28	3	5	25	47	21	33	0	0	7	11
	Lop-and-scatter	3	75	1	33	--	--	--	--	1	25	--	--	--	--	2	[5] 67
Four-bit Creek (basaltic soil)	Slash dam	48	72	31	47	9	14	9	14	9	14	7	11	0	0	19	29
	Log water bar	51	66	59	77	5	7	14	18	21	27	4	5	0	0	0	0
	Lop-and-scatter	4	100	3	90	--	--	--	--	--	--	1	[6] 10	--	--	--	--
	D-4 cat and shovel ditches	4	15	8	30	6	22	3	16	12	44	16	84	5	19	0	0

[1] Based on total number of treated skidtrail intervals examined in 1955 and 1957.
[2] The entire length of one skidtrail was eroded, and 25 percent of another. Overall, 25 percent ot the total length of five skidtrails was eroded.
[3] The entire length of one skidtrail was eroded, and 50 percent of another. Overall, 30 percent of the total length of five trails was eroded.
[4] Includes additional intervals treated late in 1955.
[5] Two skidtrails were 100 percent washed out; the third was not, hence 67 percent of the total length of three skidtrails was eroded.
[6] Since 40 percent of the length of one skidtrail was eroded, 10 percent of the total length of four skidtrails was eroded.

The volume of soil displaced is shown in table 2. Generally, more sediment was eroded from longer skidtrail intervals than from shorter intervals, but the increased erosion was not necessarily proportional to the increased distance between structures. Moreover, as much soil was eroded from some gentle slopes as from steeper slopes.

Table 2.--Average volume of soil eroded per skidtrail by slope gradient class, structure spacing, and soil parent material

Slope gradient (Percent)	Structure spacing	Average volume of soil eroded per skidtrail: Granite	Basalt
	Feet	Cu. ft.	Cu. ft.
20-30	25	[1]1.92(4)	1.82(4)
	50	5.14(3)	4.94(6)
	75	20.42(1)	--
40-50	10	1.84(5)	--
	25	2.13(4)	--
	50	9.06(1)	.54(1)
60-70	10	.63(1)	--
	25	4.62(5)	--
	50	5.91(3)	--
		(27)	(11)

[1] Numerals in parentheses are numbers of skidtrails measured.

A series of statistical tests confirmed these conclusions. Values for missing data were estimated by approved methods. An analysis of variance showed structure spacing to be highly significant, whereas slope class was not significant. In other words, irrespective of slope gradient (greater than 20 percent), an increase in spacing between structures is accompanied by an increase in soil movement that often is appreciable.

On the basis of sediment trapped, the control structures generally demonstrated varying degrees of trap efficiency. The two types of structures, log water bars and slash dams, although comparable in size, handled overland flow in distinctly different manners. The log water bars diverted overland flow and sediment off the skidtrail and onto the forest floor; whereas the slash dams filtered sediment from the overland flow and did not divert the running water from the skidtrail surface. Structures of both types trapped more sediment on basalt-derived soil than on granite-derived soil (table 3). Gentler terrain on the basalt area meant that most of the skidtrails were located on the gentler (20-30 percent) slope class; Hence, velocities of sediment-laden flows were not great enough to seriously overtop or undermine the structures.

Although results of the 1955 study indicated some strong trends pertaining to relations between gross soil loss and spacing interval, the quantitative data were insufficient to warrant separating the skidtrails treated by slash dams from the trails treated by log water bars, or separating sidehill data from ravine data. Two years later, evaluation by qualitative indexes made it possible to separate the effects of structure type, slope gradient, soil parent material, and topographic location upon erosion.

1957 QUALITATIVE DATA

By the end of the second measurement period, many skidtrails showed few or no signs of erosion; others were healing rapidly; and still others were actively eroding. Why were these skidtrails responding so differently, and what were some of the contributing factors?

Performance ratings for each skidtrail (see Rating System, Appendix), regardless of the degree of erosion, were averaged and then classified first by soil against topographic location (table 4), and second by soil against slope gradient (table 5). Performance, by these ratings, meant the functioning of the structures with regard to overall effectiveness. An analysis of variance of data in table 4 showed that more erosion occurred in ravines than on hillsides--an expected result that was almost significant at the 5-percent level. Treatment (control structures) was

Table 3.--Sediment flow measurements, 1955

Soil type	Skidtrails established	Skidtrails eroded: No.	Pct.	Sediment eroded: Amount trapped: Cu. ft.	Pct.	Amount not trapped: Cu. ft.	Pct.
Granitic	80	27	34	31.91	29	79.83	71
Basaltic	25	11	44	25.32	78	6.97	22

Table 4.--Average performance ratings of control structures by type and location, 1957

Control structure	Location	Granitic soil	Basaltic soil
Lopping and scattering	Sidehill	2.42	1.14
	Ravine	3.53	2.42
Slash dams	Sidehill	1.91	2.19
	Ravine	2.56	3.65
Log water bars	Sidehill	1.88	1.67
	Ravine	2.36	1.58
Average--all structures	Sidehill	1.95	1.77
	Ravine	2.65	2.74

not significant in the analysis of variance because all types of structures were generally ineffective in ravine bottoms. Soil, also, was not significant for the similar reason that skidtrails located in ravines produced heavy soil losses regardless of parent material.

Disregarding topographic location, statistical analysis of data in table 5, exclusive of the 80- to 90-percent slope class, revealed that the difference in erodibility between soil derived from granite and that derived from basalt was almost significant at the 1-percent level. In other words, the structure rating values were lower on basalt; this suggests that basaltic soil is inherently less erodible and more productive in growing ground cover that is effective in controlling erosion. This trend agrees with results in Oregon and northern California reported by Anderson[5] and André and Anderson.[6] Their studies indicated that soils developed from acid igneous rock (including granite) are about 2-1/2 times as erodible as soils developed from basalt.

As expected, the interactions of soil and structure treatment (S X ST) and soil and slope gradient (S X SG) were most important. They were significant at a level between 1 and 5 percent. This means that soil had a variable effect on the structure performance rating, depending upon the type of structure used and slope class. The overall effect of structure treatment alone was almost significant at the 5-percent level. In general, the water-diverting structures (log water bars and cross ditches) were more effective than the sediment-filtering methods (slash dams and lopping and scattering of slash).

A SPACING GUIDE FOR SKIDTRAIL STRUCTURES

During the 1957 rating of the condition of structures and skidtrail surfaces, additional notes were made for item 5, "General observations," in the Appendix. If the structures were judged to be spaced too far apart or too close together (based on amount and type of erosion present), an estimate was made of what would have been the correct spacing. These estimates were later averaged with those measurements on skidtrails whose structure spacings were considered correct to aid in determining optimum structure spacing for different degrees of slope.

[5] Anderson, H. W. 1954. Suspended sediment discharge as related to streamflow, topography, soil, and land use. Amer. Geophys. Union Trans. 35: 268-281.

[6] André, J. E., and H. W. Anderson. 1961. Variation of soil erodibility with geology, geographic zone, elevation, and vegetation type in northern California wildlands. Jour. Geophys. Res. 66: 3351-3358.

Table 5.--Average performance ratings by type of structure, soil parent material, and percent of slope, 1957

Structural treatment	Soil parent material	Percent of slope				
		20-30	40-50	60-70	80-90	All slope average
Lopping and scattering	Granite	2.44	3.28	3.02	--	2.93
	Basalt	2.32	1.24	1.24	--	1.60
Slash dams	Granite	2.50	2.10	2.08	--	2.15
	Basalt	3.00	1.56	2.20	--	2.25
Log water bars	Granite	1.84	2.24	1.90	1.12	1.78
	Basalt	1.80	1.38	1.44	--	1.54

On 14 of the 40 skidtrails treated with slash dams, and on 12 of the 41 skidtrails treated with log water bars or shovel ditches, the structures were deemed to be too far apart for maximum effectiveness. Contrariwise, on three trails treated with slash dams and three trails with log bars, the structures were considered to be spaced too closely. Structures on these six skidtrails were installed at 10-foot intervals.

Spacings recommended in table 6 are based on three sources of data:

1. Packer's unpublished study of 73 skidtrail intervals. (See footnote 3.)

2. Customary spacing used by the Boise National Forest erosion control crews.

3. Author's analysis of 569 skidtrail intervals, reported herein.

Table 6.--Recommended spacing for skidtrail erosion control structures on soils derived from granite and basalt in west-central Idaho.

Slope (Percent)	Spacing on--			
	Soil from granite		Soil from basalt	
	Sidehills	Ravines	Sidehills	Ravines
	Feet	Feet	Feet	Feet
10	65	50	90	80
20	50	35	70	65
30	40	25	60	50
40	30	20	50	40
50	20	15	40	35
60	15	10	25	20
70	10	10	15	15

When installing erosion control structures on skidtrails after logging, these spacings are recommended as basic distances. Certain factors must be considered in deciding which spacing to use under different conditions. Wider spacing is allowable on soil from basalt because it is less susceptible to erosion than soil from granite. Any area whose potential runoff may drain down a skidtrail should be examined carefully; for example, a ravine skidtrail that drains several acres needs control structures spaced more closely than a sidehill skidtrail that drains a very small area.

Any decision about the type of structure to be used depends on the situation that prevails on a given area. Slash to build slash dams may not be available in sufficient quantities; occasionally small straight poles for log water bars may be in short supply. Results of this study show that slash dams should not be recommended for sidehill use because they do not divert water and are relatively costly. Construction costs estimated by a District Ranger[7] were \$2.00, or 1.25 man-hours per structure. This same Ranger also stated that after a year it was necessary to dig diagonal cross ditches below every third slash dam to divert water from the skidtrails because spring runoff had created erosion gullies between structures. Slash dams are recommended for use in ravines only if they can be built large enough to filter out most of the sediment and materially retard the waterflow.

Log water bars are excellent for diverting water from either flat or shallow, trough-shaped sidehill skidtrails. Construction time is about 1 man-hour per structure. Log water bars usually do not deteriorate as quickly as slash dams, which usually become ineffective after 1 or 2 years.

Hand-shoveled or bulldozed cross ditches, which are no more than water bars without the log, may be substituted for log water bars. However, slough from natural causes or from trampling by game may reduce the effectiveness of logless water bars; hence it is prudent to make every third or fourth structure a log water bar to insure that overland flow will be diverted. Of the erosion control structures, cross ditches are considerably quicker and less expensive to build. Depending on depth of soil, terrain, and structure spacing, construction time for a hand-shoveled ditch varies from 5 to 10 minutes.

Lopping and scattering slash is recommended on gentler slopes and where undercutting by surface flow will be at a minimum. The slash provides a mulch that protects the bared skidtrail surface during rainstorms, retards overland flow, and improves site conditions for plant invasion and establishment of reseeded species.

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[7] Office memo dated June 14, 1957, from R. Stemple, formerly District Forest Ranger, Krassel Ranger District, Payette National Forest. Martins Creek study area is on this District.

SUMMARY

Erosion measurements on 569 intervals of 105 logging skidtrails revealed the following:

1. Erosion is greater and rate of healing is slower on soil derived from granite than on soil from basalt.

2. More soil is eroded from skidtrails unavoidably located in ravine bottoms than from trails on sidehills.

3. Control structures that divert water off the skidtrail onto undisturbed forest floors are superior to those that only retard water movement and filter out sediment along the skidtrail.

4. Any increase in spacing between control structures is accompanied by increase in soil movement.

5. Optimum spacing between erosion control structures depends upon the percent of slope, whether location of the skidtrail is on a sidehill or in a ravine, and the soil parent material.

APPENDIX

RATING SYSTEM FOR SKIDTRAILS AND SKIDTRAIL STRUCTURES

1. Erosion between structures
   - 1.0 = little or no erosion
   - 1.2 = moderate sheet erosion
   - 1.4 = pronounced sheet erosion
   - 2.0 = few rills
   - 2.5 = moderate rilling
   - 3.0 = numerous rills
   - 4.0 = single shallow gully
   - 4.5 = single deep gully
   - 5.0 = deep gullies
   - 6.0 = washout

2. Revegetation of skidtrail
   - 1.0 = excellent grass cover
   - 1.2 = moderate grass cover
   - 1.5 = poor grass cover
   - 2.0 = numerous shrubs
   - 2.2 = moderate amount of shrubs
   - 2.5 = few or no shrubs
   - 3.0 = numerous tree seedlings
   - 3.2 = moderate number of seedlings
   - 3.5 = few or no tree seedlings
   - 4.0 = very little cover or bare

3. Condition of structures
   - 1.0 = good
   - 2.0 = fair
   - 4.0 = broken
   - 5.0 = washed out

4. Sediment flow and sedimentation
   - 1.0 = stopped by structures
   - 2.0 = structures overtopped
   - 2.0 = "end-around" flow
   - 4.0 = "through or under" flow

5. General observations
   - 1.0 = structures spaced about right
   - 2.0 = structures too close
   - 4.0 = structures too far apart
   - 5.0 = washout

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FLOWER INDUCTION AND STIMULATION IN WESTERN WHITE PINE

by

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FLOWER INDUCTION AND STIMULATION IN WESTERN WHITE PINE

Burton V. Barnes and R. T. Bingham[1]

INTRODUCTION

Tree improvement programs are necessarily concerned with flower induction. Both the time and cost involved in producing and tending progenies and the need to get graft or seedling orchards into production compel research efforts in flower induction. Empirical studies are helpful in establishing effective kinds and levels of treatments devised long ago by horticulturists and plant breeders to induce or stimulate flowering.

LITERATURE REVIEW

The literature on the nature of flowering and its control reflects the increasing interest of plant physiologists, biochemists, agronomists, horticulturists, and foresters. Matthews (1963), Nienstaedt (1961), and Richardson (1962) have reviewed the flower induction literature applicable to woody plants. The brief review below summarizes literature pertinent to the experiments described later in this report.

All plants pass through a vegetative stage before they reach the stage of ripeness-to-flower (Bonner and Galston 1952). Therefore, one approach for the scientist is to explain the basis of the transition from vegetative to flowering stage and discover means to effect this shift as quickly as possible. A second and equally important research task is stimulating flower production once the ripeness-to-flower stage has been attained. First, let us examine our knowledge of the vegetative and flowering stages in woody species and then consider (1) the transition from one stage to the other and (2) flower stimulation once the ripeness-to-flower stage has been reached.

In many woody plants the vegetative or juvenile stage (or stages) is distinguishable from the ripeness-to-flower or adult stage. The lower parts of a tree typically may remain in the juvenile stage after the upper parts have attained the adult stage. The difference between the two stages has been demonstrated by differences in flowering behavior, flushing, rooting capacity, and various vegetative characteristics (leaf shape and size, leaf abscission, leaf color, presence or absence of thorns, etc.). Many experiments have shown that lack of flowering is characteristic of the juvenile stage in woody plants (Schaffalitsky de Muckadell 1959). Both the genetic constitution of the plant and the environment may affect the duration of the juvenile stage (Mergen 1961; Nienstaedt 1961; Schaffalitsky de Muckadell 1959). Possibly, environmental changes can more effectively promote flowering the nearer the plant is to the adult stage--or some environmental conditions (such as nutritional status) can prolong the juvenile period.

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[1] Research forester and plant pathologist, respectively, U.S. Forest Service, Intermountain Forest and Range Experiment Station, Moscow, Idaho.

Robbins (1957) has given a good working hypothesis of the nature of the juvenile phase:

> ". . . I suggest as a working hypothesis that juvenility is an instable metabolic state which exists in the meristem and which proceeds through a series of steps to a relatively stable metabolic state characteristic of the adult meristem. The change from unstable to stable may be associated with the loss in ability to synthesize physiologically important chemical substances and/or the development of the ability to synthesize others."

Thus, a chemical substance, such as the flowering hormone (Bonner and Liverman 1953; Bonner 1959) probably regulates flowering once the adult stage has been attained.

Through experiments with Betula, Wareing (1959) found that the "attainment of a certain absolute size is the primary factor determining the transition to the adult condition . . . ." Büsgen and Münch (1929), Langner (1951), and Matthews (1955) also have observed that, in general, vigorous, healthy trees are the first to bear flowers. Wareing also postulates that in some species "the attainment of the flowering condition depends upon a certain degree of aging of the shoot-systems." The terms "maturation" and "aging" were put forth by Wareing to distinguish between the transition from the juvenile to the adult stage (maturation) and the loss of meristematic vigor as the tree develops (aging). Whether the physiological processes governing these phenomena are clearly different seems still open to question.

Mergen (1961, 1962) successfully induced male and female strobili on white pine hybrids (Pinus griffithii McClelland X Pinus strobus L.) less than 2 years old by combined high temperature and humidity and liquid fertilizer treatment. Unless this phenomenon is solely associated with interspecific hybridization, it demonstrates that by manipulation of the environment, flowering can be induced on trees apparently in the juvenile stage. Whether the flowering condition has been permanently fixed without annual treatment is yet to be determined.

Once the ripeness-to-flower stage is attained, flowering may commence immediately and automatically in some plants. For other plants, however, favorable environmental conditions are necessary for the onset of flowering. The two factors typically involved are relative day-length and temperature. In some plants photoperiodic treatment can permanently induce flowering. Phytochrome, the substance responsible for triggering the production of the flowering hormone, recently has been detected and extracted (Borthwick and Hendricks 1960). Phytochrome is a blue or bluish-green protein existing in two forms interconvertible by light (ibid.), and is known to control numerous biological phenomena, e.g., seed germination, pigment formation, elongation, etc. (Hendricks 1959). Photoperiodic treatment induces a chain reaction whereby a floral hormone is produced in the leaves and thence translocated to the buds where flower bud differentiation commences.

Woody species are thought to be day-neutral plants (Mirov 1956; Wareing 1959), i.e., plants whose flowering is controlled by factors other than relative length of day and night. Though day-length apparently has little effect upon flowering in forest tree species, it cannot be entirely disregarded. Larson (1961) introduced evidence to show that synchronization of climatic conditions and relative day-length with bud development may exert an influence upon flowering behavior.

Foresters have had varied success with cultural treatments, grafting, girdling, root pruning, strangulation, etc., to induce or stimulate flowering. Zobel et al. (1958) reviewed this literature and concluded that, although numerous methods have promoted or stimulated flowering in given instances, several were probably too injurious to use in seed orchards. Further, they believe the most satisfactory and safest method to be fertilization, together with moderate root pruning.

Soil fertility, fertilizers, and nutritional requirements of crop plants have been reviewed in detail by Åslander (1958) and Tisdale and Nelson (1956). Forest fertilization literature has been compiled by White and Leaf (1958), the relationship of mineral nutrition and growth of forest trees described by Leyton (1958a, 1958b), and the appropriate use of fertilizers in forest nurseries and stands summarized by Wilde (1958, 1961). Studies of fertilization in relation to soil deficiencies and plant deficiencies have received considerable attention (Heiberg and White 1951; Stoate 1950; Stone 1953; Swan 1960, 1961).

DESCRIPTION AND RESULTS OF THE EXPERIMENTS

The chief purpose of the experiments described below was to discover means of inducing strobilus[2] formation in young seedlings and grafts of western white pine. Experiment 1 was an attempt to induce flowering of seedling scions by grafting them into the crown of (a) trees of fruiting age and (b) young trees from 10 to 15 years old approaching fruiting age. Experiment 2 was similar to 1(b)--grafting seedling scions into 15 trees about 12 years old at each of two locations in northern Idaho and at two locations in western Washington (where many 7- to 10-year-old trees were found bearing female strobili). The effect of fertilizer, water, and cultivation upon strobilus production on 10-year-old wild trees was investigated (experiment 3). In experiment 4, cone bearing trees about 30 years old were fertilized in an attempt to stimulate strobilus production. All experiments were established in 1955 with the exception of experiment 2 (established in 1956), and all tests were observed annually through 1960.

EXPERIMENT 1. TOP GRAFTING--IDAHO EXPERIMENTS

At each of three locations in the St. Joe National Forest (Clarkia Peak, Butterfield Meadows, and Sheep Creek) 5-year-old seedling scions were grafted into the tops of two trees of fruiting age (average age 28 years) and five trees about 12 to 15 years old. Grafting, using the approach graft technique with budding bands was accomplished during mid-June of 1955. The seedling, still in its pot, was tied into the stock tree. The graft union was covered with a small handful of moist peat moss and wrapped with a small piece of vinyl film. Five seedlings from the same nursery lot as the scions were planted in the open near each stock tree to serve as controls.

Of 76 grafts attempted on the six fruiting-age trees, 57 percent survived the first year and 51 percent were alive in July 1960. Although all stock trees were observed flowering annually, no flowering was observed on the seedling scions. Of the 30 control seedlings planted, 29 were alive in 1960; in 1960 one male strobilus was discovered.

One hundred and nine grafts were attempted in the 15 young trees; 28 percent survived the first year, and 27 percent were alive in July 1960. No flowering was observed during the period 1956-1960. Of the 45 control seedlings planted (3 near each stock tree) 44 percent were alive in 1960, and no flowering had been observed.

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[2] The term strobilus is used to designate the juvenile female reproductive structure (before pollination); the term cone is used to designate all later stages (overwintering, maturing) of the same structure.

Besides the grafts in the two trees of fruiting age at each of the three sites, 4-year-old scions were grafted into the top of one heavily fruiting tree near Butterfield Meadows in 1951 as a preliminary test. One scion bore eight female strobili in 1958 (scion age 11 years), three in 1959, and three in 1960.

EXPERIMENT 2. TOP GRAFTING--IDAHO-WASHINGTON EXPERIMENTS

Two 6-year-old seedling scions were grafted by the approach method into the top of each of 15 young pines at each of two sites in northern Idaho and western Washington in May 1956. Average age of Idaho trees was 12 years; average age of Washington trees was 14 years. Two seedlings from the same nursery lot as the scion material were planted near each stock tree. Grafted pines and planted control seedlings were released as necessary to provide opportunity for growth and flowering.

In spite of animal and vandal damage, 85 percent grafting success was achieved at the Idaho plots and 93 percent at the west coast plots 1 year after grafting. In 1960 (scion age 10 years), 43 percent of the Idaho grafts were alive, but no strobili were observed on scions during the 4-year period. Two stock trees flowered in 1959. No strobili were observed on the planted seedlings.

Both graft survival (72 percent) and flowering were greater at the west coast plots. Seven stock trees and six scions flowered during the period 1956-1960. Grafted scions produced five female strobili, all of which aborted; 17 male strobili were produced.

EXPERIMENT 3. CULTIVATING, WATERING, FERTILIZING YOUNG TREES

At each of three locations in northern Idaho, five pairs of trees (average age 11 years) were selected for uniformity in age, vigor, and growing space. All trees were released from competing trees and shrubs. One tree of each pair received annual water, cultivation, and fertilizer treatments; the other tree received no treatment. A 14-14-14 nitrogen-phosphorus-potassium fertilizer was spread around all treated trees at the rate of 1 pound per 2 feet of tree height, or at a rate of approximately 370 pounds each of N, P_2O_5 (161 pounds of elemental P), and K_2O (307 pounds of elemental K) per acre. Treated trees were cultivated annually at the time of fertilizer application in May. Trees were watered one to three times per summer, depending on summer moisture conditions.

Of the 15 treated trees 11 were alive in 1960. Mortality was due to cultivation (2 trees), blister rust canker (1 tree) and bulldozing (1 tree). Three of the 11 trees produced 13 female strobili and 21 clusters of male strobili (table 1). All 15 untreated trees survived and one tree produced 24 female strobili, but no male strobili (table 1). Most of the female strobili (65 percent) were produced in 1958--a bumper year for strobilus production. This peak of production also coincided with the most watering in a previous summer, and the earliest application of fertilizer (April 30 vs. ca. May 27 in other years).

The average total height of treated and untreated trees in 1955 was identical (5.5 feet); in 1960, untreated trees were slightly taller than treated trees (14.8 feet vs. 14.6 feet). Treated trees have failed to grow faster than untreated trees; furthermore, of the four treated trees, two died as a direct effect of cultivation injury.

Because of the expense of irrigation treatment, the frequency of application was held to a minimum. More liberal application of this treatment might cause greater effects.

Table 1.--Strobilus production by young western white pine trees in experiment 3

Location		Trees in 1955	Trees in 1960	Strobilus production											
				1956		1957		1958		1959		1960		Total	
				♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Keeler Creek	(Treated[1]	5	4	0	0	0	0	1	0	0	0	0	0	1	0
	(Untreated	5	5	0	0	0	0	0	0	0	0	0	0	0	0
Butterfield Meadows	(Treated	5	4	0	0	0	[2]4	8	2	0	15	4	0	[3]12	[4]21
	(Untreated	5	5	0	0	4	0	16	0	4	0	0	0	[5]24	0
Sheep Creek	(Treated	5	3	0	0	0	0	0	0	0	0	0	0	0	0
	(Untreated	5	5	0	0	0	0	0	0	0	0	0	0	0	0

[1] Trees receiving cultivation, fertilizer, and water treatments annually.

[2] Number of clusters of male strobili.

[3] ♀ Strobili produced by three trees.

[4] ♂ Strobili produced by two trees.

[5] ♀ Strobili produced by one tree.

EXPERIMENT 4. STIMULATING STROBILUS PRODUCTION IN FRUITING-AGE TREES

Three groups of four fruiting-age trees (average age 28 years) in the St. Joe National Forest near Elk River, Idaho, were selected to test the effect of fertilizer levels on strobilus and cone production. Initially the four fertilizer treatments were 0, 5, 10, and 15 pounds of a nitrogen, phosphorus, and potassium mix per tree. Each treatment was given to three trees--one randomly selected tree in each of the three groups. In late May 1956, fertilizer was spread around each tree on an area approximately equal to the crown projection. Although for a given treatment the same amount of fertilizer was given to each tree, the effective amount per acre would vary with the crown projection area of the tree. In general, the rate per tree in pounds of fertilizer was (1) 5--approximately 100 N, P_2O_5 (44 of elemental P) and K_2O (83 of elemental K) per acre, (2) 10--200 per acre, and (3) 15--300 per acre. Fertilizer application was initially scheduled for 1956 only, but because no increase in strobilus production was noted in 1956 or 1957, subsequent applications--doubling the original treatment levels--were made in the spring of 1958 and of 1959. Early in mid-July of each year during the period 1956 through 1960, strobili and cones were counted by climbing each tree and examining each branch.

The results show no obvious or general stimulating effect of fertilizer on strobilus production (table 2). Strobilus production was erratic. Neither the hypothesis that spring fertilization will stimulate strobilus production the same year nor the hypothesis that the increase will occur the following year satisfactorily explains these data. The total production for the 5-year period reveals no marked differences in the four treatments.

Table 2.--Strobilus production by fertilized and unfertilized western white pine trees, Butterfield Meadows, St. Joe National Forest, Idaho, experiment 4

Fertilizer treatment [1]	Number strobili produced [2]						
	1956 [3]	1957	1958 [3]	1959 [3]	1960	Total	Average per tree per year
No treatment	59	326	566	196	102	1249	83
5 (10) pounds	97	203	502	169	357	1328	88
10(20) pounds	30	400	289	244	133	1096	73
15(30) pounds	103	131	344	168	373	1119	75

[1] Initial treatments of fertilized trees were 5, 10, and 15 pounds in 1956; in 1958, treatments doubled to 10, 20, and 30 pounds.

[2] For each year the number of strobili is the sum of the strobili produced on three trees treated alike.

[3] Year of fertilizer application.

The great loss of cones due to insect infestation (Conophthorus monticolae Hopkins) is striking (table 3). Although the percent of uninfested cones for treated trees is somewhat greater than for untreated trees, too few trees were observed for a meaningful comparison. Insect damage was assessed only in the spring. The extent of damage occurring in the summer, caused by Dioryctria abietella (D.&S.) and Eucosma rescissoriana Heinrich, was not determined.

Table 3.--Uninfested cone production by fertilized and unfertilized western white pine trees, 1957-1960, Butterfield Meadows, St. Joe National Forest, Idaho, experiment 4

Fertilizer treatment [1]	Cone production [2]									
	1957		1958		1959		1960		Total	
	No.	Percent uninfested [3]	No.	Percent uninfested	No.	Percent uninfested	No.	Percent uninfested	No.	Percent uninfested
No treatment	59	12	208	4	442	1	184	1	893	3
5 (10) pounds	96	73	139	9	462	2	118	3	815	11
10(20) pounds	29	17	171	5	322	1	210	1	732	3
15(30) pounds	103	67	75	4	302	3	87	9	567	16

[1] Initial treatments of fertilized trees were 5, 10, and 15 pounds in 1956; in 1958, treatments doubled to 10, 20, and 30 pounds.

[2] Number of immature cones counted annually in July on three trees treated alike.

[3] Percent of total cones free of Conophthorus monticolae at time of cone count in July each year.

DISCUSSION

Not one of the methods attempted was successful in markedly inducing or stimulating strobilus production of western white pine during the test period. In Idaho, top grafting was successful in only one instance (7 years after grafting at scion age 11), where a single, heavily fruiting stock tree was selected. Instances of precocious flowering when juvenile scions were grafted into the tops of heavily fruiting trees have been reported by Mirov (1951) with pine and Kemmer (1953) with apple. Most of the evidence, including these trials with western white pine, indicates that flowering is not markedly hastened by grafting juvenile scions onto adult stocks (Schaffalitzky de Muckadell 1959; Mergen 1962). Apparently precocious flowering can only occur when the shock or nutritional change is great enough, or when a highly labile genotype is involved. Top grafting in western white pine is probably not a practical or feasible way to effect the change from the juvenile to adult condition.

Cultivating, watering, and fertilizing of young, wild trees did not substantially increase flowering although a slight increase for treated trees was noted at one location. Although more intensive application or different timing of these treatments might have increased flowering somewhat, it appears that no overall and rapid change from the juvenile to adult stage can be achieved in wild trees.

Thus far, it appears that Wareing's hypothesis of plant size as an important criteria for flowering probably offers the best possibility for achieving early and abundant flowering. Attainment of a certain absolute size or degree of complexity possibly may be the best practical way to achieve early flowering for western white pine grafts or seedlings. In seed orchard management, precocious flowering is only initially important, thereafter the quantity and quality of production will be more highly prized. Cultivation, fertilization, and watering is known to markedly increase growth and complexity of young, seedling western white pine (U.S. Department Agriculture, Forest Service 1961). Large trees should have the physical capacity to produce more abundantly than much smaller trees which conceivably might be forced into early production by mechanical mutilation.

The liquid fertilizer and high temperature and humidity shock treatment used successfully by Mergen[3] with Pinus strobus L. and Pinus griffithii McClelland X P. strobus is also promising, particularly if the treatment effects a permanent change from nonflowering to flowering stage.

Late May through early June fertilizer application did not increase strobilus production of fruiting-age pines. Fertilizer treatment is known to stimulate flowering of reproductively mature trees in a number of woody species (Allen 1953; B.C. Forest Service 1960; Hausser 1960; Hoekstra and Mergen 1957; Mayer-Krapoll 1959; Steinbrenner et al. 1960; Stoate et al. 1961; Wenger 1953), and we know it can promote flowering in western white pine.[4] Thus, failure in this test may be due to several reasons, e.g., (1) high nutrient status of the trees, (2) improper time, amount, or method of fertilizer application, and (3) large differences between the trees (site, surrounding density, inherent fruitfulness, etc.). Wilde (1961) stresses clearly that indiscriminate application of fertilizer will not always stimulate flowering.

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[3] Mergen (1961, 1962), and personal communication April 10, 1962, from Francois Mergen, Associate Professor of Forest Genetics, School of Forestry, Yale University.

[4] Replicated experiments in a western white pine seed production area showed that both nitrogen and N-P-K fertilizer applications at the rate of 300 pounds per acre significantly increased strobilus production in 40-year-old trees.

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A TEST OF AERIAL PHOTO CLASSIFICATIONS IN FOREST MANAGEMENT-VOLUME INVENTORIES

INTRODUCTION

The growing interest in combined forest management-volume inventories[1] and continuing developments in aerial photo volume estimating justify a critical look at the forest classifications now used on aerial photos. Most of these classification schemes--whether based on species, stand size, age, stocking, volume, or site--are those which evolved from experience in ground surveys. Conceived primarily as map strata, their basic definitions remain those developed before aerial photos or statistics were considered foresters' working tools. Few of these basic criteria are directly measurable on aerial photos.

These standard classifications, although traditionally recommended in forestry texts, are often inefficient when used on aerial photos. During the past 20 years, many forest photo interpreters have attempted to take the type, stand-size, and density classes used in timber cruising and redefine them in terms recognizable on aerial photos. Some schemes have been based on photo interpretation keys which made use of aerial or ground stereograms; others relied wholly upon written descriptive material. The use of photo interpretation to recognize these familiar but often arbitrary field classifications is subjective to a large extent. This is an important weakness.

The use of aerial photos in a survey usually implies double sampling. In double sampling a large number of plots are classified on the photos and then a subsample of these is measured on the ground to obtain mean volumes. The subsample is subsequently reclassified on the ground in order to adjust the proportions of photo plots on which area estimates are based. Although photo and ground classifications have the same designation, different tree or stand features are measured. For example, in classifying by stand size, tree diameters are measured on the ground, whereas the photo interpreter can only measure height and crown diameter. Although these criteria are related, different classifications often result. These differences are considered photo interpretation errors and are used to adjust the photo estimates of area. As errors, they are assumed to be reflections on the effectiveness of photo stratification.

This roundabout procedure, wherein photo interpretation is expected to classify plots into essentially ground-defined strata, is justified on the assumption that the traditional ground classifications are the most efficient approach to volume estimates; but, are they?

Since the primary purpose of stratification in timber cruising has always been to obtain a good volume estimate, the most effective photo scheme to accomplish this will be one whose criteria are most closely related to ground volume. If the objectives also include an estimate of acres needing cultural or other management treatment, the best scheme may be one whose criteria are also related to these. Before traditional ground classification schemes are recommended for photo use, they should be tested.

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[1] Inventories made to assess cultural and improvement opportunities as well as area, volume, growth, and mortality in forest stands.

THE PROBLEM

Although several studies have tried to determine which of the many possible photo schemes result in strata most closely resembling those used in ground surveys, few seem to question the value of the original ground strata in volume or management estimates. Instead, they concentrate on ways of rating photo-classification schemes by photo-field differences, and on methods of adjusting for these differences.

At least three studies have broken with tradition by testing the usefulness of photo classifications in the light of their improvement of volume estimates. Bickford (3)[2] reported that cubic-volume classes were more efficient than stand-size classes in estimating cubic volume on plot sampling surveys. Kendall and Sayn-Wittgenstein (4) reported that a combination of cover type, stand height, and cover density gave best results when areas were delineated (mapped) rather than point sampled. Macpherson (5) reported two-way stratification by cover type and volume classes about equal to three-way stratification using cover type, volume, and maturity group. However, it is quite significant that the gains shown by these studies were made without the use of precise photo measurements and aerial photo volume tables.

When examining this problem of which stratifications should be used on aerial photos, it is well to remember the limitations of the photo interpreter as well as his strong points. In general, he studies the forest, not the trees. For example: The photo interpreter is limited in the number of direct measurements he can hope to make. He can measure only what he can see on his aerial photos. Direct plot measurements therefore are limited to total height, crown diameter, and crown coverage of the visible trees. On medium-scale photos, he often finds it difficult to measure individual trees; instead, his measurements are plot averages. His conception of stocking must be based on crown coverage of all visible trees; he cannot directly recognize dead or cull trees. He can, however, record measurements for two or more height classes, and the coverage of each in many two-storied stands. Because topographic differences are accentuated on aerial photos, he can often recognize broad soil and site differences and can measure slope and aspect with considerable accuracy. In addition to these reasonably objective measurements, the photo interpreter may be able to deduce from photographic tonal differences many changes in species composition or stand condition due to past history of fire, logging, or insect devastation. These varied photo measurements and interpretations have been combined into numerous classification schemes. Those based strictly upon direct photo measurement are quite objective. Those which rely largely on tonal differences and image shape or appearance are almost wholly subjective.

In management inventories, as in timber estimates, sampling by strata can mean a better estimate at less cost. The amount of gain depends on the type of strata used. These must be defined so that each stratum is fairly homogeneous and so there are real differences between strata. And to afford adequate sampling in each, the total number must be kept quite low. Bickford (2) states: "For timber cruising aerial photos provide the most practical basis for defining classes needed for stratified sampling." He also emphasizes that the most effective classes are those closely related to the data being estimated. When volume is being estimated, the best stratification schemes will be those that are most effective in reducing volume variation within classes.

The stratification problem is further complicated when considering combined management and volume inventory surveys. The photo schemes most valuable for estimating gross cubic

[2] Underlined numbers in parentheses refer to Literature Cited.

volume are not necessarily the best for estimating net board-foot volume, and may be weak in selecting acres of high risk timber or acres where thinning is needed. In a single limited study it is hardly possible to test the value of the many photo-stratification schemes for all types of data collected in volume and management inventories. However, it is possible to evaluate a number of photo or field stratification schemes by means of indices based on one or two types of data collected.

The purpose of this paper is not to outline a survey plan, but rather by evaluating a number of photo-stratification schemes, to provide a reasonable basis for selection of a scheme when considering photo stratification in timber cruising or combined forest management volume inventories.

The question to be answered is: Which classification scheme uses this available aerial photo information most effectively in stratifying forest stands for combined forest management and volume inventories?

During the 1960 field season the Intermountain Forest and Range Experiment Station, in cooperation with other Stations and Regions of the U.S. Forest Service, conducted the St. Regis study--a pilot test of a new survey procedure designed to collect basic information to satisfy both inventory and management needs. This was primarily a field study; however, the ground plots measured for this test were also measured on aerial photos and these paired plots furnished the basic data used in this study of aerial photo-stratification schemes.

OBJECTIVES

In general we wanted to know which aerial photo-classification scheme would contribute the most in a combined forest management-volume inventory.

Specifically we wanted to:

1. Evaluate the several methods of photo or map stratification by their ability to increase the efficiency of the estimates of cubic- and board-foot volume.

2. Rank the methods by their ability to segregate areas of high risk sawtimber and young stands needing thinning or other management treatment.

3. Determine which method would best combine these management and volume inventory aims.

4. Estimate the saving in cost possible by use of this method.

THE STUDY

For this study we had available 126 1-acre plots systematically located throughout a 132,000-acre unit in the St. Regis Ranger District of the Coeur d'Alene National Forest, Montana. These plots were first measured and classified on aerial photos and then on the ground during the 1960 field season.

Nominal 1:16,000-scale $8\frac{1}{4}$-inch focal length USDA photos flown in 1958 were available for the area. Recent 1:62,500-scale USGS quadrangles with 80-foot contour intervals were also available. Mean flying height and photo-scale reciprocals were determined for 200-foot elevation changes from 68 scale lines measured on the maps and photos of the area.

Photo and field plots were located systematically. Plot centers were pinpricked approximately 1,320 feet west of the principal point of each aerial photo lying within the sampled tract. Plot intervals averaged about 1.0 mile east and west and 1.5 miles north and south, throughout the area. Plots were numbered consecutively and marked on the existing type and stand-class map for the area, and on the USGS quadrangles.

AERIAL PHOTO DATA

Photo measurements for the dominant stand consisted of total height and crown diameter in feet, and crown cover in percent. Height and crown cover were also recorded for the understory in two-storied stands. Stand-height measurements were made under lens stereoscope using parallax wedge. Crown cover was measured by a crown-density scale. Measurements of slope percent were also made through each plot center. These stand measurements were converted to gross cubic- and board-foot volumes per acre using an aerial volume table (6).

In addition to the measurements several photo interpretations were made. These interpretations of species-type, stand size, topographic site, and aspect, were primarily subjective although the stand measurements and volumes were used in making them. Insofar as possible Forest Survey definitions were used for these photo classes.

Photo measurements and interpretations for the 1-acre plot surrounding each pinpricked location were recorded on 3- by 5-inch cards. Also included were plot and photo flight line numbers, elevation, photo scale, and parallax factor.

To assure independent observations all photo interpretations were made and recorded prior to any field examination. All field classifications and measurements were made independently from photo interpretation except that field plots were located by means of the same aerial photos previously measured by the photo interpreter. The pinpointed plot centers were located as precisely as possible on the ground and formed the starting point for location of the 16-point field sample grid described below.

FIELD DATA

Stand volume and tree distribution were obtained from a grid of 16 points located on each 1-acre sample (8). Pole and seedling-sapling volumes and counts were determined on a 1/256-acre fixed plot around each grid point. Sawtimber volume was obtained from variable plots located at each of the 16 points and averaged for the acre location. Detailed description of crop trees, a measure of competition, and a quantitative estimate of excess trees were also obtained from the grid plots. Finally, a qualitative description of sawtimber was recorded as a basis for risk classes.

Using these data and Forest Survey volume tables, we determined cubic- and board-foot volume for each acre sample. These volumes, together with the following data, were also recorded on each 3- by 5-inch photo plot card:

- Tree and stand heights (tallest, five tallest, average)
- Total stocking and desirable tree stocking
- Field stand-size class
- Field category
- Field site class
- Management prescription
- Aspect and slope percent

These field classifications were those used in the original St. Regis study which developed a procedure for collecting basic information for combined volume inventory and management requirements. The definitions of these classes are those standardized by the National Forest Survey, U.S. Forest Service.

STRATIFICATION SCHEMES

The 126 plots were then sorted by means of the previously recorded classifications into each of 18 stratification schemes selected for testing. These schemes include most of the traditional forest classes common to volume inventories plus a few peculiar to management surveys. They included seven schemes based on field classification and measurements, eight schemes based on photo interpretation and measurement, and three schemes based on classifications from a previously prepared type and stand-size map. The following brief description includes the number of strata and the source of the measurements of interpretations used in classifying.

The first seven methods of stratifications are those based upon computed data from field measurement of sample plots:

1. Field stand size and density (10 strata).--Includes sawtimber, poles, seedling-sapling, poor, medium, well stocked, and a catchall stand-size class of nonstocked.

2. Field stand size (4 strata).--Same data as 1--collapsed into sawtimber, poles, seedling-sapling, and nonstocked.

3. Field density (3 strata).--Same data as 1--collapsed into poor, medium, and well stocked.

4. Field species (10 strata).--Plots were stratified into white pine, ponderosa pine, larch, Douglas-fir, grand fir, alpine fir, cedar-hemlock, spruce, lodgepole pine, and nonstocked by plurality of cubic volume.

5. Field site class (6 strata).--Site index from site tree measurements taken on sample plots was used to classify plots into six site classes.

6. Field management category (5 strata).--Includes high risk, low risk, and immature sawtimber; pole and sapling stands not needing treatment, and such stands in need of treatment. This is a management classification. Its efficiency in volume estimating is easily tested, but its relative value in management surveys cannot be determined since these same five categories were used in computing ranks.

7. Field cubic-volume class (11 strata).--Includes 500 cubic-foot classes up to 4,000 cubic feet, and 1,000-cubic-foot classes from 4,000 through 6,000 cubic feet. Relative value for management surveys is easily determined, but volume efficiency cannot be determined since computed plot volumes were used in stratification.

The next eight methods of stratification are those patterned after the traditional field classes but rely on strata identified on aerial photos by interpretation or measurement.

1. Photo stand size and crown cover (9 strata).--Includes classes of sawtimber, poles, seedling-saplings, poor, medium, and well stocked, as identified by measurements of total height, crown diameter, crown cover, and tabular volume.

2. Photo stand size (3 strata).--Same data as 1--collapsed in three stand sizes.

3. Photo crown cover (3 strata).--Same data as 1--collapsed in three crown-cover classes.

4. Photo volume (500 cubic feet) class (13 strata).--Classes based on an estimate of cubic-foot volume obtained from photo measurements of total height, crown diameter, and crown coverage used with a previously compiled aerial volume table.

5. Photo volume (1,000 cubic feet) class and topographic site (28 strata).--Classes based on estimated cubic volume obtained from photo measurements and a previously prepared aerial volume table, and photo interpretation of topographic site.

6. Photo volume (1,000 cubic feet) class (7 strata).--Same data as 5--collapsed into volume strata only.

7. Photo topographic site (4 strata).--Same data as 5--collapsed into four sites based on aspect and position on slope.

8. Photo species class (6 strata).--Plots were classified as white pine, ponderosa pine, larch fir, spruce fir, lodgepole pine, and brush by photo interpretation and measurement.

The next three methods of stratification were obtained from a standard forest type map prepared by Northern Rocky Mountain Region, U.S. Forest Service. Original type delineation was on aerial photos, combined with field examination and checking. These delineations were then transferred to a base map of the area to prepare the finished map. Plots were located on this map and classified according to the type in which they fell.

9. Map stand size and density (9 strata).--Includes sawtimber, poles, and seedling-saplings, and poor, medium, and well stocked classifications obtained from the previously prepared type and stand-size class map of the area.

10. Map stand size (4 strata).--Same data as 9--collapsed to stand size.

11. Map density (3 strata).--Same data as 9--collapsed to density.

ANALYSIS

In the analysis all stratification schemes were evaluated for both volume and management use by means of one or two selected indices. For example, net volume by species, by diameter class, and by age group, growth rates, quality, and cull percents are all legitimate requirements in a volume cruise, but evaluation of each scheme by each of these factors would be far beyond the scope or needs of this study. Instead, gross cubic-foot volume and gross board-foot volume per acre were selected as indices to evaluate the strata for volume estimating.

In management inventories, areas of high risk, mature, and immature sawtimber, young stands in need of treatment and others where treatment might not pay off, are usual requirements together with details such as stand size, age, stem counts, and basal areas. Following the above reasoning, areas of high risk sawtimber and young stands in need of treatment were selected as management indices.

Although designed to evaluate photo stratification schemes, this study also evaluates the several field schemes after which most photo schemes are patterned. Classification was accomplished by data from the measured field plots but these field schemes are evaluated by means of the same indices used for the photo schemes, and their value is therefore comparable.

RELATIVE GAIN IN ESTIMATING VOLUME

In volume estimation the most effective schemes are those which reduce variation within and increase variation between classes. Since the number of field samples required to obtain a mean of given reliability is directly related to the variance, each sampling scheme can be evaluated by dividing its pooled within-stratum variance by that of the unstratified sample. When the resulting percentage is subtracted from one, the remainder is an estimate of the reduction in needed field samples. The most efficient scheme is the one with the lowest variance ratio and therefore the greatest reduction in field plots.

For this analysis all methods are considered proportional sampling, that is, strata areas are assumed to be proportional to the number of field samples classified in them. Then:

S^2 = the total variance of the unstratified sample.

$\sum P_i \; S_i^2$ = the pooled within-stratum variance obtained by weighting the variance of each stratum by the percent of the total area occupied by the stratum.

$\dfrac{\sum P_i \; S_i^2}{S^2}$ = the variance ratio obtained by dividing the pooled variance by the unstratified variance.

$1.00 - \dfrac{\sum P_i \; S_i^2}{S^2}$ = the expected percentage reduction in required field plots.

While this is not an absolute measure of sampling efficiency, it is a relative and reasonably simple method of rating a large number of stratification schemes for comparison.

The various field stratification schemes are listed in table 1 for comparison with the aerial photo and map schemes listed in table 2. The number of strata, variance ratio, expected reduction in field plots, and rank is shown for each scheme.

Those schemes 4, 5, and 6 (table 2), based on cubic-volume classes, are better than any other photo scheme and even better than any usable ground scheme shown in table 1. Referring again to table 2, photo scheme 5, based on cubic volume in 1,000-foot classes and topographic site, ranks first but cubic volume alone in either 500- or 1,000-cubic-foot classes is nearly as good. To get adequate sampling in each class the number of classes should be kept quite low, and for this reason the scheme using 1,000-cubic-foot classes alone would probably be the most practical even though it ranks third.

Table 2 indicates that, compared with volume classes, much less gain can be expected from stand-size and crown-cover classification and still less from species and topographic site. Crown cover, using only three classes, appears to be worthless in volume estimating. In general, classifications taken from existing type maps appear even less useful. Since these maps were prepared by photo interpretation, but not measurement, we must assume that subjective photo methods complicated by drafting limitations, add up to much poorer stratification than would be possible from use of aerial photo volume tables.

Comparison of the ratings shown in tables 1 and 2 indicates stratification by means of ground measurements results in stand-size and density strata only a little better than those

Table 1.--Variance ratio, expected reduction in field plots, and rank of the field-stratification methods for volume estimating

No.	Stratification method: Description	Stratification method: Number of strata	Cubic volume: Variance ratio	Cubic volume: Reduction in field plots	Cubic volume: Rank	Saw log volume: Variance ratio	Saw log volume: Reduction in field plots	Saw log volume: Rank
			- - - -Percent - - - -			- - - -Percent - - - -		
	None		[1]100	--		[1]100	--	
1	Stand size and density	10	46	54	2	49	51	3
2	Stand size	4	53	47	3	52	48	4
3	Density	3	91	9	7	96	4	7
4	Species	10	91	9	6	89	11	6
5	Site	6	90	10	5	87	13	5
6	Management category	5	56	44	4	48	52	2
7	Cubic volume--500-cubic-foot class	11	1	99	1	14	86	1

[1]Total unstratified variance: Cubic, 2,122,100; Saw log, 69,451,100.

NOTE: Method 7 is academic for cubic volume since the stratification was made by the same volumes used in computing variance.

obtained from photo measurement. In the case of species, field classification showed even less gain than that made on photos. Quite obviously, stratification by these traditional schemes even through use of field measurements does not equal the gain possible by use of volume strata and aerial photo measurements. Comparison of cubic and saw log volume data (table 2) indicates cubic-volume classes are just as useful for saw log volume, and therefore the following comparisons will be made on the basis of cubic-volume classes only. Since this study considers combined management and volume inventories, the next step is to evaluate the methods used in estimating the areas needing management.

RELATIVE VALUE IN ESTIMATING AREAS NEEDING HARVEST OR OTHER MANAGEMENT TREATMENT

For this purpose there is no readily measured unbiased index comparable to the variance used in volume estimating. A widely accepted method of evaluating photo stratification for area estimating compares photo and field classifications by means of Chi-square test. This test assumes the traditional field classifications are more closely related to the desired management classifications than are any made on aerial photos. In the light of the volume analyses this assumption seems unwarranted.

A second less familiar approach assumes the superior stratification scheme will be that one which confines the plots on which management treatment is needed to the fewest possible strata. This evaluation made through use of Bartlett's test for homogeneity of variance can be used equally well on both field and photo schemes. For example: Assume two photo-classification schemes each having 10 strata are used to classify an area. Each scheme is sampled proportionally on the ground, and each field sample is classified as needing or not needing management treatment by means of field measurements and observations. Nearly all plots needing treatment are classified in only one or two of the 10 strata set up by the first photo scheme. In the second scheme the plots needing treatment are found to be distributed through five or six of the 10 strata used. The first scheme would be most valuable for use on aerial photos since it eliminated eight of the 10 possible strata as a likely source of area needing management.

Bartlett's test ranks these two schemes by means of the corrected sum of the squares obtained from the numbers of plots needing treatment. The scheme with plots needing treatment concentrated in the fewest strata will have the highest sum of the squares and consequently will be ranked first. We recognize that this test offers no means of determining whether any of these techniques is better than no stratification at all, and that the ranking obtained is relative and not on a consistent mathematical scale. Also that the ranks are likely to be nonsignificant particularly in the lower ranks. Nevertheless, it does offer some indication of the better method and has the unique advantage of comparable evaluation for both field- and photo-stratification schemes.

Table 2.--Variance ratio, expected reduction in field plots, and rank of the aerial photo and map stratification methods for volume estimating

No.	Stratification method: Description	Stratification method: Number of strata	Cubic volume: Variance ratio	Cubic volume: Reduction in field plots	Cubic volume: Rank	Saw log volume: Variance ratio	Saw log volume: Reduction in field plots	Saw log volume: Rank
			- - - -Percent- - - -			- - - -Percent- - - -		
	None		[1] 100			[1] 100		
1	Stand size and crown cover	9	58	42	4	66	34	5
2	Stand size	3	59	41	5	65	35	4
3	Crown cover	3	99	1	11	100	--	11
4	Cubic volume--500-cubic-foot class	13	34	66	2	30	70	2
5	Cubic volume--1,000-cubic-foot class and topographic site	28	31	69	1	30	70	1
6	Cubic volume--1,000-cubic-foot class	7	35	65	3	31	69	3
7	Topographic site	4	95	5	10	97	3	10
8	Species group	6	83	17	8	77	23	8
9	Stand size and density (map)	9	76	24	6	76	24	6
10	Stand size (map)	4	77	23	7	77	23	7
11	Density (map)	3	92	8	9	97	3	9

[1] Total unstratified variance: Cubic, 2,122,100; Saw log, 69,451,100.

NOTE: Map stratifications were taken from existing type map rather than directly from photo.

Bartlett's test was used to rank both field and photo schemes as to their ability to select stands classified by field crews as high risk sawtimber, and to select those classified as young stands needing management treatment. The field schemes are listed and ranked in table 3. Field-stratification method 6 based on management categories could not be ranked by this method. The photo and map techniques are ranked in table 4. These data show that photo stratification by 1,000-cubic-foot volume classes ranks first in selecting both high risk sawtimber and young stands needing treatment. Detailed examination of the limited basic data lends credence to this ranking since most high risk sawtimber was confined to the higher cubic-volume strata, and most young stands in need of thinning were confined to the lower cubic-volume strata. Species group appeared next in value for management strata with stand size and crown cover next. Crown cover appears to have value in locating young stands needing thinning. The wholly subjective map classifications even though checked for accuracy on the ground are ranked below the measured photo-volume strata.

Study of table 3 indicates the ranking of the field methods is somewhat different from the ranking of corresponding photo method. Cubic-volume strata are again best in segregating high risk sawtimber. Stand density leads as a method of segregating young stands needing thinning with species classification second.

Table 3.--Field-stratification schemes ranked by ability to segregate high risk sawtimber and young stands needing management treatment

No.	Stratification method: Description	Stratification method: Number of strata	High risk sawtimber Category 1	Young stands needing treatment Category 5
			Rank	
1	Stand size and density	10	2	4
2	Stand size	4	5	3
3	Density	3	6	1
4	Species	10	3	2
5	Site	6	4	6
6	Management category [1]	5	--	--
7	Cubic volume--500-cubic-foot class	11	1	5

[1]This classification used in making the test.

NOTE: Ranks are not on a consistent numerical scale.

Table 4.--Photo-and map-stratification schemes ranked by ability to segregate high risk sawtimber and young stands needing management treatment

No.	Stratification method: Description	Number of strata	High risk sawtimber Category 1	Young stands needing treatment Category 5
			Rank	
1	Stand size and crown cover	9	6	7
2	Stand size	3	9	10
3	Crown cover	3	10	4
4	Cubic volume--500-cubic-foot class	13	4	5
5	Cubic volume--1,000-cubic-foot class and topographic site	28	3	6
6	Cubic volume--1,000-cubic-foot class	7	1	1
7	Topographic site	4	7	11
8	Species group	6	2	3
9	Stand size and density (map)	9	5	8
10	Stand size (map)	4	8	2
11	Density (map)	3	11	9

NOTE: Ranks are not on consistent numerical scale.

RELATIVE VALUE FOR COMBINED MANAGEMENT AND VOLUME INVENTORY

The photo-classification method rated best for volume estimating is not necessarily the best for estimating management prescription. In order to visualize how these methods affect both jobs, we prepared a summary, table 5, which ranks each photo or map method according to its ability to segregate stands classed as field category 1 (high risk sawtimber) and stands classed as field category 5 (young stands in need of treatment). The relative efficiency in volume inventory (probable percentage reduction of field plots) is shown directly below the method number. Although the index of relative volume efficiency is numerically reliable, the ranks used in this table should not be interpreted as having consistent numerical meaning. Lack of data precludes not only rating the efficiency for management purposes but in most cases even the testing of significance among ranks. However, this table does indicate that stratification by 1,000-cubic-foot photo volume classes obtained from measured plots and aerial volume tables is superior to any other photo method in combined management and volume inventories. Other schemes combining cubic volume and other strata rate above average for combined surveys, but may be less valuable than stand size or density or species in segregating young stands needing management treatment.

Table 5.--Photo-stratification methods ranked by ability to segregate areas needing management treatment

Management category 1--high risk sawtimber	Management category 5--young stands needing treatment										
	Rank										
	1	2	3	4	5	6	7	8	9	10	11
Rank											
1	6 0.65										
2			8 0.17								
3						5 0.69					
4					4 0.66						
5								9(M) 0.24			
6							1 0.42				
7											7 0.05
8		10(M) 0.23									
9										2 0.41	
10				3 0.01							
11									11(M) 0.08		

NOTE: Percentage indicates probable reduction in needed field plots based on cubic-volume variance. Ranks for management purposes are not on a consistent numerical scale.

Key--Photo-stratification methods

1 Stand size and crown cover
2 Stand size
3 Crown cover
4 Cubic volume--500-cubic-foot class
5 Cubic volume--1,000-cubic-foot class and topographic site
6 Cubic volume--1,000-cubic-foot class
7 Topographic site
8 Species group
9 Stand size and density (map)
10 Stand size (map)
11 Density (map)

A primary objective of this study has been to rate selected photo-stratification schemes as simply and as directly as possible. Although complete cost data were not obtained on this study, no discussion of stratification methods would be complete without some reference to costs.

RELATIVE COSTS

In mountainous regions, field plot costs depend more on travel time than on time actually spent in plot measurement. Based on the St. Regis study, total field measurement time can be expected to average about 14 man-hours per location. The Forest Survey records for this area indicate average costs of $70 per location with some locations exceeding $100.

Photo interpretation costs are affected little by topography, but depend almost entirely on the kind of measurements and classifications made. In commercial forest stands where cubic- and board-foot volumes are estimated by means of precise photo measurements and these estimates and measurements are used to stratify the plots, studies (7) show that experienced photo interpreters can average about five plots per man-hour. Where classifications are made without measurement, or in areas where many plots are nonforest, much higher averages are possible and sustained rates for stereo classification may reach 200 plots or more per man-day. The skill and precision expected of a good photo interpreter may require a year or more of intensive training and experience, but this interpreter should then be able to measure and classify plots for about 70 cents each or 1 percent of the cost of fieldwork.

The cost of aerial photos can generally be ignored in any evaluation of survey methods. Aerial photos are working tools of the forester. They are obtained for many purposes in addition to forest inventory, and are readily available on most forests. In this particular case, the photos used were originally purchased for field plot location in the St. Regis field study. Since all photo methods were based on one set of photo measurements and classifications, and were tested by field data taken on the same plots, the cost of aerial photos can have no significance in these results. The same may be said for such routine chores as trimming and filing photos, determining photo scale, and marking plots on both photos and maps. They are needed equally in every method used. For example, no qualified photo interpreter would suggest plot classification by any scheme in mountainous areas without knowing photo scale.

Both photo and field plot measurements used in this study were made by personnel with pay scales considerably above average. A comparison of costs is therefore more meaningful when based on man-hours. Photo interpretation including stand heights measured by parallax wedge, crown cover by comparison, and again by dot count, slope percent computed from horizontal and vertical photo measurements, cubic- and board-foot volumes read from aerial tables, and finally, classification of all plots by six different methods was performed at a rate of about 30 plots per man-day.

As this study indicates, merely sorting these measured plots by different methods can result in widely different field plot requirements for reliable volume estimates and corresponding savings in overall costs. These costs can be compared in a simulated problem. Assume 100 unstratified field plots are required to obtain a reliable volume estimate and that measuring the plots on the ground would require 1,400 man-hours of field time. To stratify these plots by stand size and density using photo interpretation without measurement would cost 4 man-hours. The gain is similar to that shown for map stand size and density (table 2) and should reduce the needed field plots to 76 and the field cost to 1,064 man-hours. Measuring the plots on aerial photos and then stratifying them into stand size and density would cost 27 man-hours. However, when these strata are sampled in the field, the required plots could be reduced to 58 and the field time to 812 man-hours. But if cubic-volume strata are used at the same cost of 27 man-hours, the needed field plots could be reduced to 35 and the required man-hours on the ground to 490. Unfortunately this example is based entirely on the gain in volume estimating. The basic data are inadequate for such an analysis of gain in estimating management needs. Nevertheless, the rank given the various photo methods is at least an indication that the use of photo-volume strata may result in cost savings for these surveys also.

APPLICATION

The use of aerial photos in volume and management inventories involves some form of double sampling. Development of a complete sampling plan for a specific project using both aerial photo and ground sampling requires consideration of both accuracy and cost. The statistical methods used have been well developed in several publications (1, 3).

In this study aerial photo-stratification schemes have been compared and rated by the simplest and most practical methods available. These data indicate that photo-volume classes are best in volume estimating and probably best in management inventory.

In spite of numerous studies made during the last decade in aerial photo estimating and the use of photo-volume strata, several reasons are repeatedly given for not capitalizing on this technique. These include:

1. Cubic-volume strata may be of little value in estimating board-foot volume or management needs.

2. Skilled photo interpreters and necessary aerial volume tables are not available when needed, and therefore photo-volume strata are unusable.

3. The number of measured field plots has reached an irreducible minimum in management plan inventories, and therefore additional photo effort will not pay off.

All these make good excuses but poor reasons. The analysis of these data indicates that cubic-volume strata are even more valuable in estimating board-foot volume than in estimating cubic-foot volume. And of all strata tested, cubic-volume strata rank highest in segregating both high risk sawtimber volume and young stands where management prescription is required. No such analyses exist to prove the superiority of the stratification schemes now in use.

Inability to hire photo interpreters skilled in forest measurement techniques is no justification for ignoring the possibilities of these techniques. When unskilled foresters are hired for field plot measurement, they are not only given on-the-job training but are expected to precisely measure almost all items reported in the belief that their measurements will be better than their estimates. Equally unskilled foresters assigned to photo interpretation receive little on-the-job training and are asked to estimate everything without measurement. Yet, the same laws of accuracy apply equally to field and photo measurements and skilled personnel must be developed in the same manner.

Aerial volume tables are not quite as common as ground volume tables, but generalized aerial tables are available. When used for volume stratification as described in this paper, composite tables published in 1956 and compiled from field plots measured in southern Idaho, Wyoming, and Utah, gave satisfactory results in this study in northwest Montana.

While it is true that the number of measured field plots used on extensive management and volume inventories is approaching an irreducible minimum, it is also true that accuracy on the area figures to which data from these plots are applied could certainly be improved through photo measurement. Interpretation of additional photo plots, particularly if these were stratified by the best possible method could improve the reliability of the entire survey.

Finally, the many considerable photo estimating studies made during the past decade have opened the door to better and less costly methods of localizing extensive management and volume inventories. The opportunity for this use alone should justify more consideration of photo measurements and cubic-volume strata.

SUMMARY

A number of photo-and map-stratification schemes were studied using data from the St. Regis test area. Primarily, we concluded:

In volume estimating, photo-volume classes offer the best means of stratification. Volume classes also appear to offer distinct advantages in stratifying for management purposes. Photo cubic volumes obtained from direct photo measurement and aerial volume tables, and stratified into 1,000-cubic-foot classes appear to offer the most practical photo approach to combined management and volume inventories. Some additional findings were:

1. Photo cubic-volume strata were found to be at least as efficient in board-foot volume estimates as in cubic-foot volume estimates.

2. The familiar and widely used stratifications of photo or map stand size and density contributed much less to either survey than did cubic-volume strata.

3. Stand-size and density stratifications based on field data, though somewhat better than their counterparts made on photos, still contributed much less than did photo stratification by cubic volume.

4. Stand density and site strata, whether obtained from photo, map, or field data, contribute little to the efficiency of volume estimates. Density is helpful in selecting young stands in need of treatment, but both density and site probably contribute most in estimating priority and the amount of work required.

5. Photo measurement cost 0.27 per man-hour and field measurement 14 man-hours per location. On a survey requiring 100 unstratified field locations, photo stratification by cubic-volume class could reduce field measurement time from 1,400 to 490 man-hours. Forest Survey records indicate dollar costs for field plot measurement may easily be 100 times the cost of photo measurement at the same location. For this reason substantial savings are possible in double sampling based on cubic-volume strata.

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SPECIFIC GRAVITY AND TREE WEIGHT OF SINGLE-TREE SAMPLES OF GRAND FIR[1]

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SYNOPSIS

Analysis of data from 108 grand fir trees sampled in northern Idaho provided the following prediction equations for specific gravity of 20-year periodic increment on the tree bole (S_{20}), average specific gravity of the tree bole (S_{ent}), and the dry weight of the tree bole (W):

$$S_{20} = 0.5413-0.08838(1/SC_{20})+0.9907(1/H)$$

$$S_{ent} = 0.5579-0.05614(1/SC_{20})-0.03299(1/SC_{ent})$$

$$W_{(cwt)} = 0.4422+0.001305(D^2 \cdot H \cdot SC_{20})-0.1990(C)$$

where: H = total tree height in feet

D = d.b.h.

C = crown class

SC_{20} = specific gravity of the outer 20 rings of increment core taken at breast-height.

SC_{ent} = specific gravity of increment core to pith taken at breast-height.

Trends of specific gravity of the increment at different heights in the tree were shown to be a function of distance from the apex, crown length, and crown class.

[1] Fieldwork for this study was conducted with the cooperation of Potlatch Forests, Inc., Inland Empire Paper Company, and the Forest Products Laboratory of the U.S. Forest Service.

INTRODUCTION

Growth and yield data for pulping species are most meaningful when expressed in units of dry fiber weight. Because grand fir (Abies grandis Lindl.) is one of the better pulping species in the Inland Empire,[2] the growth and yield study of this species conducted by the author was designed to provide data on specific gravity at breast height on each yield plot. In this report, the prediction equations for converting the breast-height specific gravity to estimates for the entire stem are derived. Three dependent variables are included:

1. Average specific gravity of the last 20 years of growth.

2. Average specific gravity of the stem.

3. Tree weight in pounds of dry matter.

Each of these variables pertains to the tree stem from a stump height of 1 foot to a top diameter of 3.6 inches inside bark.

COLLECTION OF TREE DATA

Field-sampling procedures.--Single-tree samples of grand fir were selected in two steps. In the first step, breast-high cores were taken from trees near the yield study plots. Each tree in this preliminary sample was numbered, and its crown class and d.b.h. were recorded. Specific gravity of the core was determined by the procedure described below. From this preliminary sample, trees were selected to cover uniformly as wide a range of specific gravities as possible within crown and diameter classes.

From the 108 trees so selected, one additional core to the pith and two cores extending through the outer 20 annual rings were taken from the three unsampled quadrants at the breast-height position. The trees were then felled, and seven disks cut from the stem at equal intervals starting at the breast-height position and extending upward to the point where the diameter inside bark was 3.6 inches. For trees taller than 100 feet, disks were cut from the top of each 16.3-foot log, at breast height, and at the point where diameter inside bark becomes less than 3.6 inches. The diameter inside bark of each disk was recorded. The total height, height to base of the live crown, and age at breast height were recorded for each tree.

Distribution of the sampled trees by diameter and crown class is shown in table 1.

[2] As used in this paper, the term "Inland Empire" includes northern Idaho and northeastern Washington.

Table 1.--Distribution of tree samples for specific gravity analysis

D.b.h. (in.)	Crown class: Dominant	Codominant	Intermediate	Suppressed	Total
	Number				
4		2	2	2	6
6	2	2	4	5	13
8	1	6	8	5	20
10	1	6	3	2	12
12	4	3	4		11
14	8	4	1		13
16	3	4	2		9
18	3	3			6
20	3				3
22	3	3			6
24	2				2
26	2				2
28	2				2
30+	3				3
Total	37	33	24	14	108

Determination of core specific gravity.--Specific gravity at breast height was obtained from cores taken with a standard increment borer. The cutting diameter of the borer was calibrated by a taper gage periodically during the fieldwork. The average diameter was 0.171 inch. The length of the core from end of last growing season to the pith was measured to ±0.01 inch immediately upon extraction. The last 20 annual rings were then severed and their length recorded. The cores were inserted in numbered paper straws for transportation to the laboratory. After drying for 25 hours at 105° C., the cores were weighed on a precision balance. Specific gravity (grams of dry wood fiber per cubic centimeter of green volume) was computed from the following formula:

$$\text{Sp. gr.} = 0.0777\ W/D^2L$$

where W = ovendry weight (grams)

D = diameter of increment borer (inches)

L = length of core (inches).

The mean specific gravity of the cores to pith was 0.388 with a standard deviation of ±0.030 per tree. The standard deviation of the separate cores about the mean for the tree was ±0.022. Hence, the standard error of the mean of the two cores to pith for a single tree was ±0.016.

The mean specific gravity of the 20-year increment was 0.397 with a standard deviation of ±0.048 per tree. The standard deviation of the four separate cores about the tree mean was ±0.054. The mean of the four cores for the 20-year increment specific gravity thus has a standard error of ±0.027.

Determination of bole weight and specific gravity.--Pie-shaped segments of the disks were split along the 20th ring from the cambium to separate the 20-year increment from the entire segment. After soaking the segments to regain lost moisture, their volumes were obtained by water displacement; then the segments were dried in several steps to an ovendry condition and weighed. From these data the total volume and increment volume were computed in cubic feet by summing the Smalian formula for volume of a parabolic frustum for each log. The volume of the section from a stump height of 1 foot to breast-height point was computed as $(0.03)(\text{dia. inside bark at b.h.})^2$ and assumed to have a specific gravity equal to that of the breast-height section.

The weight of each bole was computed by multiplying each end-area in the volume summation by its corresponding specific gravity, then multiplying the total by 62.4 pounds per cubic foot. The bole specific gravity was obtained as an intermediate step by dividing the above total by the total volume. Analogous calculations were used to determine the specific gravity of the outer 20-year increment.

VARIATION IN SPECIFIC GRAVITY AS A FUNCTION OF HEIGHT

The way in which specific gravity of a given annual increment changes with height must be considered in deriving formulas to convert breast-height data to total-tree estimates. Much has been written concerning variation in specific gravity (Goggans 1961). However, three papers provide special insight into the causes and nature of the variation of specific gravity with height.

1. Larson's (1960) investigations showed that the transition from large diameter to small diameter cells was related to the cessation of terminal elongation, and that the vertical extent and magnitude of the change in tracheid development depended upon the intensity of the apical stimulus. This theory suggests that variations in tracheid development should be related to distance from apical meristem, rather than to height above the ground level. Although cell diameter is only one factor affecting specific gravity, the correlation of secondary wall thickening with cell diameter permits a similar argument to be applied to specific gravity.

2. The strength of this approach is demonstrated by data cited by Richardson (1961). Of the three sequence types described by Duff and Nolan (1953), the type I or oblique sequence showed the best concordance of data from various portions of the tree bole. In this sequence, a single annual increment is traced from the apex to the base. Points are identified by the number of internodes from the apex at the time of deposition. For Corsican pine, Richardson reported that gravity decreased to a minimum at about the fifth internode from the apex, then increased to about the 20th, and subsequently leveled off.

3. Smith and Wilsie (1961), studying the effect of summer water deficits on tracheid development in the oblique series in loblolly pine, found that the slope of the linear regression of specific gravity on internodes from the apex was closely related to the moisture stress during the year of formation.

These three papers indicate that:

1. Factors such as crown development and vigor may affect the trend of upper tree specific gravity by supplying additional sources of auxin from elongating laterals.

2. Much of the variation in specific gravity at breast height may be simply the result of sampling at different distances from the apex.

3. Regression coefficients depend on the past climate, especially for estimating specific gravity of increment over the bole surface.

An analytical expression for this function can be derived from the following assumptions:

1. One component of specific gravity at distance (T) from the apex is inversely related to the concentration of auxin per unit area of cambium (C) (perhaps through the mediation of other substances present in proportion to the auxin transported from the apex).

2. A second additive component represents effects proportional to the distance from the apex. An example of this latter type is the effect of wind stresses acting through a moment-arm proportional to the length of the stem (T) above the point of measurement. Thus

$$S = a + b/C + cT \tag{1}$$

3. The tree bole is approximately a paraboloid. For D_T = diameter at distance T from apex:

$$D_T = gT^{\frac{1}{2}}. \tag{2}$$

Since concentration would vary inversely proportional to cambial area, for a given vertical dimension, it is inversely proportional to the horizontal dimension. Hence

$$C = k/D = \frac{k}{g} T^{-\frac{1}{2}} \tag{3}$$

because circumference is proportional to diameter.

Taking differentials of (1) and (3)

$$\partial S = -b\, C^{-2} \partial C + c\, \partial T \tag{4}$$

$$\partial C = \frac{-k}{2g} T^{-3/2} \partial T \tag{5}$$

and, substituting (3) and (5) in (4):

$$\partial S = -b\, (\frac{g^2}{k^2} T)\, (\frac{-k}{2g} T^{-3/2})\, \partial T + c\partial T$$

$$\partial S = \frac{bg}{2k} T^{-\frac{1}{2}}\, \partial T + c\partial T. \tag{6}$$

Integrating: $$\int \partial S = \int (\frac{bg}{2k} T^{-\frac{1}{2}} + c)\, \partial T$$

gives $$S = \frac{bg}{4k} T^{\frac{1}{2}} + cT + a_o \tag{7}$$

or, combining coefficients:

$$S = a_0 + a_1 T + a_2 T^{\frac{1}{2}}. \tag{8}$$

This equation, for appropriate coefficients a_1 and a_2, has an analytical form similar to that described by Richardson (1961).

ANALYSIS OF DATA

The above analysis applies to specific gravity of a single annual increment. A similar functional form should also apply to the average specific gravity of a uniform number of annual increments. Because the cores taken from the trees on the growth study plots were measured for the specific gravity of the outer 20 years' increment, this period was used for the analysis of the individual tree data.

The specific gravity of the outer 20 annual rings of each disk was used to estimate the three coefficients in (8) for each tree.

These three coefficients formed the components of the dependent vector of a multiple linear regression on the four independent variables: d.b.h., crown length, age, and crown class of the sample tree. A test statistic for the predictive value of each of the independent variables was computed. This statistic has the F-distribution with 3 and 103-q degrees of freedom where q is the number of independent variables included in the multivariate regression. In the first part of table 2, this statistic is indicated for each variable separately.

After removing the effect of crown length, crown class still accounted for a significant part of the remaining generalized variance, but d.b.h. did not.

The regression equations for the coefficients of (8), finally expressed in terms of crown length (L) and crown class (C), were:

$$a_0 = 0.377 - 0.000971\ (L) + 0.0628\ (C)$$

$$a_1 = 0.000552 - 0.0000883\ (L) + 0.00229\ (C)$$

$$a_2 = 0.0474 + 0.000678\ (L) - 0.0223\ (C).$$

Curves predicted from these regressions are shown in figure 1 for two typical crown lengths in each crown class.

ESTIMATING INCREMENT SPECIFIC GRAVITY FROM BREAST-HEIGHT CORE DATA

The average specific gravity of the layer of wood produced in a 20-year period is the weighted average of the ordinates of the curves in figure 1, where the weights are the cross-sectional area of the increment at the corresponding distance from the apex. The specific gravity of the outer 20 rings of the core taken at breast height provided the principal index to relative position of the curve for a particular tree.

Table 2.--Value of variables for predicting parameters of trend of specific gravity with distance from apex

Variable	F-statistic	Degrees of freedom
Crown class	17.0**	3,102
Crown length	16.6**	3,102
D.b.h.	14.3**	3,102
Age	2.4	3,102
	Independent of crown length:	
Crown class	6.24**	3,101
D.b.h.	1.60	3,101

** Significant at the 1% level.

The 20-year sheath of increment studied here was laid down in the years 1940 to 1959 inclusive. Application of the predictors derived below should be restricted to trees subject to moisture regimes similar to those experienced in the Inland Empire during that period.

The analysis of the previous section showed that this curve changed slope with crown length and crown class, and particular attention was paid to exploring the possible functional form in which these variables might enter the prediction equation for increment specific gravity. Tree height, (H), as a measure of the distance from the apex at which the specific-gravity sample was taken, was also expected to be an important variable. In addition, age, volume growth percent, d.b.h., and diameter growth rate were also considered because other workers had hypothesized that these variables are related to specific gravity. Three separate regressions were computed using 18 to 28 variables representing various transformations and interactions of the variables in the above list. In each regression, two terms were sufficient to explain all but an insignificant portion of the explainable variance.[3]

Breast-height core specific gravity (SC_{20}) was the most important factor. Its reciprocal was consistently the best functional form of this factor. The best prediction equation of the set solved was:

$$S_{20} = 0.5413 - 0.08838\ (1/SC_{20}) + 0.9907\ (1/H).$$

The coefficient of determination was $R^2 = 0.771$ and the standard error of estimate was ± 0.0146.

[3] In this paper, explainable variance is taken to be (Variance of Y) (Max (R^2)) where the Max (R^2) is the coefficient of determination for the multiple regression on the entire set of independent variables.

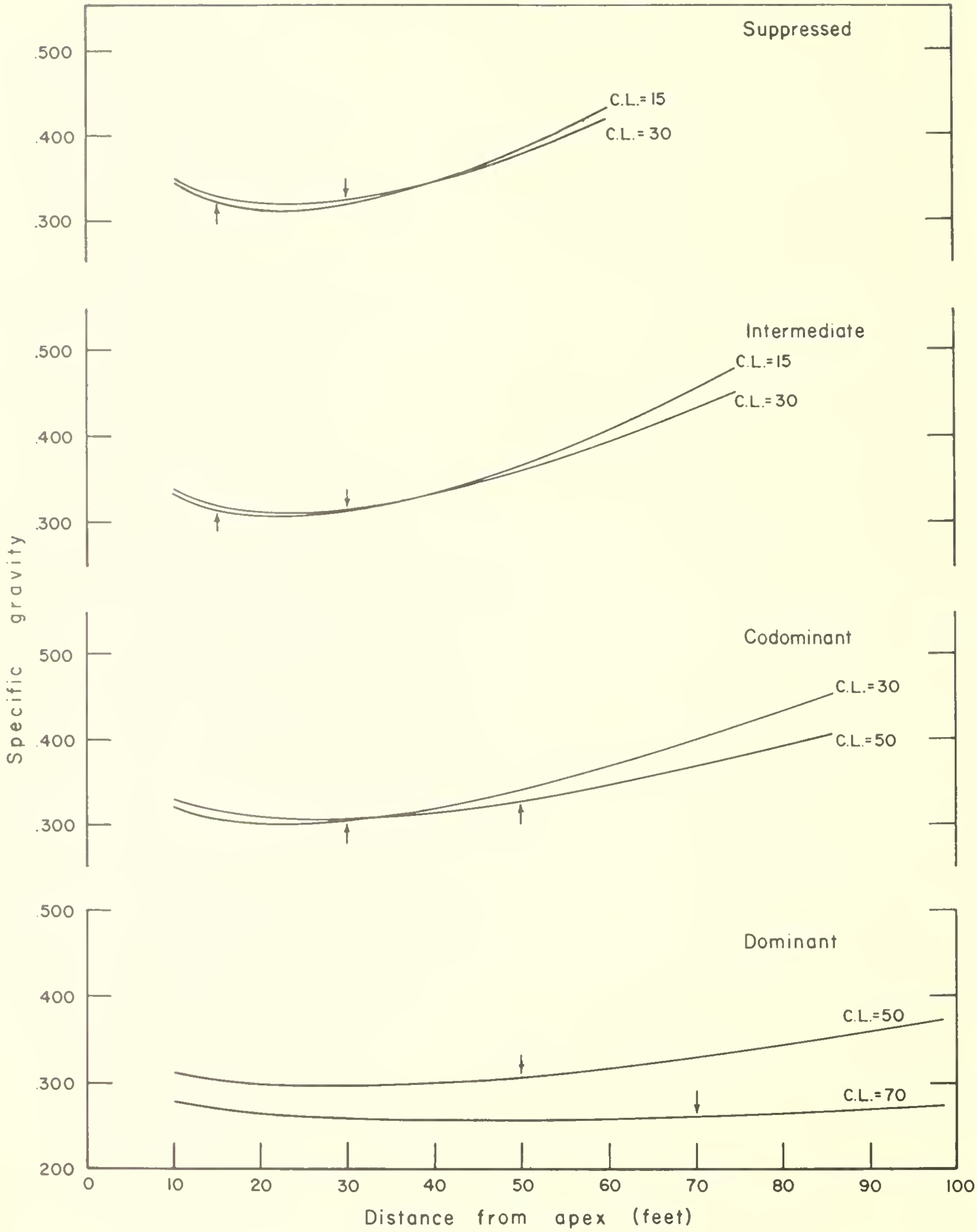

Figure 1.--Specific gravity of the outer 20 annual rings as a function of distance from apex of the tree for Abies grandis. Separate curves are drawn for two typical crown lengths in each of four crown classes. Arrows indicate base of live crown.

Although the coefficient of the reciprocal of height was very significantly different from zero, dropping this variable only reduced the coefficient of determination to $R^2 = 0.741$. The simpler prediction equation was:

$$S_{20} = 0.5592 - 0.09022\ (1/SC_{20})$$

with a standard error of estimate of ±0.0153.

Zobel et al. (1960) reported one of the few studies in which the outer sheath of wood was treated separately. For the regression of outer bole on outer breast-height specific gravity, he found standard errors of ±0.016 and ±0.011 for slash and loblolly pines, respectively. His breast-height samples consisted of 1-inch disks.

ESTIMATING BOLE SPECIFIC GRAVITY FROM BREAST-HEIGHT CORE DATA

The average specific gravity of the bole to 3.6" i.b. (S_{ent}) was the dependent variable of a regression on 15 independent variables derived from the same factors studied in relation to increment specific gravity. In addition, the specific gravity of the entire core from cambium to pith (SC_{ent}) and its reciprocal were added. Of the 17 independent variables, two variables, the reciprocals of SC_{20} and SC_{ent} were sufficient to explain most of the explainable variance. The prediction equations were:

$$S_{ent} = 0.5579 - 0.05614\ (1/SC_{20}) - 0.03299\ (1/SC_{ent})$$

with $R^2 = 0.696$ and standard error of estimate of ±0.0145, and

$$S_{ent} = 0.5175 - 0.0738\ (1/SC_{20})$$

with $R^2 = 0.666$ and standard error of estimate of ±0.0151.

The ratio of crown length to total height explained an additional 1 percent of the total variation. Although statistically significant, the contribution of this additional variable is too small to be of value for prediction purposes.

It is interesting to note that the correlation of the outer 20 years of the core with average bole specific gravity was 0.78 while the correlation of the entire core with average bole was 0.71. Apparently the central portion of the bole follows a less well-defined trend of specific gravity with height in the tree than does the sheath of increment. Zobel et al. (1960) found a similarly small change in correlation when the juvenile wood was ignored.

Wahlgren and Fassnacht (1959) obtained standard errors of from ±0.021 to ±0.0285 for four species of southern pine when the independent variable was the reciprocal of specific gravity of a single breast-height core. Gilmore et al. (1961), also working with southern pines, found standard errors of ±0.017 when predicting tree specific gravity from a single breast-height core could be reduced to ±0.015 when the prediction was based on the product of two core values, breast height and stump height. Judging from the within-tree variance of specific gravity at breast height found in the present study, the advantage of Gilmore's second core may be chiefly a matter of obtaining more samples, rather than a virtue of position. Whether the same argument holds for adding SC_{ent} to the predictions for grand fir is not clear, because in this case the SC_{ent} sample includes two of the four SC_{20} cores.

Zobel et al. (1960), using disks at breast height rather than cores, arrived at a standard error of ±0.016 for slash pine. They estimated specific gravity at breast height without the sampling error inherent in the increment core methods (but still having some measurement error). From Wahlgren and Fassnacht's data, it appears that their standard errors in prediction would have been reduced from about ±0.025 to ±0.015 by replacing the core by the surrounding disk.

Apparently, several cores to pith are adequate to provide a means of predicting tree specific gravity with a standard error comparable to that obtainable from an entire disk taken at breast height.

ESTIMATING DRY WEIGHT OF THE TREE BOLE

Dry weight of standing trees can be estimated by procedures analogous to those used to estimate the cubic contents of such trees. One approach might be to use the equations of the previous section to estimate specific gravity and a conventional volume table to estimate the cubic-foot contents of the bole. Multiplying the product of these two factors by 62.4 lbs./cu.ft. would give an estimate of tree dry weight. However, such a procedure would make it very difficult to assess the possible effect of crown characters acting through specific gravity and form class on the final estimate of weight. A more direct procedure is to use dry weight of the tree bole in hundreds of pounds (W) as the dependent variable in a multiple regression.

The variance of dry weight increases with tree size. Hence, a set of weights inversely proportional to the variance was needed to improve the estimates for the smaller tree sizes. In previous analyses, the variance of specific gravity had appeared to be independent of tree size. Thus, most of the change in dry-weight variance must be the result of the increase in variance in cubic feet. Accordingly, a weighting function derived in the course of calculating a cubic-foot volume table for grand fir was used to stabilize the variance of dry weight.

Independent variables were selected by combining breast-height core specific gravity with the combinations of d.b.h. (D) and height (H), commonly used in volume equations. The specific gravity at breast height was based only on the data for the outer 20 rings of the core. This portion of the core was used because it corresponds to the data collected on the grand fir growth and yield plots. The analysis of the previous section showed that adding the data for the entire core would have resulted in only a small increase in precision of the estimate.

In addition, crown length (L) and crown class (C) were introduced to account for changes in form class and specific gravity associated with crown characters.

Four significant variables explained 98 percent of the variance in dry weight, but the combined variable $D^2 \cdot H \cdot SC_{20}$ alone accounted for 97 percent! The most useful additional variable was crown class. Together, these two variables resulted in a prediction equation having a coefficient of determination of 0.978 and a standard error of estimate of ±27.2 lbs. (for an observation of unit weight).

The two prediction equations were:

$$W_{(cwt)} = -0.2807 + 0.001345(D^2 \cdot H \cdot SC_{20})$$

$$s.e. = \pm 0.307$$

and

$$W_{(cwt)} = 0.4422 + 0.001305(D^2 \cdot H \cdot SC_{20}) - 0.1990(C)$$

$$s.e. = \pm 0.272.$$

The units of the variables are:

D = diameter at breast height in inches

H = total tree height in feet

SC_{20} = specific gravity of the outer 20 rings of an increment core taken at breast height.

C = crown class coded as:

Dominant	= 1	Intermediate	= 3
Codominant	= 2	Suppressed	= 4

The average of the absolute percentage deviations was 11.3 percent of the tree weight. By comparison, a similar cubic-foot volume table with arguments of height and diameter prepared by the author had an average absolute percentage deviation of 9.8 percent.

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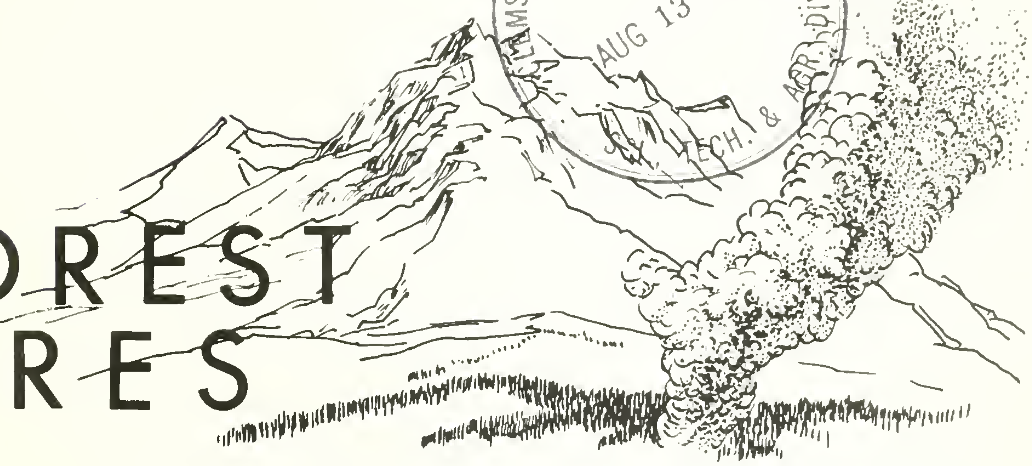

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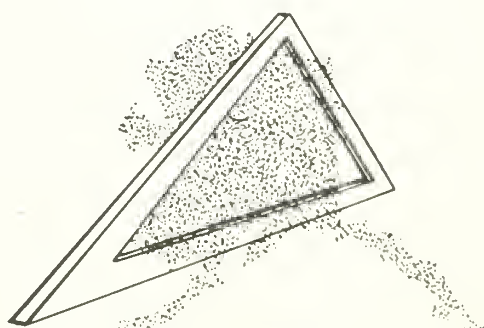

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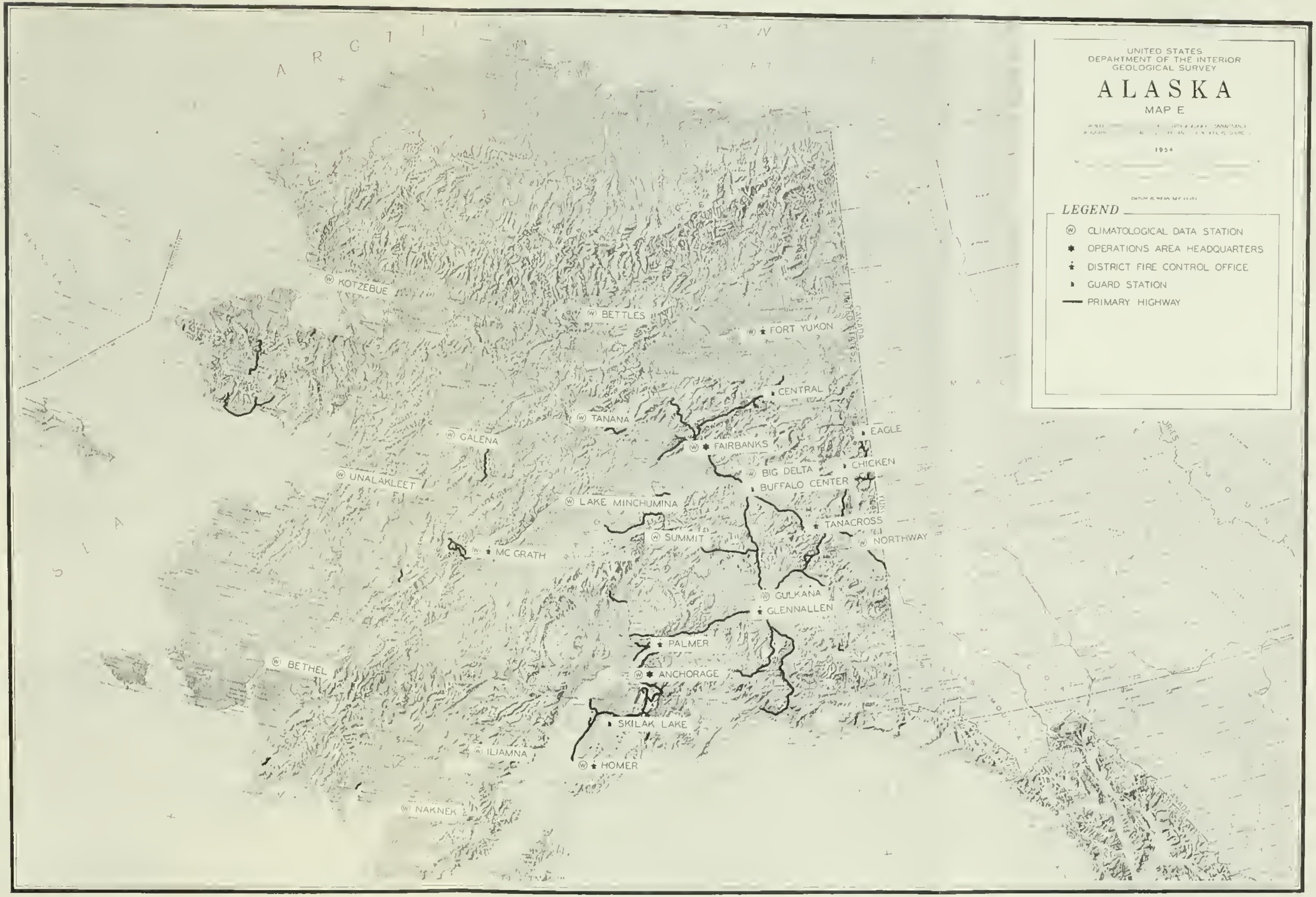

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FOREST FIRES IN ALASKA

by

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C. E. H. and J. W. F.

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CHAPTER 1
INTRODUCTION

PURPOSE OF THIS PUBLICATION

Alaska has long been thought of as an area to be exploited rather than developed. Only recently have the advantages of managing a continuous resource gained much support. Even as late as the end of World War II the official feeling towards the timber supply in Interior Alaska was pretty clearly indicated in the following quotation from a United States Department of Interior report, (USDI 1945): "It seems reasonable to suppose that little of the interior timber will ever come into the general timber-products markets though birch trees of the best quality are suitable for cabinet making . . . ."

The term, "Interior Alaska," describes that portion of the State which lies west of the 141st meridian except for the rugged south coast east of the Kenai Range on the Kenai peninsula. Most land south and east of this line is managed by the U.S. Department of Agriculture's Forest Service in the form of three National Forests. All the rest of the State, some 360,000 square miles, is protected by the U.S. Department of Interior's Bureau of Land Management; 225 million acres require active fire protection. The 1950-1958 average annual loss from fire is 1.1 million acres; however, this varies from 37,000 to more than 5 million acres in individual years. Some administrators hope that knowledge gained through research and development will increase our effectiveness in combating fire and lead to a reduction of the annual loss to one-tenth of this tremendous amount.

This publication was written to serve two audiences: The first consists of those who are interested in the fire protection problems but who do not already have knowledge of the overall geography, climate, economic values, and the fire control "picture"; the second audience is made up of practicing foresters who wish to gain specific information based on fire weather, behavior, statistics, and control data for fire research, fire control planning, and fire suppression purposes. Interior Alaska has a great many resources that deserve a much higher level of protection than they have been receiving. In order to protect a land adequately, much knowledge must be had about the enemy—in this case, fire.The geography and climate of the area are described here in terms of their significance to fire control. Analysis of climate, fire behavior, and fire statistics over the past several years should help establish normals against which future fire seasons and fire control actions can be measured; also, it may help shape the type and size of fire detection and control organization deemed necessary to protect the resources to an extent commensurate with their values. For those who wish to delve into statistics, the appendix contains the basic information from which most of the charts and tables in this report were derived.

The authors wish to point out that it is not their intent to draw major conclusions from the information presented nor to set forth a comprehensive research program, but to put under one cover the major facets of wild fires in Interior Alaska. Researchers can utilize the information in this publication for formulating research programs; resource managers should find this material beneficial in fulfilling their fire control planning and suppression responsibilities.

The bulk of the statistical information is for the period 1950 through 1958; however, a few references as late as 1961 do occur. Some items of information were gleaned from conversations and general listening and reading; such information cannot easily be referenced nor substantiated, and can even be erroneous. The authors have attempted to minimize these sources and they do apologize if misleading information still remains in the text.

LITERATURE REVIEW

Literature pertinent to forest fire control in Interior Alaska is scarce. Most of the available references that bear on some facet of fire research and control are specifically referred to in appropriate chapters. However, some publications that may have only general application to the problems at hand are mentioned here.

Aboriginal and white man share jointly the responsibility for the tremendous burned areas in Interior Alaska. Aboriginal man had no easy way of starting a fire; so when he once had one burning, he was loath to put it out. Extinguishing a fire also was quite a chore as tools were very primitive and much hard work was required. Early man had many uses for fire, the more prevalent being communication by smoke signals, hunting by driving game into pockets or into the water by setting fires, fighting hostile tribes by advancing firelines, and combating insect pests; in fact, it has been said that mosquitoes are the cause of more forest fires than any other one thing. Clearing the forest for easier travel and obtaining dry fuel wood were other common reasons for setting fires (Lutz 1959).

The white man set fires for many of the same reasons as the aboriginals, but he also had reasons of his own: to accelerate growth of grass for livestock, to clear crop land, to see rock surfaces better when prospecting, to remove vegetative cover for strip mining, to clear road and railroad rights-of-way, and just to see fire burn. Carelessness and indifference by both aboriginal and white man have resulted in keeping timberland from progressing to climax status.

The militarily strategic location of Alaska, and the Nation's reliance upon air defense have prompted a large number of meteorological research projects during the past decade or more. Information gathered for forecasters particularly interests fire research personnel because of the wealth of data on air circulation, winds, pressure distribution, and storm patterns, as described by Arctic Weather Central, 11th Weather Squadron (1950); U.S. Weather Bureau, Climate and Crop Weather Division (1943); and Elmendorf Forecast Center Headquarters (1953). Use of the cold polar lows, as studied by Reed and Tank (1956) is important to fire-weather forecasting, particularly in predicting the effect of upper lows as summer storms move along the fringe of the Arctic land mass. Reed's work (1958, 1959) points up the importance of atmospheric influence on the whole fire season and on individual fires.

This Nation has a large inventory of wood for lumber and fiber products. By 1975 the demand will come close to the available supply; by 2000 the demand will far exceed the supply unless better forestry practices are employed or vast new sources of timber are found. Three-fourths of the commercial forest land in the United States is privately owned, and 86 percent of the ownership is in tracts of 100 acres or less. The anticipated rate of gross national product increase, and likewise timber demands, is greater than the population increase because the standard of living is expected to increase. At present there is no excess of commercial forest lands; less will be available in the future upon which to grow a greater amount of timber (U.S. Forest Service 1958).

Protection of the Alaskan forests from fire is an essential feature of all future planning. Protection and management of our extensive present and potential timber resource of Interior Alaska may provide that extra wood and fiber necessary to get us "over the hump."

Interior Alaskan forest resources are now being carefully surveyed by photographic techniques. The major problem is determining the potential timber type on formerly forested land and also differentiating between land that is capable of producing industrial wood and land that is not. Lutz and Caporaso (1958) consider forest land classification indicators from two primary standpoints — vegetation and topographic situations. The completed survey and map project may serve as a basis for broad-scale fuel type classification.

When speaking of wildlife population and distribution and forest cover, Alaska has been referred to as a continuum of edge. "The forest wildlife of Alaska is truly more a product of the edge, transition types, forest line, and timber line than of specific forest types . . . the ranges of various species of wildlife are neither distinct nor constant for forest type" (Nelson 1960, p. 461). The 2-million-acre Kenai National Moose Range, managed by the Bureau of Sport Fisheries and Wildlife, becomes one of silvicultural manipulations to retard the succession from birch-aspen to climax spruce stands, and to convert mature forests of both types by mechanical, chemical, and controlled burning methods into young hardwood growth essential for maximum production of browse, The story of reindeer differs from that of the multitude of other game species in that the reindeer is an intraduced species (as are bisan at Big Delta and elk on Afagnok Islond). Same 1,300 head were transplanted fram Siberia during the period 1890-1902. The number increased ta 1 millian by 1936, but dwindled to 26,000 by 1950. Ten years later the herd had made a modest increase ta about 38,000. During this lang period overgrazing and fire caused seriaus deterioration af reindeer feeding sites; recovery af this lichen range, under close pratectian, may require 20 ta 40 years (Heintzleman 1936; Zumwalt 1960; Polmer and Rouse 1945).

Objectives af fire reseorch and fire cantrol monogement in much of Canada are similar to thase for Interiar Alaska. Canada is divided inta 13 protective zones, within which acceptable average annual burning rates have been calculated far experimentol, recreatianal, productive and nanproductive farest areas, and far nanforested areas. Twenty-eight praductive forest types are recagnized. The burned area abjectives take inta occount values requiring pratectian and factars that affect the difficulty af pratectian (Beall 1949).

Fire research persannel in Conada are studying many phases af fire behaviar and cantrol. Praposed expansian of programs alang the fallawing lines will camplement anticipated research in Interiar Alaska: study af fuel burning potentials, fuel type classificatian, draught index tables, improved detection methads, air and graund applicatian of impraved retardonts, and on integrol economic study af fire suppression efforts in Conado (Besley 1959).

One might ossume thot in older estoblished countries like Sweden, where the econamy of the Nation hos leaned heavily on its timber supply, the fire cantral organizatian wauld be highly developed ond efficient; but this is not necessarily true. Methads and even cancepts af fire cantral must change with times. The Swedes have faund that it is difficult ta compare data spread over a several-yeor periad when knawledge and accurocy ore much better at the end than at the beginning af the periad (Stromdahl 1956 and 1959). Much the same is true for the dota analyzed and presented in this publication.

SUMMARY

Interiar Alaska's forest resaurces have great patential volue — a fact that received little recognition until after Warld War II. One millian acres aut af the 225 million acres pratected burn aver annually. Toa little is knawn abaut the special fire prablem in high latitude narthern farests. Analysis of climate, fire behaviar, and fire statistics aver the past several years shauld help establish narmals against which future fire seasans and fire cantrol actians can be measured; alsa, it may help shape the type and size of fire detection and control arganization deemed necessary ta protect the resaurces ta an extent cammensurate with their values.

Lutz and Uggla are recagnized leaders in research pertaining ta the fire ecalagy af high latitude farested areas, and have contributed substantially to a better understanding af the farest fire situation in Interior Alaska. The importance of Alaska ta natianal defense prampted the military services to spansar extensive meteoralogical and climatolagical research. Same of their work involved studies af weather circulation patterns that affect nat only Interiar Alaska but the entire cantinent. The resumé af literature in this publication by na means accounts far the tatal amaunt af material written an matters that affect forest fire research and cantral in Interior Alaska, but it daes indicate the type of wark that has been dane.

The predicted increase in U.S. population will impose a terrific strain an the supply af waod products by the year 2000 accarding to recent studies. The large volumes of wood fiber moteriol ovailable in Interiar Alasko will be needed to help meet the demands by that time. Forty million acres af cammercial forest land cantain 180 billian board feet of woad and yield, at present, an estimated net grawth af 4 billian baard feet. Much af this cammercial farest land is capable af producing mare than 10,000 baard feet of timber per acre.

Cammercial use af fish and wildlife is a $100 million industry; it can ill affard fire-caused stream siltation with its resultant reduction of axygen and plant life. Expenditures by sportsmen and recreatianists naw exceed $20 millian per year; taurists like to see farests af green

trees, not snags or retrogressed sites. The services industry likewise benefits from contented tourists. The well-being of the wildlife resource depends upon healthy forest environment under adequate protection. A period of 40 to 100 years is often required for caribou and reindeer range to recover from fire. Fur quality is much reduced in burned-over country. Many of the Nation's duck and geese originate in Alaska; destruction of their eggs and nesting grounds reduces the hunting potential in the western half of the United States.

Mining operations, still important in Alaska, must have a constant flow of water, with neither flooding nor drought, for their ventures to be economically successful. Interested potential investors tend to shy away from establishing business or industry where a continuous source of raw material cannot be reasonably assured and protected. Well-cared-for watersheds are necessary for all resource development and maintenance. Aircraft use for defense, profit, or pleasure requires smoke-free skies. Airborne fire control operations in particular cannot succeed when the sky is full of smoke.

No reliable means of determining intangible loss from fire has yet been developed. Even the full impact of fire on tangible assets of timber, forage, and improvements is sometimes difficult to ascertain. Research and development must be aimed at establishing and maintaining standards of fire control commensurate with the needs for industrial, recreational, and personal security.

Alaska's 586,000 square miles make it by far the largest State in the Union. Geographically, the peninsula of Alaska varies from a southern coastline of precipitous ice-packed mountains, to vast flood plains along the Bering Sea, to extensive interior valleys separated by rolling hills. The State can be divided by geographic formations into seven distinct divisions. Southeastern Alaska lies along the coast southeast of longitude 141° W. to the end of American ownership south of Ketchikan. The Alaska Range separates Cook Inlet, Copper River, and South Coast Divisions from the others and confines them to the maritime climatic influence. West Central and Bristol Bay Divisions are made up of hills and broad flood plains and open out onto the Bering Sea. The Brooks Range separates the Arctic Drainage Division from the rest of the State. The broad valleys of the landlocked Interior Basin embrace most of the Yukon, the upper Kuskokwim, and the Tanana River drainages.

The movement of high and low pressure systems over the northern Pacific and the Alaskan mainland areas influences the climatic conditions experienced in the several climatic regions of Alaska. Summertime heating of the land surface of the interior under the influence of long days causes a relatively low pressure while pressure builds up over the cool waters of the North Pacific. As a result, weather becomes warm, sometimes hot, with occasional rains. Climatically, the State is divided into four general zones: the Maritime Zone consists of the coastline from southeastern Alaska through the Aleutian peninsula; the arc farther inland, but extending along the Bering Sea, constitutes the Transition Zone; the great Interior Basin is called the Continental Zone because of its definite continental climatic characteristics; and the Arctic Drainage Zone is one of dominant Arctic influences.

Climate of the Maritime Zone is characterized by small variations in summer temperature, high humidities, high fog frequency, considerable cloudiness, and abundant precipitation. The Transition Zone receives considerably less precipitation than the Maritime Zone. Thunderstorms are common in the Copper River portion. Winds in this zone are generally light, but locally strong and erratic. The Continental Zone is set apart from the others by topographic barriers. Summertime temperatures may reach into the high 90's; annual precipitation in some localities is as little as 6 inches. The Arctic Zone is not important to fire control activity. Precipitation and temperature are both low. Average windspeeds, however, are relatively high. The sun's rays in this extremely high latitude cause little surface heating.

Data from 18 weather stations throughout Interior Alaska were analyzed for the period 1950-58 to determine the weather regimes under which fires burn and control action is taken. Precipitation generally decreases from the south to the north and increases from April through August. Average afternoon temperatures increase and relative humidities decrease from the Anchorage area northward towards the Fairbanks-Fort Yukon area, causing fuels to become progressively drier. Humidities are lower in May and June than in July and August. The length of day increases with latitude; Fort Yukon has nearly a month of continuous daylight. As expected, winds in the afternoon are stronger than those in the morning; winds in May are stronger than those in July. Proximity to glaciers lying in long, deep canyons tends to increase the force and irregularity of windspeed and direction. Cloud ceilings are generally above 1,000 feet during May to early July, but become lower more frequently during the rest of the summer. Smoke and haze become increasingly detrimental to firefighting activities after the end of June. Permafrost is more than 1,000 feet thick in the extreme north of the State but is nonexistent in the southern portion; the thick layer of mosses and lichens insulates the soil and retards its thawing; roots remain cold late into the spring and tend to delay the start of vegetative growth; the resultant late dormancy may cause fuels to remain dry much later into the early summer than one might normally expect.

Since Alaska has no fuel type classification system, fire behavior is described according to its relative violence in various general cover types. As in continental United States, fire becomes more active when it travels through finely divided fuels. Mosses, lichens, and spruce branches extending to the ground provide a nearly unlimited path of fine fuels through which fires may advance. Each of several major cover types presents various fire behavior possibilities. Birch, aspen, and cottonwood stands do not normally carry fire rapidly. Increase in the spread rate of fire is closely associated with increased ratio of spruce to hardwoods. Rate of spread is most rapid in black spruce because of the combined horizontal and vertical continuity of fuel in this cover type. Light burns do not often cause severe type retrogression, but severe single burns or repeated mild burns do. An empirical table groups expected rates of fire spread in major cover types into fire classes.

Fire-danger rating was not used in Interior Alaska prior to 1956, nor were there any data available from which to develop a suitable system. The need for a guide to help fire control officers do a more competent fire management job led to establishment of the Intermountain System in Interior Alaska. Use of this system has accomplished two objectives: (1) to serve as a fire management guide, and (2) to obtain research data to be used in improving fire-danger rating techniques and in making local modifications to a national uniform system. Fire-weather factors are not as severe as those in continental United States, but rates of spread in Interior Alaska may approach those known to occur in many of the more southerly States. The diurnal fluctuation of fire-danger rating factors is less in Interior Alaska than in northern Idaho; this indicates that perhaps extended periods of moderately severe weather produce the same conditions in terms of fire behavior as a short number of hours of very severe weather. Establishing fire-weather stations and using information from them was a long step forward, but the 14 stations in operation by 1960 were still grossly inadequate for intensive fire control management purposes. Measurements from these stations indicate that burning indexes are highest in May and June; in Montana and Idaho they are highest in July and August. These burning indexes, along with climatological information, show why the greatest fire load is in May and June.

Forest fires have burned in Interior Alaska from time immemorial. Until recent years, nearly all fires in the State were thought to have been man caused. Analysis of all fires reported during the 9-year period 1950-58 revealed much valuable information. Individual fire reports show that *lightning causes about one-fourth of all fires and that these lightning fires account for three-fourths of the acreage burned.* Sixty-two percent of all public domain land protected by the Bureau of Land Management is in Alaska, or 27 percent of all land under organized protection in the entire United States. Reports show that on the average 253 fires burn 1.1 million acres annually, with an average area per fire of 4,400 acres. This is compared to 99,848 fires burning 3 million acres, or 30 acres burned per fire, on all other land under protection in the rest of the United States. The number of reported fires per million acres protected is 1.1 in Interior Alaska compared to 168 in the rest of the United States.

Records indicate that if a fire in Interior Alaska is not controlled while its area is less than 300 acres, it may and often does spread to several thousand or even to several hundred thousand acres. Seventy-four percent of all fires in Interior Alaska burn in the highly flammable spruce and tundra types. The final size of a lightning fire averages 10 times the size of a man-caused fire primarily because lightning fires are common in the Interior Basin, but detection and access are both difficult. During the period of analysis *33 percent of lightning fires and 9 percent of man-caused fires never receive any control action.* These figures include many fires extinguished by nature before action could be taken; also, action is not taken on fires on private or entry land unless real danger to adjacent public lands develops. Fires on which no action was taken account for 35 percent of acreage burned by lightning fires and 68 percent of acreage burned by man-caused fires. Eighty percent of all lightning fires occur in June and July; but 73 percent of the acreage burned by these lightning fires is burned in June. Fifty-seven percent of man-caused fires occur in May and June; but 70 percent of all acreage burned by these man-caused fires is burned in May. In general, as the total number of fires increases, the number of Class E fires (more than 300 acres) also increases, and the number of Class A fires (less than one-fourth acre) decreases; early overloading of a small suppression force may account in part for this.

Most man-caused fires occur near population centers, as would be expected. More than a usual number of reported lightning fires also burns in a somewhat similar pattern; the distribution will no doubt appear different when better detection and reporting procedures are developed.

Southeastern Alaska has not been treated in this analysis because fire conditions there are not as critical as in the Interior. An average of 26 fires — virtually all man-caused — occurs annually in southeastern Alaska and burns about 638 acres, or 25 acres per fire, compared to 4,400 acres per fire in Interior Alaska. However, the fire potential in southeastern Alaska is increasing as logging activity increases.

Virtually no specific data were available describing the behavior of wildfires in Alaska prior to 1958. During 1958 and 1959, fire behavior teams collected data on the fireline from 19 fires. The teams measured rates of spread, weather factors, and fuel variations, and observed their interrelationships. The primary question to be solved was, "Why do fires in Interior Alaska get so large so fast?" The most probable explanation of the behavior of seven of these fires is briefly summarized below:

1. Healy: High winds resulting from topographic features.

2. Murphy Dome: Broken topography, high burning index, thunderstorms, and atmospheric instability.

3. Kenai Lake: Steep topography causing diurnal wind reversals; frontal movement passing over area.

4. Colorado Creek: Highest burning indexes of all fires studied; topography altered winds.

5. Lake 606: Strong winds, thunderstorm downdrafts.

6. Stony River: Unbroken horizontal fuel continuity; frontal movement.

7. Huggins Island W-10: Rough topography; variable and gusty surface winds due to atmospheric instability.

Data from these fires indicate that nearly all extreme behavior can be explained qualitatively but not quantitatively at present. Important problems in fire control are: (1) forecasting fire-weather conditions, (2) predetermining fire behavior, and (3) determining the influence of different fuels on rate of spread under various weather regimes.

Organized forest fire control in Interior Alaska began in 1939 with an appropriation of $37,500. The high potential value of the timber resource is now receiving more nearly adequate recognition; but even so, a comparison of the fire control organization in Interior Alaska with that of Region 1 of the U.S. Forest Service (Montana, northern Idaho, northeastern Washington, and northwestern South Dakota) reveals there is still a long way to go before an adequate fire control organization is achieved. The Bureau of Land Management in Interior Alaska protects seven times as much area, has one-fourth as many fires, and fights them with 11 percent as many regular fire personnel as Region 1. Alaska has only 8 percent as many people per square mile to draw upon for fighting fires in its vast, inaccessible territory. The annual burned area is 250 times as large as that in Region 1, or 36 times as great per million acres protected.

Major operational bases and warehouse facilities located at Anchorage and Fairbanks are augmented by several district centers and guard stations. Since the source of supply of many basic firefighting needs is many thousands of miles away from these two cities and economical delivery of them is very slow, successful dispatching of men and equipment is dependent upon close planning many months in advance. A highly reliable communication system is mandatory for operating such a widely spread fire control system. Radio equipment is being updated and the system expanded. Firefighting crews are hard to find, but crews of native Indians and Eskimos from small villages have proved to be excellent firefighters. Some tools and equipment commonly used elsewhere in the United States can be used effectively in Interior Alaska, but specially developed tools are needed to obtain maximum performance from the few available firefighters. Use of heavy fireline equipment is limited to dry slopes near roads.

Aircraft, both government and private, are being used increasingly for detection, transportation of personnel, smokejumping, supply, reconnaissance, application of retardants, and general administration. Use of helicopters is closely coordinated with other air and ground attack procedures. Foot travel is impossible over much of Interior Alaska because of bogs, meandering rivers, lakes, uneven terrain, and long distances.

Early detection of fires is a major problem since no fixed lookouts exist in Interior Alaska, and aerial patrol consists of one World War II pursuit-type airplane and intermittent use of other smaller craft during critical periods. Reports from commercial and military aircraft help, but since large areas are seen only occasionally, many fires cover hundreds of acres before being discovered and other fires are never seen until they have become extinguished from natural circumstances. Procedures must be developed for detecting, tracking, and reporting thunderstorms since they are responsible for three-fourths of the total area burned annually.

Attack time is being shortened by dropping retardants from planes and immediately following them by smokejumpers. Helicopters and ground forces are quickly moved in so that jumpers can return to base to become available for new fires. Forty-four percent of all reported fires start farther than 100 miles from headquarters. Speeding up of detection will pay off well by reducing the size of fires and the cost of suppression. Size class of fires increases as the length of time between discovery and control increases. Small fires are controlled within 2 hours from attack; but nearly half of all fires that cover more than 300 acres require more than 3 days to control. In the spruce type, 70 percent of small fires are only smoldering when attacked, whereas 47 percent of large fires are crowning at time of attack. The increasing violence of fires as their size increases again illustrates the need for early discovery and attack.

Total cost of fire protection in 1958 was 1.01 cents per acre as compared to 0.80 cent per acre on land in other States protected by the Bureau of Land Management; but Interior Alaska's burned area on 225 million protected acres averaged nearly seven times that for other States on 138 million protected acres for the period of 1950-58. The long-term goal of annual allowable burn is a maximum of 100,000 acres.

Several methods for using fire in disposing of land-clearing debris have been studied and some guides developed, but none have been found completely suitable for universal adaption. As yet untapped are means for fully using fire as an effective tool in attaining forest management objectives. Research in economics, forestry, and fire control operations is critically needed to help strike a balance between the strength of detection, presuppression, and suppression, and the most favorable overall cost of protection. In fire control planning and suppression, the primary factors that influence fire size and difficulty of control — weather, fuels, and topography — must at all times be kept in the forefront; no fire protection plan can be complete without incorporating the probable effect of these major influences.

CHAPTER 2

VALUES AT STAKE

TIMBER RESOURCES

Volumes have been published during the past few years describing the population explosion in the United States and showing how it will increase demands for all types of manufactured products. The demand for and the available supply of wood products during the next 40 or more years will have to be reckoned with *now* if a balance is to be obtained.

The recent Timber Resource Review emphasizes the fact that national demands *can* be met only if better and more ingenious forestry practices are instituted and utilization is made of large volumes of wood not presently usable or available.

Statements in the Timber Resource Review repeatedly note that the trend during the first half of the 20th century has been from a predominantly lumber consumption economy toward a pulpwood consumption economy. During the last half century, total consumption of lumber (boards, dimension stock, etc.) has not changed, but the population increase has about halved the per capita use. On the other hand, total pulpwood consumption has increased about twelvefold, causing a per capita consumption increase of about sixfold.

One way to help insure adequate timber supplies for the United States through the next 50 years is to increase utilization of a vast tract of forest land hitherto virtually untapped; namely, Interior Alaska. Timber resources of Interior Alaska were not included either in the statistical summaries or in analytical discussions in the Timber Resource Review because accurate information was almost nonexistent. Out of approximately 300 million acres of Interior Alaska land administered by the Bureau of Land Management, 120 million acres is forested; one-third of this forested land, or 40 million acres, is considered to be of commercial quality. Of this, 4 million acres or 10 percent is presently considered accessible from towns, roads, or railroads.

Many persons believe that Interior forests are slow-growing, stunted Arctic stands that have little or no value. Taylor (1956) has shown that this is not so. The estimated annual net growth of 20 cubic feet per acre can be increased considerably under good management. Well-protected managed stands should produce 3,900 cubic feet, or 15,500 board feet, of timber per acre at a rotation age of 160 years; this indicates a good margin of operability, since stands of 3,000 cubic feet in Maine and 1,500 cubic feet in Finland are now supporting pulp industries.[1] Canada has built a major pulp industry upon the same species of white spruce that grows in Interior Alaska. The timber economy of northern European countries is based upon small diameter spruce and hardwood forests growing under much the same conditions as exist in Interior Alaska. Perhaps when many of the present economic problems of labor, power, accessibility, and distance to market can be solved, a thriving pulp industry can be built upon this vast store of timber.

Interior Alaska holds many attractions for an increased wood fiber industry. Timberlands in large blocks no longer exist in mainland United States. The timber in Alaska's interior probably will have little value on the export *lumber* market because of high costs and low lumber grades, but Alaska's *pulp* can sell profitably on the world markets. Southeastern Alaska has already benefited by the establishment of two pulpmills since 1954.

Any proposal to increase productivity must be accompanied by a plan to increase protection of the investment. History and personal observations indicate that 80 percent of the forest land in Interior Alaska has been burned over sometime during the past 70 years. No large business concern can afford to invest 25 to 50 million dollars in a pulpmill without reasonable assurance that the raw material will be protected and kept available during the long number of years the mill must operate. Today, fire is a major danger to pulp stands, and one fire can wipe out many years' backlog of raw material required for operating a multimillion-dollar mill.[2]

[1] More recent plot data indicate 140 years is a better suited rotation age, and an optimum volume per acre would be somewhere between 10,000 and 15,000 board feet.

[2] The cost of one mill proposed for Alaska will be five times the price the United States paid for Alaska in 1867

USFS

Figure 1. — Typical small sawmill, Circle.

USFS

Figure 2. — Extensive stand of Alaskan timber.

FISH AND WILDLIFE RESOURCES[3]

The full value of the wildlife resource to the residents of Alaska is greater than is immediately apparent. Wildlife plays an important part in the economy of Alaska as judged by the criteria of money, recreational use, time, employment, and social welfare. The value of fish shipped from Alaska since its acquisition has repaid its original purchase price of $7,200,000 more than 300-fold; the value of furs, 30 times over. During 1957, some 59,510 persons spent $17,018,500 to purchase hunting and fishing licenses; they spent 981,800 man-days enjoying their sport. In 1958, tourists spent $18,165,000 in Alaska. If one-fourth of that amount was attracted by wildlife, $4.5 million was expended for the enjoyment of the wildlife.

The four basic industries, numbers of persons employed, and the raw value of products in dollars for fiscal year 1957 were:

Industry	Persons employed	Raw value
Fish and Wildlife	60,000	$ 90,115,739
Agriculture	750	4,231,134
Forestry	500	6,914,000
Mining	1,991	23,408,000
		$124,668,873

FISHING RESOURCE

Of the 60,000 persons employed in some business related to fish and wildlife, nearly 24,000, or 40 percent, were engaged in commercial fishing. Salmon is the primary commercial species. The entire packing industry depends upon a successful spawn and healthy, thriving young fish that return to the sea to complete their life cycle.

Fire-damaged watersheds deteriorate through the action of the natural elements. Soil becomes unstable, and overland flow following heavy precipitation washes it into streams; the combined effect of oxygen reduction and destruction of streambed algae and other necessary minute food sources by scouring can render fish habitat untenable.

Any destroyed streambed ruins not only the current year's salmon spawn, but also eliminates proper grounds for spawning during the next several years. Rebuilding a depleted salmon population takes many years, even after a stream is again conditioned for proper spawning. Any decline in fish population reduces the catch for the cannery and the income to both the industry and the State.

USFS

Figure 3. — Salmon thrive best in waters from stable watersheds.

WILDLIFE RESOURCE

The annual recreational value of Alaska's wildlife runs into substantial figures. Expenditures by residents of Alaska amount to 59 percent of the $21 million spent, including an estimate of $4.5 million worth of esthetic value.

Some of the most important nesting grounds for wild ducks and geese are in Interior Alaska, especially along the lower Yukon River. Since these nesting grounds support vast numbers of migratory fowl that use the Pacific and mountain

[3]Most of the statistical information for this section was obtained from the U.S. Fish and Wildlife Service (Buckley 1957).

BLM

Figure 4. — Sport fishing is a major attraction.

USFS

Figure 5. — Big-game hunting nets meat, sport, and revenue.

flyways, bird hunters throughout central and western United States depend upon their well-being. Fires destroy the protective covering; they burn nests and eggs and often kill fledglings and even adults. Although specific data are not available, fires along the lower Yukon River in the disastrous season of 1957 must have caused tremendous losses of eggs, fledglings, moulting ducks, and even mature birds.

Forest fires damage wildlife habitat, but repeated burns destroy it completely. At least 10 years is required for vegetation and cover to reappear in quantities and form sufficient to accommodate furbearing animals. From 40 to more than 100 years may be required for a caribou and reindeer lichen range to regain its optimum carrying capacity. Uggla (1958a) drew similar conclusions after intensive ecological studies in Sweden. Three hundred years may elapse before the more palatable and valuable, but least common, species recover to a point where they can be safely grazed.

Some animal species, for instance the marten, leave the country permanently after their habitat has been destroyed by fire. Furbearers appear to produce poorer quality pelts if they live in burned areas. The Hudson Bay Company pays premium prices for furs that were trapped in unburned country.

RECREATIONAL RESOURCES

Recreation is a rapidly growing major industry in Alaska. It probably will produce an annual income of $100 million to Alaska within the next few years. Tourists come in increasing numbers every year; and they come earlier and stay later than formerly. They come primarily to see the country and enjoy the beauties of nature — the mountains, forests and rivers, and the novelty of glaciers and unfamiliar species of wildlife.

The map showing frequency of man-caused fires (fig. 57) shows why many tourists are extremely disappointed in what they see along the primary highways and along the Alaska Railroad route. Frequency of these fires is highest along major travel routes. Some have resulted from carelessness and some from road construction activities. Prevention and control of fires in these areas are imperative so that the country can reestablish itself to timber.

Recreational value should by no means be considered as confined to the tourist trade. On weekends and holidays and during vacations, Alaskan families fill the roads as they drive to the woods, the lakes, or the numerous picnic and fishing spots. An average family thinks nothing of getting into the car, or even airplane, and traveling hundreds of miles on a weekend just

USFS & WLS

Figure 6. — Nesting grounds need protection.

BLM

BLM

USFS

Figure 7. — Picnicking, boating, and spectacular scenery attract recreationists.

to enjoy the scenic beauties of the State. People live in Alaska not only to earn their livelihood, but because they are enthusiastic lovers of the outdoors; so they are vitally interested in the maintenance and enhancement of the outdoor recreation resource.

Fire damage to recreational facilities cannot be estimated accurately in dollars. The fisherman, the hunter, the camper, and the picnicker all suffer in an intangible personal way. Only rough estimates can be made to determine how much more traffic would occur if all the land were productive and beautiful. Many categories of business are affected by both the short-term and long-term results of fire. A few of these are: lodging, food, and automotive repair services; aircraft charter and guide business; and photographic and sporting goods merchants.

USFS

Figure 8.— Commercial recreation area near Fairbanks.

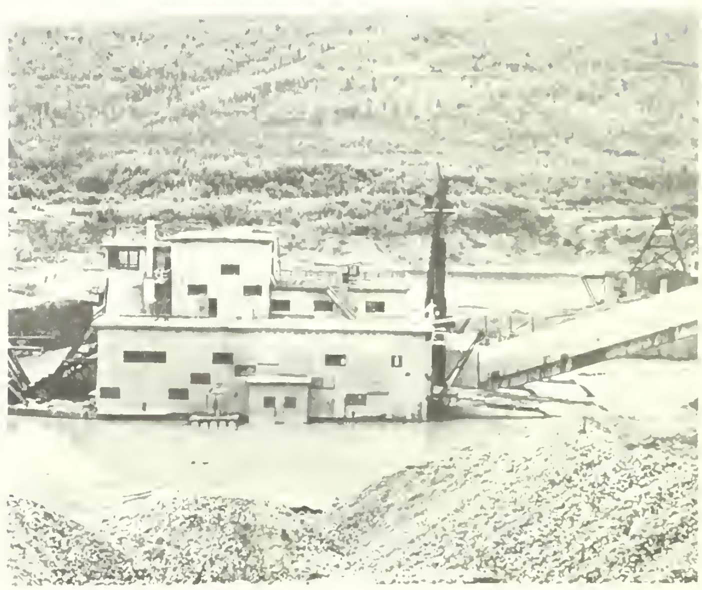
MINING

Mining has been one of the three major industries in Alaska for the last 7 decades. Gold stimulated rapid development of mining in the late 1800's and early 1900's. Most gold mining in western and Interior Alaska is placer mining, and is completely dependent upon water to process gravel and remove the minerals. High costs of production have seriously reduced volume of the mining industry, but it still is far from being eliminated; in 1957, mining was second high in economic value to the State — wildlife was first (Buckley 1957).

Placer mining requires removal of overburden and gravels down to bedrock in order to make the mineral-bearing strata accessible to shovels, dozers, draglines, and other equipment. Preparation of an area, including the cutting of bedrock drains and digging of holes prior to actual mining, is extremely expensive. Floods, always a threat to mining operations, may fill the cuts and cause loss of equipment, work, and time during the short field season which runs usually from early June until late September.

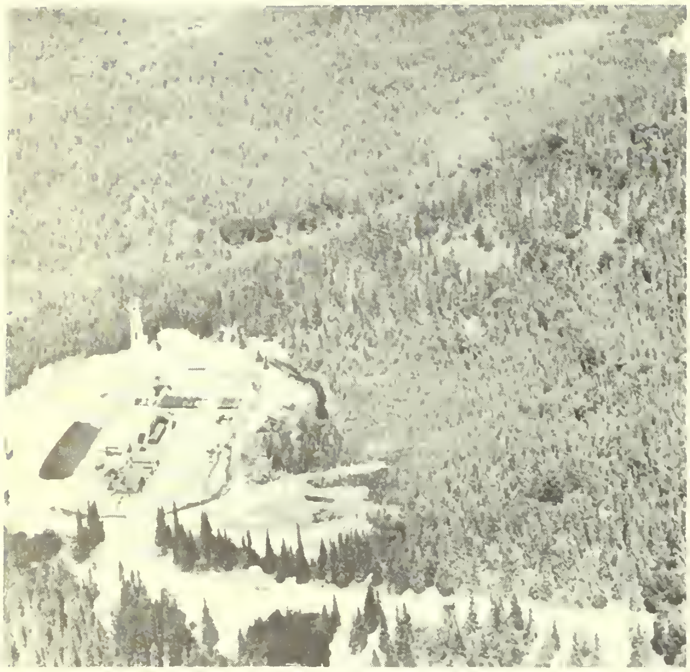
Mining operations often produce silting, which damages rivers and smaller streams. Mining may also be detrimental to stability of individual watersheds. Forest fires can cause any such potentially serious situation to become disastrous.

Oil and gas production is at the threshold of becoming big business. Much of the current exploration, well drilling, and pipeline construction is in timbered country. Protection from large fires is imperative for the safety of workmen as well as for the large investments. Income to the State from oil and gas leases is already substantial. By law, the State receives 90 percent of the Federal revenue, which for the first half of 1959 amounted to \$4-1/3 million.



USFS

Figure 9. — Gold mining operation, near Fairbanks.



BLM

Figure 10. — Alaska's first commercial oil well.

WATERSHEDS

Wherever located, an undamaged watershed performs the same useful function: it catches rain or snow and allows the water to percolate into the soil; thus, it controls streamflow in an orderly fashion. A good watershed slows the flow of water into streams during the spring and early summer. It also acts as a storage basin and allows water to flow into streams slowly during the season when precipitation is low.

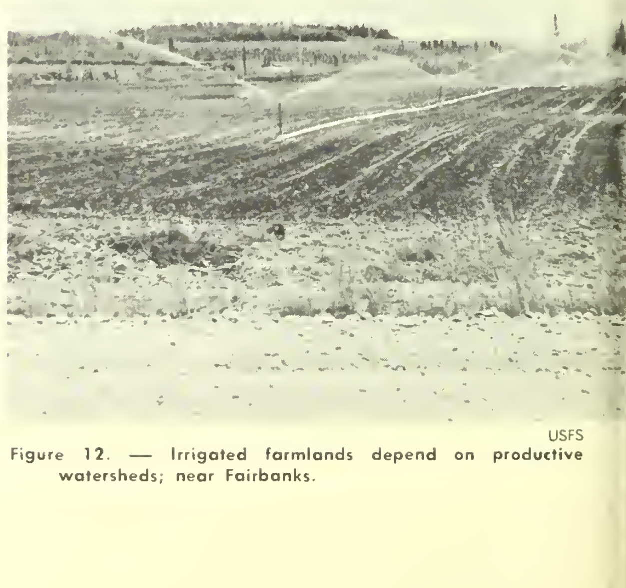
Many effects of fire on characteristics of soils and watersheds and on species distribution are similar to what is expected in more southerly States. Interior Alaskan soils are generally shallow. Fine-textured soils become poorly aerated and cooled; organic matter tends to remain unincorporated in the mineral soil and to rest on the soil as a mantle. The moss and lichen cover is a good insulator in the summer; its removal causes a lowering of the permafrost level. Though fire may not alter soil texture and structure, it does reduce the infiltration rate and increase overland flow.

Not all ecological effects of uncontrolled fire are detrimental to the environment. Thermal effects on soil temperature are generally favorable, as are the chemical changes. Nutrients that are normally locked up on the cold forest floor are liberated for assimilation by new plant growth.

Interior Alaska has one watershed feature that exists nowhere else in the United States: permafrost. Changes in permafrost resulting from forest fires are discussed further in chapter 3. Briefly, fire destroys the moss insulation and permits warm air and solar radiation to melt the permafrost. The earth on slopes often moves or sags, trees fall over, and the water table drops. Evaporation excessively dries the soil surface after the permafrost level has been lowered; this in turn defeats efforts at revegetation.

USFS

Figure 11. — This accelerated erosion started after surface vegetation was burned; near Fairbanks.



USFS

Figure 12. — Irrigated farmlands depend on productive watersheds; near Fairbanks.

USE OF AIRCRAFT

Alaskans are the most airminded people in the world. On a per capita basis, they own more aircraft and fly more people and freight than any other population group. Airlines must fulfill definitely scheduled flights; people depend upon these flights to run on schedule so that they can carry on necessary business. The State has numerous charter aircraft companies, and an astounding number of private aircraft operates in the State. Some are used for pleasure, but many are for business. These private planes also must be able to fly when the need exists so that their operators and owners can perform their business. An article in a recent issue of the *Alaska Sportsman* (1961, p. 27) stated, "There are an estimated 900 private planes in Anchorage, 200 commercial aircraft, 300 private seaplanes, and 50 commercial seaplanes. An estimated 35 helicopters also register out of busy Anchorage airports." When large fires occur, the atmosphere becomes so smoked up that commercial and private flying becomes nearly impossible.

Aircraft are essential to many firefighting activities — detection, patrol, chemical attack, smokejumping, crew transportation, helicopter use, and servicing of fire crews. Grounding these planes on account of reduced visibility due to smoke sharply pyramids the fire problem. In 1957, smoke covered the entire Interior with such a thick layer that virtually no aircraft operated for days at a time. The only exception was that a few Bureau of Land Management planes were permitted to fly as an emergency measure to service firefighting crews.

Location gives this State extremely strategic importance in the defense of the rest of the United States. Since aircraft are a major military tool, planes dare not be grounded because of smoke-filled air.

USFS

Figure 13. — Defense communication outposts must be protected from forest fires.

USFS

Figure 14. — A small portion of the Anchorage float plane basin.

USFS

Figure 15. — Anchorage International Airport.

BLM

Figure 16. — Alaskans travel on wings.

ASSESSMENT OF DAMAGES

No uniformly acceptable method for assigning monetary values to damage by wildfire has ever been developed. Most fire control agencies use empirical formulas for estimating losses of such tangible items as timber, forage, and improvements. But there is no reliable means of estimating losses of such intangible values as watershed, wildlife, recreation, and potential industry. The final evaluation also depends on several controlling factors such as severity of burn, weather and fuel conditions at the time of burn, topography, and even the time of year.

The Battelle Institute states in the conclusion and recommendations of its report on the cooperative forest fire control problem that no statistically supportable method is now available for evaluating the impact of fire on natural resources, and that further studies on the consequences of wildfire to watersheds, including downstream effects, should be encouraged (Swager, Fetterman, and Jenkins 1958).

The annual reports of the Director of the Bureau of Land Management show assigned estimated damage from wildfire. For the years 1950-58 the average estimated dollar value of damage amounted to approximately 10 cents per acre in Alaska compared to 8.6 cents per acre for all other land protected by BLM personnel.

Three questions arise: (1) How realistic are the present damage estimates? (2) By how much would damage be reduced if the expenditure for protection were doubled or even quadrupled? (3) How much research is warranted to help bring these two figures into a proper economic relationship, bearing in mind the values at stake discussed earlier in this chapter?

Table 44 lists three categories of tangible damage — timber, reproduction, and forage. Since the money value of timber and reproduction in Interior Alaska is now only a potential one, the value assigned to destroyed timber can also be only potential. Persons concerned with developing an assured future supply of wood and fiber know that it is necessary to protect the present crop, but without adequately developed procedures they cannot prove it in actual dollars and cents.

Values for immediate loss of forage can be computed within reasonable limits of accuracy. A more difficult task is estimating the impact on animals that have to graze on other ranges and the hardship on local residents when the game or reindeer that they depend upon for food move out of their area.

Losses of homes, farm property, and business establishments are both tragic and costly to owners. Computation of monetary loss from such misfortunes, however, is rather simple since accepted methods of damage appraisal have been used for many years and are available for that class of property.

No one knows how much employment and revenue may be lost because interested potential investors tend to shy away from establishing businesses or industries in an area where a continuing source of raw material cannot be reasonably assured. This problem certainly exists or will exist in the near future for the wood fiber industry in Interior Alaska. Research and development must aim at establishing and maintaining standards of fire control commensurate with the need for industrial security.

BLM

Figure 17. — Totally destroyed stand of young spruce.

BLM

Figure 18. — More than money was destroyed here, near Fairbanks.

CHAPTER 3

GEOGRAPHY AND CLIMATE

From a fire control standpoint Alaska, like most western States, has some portions that are considered easy, some moderate, and some critical. What makes one area easy and another critical? Usually considered pertinent to this question are the following factors: (1) The geographic arrangement of the land in relation to elevations and general weather patterns, (2) climatic conditions, which are generally influenced by the geographic pattern, (3) weather patterns on a local and short-term basis, and (4) fuels, as influenced by all the above factors. Fuels are dealt with in a separate chapter (ch. 4). The first two factors are described in rather general terms to help set the stage for more specific information that follows in the remainder of the publication.

PHYSICAL GEOGRAPHY

Alaska is by far the largest of the 50 States—a vast expanse of land lying north of the Pacific Ocean, separated from the larger land mass of Siberia to the west by Bering Strait and joined along the 141st meridian on the east to Yukon Territory, Canada. Alaska contains 586,400 square miles (375,296,000 acres); about one-third of this acreage is in the Interior Basin. Geographically, Alaska is divided into seven areas — South Coast, Copper River Valley, Cook Inlet, Bristol Bay, West Central, Arctic Drainage, and the Interior Basin as drawn in figure 19.

SOUTH COAST

The Aleutian Islands and Southern and Southeastern Coastal Areas combine to form a 1,500-mile crescent-shaped coastline; at some points it is 120 miles in depth. At its eastern extremity this area is mountainous, cut by a great number of tidewater bays, sounds, inlets, and fiords. Huge glaciers descend the mountain passes and often flank these shoreline indentations. Mountaintops are above 5,000 feet and several rise to heights of 10,000 to 15,000 feet. The precipitous slopes of the mountains from Kodiak Island eastward are mostly clothed to heights of 1,000 to 3,000 feet by dense stands of spruce, hemlock, and some cedar. The Alaska Peninsula and adjacent islands southward from Kodiak Island are devoid of forests, but are covered with luxuriant growth of native grasses. About half of southeastern Alaska consists of islands. Prince of Wales Island — the largest — is 140 miles long by 40 miles wide. The largest fresh-water streams in the area are the Stikine and Taku Rivers, which rise in British Columbia.

COPPER RIVER VALLEY

Copper River Valley is surrounded by four mountain ranges varying in height from 4,600 to 17,000 feet. The Alaska Range forms the north boundary, St. Elias the east, Chugach the south, and the Talkeetna Range the west. Copper River Valley is nearly 120 miles long and up to 50 miles wide. Icefields and glaciers are the main sources of water for the Copper River. The basin is a high plain with elevations as great as 2,500 feet above sea level. This valley is dotted with numerous lakes surrounded by stands of spruce and birch timber. Many areas within the valley are covered by dense stands of native grass and tundra species.

COOK INLET

Cook Inlet Division embraces most of the Kenai Peninsula, the famous Matanuska Valley, and the delta of the Susitna River. It is bordered by the Alaska Range, and the Talkeetna and Kenai Mountains. Elevation of the valley floor varies from sea level to about 2,500 feet. Vegetation varies from rather luxuriant grasses and some spruce and hardwoods on the Kenai Peninsula to heavy stands of spruce and some very fine birch in the central and northern portions of the Division.

BRISTOL BAY

Bristol Bay Division, nearly 500 miles long by 180 miles wide, drains into the Bering Sea. The Kuskokwim River is the largest river that drains this area.

The coastal and valley portion is undulating to rolling; its elevation varies from sea level to nearly 2,000 feet. It is studded with hundreds of lakes and potholes. On the northwest the zone is bordered by the Kuskokwim Mountains and on the south and east by the Aleutian Range. These mountains vary from foothills to precipitous peaks nearly 9,000 feet high.

The land is clothed with dense growths of tundra and native grass species, but island-fashion stands of spruce and birch timber are scattered over it.

WEST CENTRAL

West Central Division embraces an area 480 miles by 300 miles with a coastline cut by scores of bays into which several rivers and creeks flow. The large delta formed from residue carried by the Yukon and Kuskokwim Rivers, which pass through more than 350 miles of this area, contains a myriad of lakes and bogs.

The topography of this large land mass generally consists of low flat muskeg bogs and undulating hills, varying in height from near sea level to 1,400 feet. However, the southern half of the Seward Peninsula is mountainous and has peaks rising to 3,800 feet.

ARCTIC DRAINAGE

Arctic Drainage Division comprises all of the area north of the Brooks Range Divide, the Kotzebue Sound Area, and the Kobuk and Noatak Rivers. Three-fourths of the 1,200-mile shoreline is north of the Arctic Circle. The Kotzebue Sound Area is a low tideland delta surrounded by gently rolling hills. Most of the land up to 3,000 feet elevation is covered by moss, lichens, brush, and grass, but some dense stands of spruce occupy the most favorable edaphic sites. The arctic slope is a high, rolling plateau, gradually lowering to near sea level, where it is dotted by numerous lakes, muskeg bogs, and rivers. The Meade, Chipp, Colville, and Canning Rivers have their sources in the plateau area of the Endicott Mountains and flow northward into the Arctic Ocean.

INTERIOR BASIN

Interior Basin embraces most of the Yukon River drainage and the upper portion of the Kuskokwim Valley. The Endicott and Philip Smith Mountains, a part of the Brooks Range, delineate the northern limits of the area; between these and the Alaska Range lies the drainage basin of the great Yukon River. The Alaska Range is composed of peaks more than 10,000 feet above sea level, including North America's highest peak, 20,300-foot Mount McKinley.

Major features of the Interior Basin Division are the Yukon Flats on and near the Arctic Circle and the adjacent mountains with elevations up to 6,000 feet. The Tanana River Valley, with an area of about 24,000 square miles, lies north of the Alaska Range, whose glaciers supply most of the southern tributaries of the river. The upper half of the valley is rough and broken, while the lower portion has considerable level and gently rolling country; some of it in the vicinity of Fairbanks is adapted to agriculture. The upper portion of the large Kuskokwim River Valley is dotted by lakes and lesser rivers, many of which are often bordered by timber stands to varying widths. The intervening area is covered by mosses, brush species, and native grasses. The elevation of much of the valley area varies from near sea level to only 2,300 feet.

CLIMATE

Climatically, Alaska is a land of dramatic contrasts. Annette, near Ketchikan, in southeast Alaska receives 97 inches of precipitation and the temperatures may fall between 1° and 86° F. But at Fort Yukon on the Arctic Circle, only 6½ inches of precipitation falls and the temperature varies from —75° to 100° F. Information in this chapter is confined chiefly to summertime conditions within Interior Alaska.

The movement of these high and low pressure regimes (p. 4) brings different climatic conditions through the State. Variation in temperature, air moisture, precipitation, and the geographic distribution of these factors is important to fire control, particularly during spring and summer seasons (Kincer 1941).

Watson's (1959) study of Alaska climate divides the State into four major zones (fig. 20) that are actually consolidations of the seven geographic divisions outlined in figure 19:

1. Zone of dominant maritime influence.
2. Transition zone.
3. Dominant continental zone.
4. Arctic drainage zone.

Isolines of figures 21 through 27 show the variation of precipitation during the spring and summer months and the normal annual total. The reader should refer to these while studying the ensuing climatic descriptions.


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
ALASKA
MAP E
1954
LEGEND
CLIMATOLOGICAL DATA STATION
OPERATIONS AREA HEADQUARTERS
DISTRICT FIRE CONTROL OFFICE
GUARD STATION
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INTERIOR BASIN
WEST CENTRAL
COOK INLET
BRISTOL BAY
COPPER RIVER
SOUTH COAST
KOTZEBUE
BETTLES
FORT YUKON
CENTRAL
TANANA
FAIRBANKS
EAGLE
GALENA
BIG DELTA
CHICKEN
BUFFALO CENTER
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TANACROSS
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BETHEL
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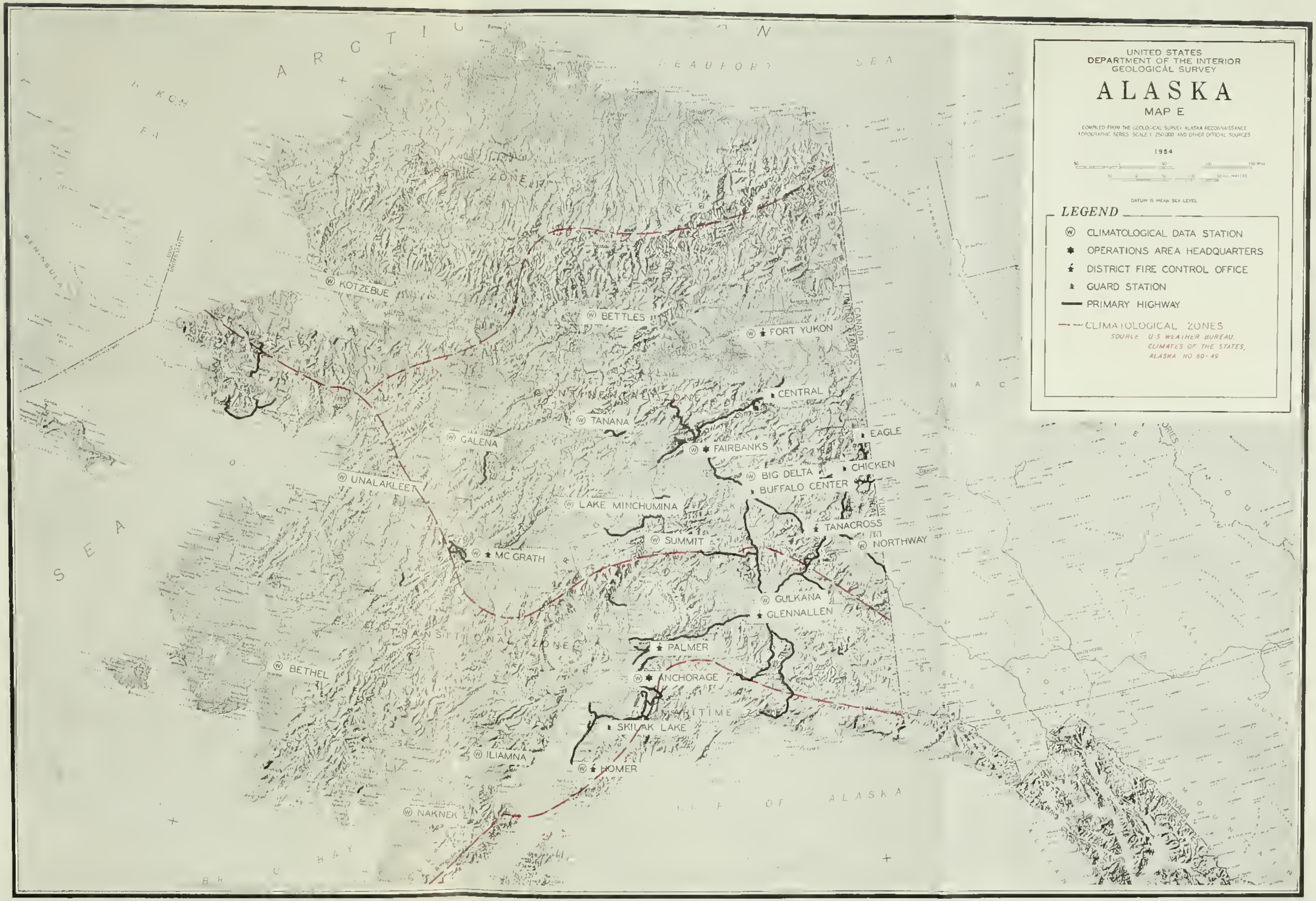
ILIAMNA
HOMER
NAKNEK

Figure 19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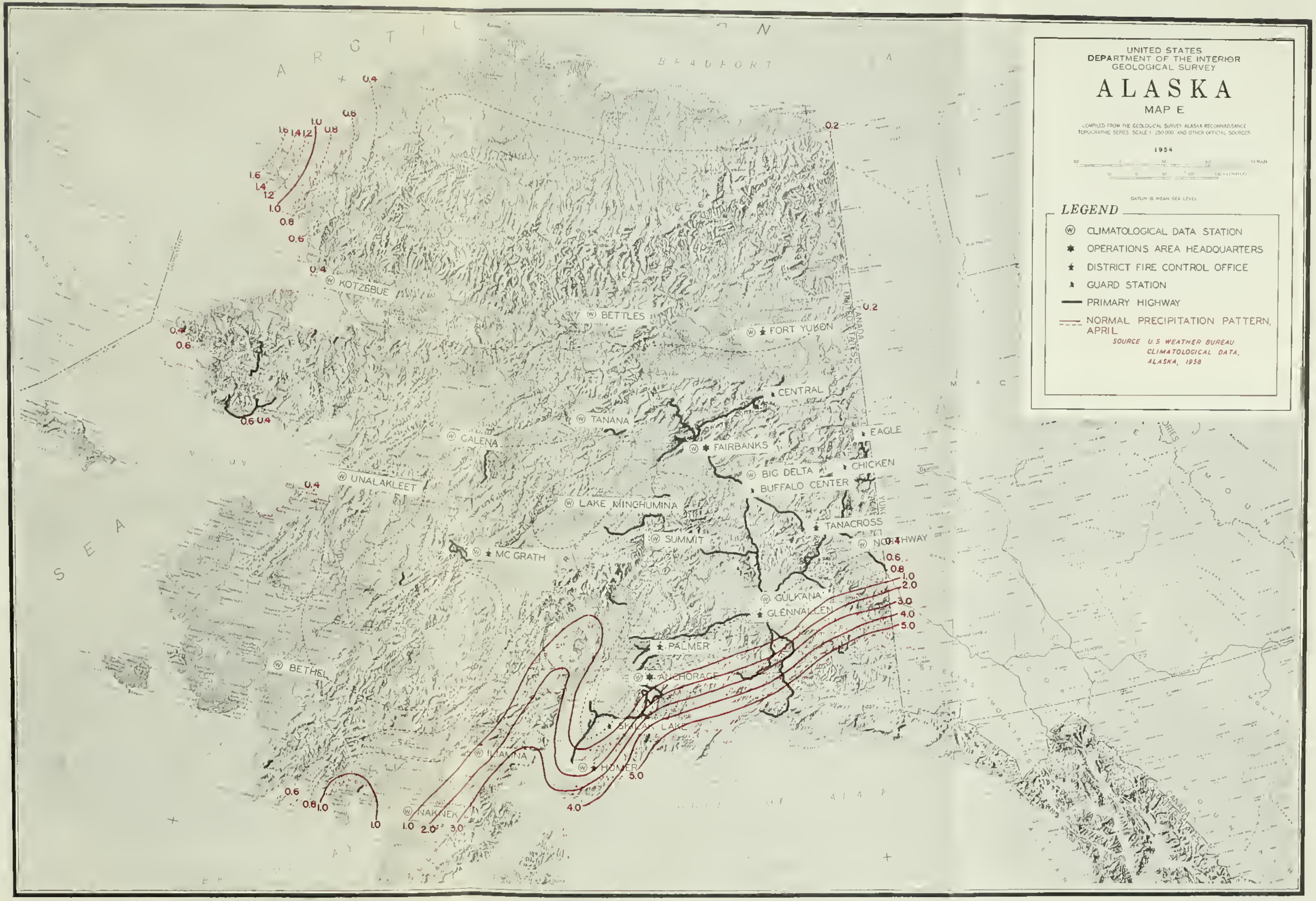
GULF OF ALASKA
TRANSITIONAL ZONE

Figure 20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BEAUFORT
SEA

Figure 21

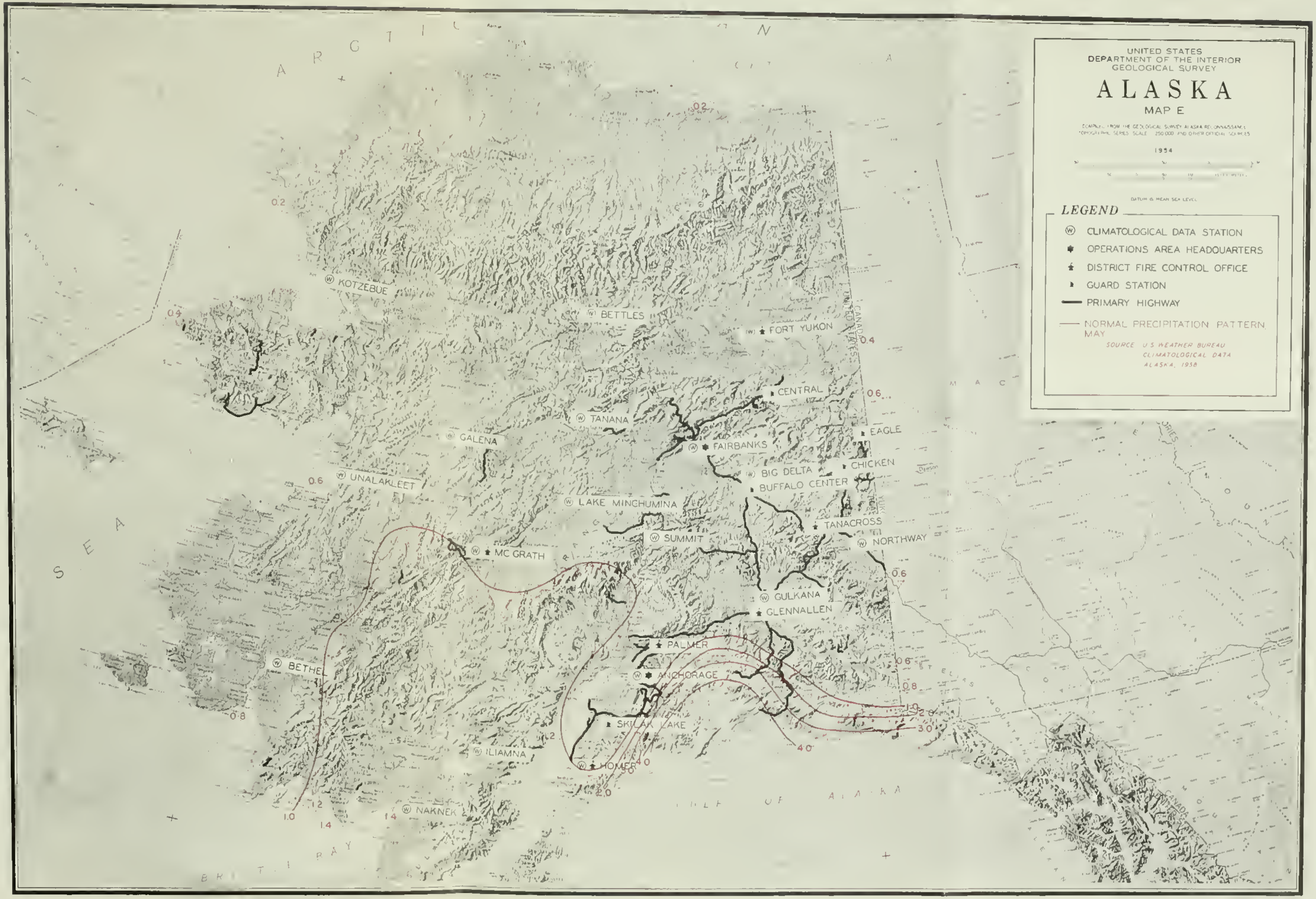
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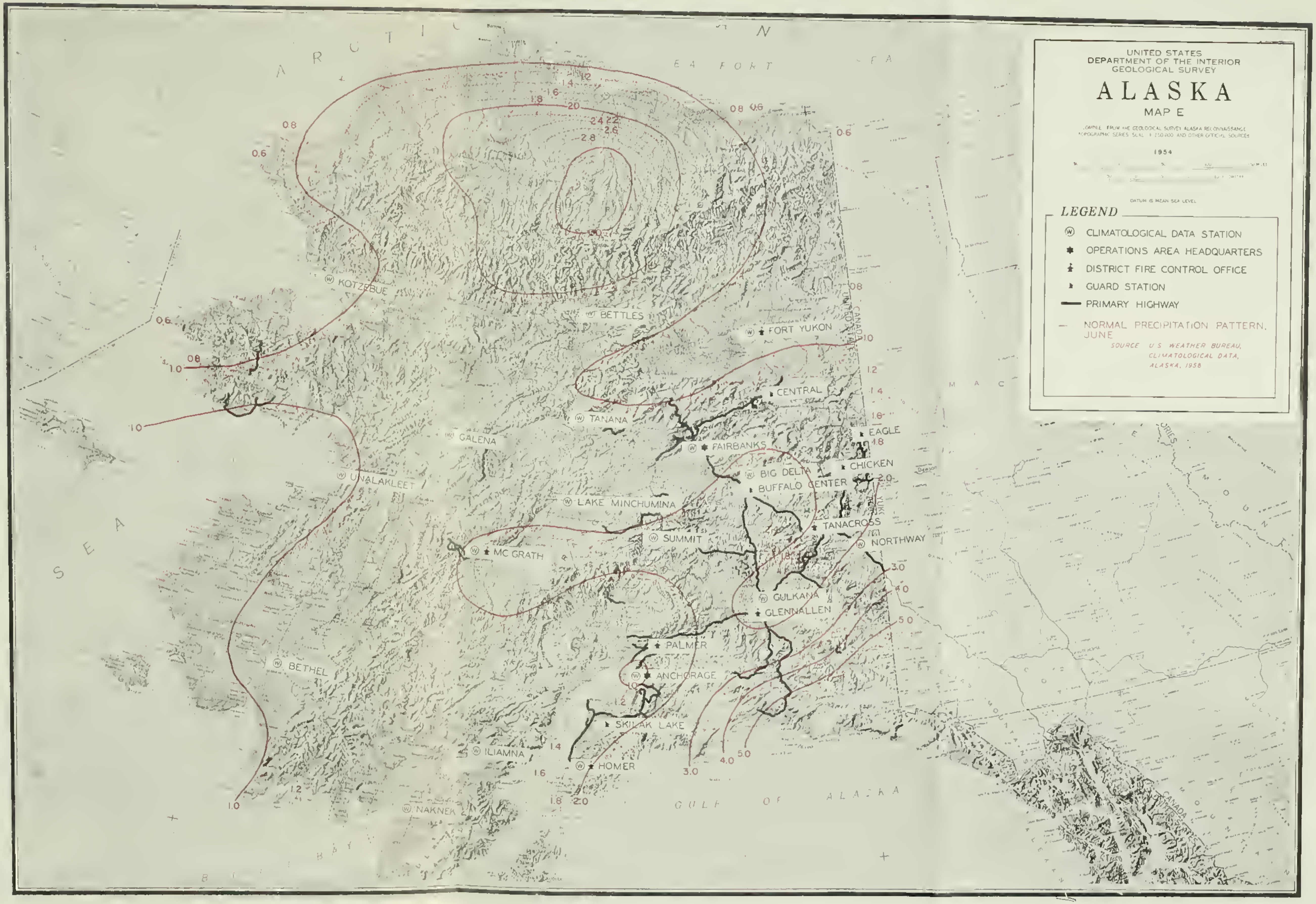
Figure 22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GULF OF ALASKA

Figure 23

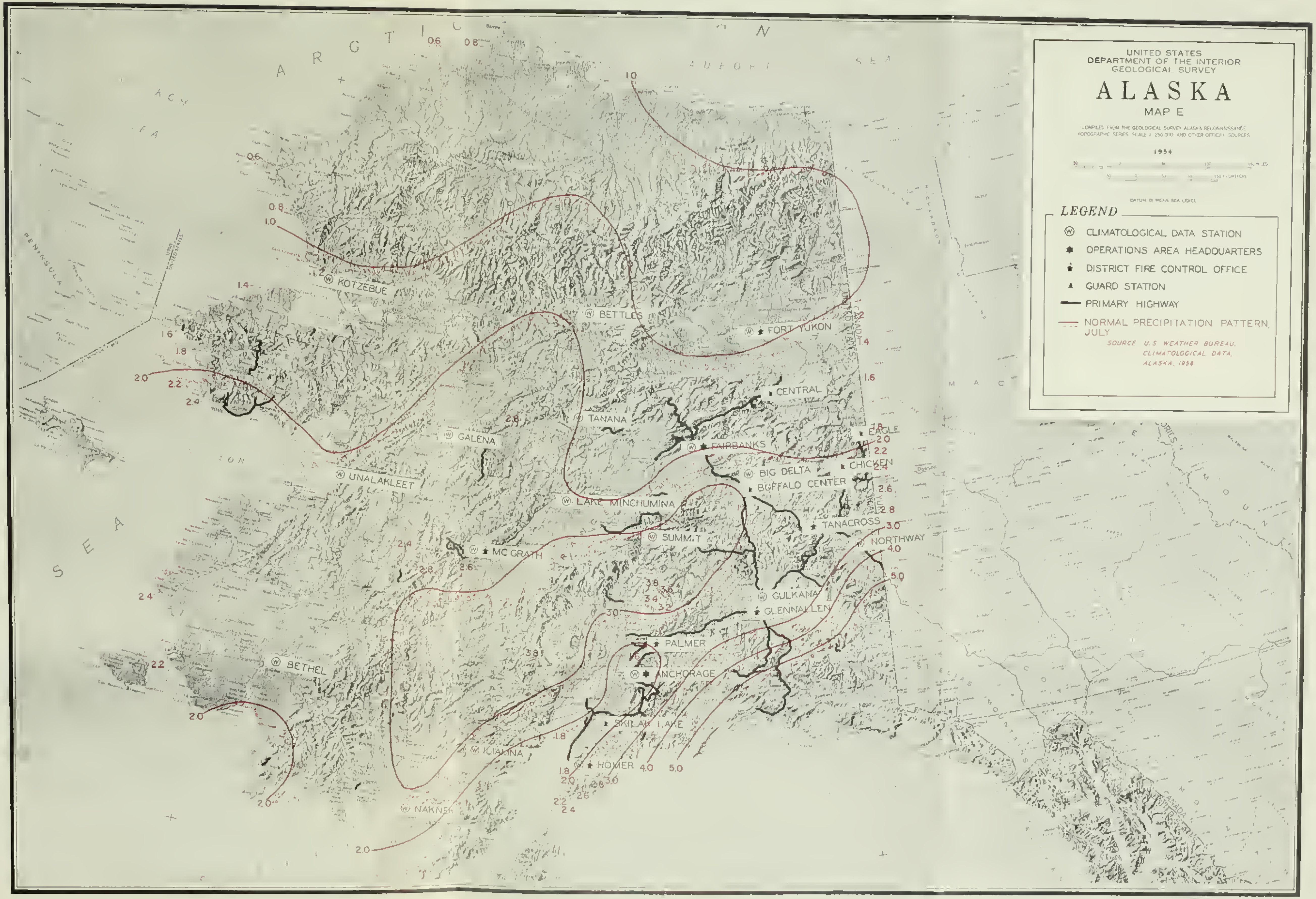
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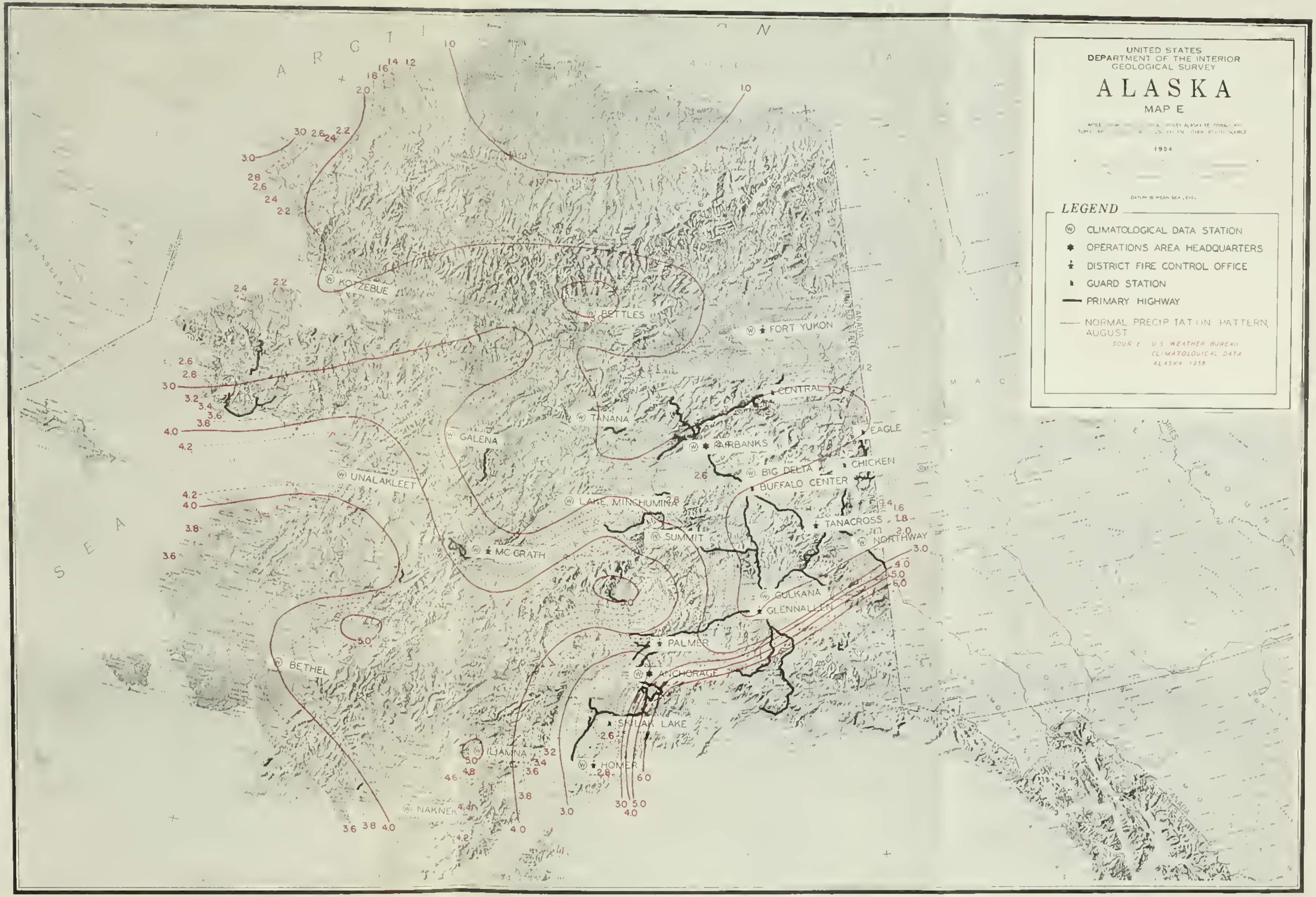
Figure 24



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NORMAL PRECIPITATION PATTERN, AUGUST
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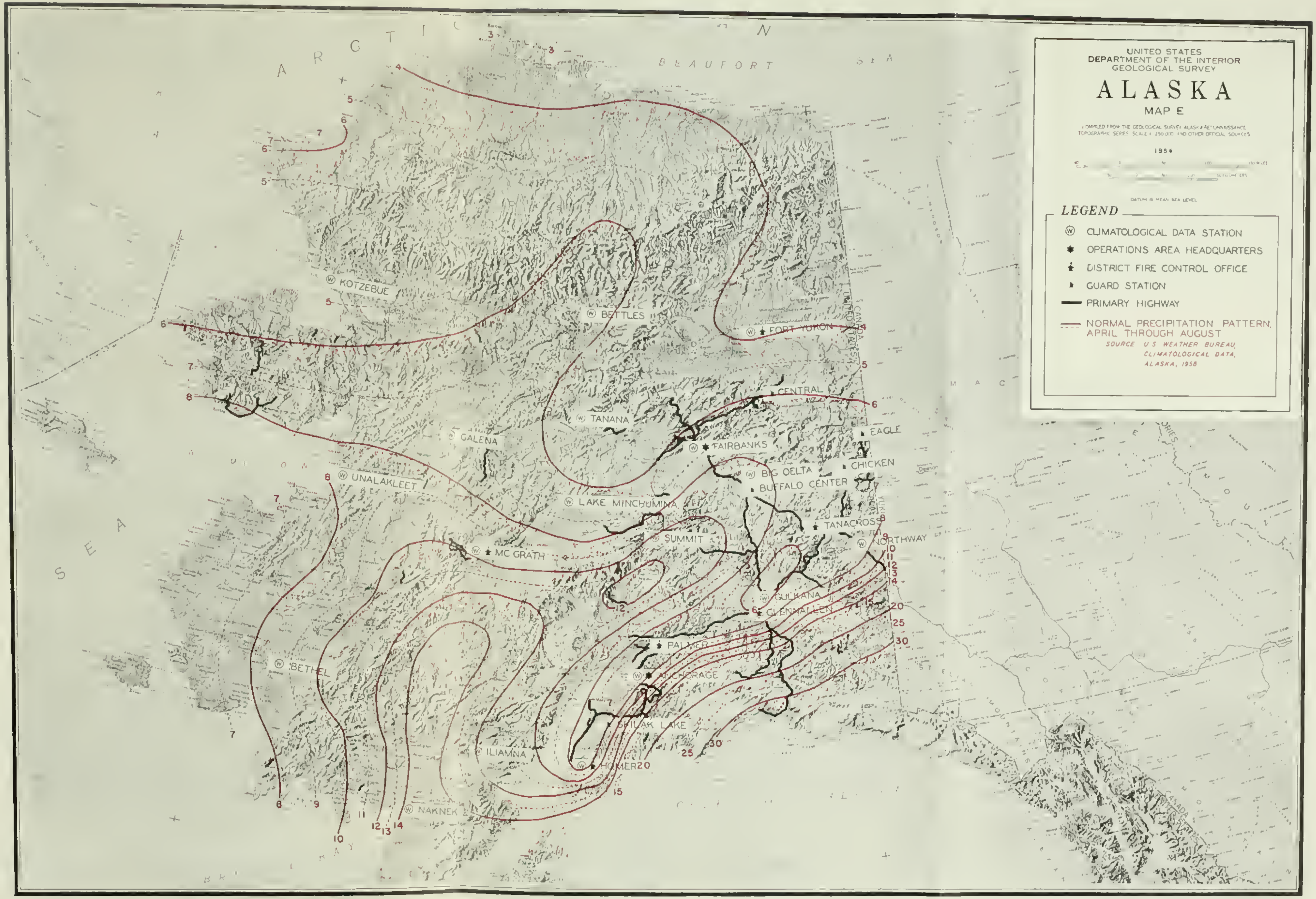
Figure 25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GUARD STATION
PRIMARY HIGHWAY
NORMAL PRECIPITATION PATTERN, APRIL THROUGH AUGUST
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KOTZEBUE
BETTLES
FORT YUKON
CENTRAL
TANANA
GALENA
FAIRBANKS
EAGLE
CHICKEN
BIG DELTA
BUFFALO CENTER
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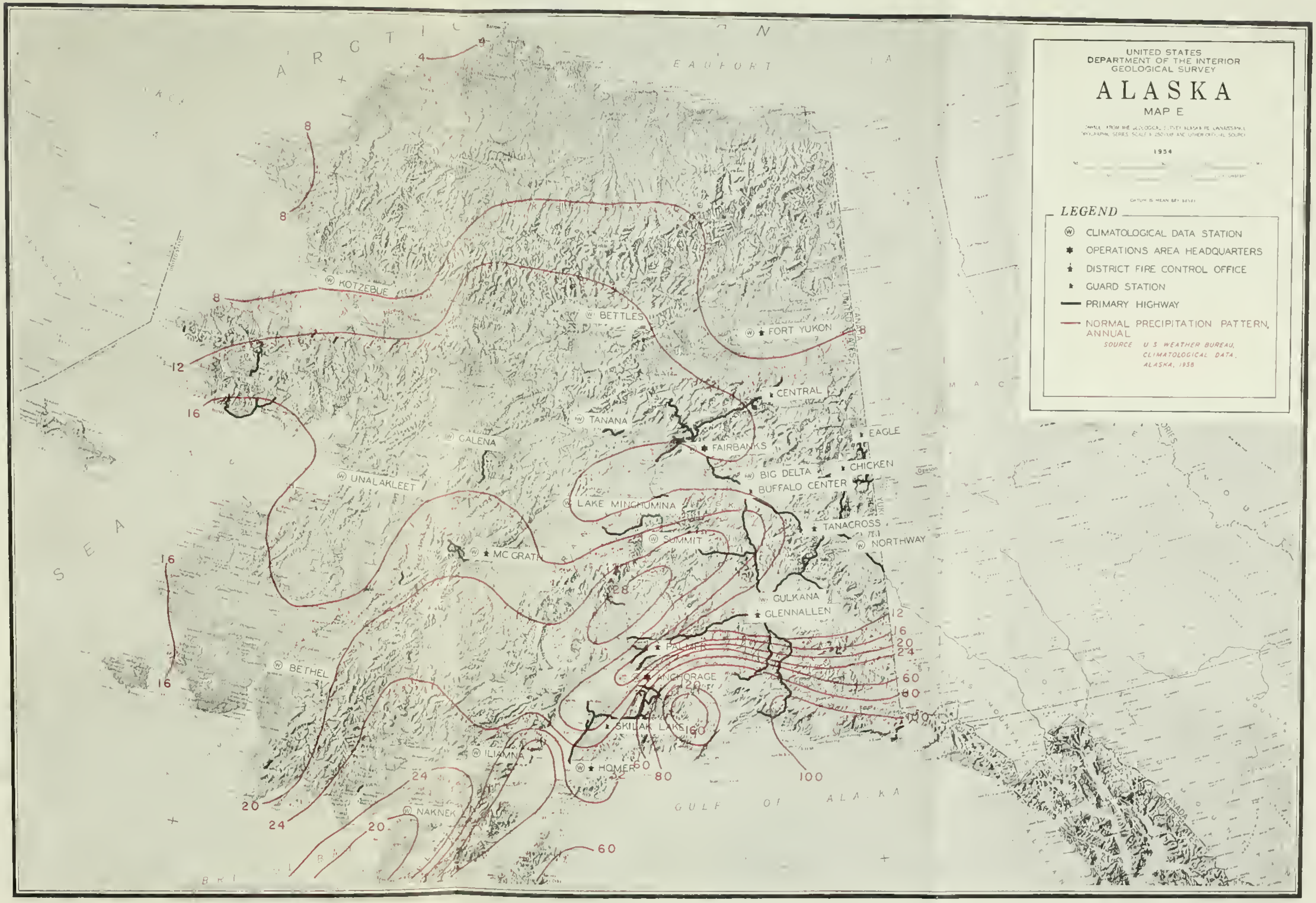
NAKNEK

Figure 26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GUARD STATION
PRIMARY HIGHWAY
NORMAL PRECIPITATION PATTERN, ANNUAL
SOURCE U S WEATHER BUREAU, CLIMATOLOGICAL DATA, ALASKA, 1958
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FAIRBANKS
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PALMER
ANCHORAGE
SKILAK LAKE
ILIAMNA
HOMER
BETHEL
NAKNEK
SEA
GULF OF ALASKA
4
8
12
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20
24
28
60
80
100
120
160

Figure 27

ZONE OF DOMINANT MARITIME INFLUENCE

Ruggedness of the topography in this zone markedly affects local climatic conditions. It produces great differences in temperature and precipitation in local areas that are not very far apart.

Climatic conditions at individual locations in this zone are characterized by small variations in temperature, high humidities, high fog frequency, considerable cloudiness, and abundant precipitation.

Extremes of temperature are quite localized and usually of short duration. The warmest temperatures usually come in late July or in August. Throughout the Maritime Zone only about one station in 15 reaches or exceeds 90° F. The mean temperature during these months is near the mid-fifties.

Temperature changes between seasons are gradual; the length of the growing season varies considerably from one year to another. The average freeze-free period varies from 120 days in the north to 150 days in the south. Freeze-free periods within any given locality vary within wide limits.

The overflow of cold air from intense high pressure cells over the mainland interior produces downslope winds that attain destructively high speeds at times. Because of its exposure to the open sea, the entire Maritime Zone is vulnerable to strong winds associated with intense cyclonic circulations that frequent these northern ocean areas. Throughout the coastal area the rugged terrain produces extremely localized wind conditions.

Precipitation ranges from about 25 inches annually in the northwest portion to 221 inches in the southeast. The steep terrain, rising out of the sea, creates topographic inducement for the high rates of precipitation along the northern Gulf Coast.

Visibility is usually low because of cloudy and foggy weather. Fog, usually the advective type, occurs frequently during the summer over the Aleutians and often drifts eastward to blanket the western Gulf Coast.

TRANSITION ZONE

The change from a maritime to a semicontinental climate characterizes the Transition Zone. This change is rather abrupt along the boundary between the South Coast and Copper River Divisions because of the sharp ridge of mountains along this boundary. The Bristol Bay and West Central portions have a gradual climatic transition since moisture-laden air moving toward the interior meets no formidable mountain barriers. Typical maritime features become less prominent farther inland: temperature varies more markedly; humidities are lower; cloudiness declines; and precipitation totals recede.

The Copper River Basin has extremely cold winters, but maximum temperatures reach 90° to 95° F. in summer. This climatic feature of the Copper River Basin indicates that its weather pattern approaches that of the Continental Zone. In areas more directly affected by maritime influences, extreme highs range around the mid-eighties.

The average freeze-free season varies from 52 to 132 days. The 169-day freeze-free period recorded at Homer one year was exceptional.

Precipitation in the Transition Zone markedly decreases from the high averages in the Maritime Zone. A drastic reduction in precipitation in the Copper River Valley and land westward to the upper Matanuska Valley is caused by the configuration of the sheltering Chugach Range. Thunderstorms are common in the Copper River area during the summer.

Precipitation generally ranges from 10 to about 30 inches. A few local areas receive heavy precipitation (75 to 80 inches) because southeasterly winds resulting from low pressure centered near the Alaska Peninsula are hardly affected by sheltering terrain. In contrast, the Kenai Range shelters the western Kenai Peninsula from the southeasterly winds, and the total precipitation there is comparable to that in Matanusko Valley (15 inches at Palmer). On the more exposed southern tip, annual totals average 25 to 40 inches.

The Aleutian low pressure cell is usually weak in early spring; hence, April has the least precipitation of any month of the year at practically all points over the zone except the Copper River portion. Precipitation increases markedly over the mainland beginning in late June. The low tends to move northward across the Bering Sea and brings a rather persistent southwesterly flow into the Interior. During August cloudy, rainy weather predominates and the interior points of the West Central portion receive measurable precipitation on 4 days out of 5. The westward drift of the low becomes pronounced in late November or early December, and precipitation declines rather sharply over most of the Transition Zone.

The permafrost area varies with summer warmth and winter cold, but it extends southward well into the northern portions of this zone. It is present from the northern slopes of the Wrangell Mountains through the Glennallen and Holy Cross areas, along the inland borders of Cook Inlet, Bristol Bay, and West Central portions. The amount of continuity is shown in figure 28.

Over the Copper River and Cook Inlet portions, winds are usually light, chiefly because of the sheltering by nearby mountain ridges. Strong, localized winds develop in some areas as the result of downslope drainage. Most frequent observations of these winds have been in the lower Matanuska and Knik River Valleys, mostly during the winter. These strong winds may persist for days when even slightly reinforced by flow patterns usually associated with low pressure systems centered near Kodiak Island or the Gulf of Alaska. Certain areas of the Bristol Bay and West Central portions are relatively unsheltered and are frequented by strong winds that often extend their effectiveness well into the interior.

DOMINANT CONTINENTAL ZONE

Two major factors contribute to the typical continental climate: (1) the area's remoteness from the open sea, and (2) mountain barriers that prevent inland movement of marine air.

The Interior Basin experiences great seasonal temperature extremes. Maximum temperatures reach or exceed 90° F. almost every summer. Fort Yukon and Eagle have daily maximum readings averaging 70° to 75° F. during July and August. Prolonged daylight in early June through late July contributes strongly in maintaining high temperatures. The sun remains above the horizon continuously for about 1 month at Fort Yukon beginning about June 5. During this season, the average diurnal temperature change is about 30° F.; however, ranges of only 10 degrees have been recorded.

The Interior Basin has recorded the highest and lowest readings for all of Alaska. Temperatures at Fort Yukon have ranged from a high of 100° F. to a low of —75° F. Combined with its counterpart in Canada's Northwest Territory, the Interior Basin records provide a classic example of the northern hemisphere continental climate.

Terminal dates of the freeze-free season (mid-May to late August) can be depended on as a result of the sharp rise in spring temperatures and an equally sharp decline in the fall.

Permafrost underlies the soil in most of the Interior Basin in spite of the warm summertime temperatures. Ground temperatures remain rather cool except for a shallow surface layer. Gradual thawing of the permafrost during the summer allows ice-cold water to permeate the soil layers immediately above it. The cooling effect, when extended to the soil mantle utilized in vegetal growth, slows seasonal production of vegetation.

The Interior Basin is almost surrounded by a high ridge of mountains; their sheltering effect is a primary cause for the light precipitation (6 to 14 inches) in this area. Most of it falls in June and July, but occasionally some occurs in August. Average monthly rainfall during these months totals close to 2 inches — slightly less than averages for the growing season over the central and western parts of the Dakotas. Total summer precipitation may vary widely within relatively short distances chiefly because shower-type precipitation predominates. In local areas thunderstorms may occur on several consecutive days.

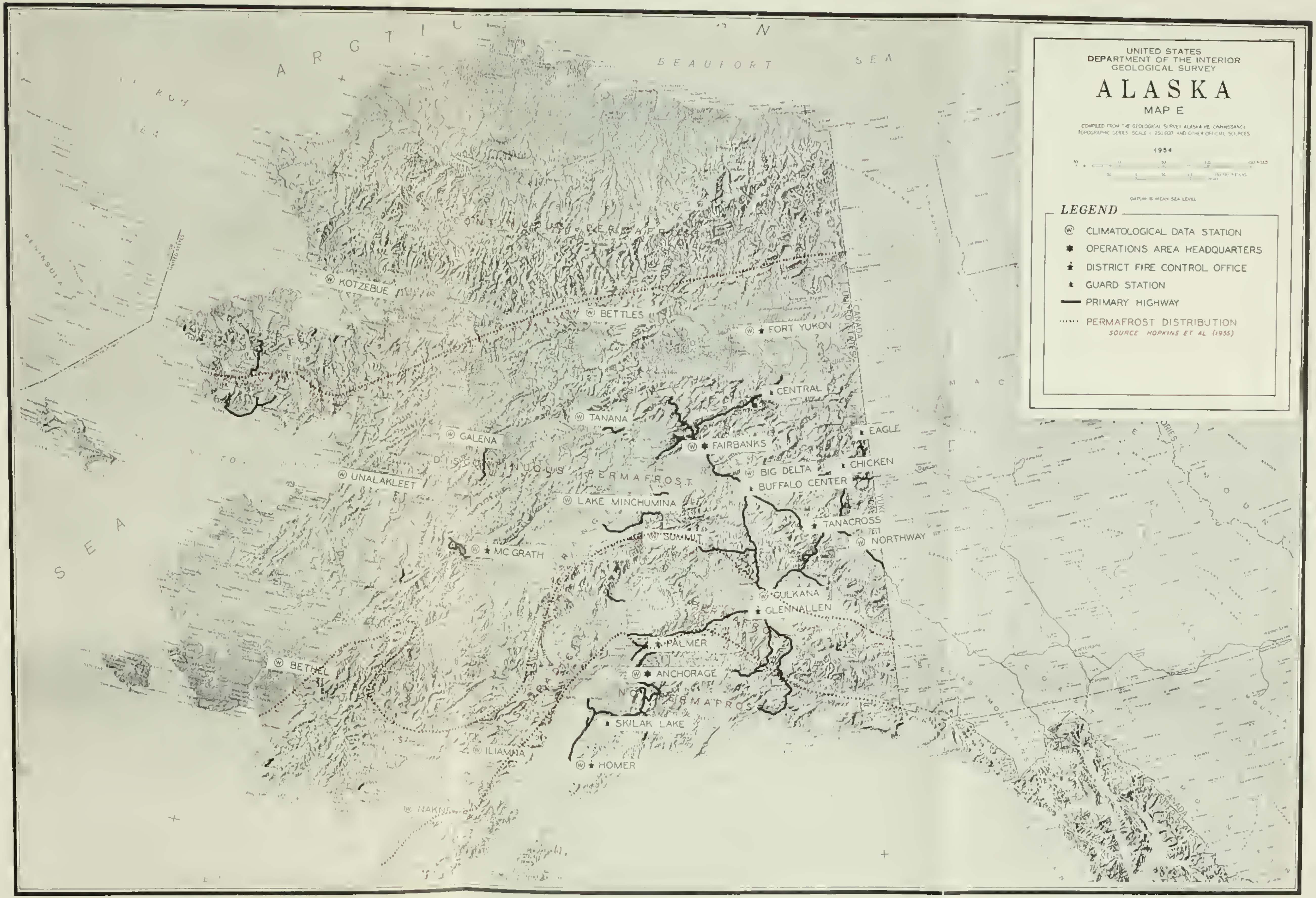

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
ALASKA
MAP E
1954
LEGEND
CLIMATOLOGICAL DATA STATION
OPERATIONS AREA HEADQUARTERS
DISTRICT FIRE CONTROL OFFICE
GUARD STATION
PRIMARY HIGHWAY
PERMAFROST DISTRIBUTION
SOURCE HOPKINS ET AL (1955)
BEAUFORT SEA
KOTZEBUE
BETTLES
FORT YUKON
CENTRAL
TANANA
GALENA
FAIRBANKS
EAGLE
CHICKEN
BIG DELTA
BUFFALO CENTER
UNALAKLEET
LAKE MINCHUMINA
TANACROSS
NORTHWAY
SUMMIT
MC GRATH
GULKANA
GLENNALLEN
PALMER
BETHEL
ANCHORAGE
SKILAK LAKE
ILIAMNA
HOMER
PERMAFROST

Figure 28

ARCTIC ZONE

Climatic conditions of the Arctic Zone are unique and contrast sharply with conditions in other zones.

The effectiveness of the Brooks Range in influencing the climate of the land area to the north has not been definitely established, although the Range is a topographic barrier.

Variations in temperature here are confined to narrower limits than in the Interior Basin. Extremely low temperatures in this zone range between —45° and —60° F. Seldom do maximum temperatures reach 80°F. Even during the prolonged period of continual daylight, the sun's rays reach the earth's surface at such low angles that they cause little surface warming.

Mean hourly windspeeds in summer average from 11 to 15 miles per hour. Maximum summertime windspeed has reached 52 miles per hour at Point Barrow.

Average annual precipitation for this zone is from 5 to 10 inches, although 16 inches occurs near Cape Lisburne. Annual snowfall totals average about 50 inches east of Cape Lisburne and from the Arctic Coast to the Brooks Range. Kotzebue experiences the warmest average temperatures and consequently receives a smaller ratio of snowfall to total precipitation than the remaining portion of the zone. The low moisture-carrying capacity of the colder air that prevails over the area accounts for this zone's having such light precipitation.

The average freeze-free period contrasts with that in other zones; it ranges from 65 days in the Shungnak area to just short of 90 days at Kotzebue. The coastal area north of the Brooks Range has minimum readings averaging near or below freezing for all months of the year; vegetal growth is limited to those species that can endure the vicissitudes of this rigorous climate.

WEATHER FACTORS THAT AFFECT FIRE BEHAVIOR AND CONTROL

Weather conditions are highly important to ignition and spread of wildfire. The amount and frequency of precipitation, air temperature, air moisture, and air movement combine to produce the dryness and consequently the flammability of fuels. Other atmospheric conditions also strongly influence behavior of a going fire. For example, a thunderstorm not only starts lightning fires, but its presence may often cause erratic winds that blow the fire out of control.

To interpret the normal weather patterns at various places and at different times of day, month, and year, weather records from 18 stations have been analyzed for the period 1950-58.[4] Observations taken from these 18 stations sample the climates experienced in their respective climatic zones (fig. 20). The individual stations are widely separated and only represent the heterogeneity of climes experienced in the State. The recorded data show the normal conditions that can be expected; however, local or temporary weather situations are often abnormally worse.

PRECIPITATION

Precipitation varies widely throughout the State, but generally decreases from south to north (figs. 26 and 27). Successive east-west mountain ranges prevent moist maritime air from reaching interior regions.

Great variation in summer rainfall is indicated by the records at representative weather stations in the Interior Basin, West Central, and Cook Inlet climatic divisions. (See table 1 and figs. 21 through 25).

The combination of time of year with amount of precipitation that falls then is an important factor influencing fire behavior. The length of time between summer rains has an important bearing on the amount of growth and the degree of curing in the herbaceous species; duration of these periods likewise affects the moisture content of dead material. Long periods of dry weather hasten the curing date of herbaceous vegetation, and thus extend the period of high flammability.

Table 2 indicates distribution of rainfall among the 4 summer months and the ratio of this season's precipitation to the annual total.

[4]Summary of the analyses appears in the appendix and is highlighted in this chapter.

Table 1. — **Variation in summer precipitation**

Weather station	May			June			July		
	Normal	Max.	Min.	Normal	Max.	Min.	Normal	Max.	Min.
Anchorage (Cook Inlet)	0.51	2.00	0.02	0.89	2.94	0.03	1.55	3.25	0.19
Bethel (West Central)	.89	2.50	.02	1.20	2.48	.30	2.29	3.95	.49
Fairbanks (Interior Basin)	.74	1.75	.07	1.37	3.52	.21	1.92	4.24	.40
McGrath (Interior Basin)	.94	1.98	.34	2.06	4.36	.42	2.32	4.73	.76

Growing conditions early in the season depend upon fall and winter moisture because too little precipitation falls early enough in the spring to promote plant growth. A deficiency of winter precipitation or early loss of snowpack may indicate the possibility of early periods of high flammability; in addition, this set of circumstances can cause deeper than normal drying of ground fuels which so often means a greater than usual resistance to control of fires. For most reporting stations, the monthly precipitation increases during the summer. Less than 20 percent of the normal annual precipitation falls between April and June. Only a few interior stations report more than 35 percent of their annual precipitation during the period generally considered the growing season.

The amount of moisture that falls in any single storm period is important to fire control. The frequency of moisture occurrence affects the flammability of the vegetative materials and the rate of buildup of fire season severity. Rainfall intensities greater than 0.25 inch in any one day occur but seldom (table 3). Virtually no precipitation falls on three-fourths of the days in May. At very few stations did more than 0.26 inch of precipitation occur on one or more days during May. During April, the weather is even drier. In May and June both frequency and intensity of rainfall gradually increase.

Table 2.—**Percent of normal annual precipitation, April through July (Av. 1950-58)**

Weather station	Month: April	May	June	July	Seasonal percent of annual	Annual ppt.
						Inches
Anchorage	2.8	3.6	6.2	10.9	23.5	14.27
Bethel	3.0	4.9	6.5	12.6	27.0	18.17
Fairbanks	2.4	6.2	11.5	16.1	36.2	11.92
Fort Yukon	2.6	4.9	10.9	14.8	33.2	6.52
Galena	1.3	4.3	11.6	18.6	35.8	14.55
McGrath	2.6	4.9	10.8	12.1	30.4	19.13
Northway	3.1	6.3	17.6	25.6	52.6	11.34

Table 3.—**Rainfall intensity classes by number of days per month (Av. 1950-58)**

Weather station	May				June				July			
	Normal ppt.	0.0-trace	0.01-0.25	0.26+	Normal ppt.	0.0-trace	0.01-0.25	0.26+	Normal ppt.	0.0-trace	0.01-0.25	0.26+
Anchorage	0.51	26.6	4.0	0.3	0.89	21.3	7.9	0.8	1.55	18.9	9.4	2.7
Bethel	.89	18.6	9.6	.8	1.20	18.1	10.8	1.1	2.29	15.5	13.0	2.4
Fairbanks	.74	25.2	5.3	.5	1.37	20.7	7.8	1.5	1.92	16.3	8.6	2.1
Fort Yukon	.32	28.0	2.8	.2	.71	23.8	5.7	.5	.96	25.3	5.4	.3
Galena	.63	24.5	6.1	.4	1.69	21.4	7.7	.9	2.69	19.4	9.4	2.2
McGrath	.94	23.8	6.5	.7	2.06	19.6	9.1	1.3	2.32	17.8	9.8	3.4
Northway	.72	23.0	6.9	1.1	2.00	19.5	8.7	1.8	2.89	18.4	10.6	2.0

Fort Yukon receives slightly less than 2 inches of rainfall during the May-July period; 77 days are rain free, and more than one-fourth inch will fall on only 1 day during the 3 months.

TEMPERATURE

Observation and knowledge of air temperature are important in studying fire behavior. Their main value lies in the relation between temperature and its effects on equilibrium moisture content and on ambient air stability conditions. Fuel temperature is affected by solar radiation and the surrounding air mass. Both exposure and arrangement of fuel particles bear on the actual temperature the fuel attains. Air temperature also affects the rate of moisture loss following a period of wetting by rain or dew.

Temperatures are higher in the Interior Basin than in any other zone. Nowhere do they stay above 80° F. for extended periods (table 4), but the sustained level over a period of 18 hours decidedly affects fuel moisture and fuel temperature.

Table 4.—**Average daily air temperature classes (degrees F.) by number of days in each temperature class per month (Av. 1950-58)**

Weather station	June						July					
	30-39	40-49	50-59	60-69	70-79	80-89	30-39	40-49	50-59	60-69	70-79	80-89
Anchorage	0.1	5.2	15.9	7.5	1.2	0.1	0	1.3	14.9	12.1	2.6	0.1
Bethel	.9	9.8	12.4	5.8	1.1	0	0	4.7	16.8	7.6	1.8	.1
Fairbanks	.2	2.3	8.9	11.3	6.1	1.2	0	1.6	9.0	11.6	7.0	1.8
Fort Yukon	.3	3.0	8.6	11.4	6.3	.4	.2	1.4	7.1	12.3	8.4	1.6
Galena	.2	3.2	11.4	10.6	4.1	.5	0	1.4	11.9	11.3	5.4	1.0
McGrath	.5	4.3	11.3	9.9	3.5	.5	.1	2.8	13.0	9.8	4.2	1.1
Northway	.3	5.2	10.5	10.2	3.5	.3	.1	3.2	10.9	10.8	5.3	.7

Afternoon temperature affects the plans for control of fires. As the long day progresses, fuel moistures reach or approach equilibrium moisture content. This in turn increases flammability. More days have higher afternoon temperatures at Fairbanks than at Anchorage (table 5). This fact may be directly related to the greater fire problem in the Fairbanks area.

Table 5.—**3:00 p.m. temperature classes (degrees F.) by number of days per month (Av. 1950-58)**

Weather station	Month					
	June			July		
	30-49	50-69	70-89	30-49	50-69	70-89
Anchorage	1.0	25.7	3.3	0	24.7	6.3
Fairbanks	0	16.1	13.9	0	15.0	16.0

PERMAFROST

Permafrost consists of organic and soil material that remains frozen year round. Regional climatic differences result in variation of permafrost thickness from more than 1,000 feet in northern Alaska to permafrost-free terrain in southen Alaska (fig. 28). Precipitation (through ground water), temperature, and insulation material affect the presence and depth of permafrost. Permafrost, in return, somewhat influences local temperature and considerably influences the supply of usable ground water.

Because of their active water movement, streams generally are underlain by deeper and wider unfrozen areas than are lakes; coarse, permeable sand or gravel is more likely to be free of permafrost than is impermeable silt. Abundant unfrozen zones at shallow depth can be expected in mountainous areas, especially on south slopes. The most favorable sites for formation or preservation of permafrost in mountain areas are on north slopes and beneath poorly drained surfaces on broad interfluves and valley bottoms (Hopkins, et al. 1955). Table 33 shows the time of season by which the ground is thawed to various depths.

Permafrost affects vegetation in several ways that bear on fire behavior and consequences. The cold soil above the permafrost layer inhibits growth and delays the "greening-up" of plants in the spring to the extent that much dry material is available for burning early in the fire season. Roots tend to grow laterally and above the frozen layer. When fire passes through a stand of timber and consumes the organic mantle, tree roots have nothing left to cling to; thereafter, even light winds can blow down large areas of trees that otherwise would have survived the fire.

The presence of permafrost often misleads firefighters. Frozen organic matter thaws and dries out when a fireline trench exposes it to open air; this permits a smoldering fire to escape across the once safe zone.

RELATIVE HUMIDITY

Air moisture is generally thought of in terms of relative humidity. In Interior Alaska, humidities in May and June are lower than in July, and considerably lower than in August (tables 6 and 25). This situation is the reverse of what is usual in most of the western United States.

Air moisture affects burning conditions mainly by varying the fuel moisture content. Most fine fuels are sensitive to changes in air moisture and follow the humidity pattern rather closely. In heavier fuels, moisture content changes more slowly since a much smaller percentage of the total volume is exposed for rapid transfer of moisture.

LENGTH OF DAYLIGHT

Both air and fuels receive heat by solar radiation. The prolonged hours of daylight and sunshine contribute to maintaining fairly high temperatures. Lengthening or shortening of daylight at a given latitude follows the change in the meridian angle of the sun. Surface temperatures are higher in the summer than in the winter not only because the sun shines longer, but because it shines more directly, and therefore, more intensely on the earth's surface. This potential worsening of fire-weather conditions is somewhat balanced by the fact that the amount of radiant energy received on any surface area decreases as we move from tropical to northern latitudes because of the lowering angle of incidence of solar radiation.

Table 6.—**3:00 p.m. relative humidity classes (in percent) by number of days per month (Av. 1950-58)**

Weather station	Month								
	May			June			July		
	<30	30-49	50+	<30	30-49	50+	<30	30-49	50+
Anchorage	1.1	16.9	13.0	0.6	10.0	19.4	0.2	6.2	24.6
Bethel	.3	6.6	24.1	.4	6.0	23.6	0	4.4	26.6
Fairbanks	6.7	17.6	6.6	5.1	16.0	8.9	3.5	12.3	15.2
Fort Yukon	1.3	16.9	12.8	1.0	18.7	10.3	.7	15.6	14.7
Galena	3.3	13.9	13.8	3.2	12.9	13.8	1.2	12.3	17.5
McGrath	2.6	16.9	11.5	2.9	13.8	13.3	1.0	11.1	18.9
Northway	5.2	15.0	10.8	5.2	15.9	11.7	2.2	15.1	13.7

Table 7 compares the number of hours of daylight for stations at three latitudes: Fort Yukon (lat. 66°35'N.), Anchorage (lat. 61°10'N.), and Missoula, Montana (lat. 46°55'N.).

Table 7.—**Duration of daylight**

Date	Location					
	Fort Yukon		Anchorage		Missoula	
	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.
May 1	17	30	16	11	14	25
11	18	52	17	06	14	53
21	20	22	17	57	15	18
June 1	22	19	18	43	15	38
11	24	00	19	13	15	50
21	24	00	19	25	15	53
July 1	24	00	19	15	15	51
11	22	18	18	47	15	38
21	20	31	18	06	15	19

The length of day or duration of possible sunshine is much greater at higher latitudes — a maximum of 5 hours greater at Fort Yukon than at Missoula, Montana. Missoula, however, receives more intense heating because the sun's rays are more nearly perpendicular to the earth's surface when the sun is at its zenith. This in turn often dries out fuels more than does the longer period of lower maximum temperatures farther north.

WIND

Wind influences the behavior of a fire. High windspeed may cause a fire to jump barriers and travel in the crowns of trees, or to spot ahead of the main fire front. Wind combined with topography can cause erratic and violent fire behavior.

As should be expected, afternoon winds usually are stronger than morning winds. Weather records indicate that Bethel is windier than most places, as the 0 to 7 miles-per-hour speed appears on very few days, but the 8 to 12 and 13 to 18 miles-per-hour range is high for morning readings and at least average for afternoon readings. Fort Yukon follows the same general trend. In May, many stations record the 13 to 18 miles-per-hour range on more days than in June or July (table 8); this indicates that winds influence fire behavior more in May than in other months.

Many factors influence the direction of airflow at any specific place. Geographic location determines whether maritime or continental airflow affects a given area. Topography can curtail, accentuate, or change the surface direction of a prevailing wind. Winds of unusually high velocity that blow out of mountain canyons are generally associated with glaciers lying in these

Table 8.—**9:00 a.m. and 3:00 p.m. wind velocity classes (in miles per hour) by number of days per month (Av. 1950-58)**

Weather station	Wind velocity classes, miles per hour: 0-7		8-12		13-18		19-24		25+	
	9 AM	3 PM	9 AM	3 PM	9 AM	3 PM	9 AM	3 PM	9 AM	3 PM
					Moy					
Anchorage	19.2	7.0	8.1	13.6	3.1	7.7	0.6	1.6	0.1	0.1
Bethel	9.5	4.5	12.0	13.2	7.8	10.8	1.6	2.3	.1	.2
Fairbonks	20.3	13.9	7.1	10.0	3.3	6.1	.3	.9	0	.1
Ft. Yukon	9.8	7.8	11.7	13.4	7.9	8.1	1.6	1.3	0	.4
Golena	13.4	10.5	11.1	11.4	5.8	7.3	.7	1.6	0	.2
McGrath	20.0	13.1	9.2	12.9	1.8	4.6	0	.2	0	.2
Northway	15.4	11.1	11.8	12.3	3.7	7.2	.1	.4	0	0
					June					
Anchoroge	20.3	11.6	8.0	12.4	1.6	4.6	.1	1.4	0	0
Bethel	8.1	7.2	14.5	13.4	6.6	8.6	.7	.8	.1	0
Foirbonks	19.7	13.3	6.7	10.5	3.1	5.1	.4	1.0	.1	.1
Ft. Yukon	12.6	7.8	9.2	13.7	6.7	6.3	1.4	1.8	.1	.4
Galena	15.2	11.6	8.8	10.8	4.9	5.7	.8	1.6	.3	.3
McGroth	20.2	15.7	7.2	9.2	2.6	4.8	0	.3	0	0
Northway	15.3	10.0	10.2	13.1	3.9	6.3	.6	.7	0	0
					July					
Anchoroge	21.9	15.6	7.7	11.0	1.3	3.7	.1	.7	0	0
Bethel	12.0	8.5	11.8	12.6	6.2	8.2	.9	1.6	.1	.1
Fairbonks	23.3	15.7	6.3	10.5	1.3	4.6	.1	.2	0	0
Ft. Yukon	14.8	9.6	9.3	12.2	5.4	6.8	1.4	2.1	.1	.3
Goleno	18.2	14.0	6.6	9.5	4.9	4.8	.9	2.2	.4	.5
McGrath	22.8	16.8	6.3	10.8	1.9	3.2	0	.2	0	0
Northwoy	17.9	14.8	9.4	11.2	3.6	4.6	.1	.4	0	0

canyons. Taku winds, Knik winds, Delta River winds, and Summit winds are well-known examples of this phenomenon. Occurrence of such winds can usually be predicted by alert forecasters. Table 9 shows the variations between reporting stations on the frequency of changes in wind direction during the month. Of interest is the shifting from month to month of predominant wind direction at the same location. These observations can be valuable in long-range fire control planning. The extremely small number of samples recorded below presents the probability that even though two reporting stations have similar characteristics the intervening area may vary greatly from them.

SKY CONDITIONS

Sky conditions have a multiple influence on behavior and control of forest fires. Some general knowledge of what to expect in various places and at different times of the season is important to a fire control officer. Appendix tables 29 through 32 summarize in detail the available information on the amount of cloud cover, types of weather (predominant moisture forms), visibility distances, and ceiling heights.

The amount or extent of cloud cover and the prevalent weather type greatly affect fire behavior and the flammability of fuels. Increased density of clouds and smoke reduces the penetration of sun rays, and allows only a portion of their heat concentration to reach the earth's surface. It also reduces the radiational heat escaping from the earth's surface. The combined effect reduces the diurnal temperature fluctuation. Rapid changes of surface temperature resulting from intermittent shading by clouds may cause troublesome changes in wind direction and velocity. On one-half to two-thirds of the days during the fire season, three-fourths of the sky is covered by some type of clouds. This is equal-

Table 9.—**3:00 p.m. wind direction classes by number of days per month (Av. 1950-58)**

Weather station	Wind direction N	NE	E	SE	S	SW	W	NW	Calm
					May				
Anchorage	1.6	0.8	0.7	4.9	9.0	2.2	6.6	4.9	0.3
Bethel	3.9	1.6	4.5	3.6	6.1	2.0	2.1	6.6	.6
Fairbanks	2.6	4.4	3.9	2.7	4.1	5.5	3.8	2.8	1.2
Fort Yukon	1.1	14.0	2.0	1.7	1.1	5.7	4.4	1.0	.0
Galena	7.3	2.8	5.6	1.8	3.7	3.4	2.1	2.0	2.3
McGrath	4.7	2.7	5.4	1.6	4.4	4.6	3.2	4.0	.4
Northway	3.0	.7	2.6	2.7	2.7	3.7	4.2	9.8	1.6
					June				
Anchorage	2.6	0.4	0.1	2.4	5.8	3.2	9.0	6.3	0.2
Bethel	2.6	2.1	2.3	2.3	7.0	4.7	2.7	5.9	.4
Fairbanks	1.7	2.8	1.9	1.6	3.3	7.7	6.3	2.7	2.0
Fort Yukon	1.2	8.3	1.0	1.0	1.6	7.0	8.3	1.6	.0
Galena	3.2	1.3	2.6	1.9	2.7	7.8	3.2	4.1	3.2
McGrath	3.7	2.7	3.1	.9	6.7	5.1	3.3	3.2	1.3
Northway	3.9	1.2	1.4	2.4	2.1	2.4	7.1	8.2	1.3
					July				
Anchorage[1]	3.3	1.0	0.2	2.1	3.0	3.8	8.7	7.4	0.8
Bethel	2.4	2.1	1.7	1.6	9.5	5.2	3.0	5.2	.3
Fairbanks[1]	1.3	2.1	1.4	2.2	3.6	6.0	8.6	2.4	2.0
Fort Yukon	.8	5.1	1.1	1.2	2.1	8.7	9.7	2.2	.1
Galena	2.2	.8	1.5	1.2	4.1	7.5	4.0	3.8	5.9
McGrath	2.6	1.7	1.6	2.8	8.9	5.6	3.4	3.1	1.3
Northway	3.0	1.8	2.4	2.1	1.8	2.8	4.8	10.1	2.2

[1]Six days' records missing.

ly true for inland and coastal areas. The amount or extent of cover gradually increases from April through August.

The interior of Alaska experiences few days during May through July when the ceiling is lower than 1,000 feet. More often the ceiling height is greater than 10,000 feet. During August, when there is more rainfall, the ceiling is lower and visibility is materially reduced.

Both smoke and haze affect surface weather somewhat but not nearly as much as they affect fire control activities. Reduced visibility makes fire detection more difficult. Most interior stations report some visibility reduction in June due to smoke haze; the effect is greater after July 1.

Thunderstorms present a double danger. First, they cause lightning fires. Second, the presence of a fully developed cell may cause high velocity downdraft winds that often make fires behave erratically and burn out of control in almost any direction. Available thunderstorm data were inadequate for useful analysis, since routine weather records indicate only thunder that is actually heard by the observer, and thus encompasses an area with a radius of a very few miles.

SIGNIFICANCE OF DEVIATIONS FROM NORMAL

The preceding discussion shows what is considered the normal expectancy for local climatic conditions. A firm knowledge of the normal situation is vital to intelligent planning and strategy for fire control. Knowledge of deviations from the normal is also extremely important. If the strength of the attack organization is to be based on average bad conditions, then the extent of variation of present conditions from the normal must be known within some given limit of accuracy. It is not logical to build up a fire control force strong enough to handle the worst season; neither is it logical to build one only strong enough to handle a normal season.

Weather conditions during two recent fire seasons — 1950 and 1957 — are considered critical. Deficient precipitation, stronger-than-average winds, low levels of air moisture, and abundance of dry lightning storms all increased the incidence and affected the behavior of fires. This buildup in fire load, of course, very soon taxed beyond breaking point the ability of the fire control forces to cope with the immediate fire situation.

1950.—The year 1950 was one of the driest recorded. Precipitation was below normal over the entire Interior. The lowest annual precipitation measured in Alaska that year (at Fort Yukon) was 3.83 inches, about 55 percent of normal. Large forest fires in that area occurred from early spring until fall. More than 2 million acres of forest land were burned by 224 fires that summer. This was one of the worst fire seasons experienced since the beginning of organized protection in the State. (In the first years of organized firefighting, 1940 and 1941, 4.5 and 3.6 million acres, respectively, were burned; records for these years are sketchy.)

Many new weather and fire records were established in 1950. Stations over most of the State reported above normal temperatures for March and April. Drought persisted in the Yukon and southern valley regions from January through September. A forest fire between the Chandalar and Porcupine Rivers in the Fort Yukon area burned 246,000 acres in the month of June; if spread over the whole month this would mean burning more than 13 square miles each day.

USFS

Figure 29. — High velocity down-canyon winds are often associated with glaciers. Matanuska Glacier.

The many dry thunderstorms from June through August caused a serious outbreak of fires each month in both the Yukon and southern valley regions; temperatures remained above normal at many stations in these regions. Some relief from the drought came in October, yet precipitation reported by many stations was still below normal.

1957.—As the 1957 season progressed, weather conditions approached the critical point. April's maximum temperatures climbed to new records at many stations. Above-normal readings continued through May; record highs were reached in the Kenai Peninsula. June temperatures were the highest ever in a wide belt extending from the northern Arctic Coast through the central mainland on to the Alaskan Peninsula.

Temperatures dropped to near normal over most of the State during July, but rose to abnormally high levels again in August. Warming trends continued at most points into September; Fairbanks registered a record high of 84° F.

As a rule, above-normal temperatures indicate airflow associated with above-normal precipitation. However, this year vast areas of the State experienced temperatures well above normal but received relatively light precipitation. The driest area was in Alaska's interior, where the precipitation total remained consistently below normal month after month.

Tanana Valley experienced the most persistent drought on record during the growing season; total precipitation from February through May totaled less than 50 percent of normal. The only other growing season with comparable deficiencies was 1950. A slight break came about June 20, but the month's total was only 40 percent of normal. The drought continued through August and September; precipitation was only about 20 percent of normal in the Fairbanks area.

More than 5 million acres burned this year, a total far exceeding that of any other year of record; this was 2½ times the area burned in 1950.

Comments.—On all forest and range lands the severe fire seasons are usually the years of more critical weather. Fire-weather and fire-danger rating records show this relation well. Years with dry springs followed by dry summers almost always have many large fires. Alaska is no different from other States in that respect. Observation of weather patterns and associated fire history reveals that in Alaska the weather does not always get hot and dry and stay that way as some may think. Further research and analysis will help produce guides whereby build-up of critical fire seasons can be more easily recognized; of importance too, use of such guides will assist prediction of conditions which are not critical.

CHAPTER 4

FUELS

In forest fire language, "fuel" refers to any material that may burn if it is ignited — grass, needles, tree trunks, logs, muskeg, peat, or even coal. It may be either dead or living. Fuel is thought of in two ways: (1) as represented by species or species groups (cover or timber type), or (2) as represented by fuel types. Within a *cover* type, e.g., white spruce-paper birch, fire behavior is estimated according to how fast it travels and how easily it can be controlled in an average stand. A *fuel* type occupies an area in which the vegetative material is classified according to how fast fire will spread in it and how easily the fire can be controlled, regardless of the cover type. Fire control men prefer to use the *fuel* type classification system as it is both more precise and more flexible.

To date, no fuel type classification system has been established for Alaska. The cover type classifications used and the relation of each type to fire are described in this chapter.

FUEL DESCRIPTION

SIZE

The initial advance of any forest fire is usually through such fine fuels as grass, moss, or dry leaves. Heavy fuels, such as down logs, may slow the advance of a fire by being a barrier between the flame and the fine fuels ahead of it. Moisture content of large fuels does not fluctuate with temperature and humidity as fast as that of fine fuels. In general, the ratio of surface area to volume determines how rapidly the moisture content of a fuel fluctuates with the change in such weather factors as temperature and humidity. This ratio is much higher in a blade of grass than in a limb or a log.

Mosses, lichens, and grass, in combination or separately, are found throughout the vegetal range of Alaska. "Moss" is a loosely used term; as a general term it includes many species of lichens, which are at least as fine as the moss species and probably more flammable. Moss grows nearly everywhere that any vegetation grows, and is an extremely finely divided fuel. A slight rise in temperature, a decrease in relative humidity, and a spark are all that are needed to ignite it. The influence of heat radiation is similarly more rapid on ignition of moss than on other fuels.

The prevailing fuel types through which an initial fire front advances in Alaska may be made up of finer fuel particles and these may have a higher rate-of-spread classification than an average fuel type in most other States.

CONTINUITY

Within the vegetative zone, Alaska has a nearly continuous e x p a n s e of ground fuels. Mosses, grasses, and lichens are found in some combination everywhere except on rivers, lakes, or barren areas. In most other localities in the United States, horizontal continuity is broken by such factors as bare soil under brush stands, roads, or cultivated lands. Needles under a well-pruned timber stand support a much slower rate of spread than does moss.

Crown fires in Alaska are not unusual; the nature of the timber stands presents an excellent opportunity for crowning to occur. Cover type descriptions point out the fact that the climax spruce stands, both white and black, are typically close-grown with branches drooping to the ground. The branches often support a heavy growth of beard lichens, which adds greatly to the amount of fine fuel that carries fire upward. These conditions complete the pattern of complete horizontal and vertical continuity simultaneously. In other words, if a fire gets under a stand of spruce timber, the chances are excellent that it will climb the tree, and, if much wind is present, will spread from tree to tree through the crowns.

This situation is intensified by the fact that spruce needles easily become detached when heated and ignited, and float ahead to accelerate the already rapid spread. In a spruce-birch stand, the highly flammable birch bark further intensifies the tendency for a fire to spread rapidly through the crowns; decadent and overmature birch trees are particularly dangerous.

COVER TYPE CLASSIFICATION

The following descriptions of cover types closely follow those of Lutz (1956), but the relation between the cover type and actual fire behavior within the type is derived primarily from Robinson.

EARLY STAGES IN FOREST SUCCESSION

Paper birch (*Betula papyrifera*). — This species generally forms even-aged stands. Within 80 years white spruce often becomes prominent as an understory component. By 120 years the spruce begins to dominate the stand. Barring major disturbances, the stand eventually becomes a white spruce-paper birch forest. Fire tends to perpetuate the birch but reduce the spruce. Birch is typically found over millions of acres as codominant with spruce. The birch tends to open up and have fairly heavy ground cover. Birch stands seldom sustain fire unless some spruce is in mixture with it. Once started, however, fires burn readily in stands containing birch because of the oily, highly flammable bark, which permits flames to race up the trees into the crowns and send sparks and chunks of bark ahead.

USFS

Figure 30. — Lichens promote crowning.

Quaking aspen (*Populus tremuloides*). — The history of an aspen stand is very similar to that of paper birch. On excessively dry south and west slopes, aspen may persist indefinitely. Aspen is relatively short lived, living from 80 to 100 years; it serves primarily as a nurse crop for white spruce. Aspen is seldom found in any extensive areas as codominant with spruce. It tends to have a shallow, clean ground cover, and prunes itself quite rapidly. For this reason, aspen stands are typically more fire resistant than other types.

USFS

Figure 31. — Horizontal continuity of fuel.

USFS

Figure 32. — Vertical continuity of fuel.

Balsam poplar (*Populus balsamifera*). — This species forms essentially pure stands an recently deposited alluvium. (Northern black cottanwood is considered a part af this general type.) Following fires, balsam poplar may invade upland areas beside large streams. It may occupy flood plains indefinitely if they frequently receive new deposits of silt. However, on stable sites white spruce gradually gains dominance. As small trees the poplars are subject to fire damage, but above 30 feet in height they become well pruned and are progressively less susceptible to fire damage; as a bottomland type it does not comprise a true fire hazard.

Willow-alder (*Salix* spp.-*Alnus* spp.). — Such a complex is not necessarily related to the early stages of succession, but it is included with the other hardwood stands. Willow is found along banks of rivers and intermittent streams and extends to the treeless plains of the Arctic. Alder is found along rivers and at brush lines on mountain slopes. These two species da not tend to carry fire unless extremely dry weather prevails and high winds are blowing. When they do burn, they burn hot and thus increase the resistance to control.

SECONDARY STAGES IN FOREST SUCCESSION

White spruce-paper birch (*Picea glauca-Betula papyrifera.*). — This type is more advanced than either the paper birch or quaking aspen types. It may develop immediately after fires or it may result from gradual entry of white spruce into an originally paper birch stand. Barring disturbance, a pure relatively open spruce stand will result. Fire tends to perpetuate the birch but reduce the spruce. The horizontal and vertical continuity of fuel, accompanied by the flammable birch bark, causes this type to be very susceptible to high rates of fire advance, both along the ground and into and through the tree crowns.

White spruce-quaking aspen. — Development of this type is analogous ta that of the white spruce-paper birch type except that aspen dies out rapidly at about 60 years, while birch will remain for 100 to 130 years. The aspen is reestablished easily after a fire, chiefly because of its capacity to produce root suckers.

CLIMAX FORESTS

White spruce (*Picea glauca*).—White spruce becomes climax on well-drained land. Young stands are usually even-aged, but may became uneven-aged with maturity. White spruce following immediately after a fire tends ta be dense, but if it develops as a replacement of aspen, birch, ar poplar it is likely to be relatively open. It is probably longer lived than other trees in Interior Alaska; ages up ta 300 years are not uncommon. An occasianal tree may attain a 28-inch diameter and a height af 90 feet. However, an average-sized tree would be more nearly 14 inches in diameter and 70 to 80 feet in height.

Single, light surface fires do not destroy the stand but create openings for the invasion of hardwaod species. Repeated severe fires may cause an area to became essentially treeless, supporting anly herbaceous or shrub communities, sometimes developing inta an aspen or birch stand. Revegetation follawing fire is rapid; bare areas are rarely seen. The outstanding effects of fires are that (1) most amaunts of existing timber are destroyed and (2) the subclimax types (principally quaking aspen and paper birch) are, at least temporarily, greatly increased at the expense of the white spruce type.

In a white spruce stand the trees have heavy, narrow crawns extending ta the ground, except trees in mature stands may often have the lower limbs pruned. On dry slopes and in the higher benchlands, white spruce tends to become an open woodland type of growth, where shorter height, broader crowns, and branches extending to the ground tend to persist through maturity. In open stands grass, dwarf birch, Laborador tea, and sedges are typical, as is a heavy continuous ground cover of moss. In dense stands, mass may be heavy along with needles, branchwood, and species of Vaccinium.

Black spruce (*Picea mariana*). —Black spruce can be termed a physiagraphic climax. It grows on poarly drained areas in relatively flat valley bottoms, on flat to gently rolling land, and on cold slopes having a narthern exposure. It forms pure stands of usually small, slow-grawing trees. Permafrost is often found at depths af anly 12

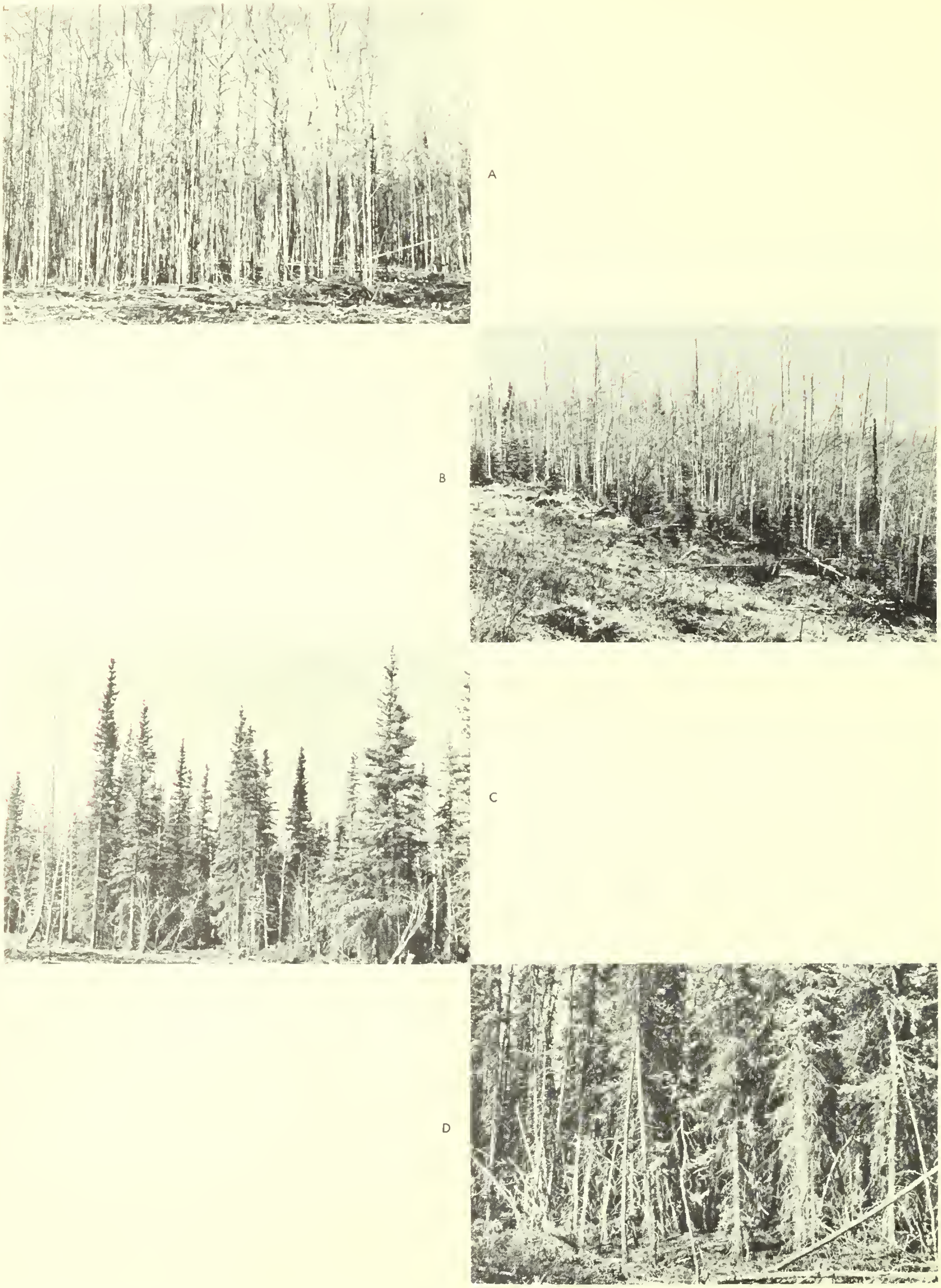


Figure 33. — Ecological succession from aspen to pure white spruce stand: A, aspen stand; B, small spruce understory; C, spruce has become dominant; D, aspen is nearly eliminated.

to 18 inches. Without fire this spruce is self-perpetuating both by layering and seeding. Even after a single intense fire it usually regenerates; but if fires are repeated often, the area may become a treeless community supporting sage-rush-grass, or low shrubs. Reentry of black spruce may then be very slow. The trees are short, small in diameter, and have full-length, narrow crowns. On excessively dry valley bottoms or low benchlands, black spruce tends to grow in extensive areas of dense thicket type stands 20 to 30 feet high, and be so dense that human penetration is impossible. With its typical moss ground cover, a black spruce site is an explosive fire type. Most of the excessive rates of spread recorded on going fires occurred in black spruce stands (ch. 7).

Grass.—Grass, a typical flash fuel, is found throughout Alaska from valley bottom to ridgetops and in unbroken continuity from small patches to single areas of hundreds of square miles. Grasses and sedges are an integral part of all muskeg types. In southwestern Alaska grasslands *Calamagrostis* may be 6 to 8 feet high with a 12- to 15-inch surface accumulation of down grass, or "rough." Fire spread in Alaskan grasses is similar to that elsewhere. Winterkilled grass burns at a flash rate of spread in spring before new growth occurs. In late fall after killing frosts, the spread rate again increases.

Muskeg.—Muskeg denotes a poorly drained site regardless of where it occurs topographically. It carries an association of heavy sphagnum mosses, tussocks of sedges, grass, various heath plants, brush, and black spruce; minor surfaces or better drained ridges within a muskeg may carry birch or white spruce. The term "muskeg" is also used to include swamps or bogs containing hundreds of p o t h o l e s , sloughs, or lakes. Wherever subsurface drainage is blocked, a muskeg association develops even on moderate slopes and ridgetops. As an ecological term, muskeg is limited generally to peat-forming vegetation in Alaska and northwestern Canada.

Moss found in muskegs may be from several inches to several feet deep carrying recognizable plant structure to those depths (peat does not). The moss and lichen types comprise a specific and difficult fire problem because their flashy

USFS

Figure 34. — Small black spruce stand near Gulkana.

USFS

Figure 35. — Typical grass type on lower Kenai Peninsula.

characteristics contribute to rapid surface spread, and their organic mass requires extensive digging in order to stop or extinguish the deep, slow-burning fires. Drought conditions such as those in 1957 and 1958 may cause extreme dryness of moss ground cover to depths of several feet.

Tundra.—The tundras mark the limit of arborescent vegetation; they consist of black mucky soil with a generally frozen subsoil, but support a dense growth of mosses, lichens, and dwarf turflike herbs and shrubs. The treeless area in the Bering Sea and Arctic littorals is largely covered by tundra.

Peat and muck.—Peat material can be classified as woody, fibrous, or sedimentary; the type depends upon the degree of decomposition and the method of its accumulation. Muck is any peat material, altered by such features as aeration, drainage, or micro-organism action or cultivation that causes so great a decomposition that its original botanical character is no longer evident. These types are not particularly pertinent to fire control except that they may hold smoldering fire for a long time. Quenching a fire in them is extremely difficult because the materials smolder similarly to punk or rotten wood.

FUEL TYPE CLASSIFICATION

Formal fuel type mapping or classification has not been done in Interior Alaska. However, through experience and observation of the manner in which different types of fuels burn under various conditions of slope and aspect, Robinson prepared a preliminary rate-of-spread classification for Alaskan fuel types. Table 10 shows generally the relative speed at which fires ignite and burn in the major fuel types.

USFS

Figure 36. — Tundra type, Steese Highway.

Table 10.—**Rate-of-spread classifications for Alaskan fuel types**[1]

Fuel type	Valley bottom		Benchland		Slopes		Ridgetops
	Wet	Dry	Wet	Dry	Southerly	Northerly	
White spruce or birch-spruce	M	H	H	E	E	H	E
White birch or birch-aspen	M	H	H	E	E	H	E
Black spruce	H	E	H	E-F	E-F	H	H
Aspen	M	M	M	M	H	M	M-H
Cottonwood	L	M	L	M	M	M	
Willow-alder	M	M	M	H	H	M	M
Grass	E	F	F	F	F	F	F
Muskeg	M	H	H	E	F	H	E
Tundra	M	H	H	E	E-F	H	E-F

[1]Rate of spread: L=low, M=medium, H=high, E=extreme, F=flash.

Based on BI of 40: 3 m.p.h. wind; 30 percent relative humidity; severity index 8; today's slot moisture content 6 percent.

CHAPTER 5

FIRE-DANGER RATING

USE OF FIRE-WEATHER INFORMATION

Fire-danger rating techniques have been used widely in National Forests and other protection organizations for more than 20 years. Each general region has developed its own system of integrating into meters or tables the primary factors that influence the start and spread of fires.

Prior to 1956, Interior Alaska had no formal system of fire-danger rating, and thus no basis upon which to build a fire-danger rating system. Fire control officers relied upon their personal judgment and experience to estimate the effect of the fire weather for the current day and for the previous several days on preparedness and suppression activities. The younger men in the expanding fire control organization needed a reliable guide upon which to base their decisions.

The Intermountain fire-danger rating system was introduced in 1956 without any modifications as an interim measure in order (1) to interpret weather information in an orderly fashion for use in fire control work, and (2) to obtain research data during the period of the system's operation for eventual incorporation into a better system, which would be designed in accordance with local conditions (Hardy and Brackebusch 1959).

After using the Intermountain system for 2 years, experienced observers noted that the burning index meter did not react to actual field changes as fast as was necessary. Appalachian slats were then substituted for the half-inch dowels (fig. 38) that comprise the fuel moisture input to the Model 8 meter. This change permitted the burning index to react faster, more in keeping with the rapid changes in the fire-carrying characteristics of the finely divided, high surface-area-to-volume Alaskan fuels.

Information from the Model 8 meter can be used satisfactorily by referring to the rate-of-spread computations shown in table 11 (Barrows 1951; Fahnestock 1951). For Alaskan fuels and burning conditions, however, the perimeter increase figures can be only approximate and relative until data from local research make possible a more reliable revision.

To explain the above statement: fires burned through black spruce stands in Interior Alaska at a rate of 120 to 600 chains per hour when the burning index was between 28 and 37,[5] while in southern Idaho fires burned through cheatgrass stands at a rate of 142 to 248 chains per hour when the burning index was between 78 and 93.[6]

By 1960, 14 fire-weather stations were operating throughout Interior Alaska. No great increase in the number of stations is likely in the near future because of the limited number of personnel available. Reliable observers, located near centers of use, with access to adequate long-distance communications are as necessary as proper locations and well-maintained instruments (Hardy, Syverson, Dieterich 1955).

The following tabulation compares the number of stations and areas involved in Interior Alaska and Region 1 of the U.S. Forest Service.[7]

	Alaska	Region 1, USFS
Number of stations	14	175
Total area involved (acres)	225,000,000	32,000,000
Average area per station (acres)	18,750,000	182,857
Area ratio	1	100

Even with the large number of stations in Region 1, the personnel are continually endeavoring to interpret fire weather from a permanent fire-weather station to specific sites on going

[5]With half-inch sticks, or 33 and 59 with slats.

[6]Traylor, R. E. Processed report of a study of eight fires in southern Idaho, 1959; on file at Northern Forest Fire Laboratory, Missoula, Montana. (Burning index based on half-inch sticks.)

[7]Montana, northern Idaho, northeastern Washington, and northwestern South Dakota

Table 11.—**Average initial rate of spread[1] according to fuel type, slope steepness, and burning index at site of fire[2]**

Fuel rate of spread type	Slope steepness[3]	Burning index 1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
	Percent	Perimeter increase (chains per hour)									
Low	0-10	0	1	1	1	1	2	2	2	3	4
	11-25	0	1	1	1	2	2	3	3	4	6
	26-50	1	1	2	2	3	3	4	4	6	8
	51-75	1	2	3	3	4	5	6	7	9	13
	Over 75	2	3	4	5	6	7	8	10	15	20
Medium	0-10	0	1	1	1	2	2	2	3	4	5
	11-25	1	1	1	2	2	3	3	4	6	7
	26-50	1	2	2	3	3	4	5	6	8	10
	51-75	2	3	3	4	5	6	7	9	13	16
	Over 75	3	4	5	6	8	10	12	15	20	25
High	0-10	0	1	2	3	4	5	6	8	9	12
	11-25	1	1	3	4	6	7	9	11	13	17
	26-50	2	2	4	6	8	10	12	16	18	24
	51-75	3	3	6	9	13	16	19	25	28	38
	Over 75	4	5	10	15	20	25	30	40	45	60
Extreme	0-10	1	3	4	5	6	8	10	13	16	19
	11-25	1	4	6	7	9	11	14	19	22	27
	26-50	2	6	8	10	12	16	20	26	32	38
	51-75	3	9	13	16	19	25	32	41	50	60
	Over 75	5	15	20	25	30	40	50	65	80	95
Flash	0-10	1	5	12	15	19	24	30	37	46	57
	11-25	1	7	17	21	27	34	42	52	65	81
	26-50	2	10	24	30	38	48	60	74	92	114
	51-75	3	16	38	48	60	76	95	117	146	181
	Over 75	5	25	60	75	95	120	150	185	230	285

[1]Average initial rate of spread refers to perimeter increase between discovery of fire and first attack. This rate of spread may be anticipated during the first 4 to 5 hours.

[2]Table based upon study of 2,955 fires in National Forests, R-1, 1936-44. Values for very high and very low burning index have been estimated.

[3]General descriptions used in slope descriptions are: Level, 0-10 percent; Gentle, 11-25 percent; Moderate, 26-50 percent; Steep, 51-75 percent; Very steep, over 75 percent.

fires or prescribed burns (Barrows 1951). It will never be possible to have such an intensive coverage of fire-weather stations in Alaska because of the sparse settlement, lack of permanent personnel, and lower order of resource utilization. However, for purposes not requiring daily measurement, recording weather stations may soon be used to fill in gaps at important locations.

Data collected from the present system of fire-weather stations in Alaska have assisted research personnel in understanding the general fire-weather complex that characterizes Alaska's interior. Fire-weather information presented in this publication was obtained from two sources: fire-weather stations and actual fire data. Use of the system by fire control personnel has enabled them to understand the trend of fire-weather conditions during the summer much better than they could previously. One example of such use is evidenced in table 12, which was devised by fire control officers in Interior Alaska to indicate progressively worsening burning conditions according to cumulative moisture content and current burning index. Such a table facilitates wiser use of equipment and manpower in organizing both fire preparation and fire suppression activities.

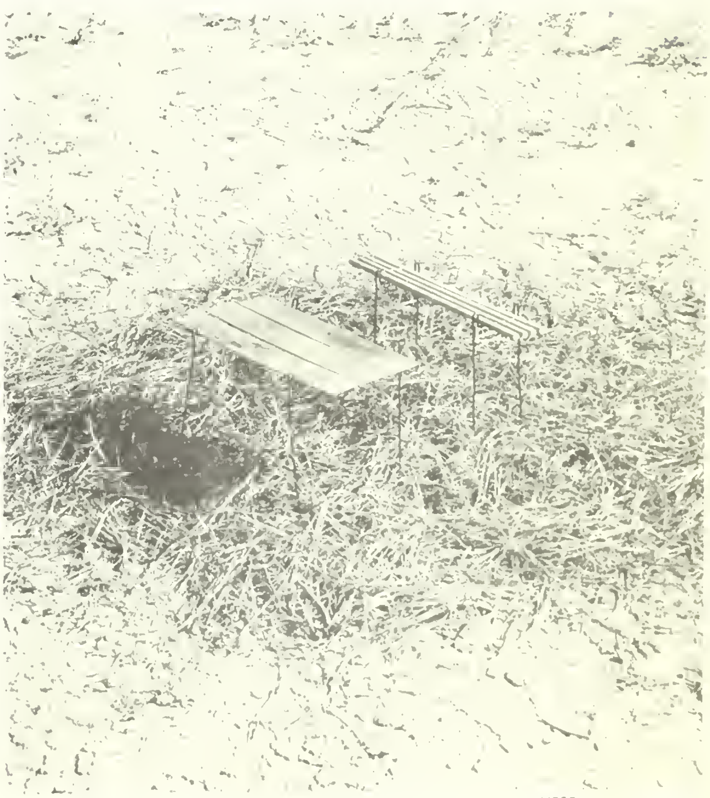
Table 12.—**Burning condition classes**

Adjective description	Cumulative 5-day fuel moisture[1]	Severity index	Burning index: Intermountain[2]	Burning index: Alaska[1]	Burning condition
	Percent				Class
Low	85+	0-2	1- 20	1-15	1
Moderate	71-84	3	21- 35	16-25	2
Average	48-70	4-5	36- 50	26-35	3
High	36-47	6	51- 70	36-50	4
Extreme	0-35	7-10	71-100	51+	5

[1]Based on moisture content of Appalachian slats.
[2]Based on moisture content of half-inch dowel sticks.

USFS

Figure 37. — Fire-weather station, Glennallen.



USFS

Figure 38. — Appalachian slats (left) and half-inch dowel sticks (right).

SEASONAL TRENDS IN FIRE WEATHER

Perhaps the reason for the greater-than-expected rate of spread of fire in black spruce is due to the fuel itself; perhaps it is due to the method of determining burning index; or perhaps it is due to a weather-length of day complex. The reader should note that such weather factors as relative humidity, fuel moisture, and air temperature, do not approach the normally expected critical points reached in such States as Montana and Idaho.

The percent of total frequency of each measured fire-weather factor during the 1958 season is shown in figure 39 — relative humidity, wind velocity, fuel moisture (both stick and slat), and the resultant burning indexes. An overall pattern becomes apparent that all factors, except wind, have an increasing percent of occurrences on the severe side of the line according to this order of stations: Anchorage, Fort Yukon, Priest River Experimental Forest, and Fort Howes.

Generally speaking, burning indexes are slightly higher in Interior Alaska in May and June than in July and August. The reverse is true for Montana and northern Idaho (table 13 and fig. 40). Statistics on fire occurrence and burned area follow the same trend as the burning index data (refer to figs. 54 and 55). As a point of interest, the fire season at the other edge of the United States (Arizona and New Mexico) also reaches its peak by mid-July, then begins tapering off.

Table 13.—**Percent of total frequency of burning index by general classes, May-August, 1956-58**

Weather station	Indicator	Month: May		June		July		August		Annual ppt.
		21-40	40+	21-40	40+	21-40	40+	21-40	40+	Inches
Anchorage	Stick	48	2	0	0	0	0	0	0	16.23
	Slat	60	7	62	0	27	2	42	0	
Fort Yukon	Stick	69	6	62	22	60	13	50	0	5.61
	Slat	39	61	43	49	64	23	75	11	
Priest River	Stick	58	3	46	1	53	30	33	41	39.45
(Idaho)	Slat	0	0	47	26	33	58	27	55	
Fort Howes (Montana)	Stick	39	33	32	22	43	50	19	70	10.47

DIURNAL FLUCTUATION OF FIRE-WEATHER FACTORS

Analysis of fire case histories (ch. 7) revealed some interesting information about involving the diurnal fluctuation of fire-weather factors. The extreme length of daylight in northern latitudes does not cause relative humidity, temperature, or fuel moisture to approach the danger point, as had been supposed previously. Also, the variation of each factor from the most severe observation (usually at 1600) during a 24-hour period is far less than at locations such as Priest River Experimental Forest (fig. 41).

Perhaps extended periods of moderate weather produce comparable conditions in terms of fire behavior as a short number of hours of severe weather (see ch. 3). The flat curves of figure 42 indicate that the extended daylight period in Alaska does not give fuels much time in which to cool off and absorb moisture. They also indicate that the spread of fire can continue night and day at a relatively uniform rate; fire-weather factors at night do not become mild enough for a fire to "lay down" as it usually does in southerly latitudes.

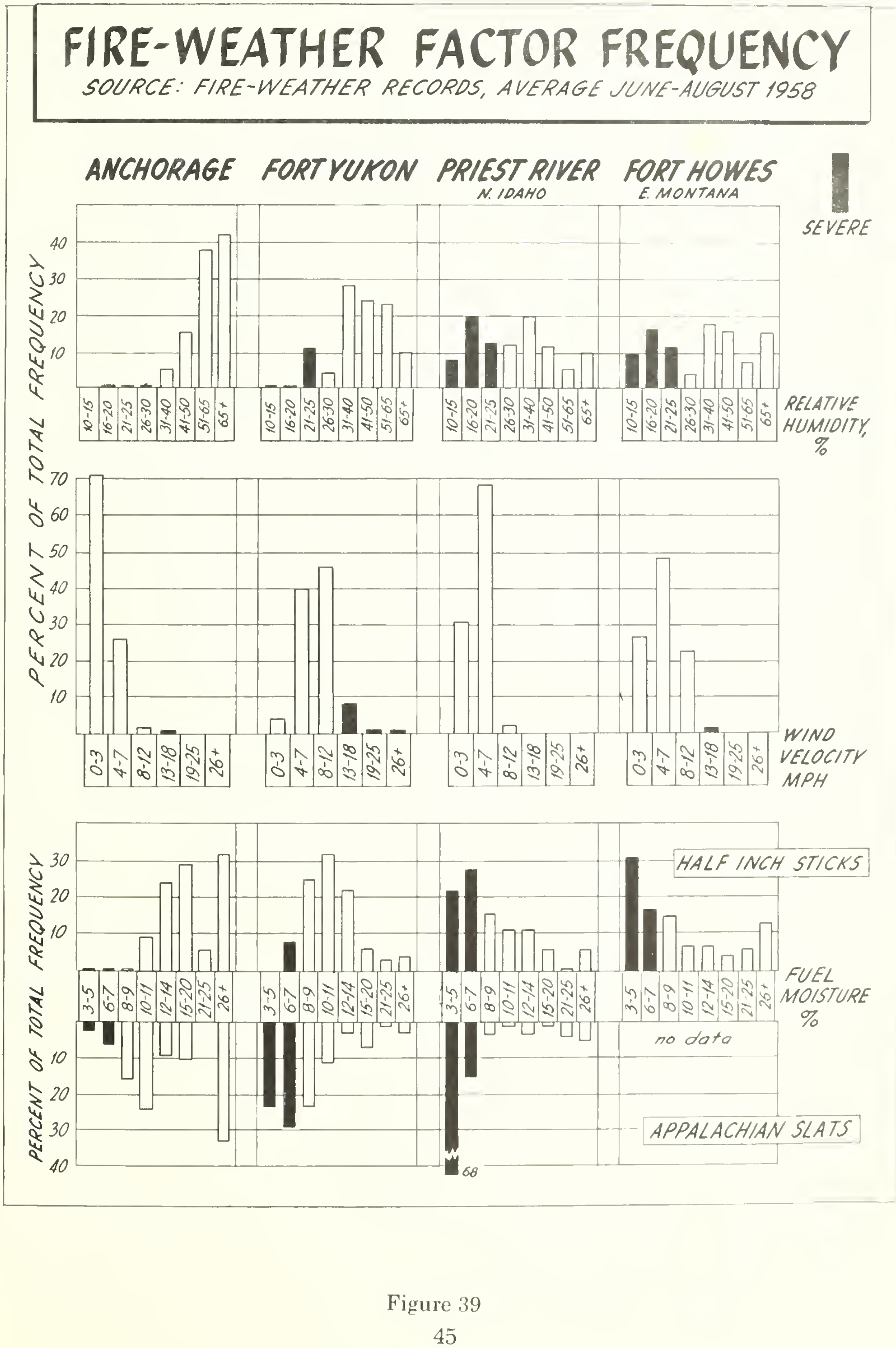

FIRE-WEATHER FACTOR FREQUENCY
SOURCE: FIRE-WEATHER RECORDS, AVERAGE JUNE-AUGUST 1958
ANCHORAGE
FORT YUKON
PRIEST RIVER
N. IDAHO
FORT HOWES
E. MONTANA
SEVERE
PERCENT OF TOTAL FREQUENCY
RELATIVE HUMIDITY, %
WIND VELOCITY MPH
HALF INCH STICKS
FUEL MOISTURE %
no data
APPALACHIAN SLATS
68

Figure 39

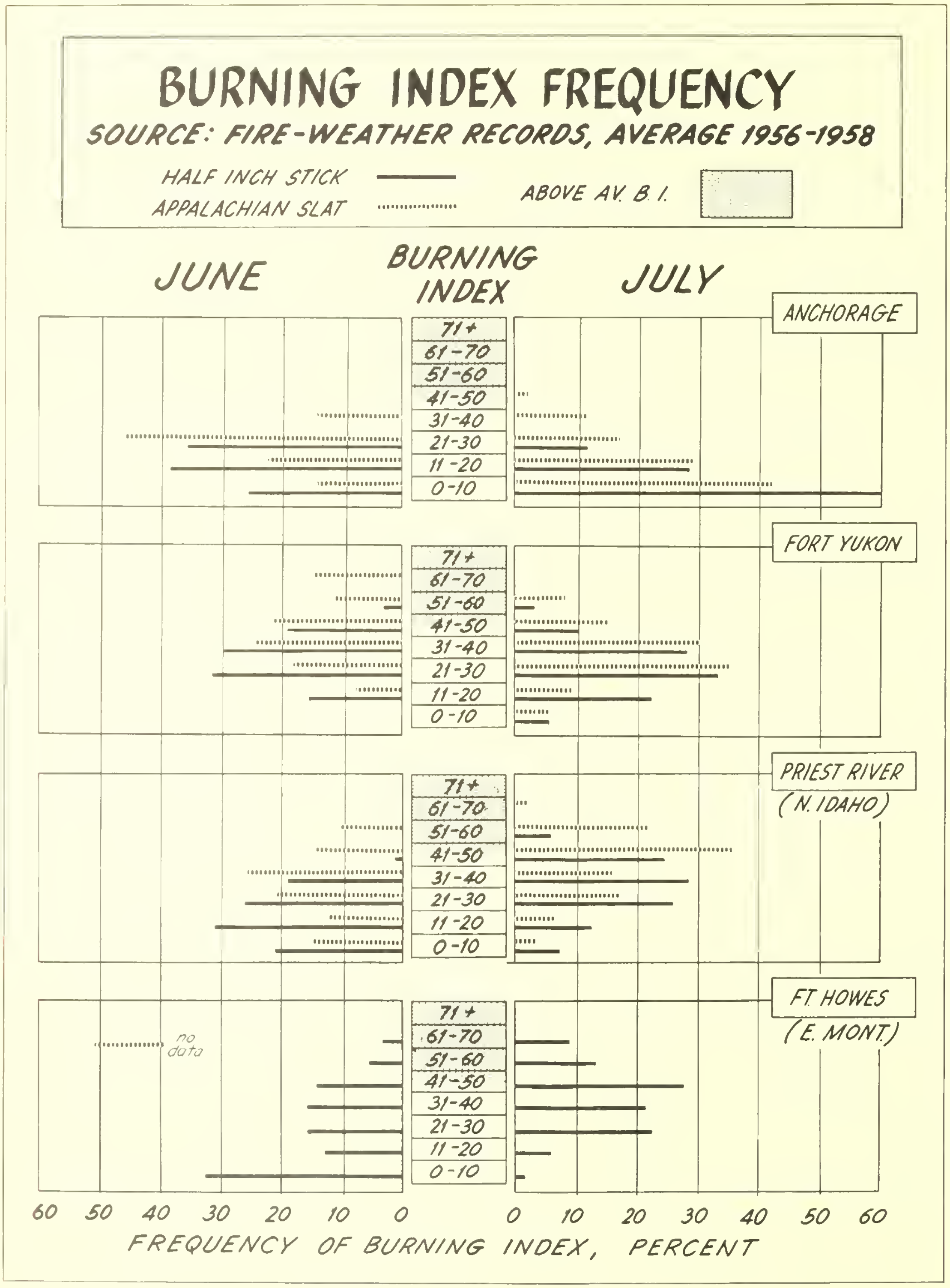

BURNING INDEX FREQUENCY
SOURCE: FIRE-WEATHER RECORDS, AVERAGE 1956-1958
HALF INCH STICK
APPALACHIAN SLAT
ABOVE AV. B. I.
JUNE
BURNING INDEX
JULY
ANCHORAGE
FORT YUKON
PRIEST RIVER (N. IDAHO)
FT HOWES (E. MONT.)
71+
61-70
51-60
41-50
31-40
21-30
11-20
0-10
no data
60 50 40 30 20 10 0
0 10 20 30 40 50 60
FREQUENCY OF BURNING INDEX, PERCENT

Figure 40

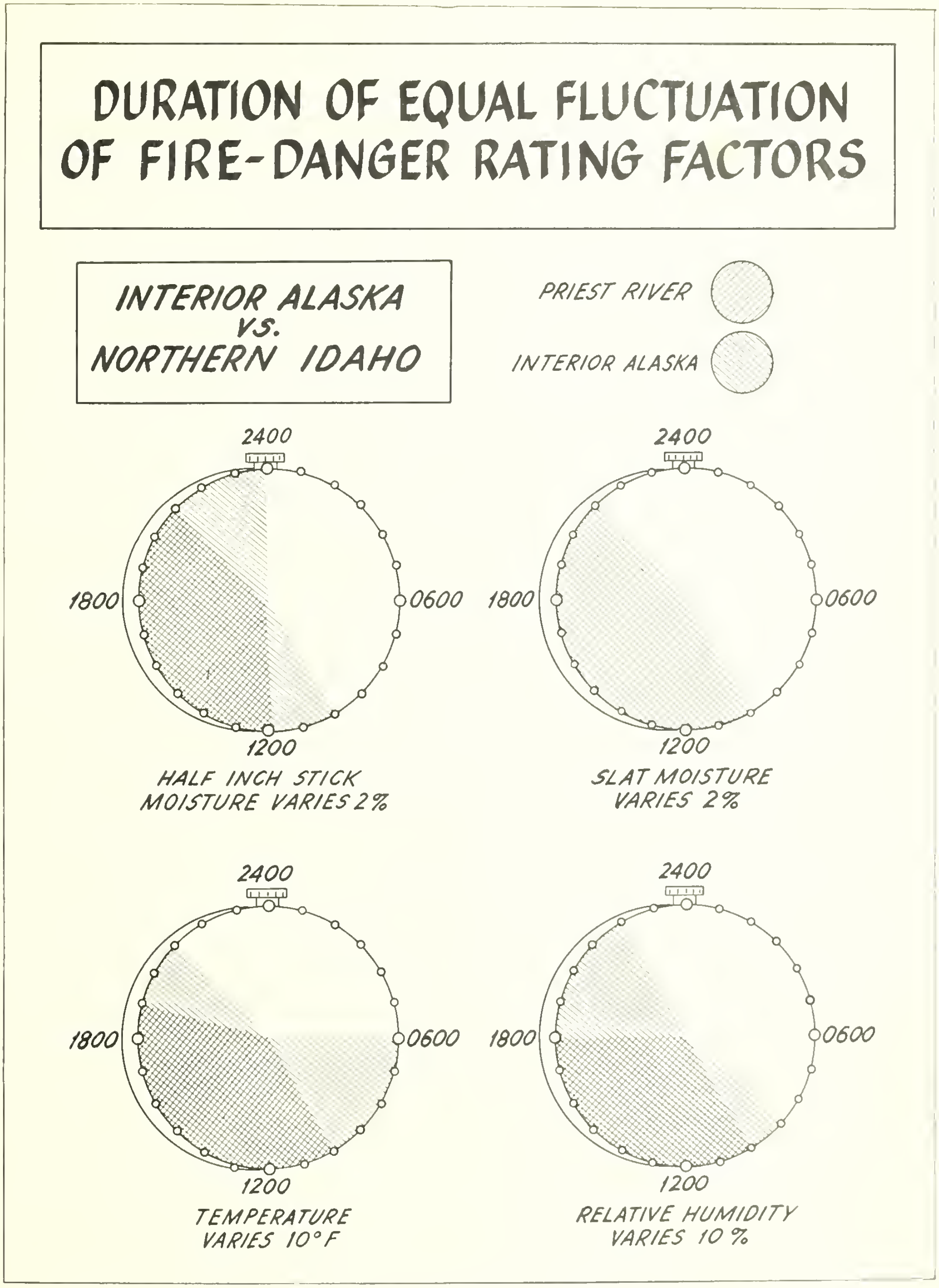

DURATION OF EQUAL FLUCTUATION OF FIRE-DANGER RATING FACTORS
INTERIOR ALASKA VS. NORTHERN IDAHO
PRIEST RIVER
INTERIOR ALASKA
2400
1800
0600
1200
HALF INCH STICK MOISTURE VARIES 2%
2400
1800
0600
1200
SLAT MOISTURE VARIES 2%
2400
1800
0600
1200
TEMPERATURE VARIES 10°F
2400
1800
0600
1200
RELATIVE HUMIDITY VARIES 10%

Figure 41

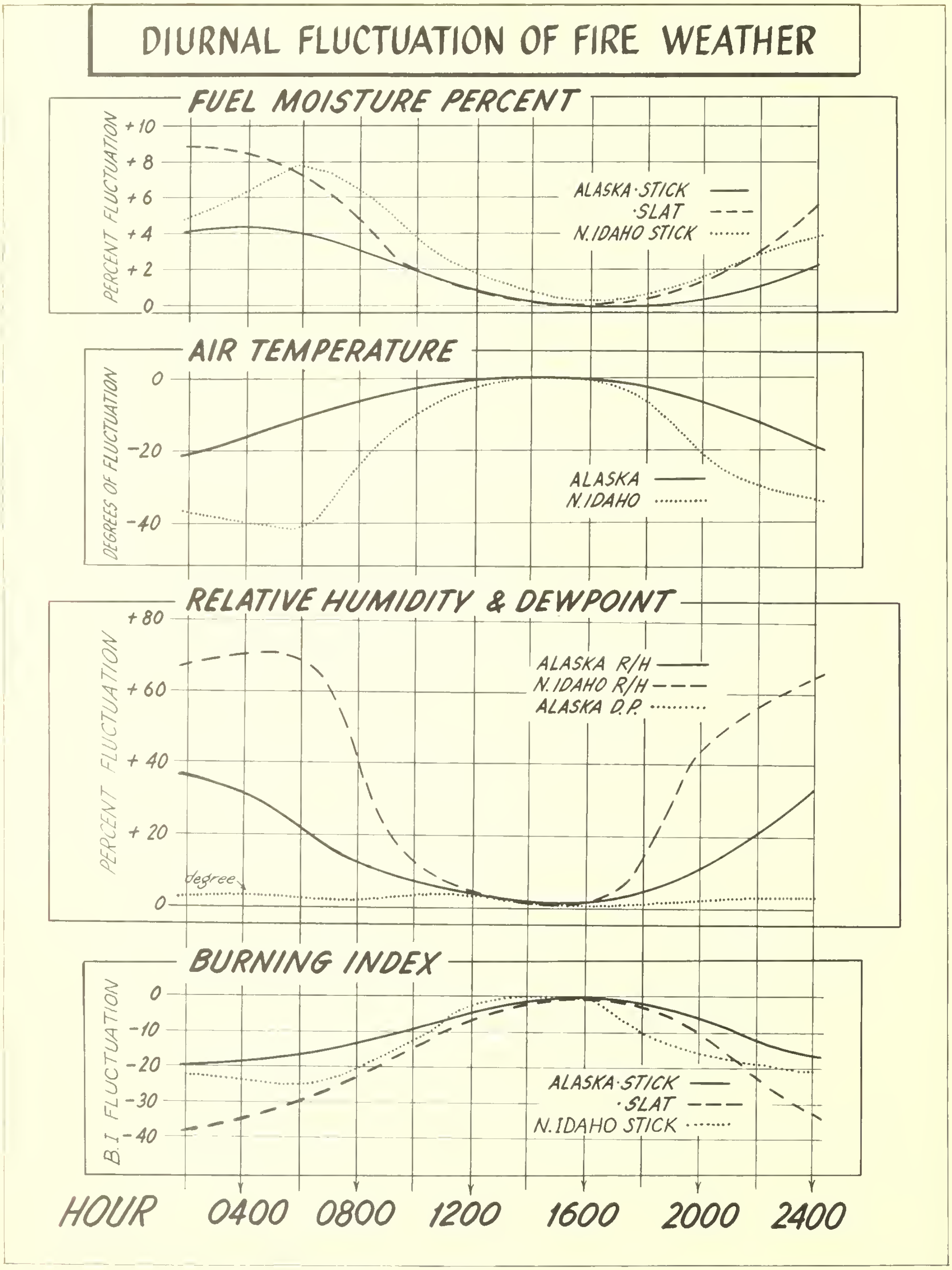

DIURNAL FLUCTUATION OF FIRE WEATHER
FUEL MOISTURE PERCENT
PERCENT FLUCTUATION
+10
+8
+6
+4
+2
0
ALASKA·STICK
·SLAT
N.IDAHO STICK
AIR TEMPERATURE
DEGREES OF FLUCTUATION
0
-20
-40
ALASKA
N.IDAHO
RELATIVE HUMIDITY & DEWPOINT
PERCENT FLUCTUATION
+80
+60
+40
+20
0
degree
ALASKA R/H
N.IDAHO R/H
ALASKA D.P.
BURNING INDEX
B.I. FLUCTUATION
0
-10
-20
-30
-40
ALASKA·STICK
·SLAT
N.IDAHO STICK
HOUR
0400
0800
1200
1600
2000
2400

Figure 42

CHAPTER 6
FIRE STATISTICS

HISTORICAL

Forest fires have burned in Interior Alaska for many centuries; their causes were the same as for fires over the rest of the North American continent both then and today — lightning and man. The forests themselves tell the history of the earliest fires; early explorers and other travelers continue the record until modern times.

Fires in the earliest times were doubtless caused by both lightning and Indians, with the greater percentage probably caused by the Indians. The extent of man-caused destruction spiraled upward with the discovery of gold in 1898 in the Klondike country. During single bad years, fires burned over several million acres. Railroad and highway construction led to some of the largest fires in the history of the State (Lutz 1959).

Ever since the gold rush days, an estimated annual average of 1 million acres has burned over in Interior Alaska. Scanning of early reports reveals that some of the worst fire years, prior to the beginning of methodical recordkeeping in 1940, were 1898, 1903, 1913, 1915, and 1923. The fact that apparent burned acreage has not been reduced in recent years can be attributed to better reporting and recording procedures. In earlier days many large burns were never seen, or at least never reported; so probably the burned area was much greater than suspected. Even in Sweden, where forests have been managed and protected for centuries, the number of fires reported annually increased from 400 to 1,100 during the recent 15-year period of 1944 to 1958 (Stromdahl 1959). The increased accuracy in fire reporting in Sweden may explain the apparent decrease of lightning fires from 50 percent to 10 percent of the total.

Ideas about the general cause of fires in Interior Alaska have gradually changed. Heintzleman (1936) stated, "Fires in Alaska are almost wholly man-caused (lightning being a negligible factor) . . . " Also, the Alaska Fire Control Service Annual Report for 1940 stated that there were no lightning-caused fires in Interior Alaska (Robinson 1960). Evidence now on hand shows that these statements were in error; they were made before there was any organized fire protection force or even reporting procedure. Fires that actually were started by lightning were attributed to trappers, miners, and natives. One-fourth of all fires between 1950 and 1958 were reported as lightning-caused, and they accounted for three-fourths of the total acreage burned.

COMPARATIVE STATISTICS

The available data on Alaska forest fires from 1950 through 1958 present a vivid picture of the Alaska fire problem, especially when they are compared with data on forest fires in the other States during the same period.[8] Tabulated data are given in the Appendix (tables 34 through 43) but the conclusions based on these data are presented in the pages immediately following. The Alaska fire problem can be best visualized and understood by direct comparison of pertinent data about separate but related phases of the problem.

INTERIOR ALASKA, WITH CONTINENTAL UNITED STATES

Area Protected

The Bureau of Land Management is responsible for protection of 93 percent of forest land in Alaska. In the other States, responsibility for protection is shared by many agencies and associations. All public domain land in the United States is protected by the Bureau of Land Management; 62 percent of this is in Alaska. This amounts to 27 percent of all land under organized fire protection in the entire United States (fig. 43).

Area Burned

Total area of forest land burned annually in Alaska averages about 1.1 million acres, while the total acreage burned annually on lands

[8] The information presented in this chapter and in chapter 8 is confined to the years 1950 through 1958 since data prior to that year are incomplete and less accurate. Even so, records of the last few years, especially 1957 and 1958, are considerably more reliable than those between 1950 and 1956. Tests of statistical significance for several of the tables indicated poor correlation; thus all tables based upon analysis of individual fire reports should be accepted chiefly for the general information they contain.

managed by all agencies in the other States is slightly more than 3 million. The area burned per fire in Alaska averages some 4,400 acres, whereas, on lands protected by all agencies in other States, the area burned averages only 30 acres per fire (fig. 43).

Number of Fires

The number of reported fires in Interior Alaska is only 1.1 per million acres protected, while for all protected land in the other States the number is 168 (fig 44). The low number of fires per unit area protected is in sharp contrast to the acreage burned per fire as noted in the preceding paragraph.

Severe and Light Fire Seasons

Number of fires.—In comparing numbers of fires between severe and light seasons, we note that each protection group faces comparable difficulties. In numbers of fires, Alaska shows a ratio of 3 fires in a heavy season to 1 in a light season, whereas in other States this ratio is about 2 to 1 (fig. 45). Also, at least for the period of record, both the severest and the lightest seasons in Alaska were not the same years as the severest and lightest seasons in other States.

Acreage burned.—The difference between acreage burned in severe and light years in Alaska is far greater than the difference in acreage burned in severe and light years in other States. The ratios are approximately 135 to 1 and 5 to 1, respectively. In Interior Alaska the greatest number of fires is 1.6 times normal and the area burned is 4.6 times normal, as opposed to 1.3 and 2.2 for all protected land in the other States (fig. 45). The data indicate that an overload of fires causes more destruction in Alaska than in the other States.

The area burned per fire is another indicator of the greater damage encountered in Interior Alaska than in other States when fire-weather conditions become critical. In Interior Alaska a fire may then become 3 times as large as in a normal year and 62 times as large as in an easy year. Suppression forces on protected land in other States have been fortunate in having sufficient strength to confine the ratio to 1.2 and 2.8, respectively (fig. 46). The percent of fires that exceeds Class B size — 10 acres — in worst, normal, and easy years does not vary greatly between areas (fig. 47); the great difference comes in the size of the fires that do exceed 10 acres, as noted above.

Number of Fires by Specific Cause

Lightning causes 24 percent of all fires in Alaska and 35 percent in the other States. A year-by-year record, however, indicates that the apparent ratio of lightning fires to others in Alaska is gradually increasing; this is probably a result of more accurate reporting procedures. Campfires cause 27 percent of all fires requiring suppression action in Alaska, but only 4 percent in other States. Also, in Alaska 21 percent of the wildland fires are caused by debris burning compared to 14 percent in the other States (fig. 48). This indicates the same type of activity in Alaska that occurred in Montana and northern Idaho in the late 1920's and early 1930's when considerable land was being cleared.

Number of Fires by Size Class

A greater percentage of fires is of Class A size (one-fourth acre or less) on Interior Alaska lands than on lands protected by the Bureau of Land Management in the other States — 42 percent compared to 19 percent, respectively. Both Alaska and other States show a larger percentage of Class E fires (larger than 300 acres) than Class D (100-300 acres). Records indicate that if a fire is not controlled by the time it reaches 300 acres in size, it may not be controlled until it reaches several hundred or even several thousand acres (fig. 49).

Number of Fires per Million Acres Protected

Fire occurrence per million acres protected in Interior Alaska is low compared to that in other States protected by BLM; an average of only 1 fire per million acres occurs annually on Alaskan land while nearly 5 fires per million acres occur on other BLM lands (fig. 50). This occurrence ratio contrasts strikingly to the average acreage burned per fire: 4,400 acres in Interior Alaska versus 267 acres on other BLM lands (fig. 46).

Area Burned According to Fuel Type

The rate-of-spread and resistance-to-control characteristics of fires in Interior Alaskan vegetation is described in reference to cover types instead of fuel types, as explained in chapter 4.

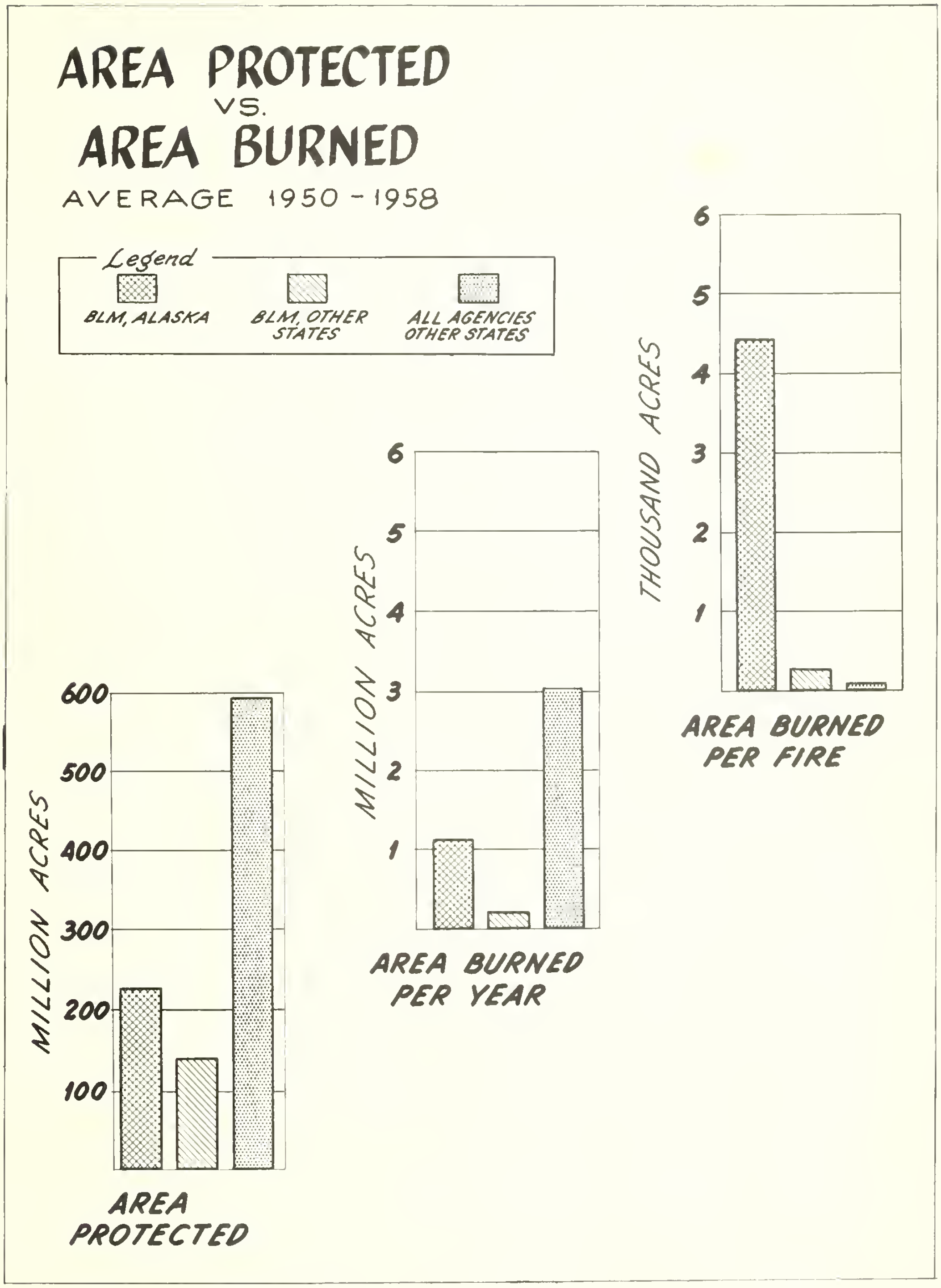

AREA PROTECTED
VS.
AREA BURNED
AVERAGE 1950 - 1958
Legend
BLM, ALASKA
BLM, OTHER STATES
ALL AGENCIES OTHER STATES
MILLION ACRES
600
500
400
300
200
100
AREA PROTECTED
MILLION ACRES
6
5
4
3
2
1
AREA BURNED PER YEAR
THOUSAND ACRES
6
5
4
3
2
1
AREA BURNED PER FIRE

Figure 43

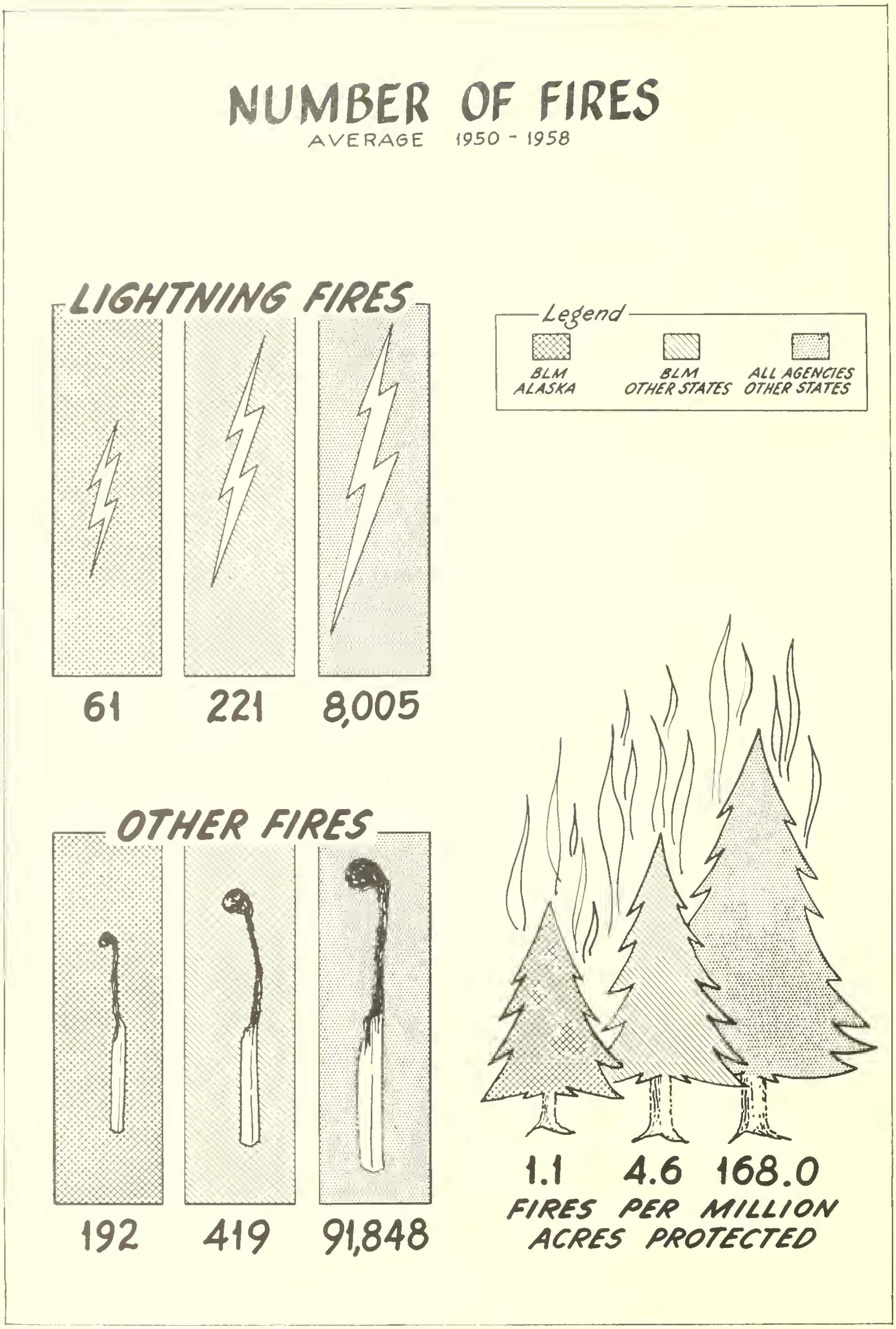

NUMBER OF FIRES
AVERAGE 1950 - 1958
LIGHTNING FIRES
Legend
BLM ALASKA
BLM OTHER STATES
ALL AGENCIES OTHER STATES
61
221
8,005
OTHER FIRES
192
419
91,848
1.1
4.6
168.0
FIRES PER MILLION ACRES PROTECTED

Figure 44

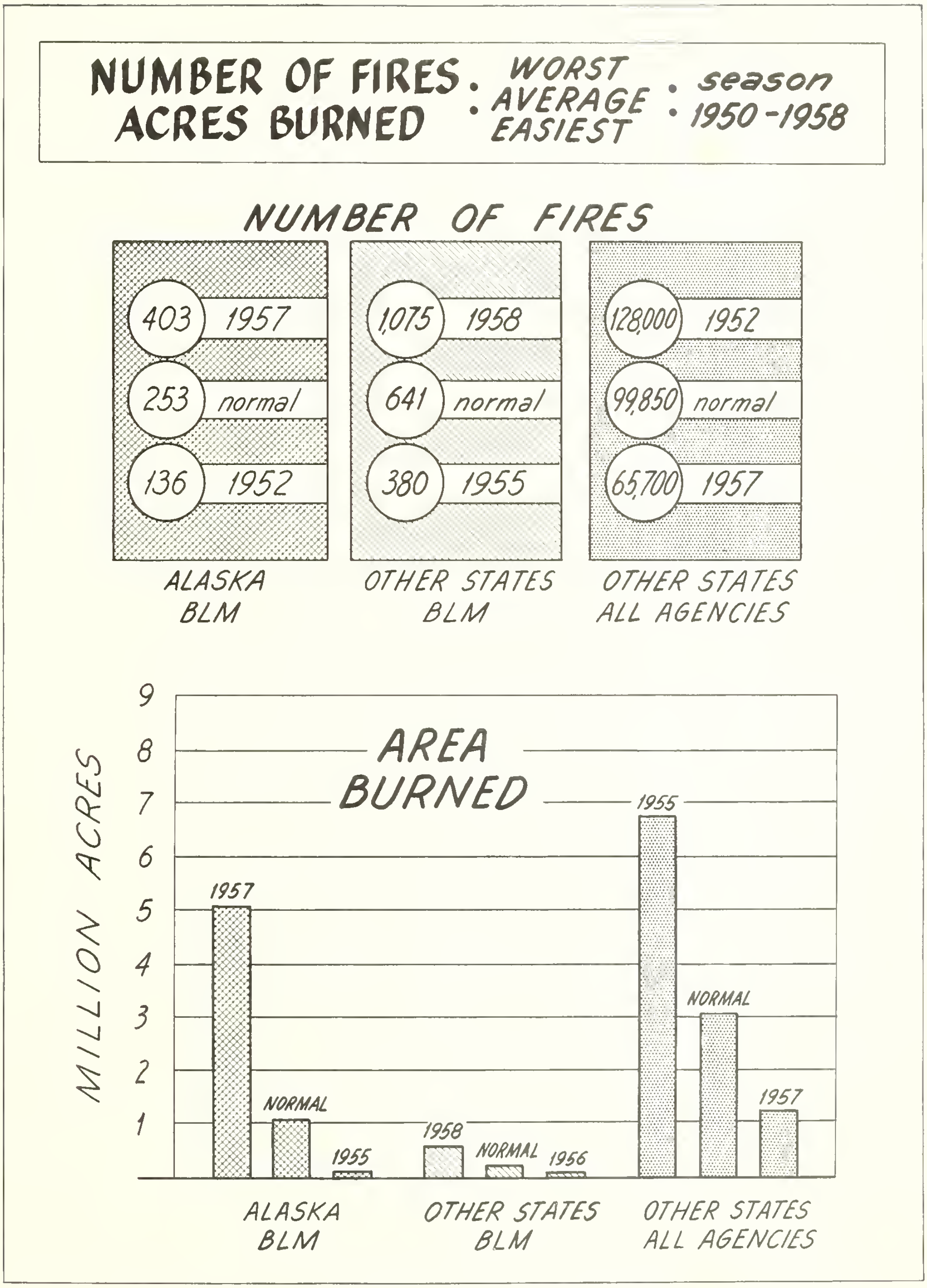

NUMBER OF FIRES . WORST
ACRES BURNED . AVERAGE
EASIEST
. season
. 1950-1958
NUMBER OF FIRES
403 1957
253 normal
136 1952
1,075 1958
641 normal
380 1955
128,000 1952
99,850 normal
65,700 1957
ALASKA BLM
OTHER STATES BLM
OTHER STATES ALL AGENCIES
AREA BURNED
MILLION ACRES
9
8
7
6
5
4
3
2
1
1957
NORMAL
1955
1958
NORMAL
1956
1955
NORMAL
1957
ALASKA BLM
OTHER STATES BLM
OTHER STATES ALL AGENCIES

Figure 45

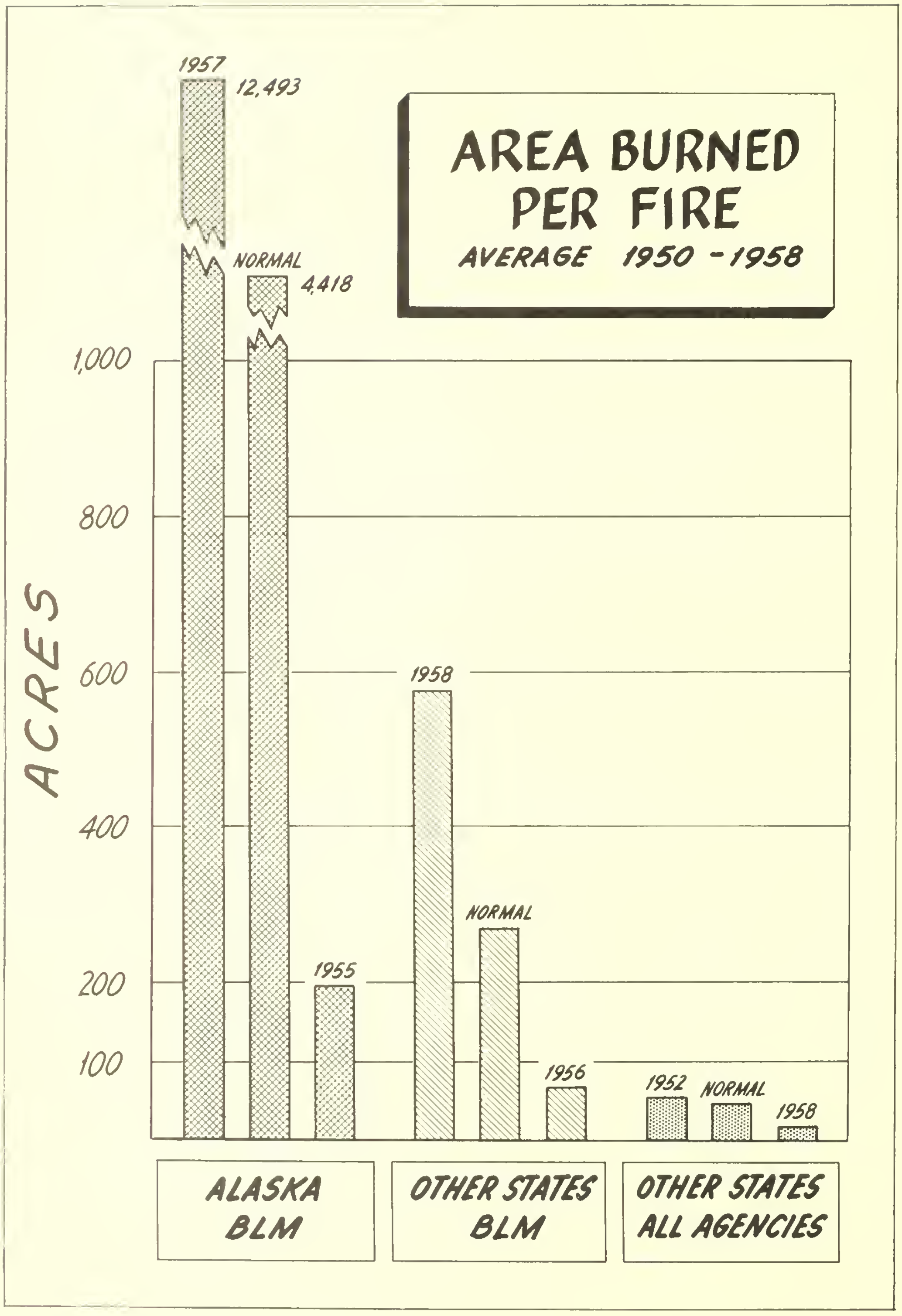

AREA BURNED
PER FIRE
AVERAGE 1950 - 1958
ACRES
1,000
800
600
400
200
100
1957
12,493
NORMAL
4,418
1955
1958
NORMAL
1956
1952
NORMAL
1958
ALASKA
BLM
OTHER STATES
BLM
OTHER STATES
ALL AGENCIES

Figure 46

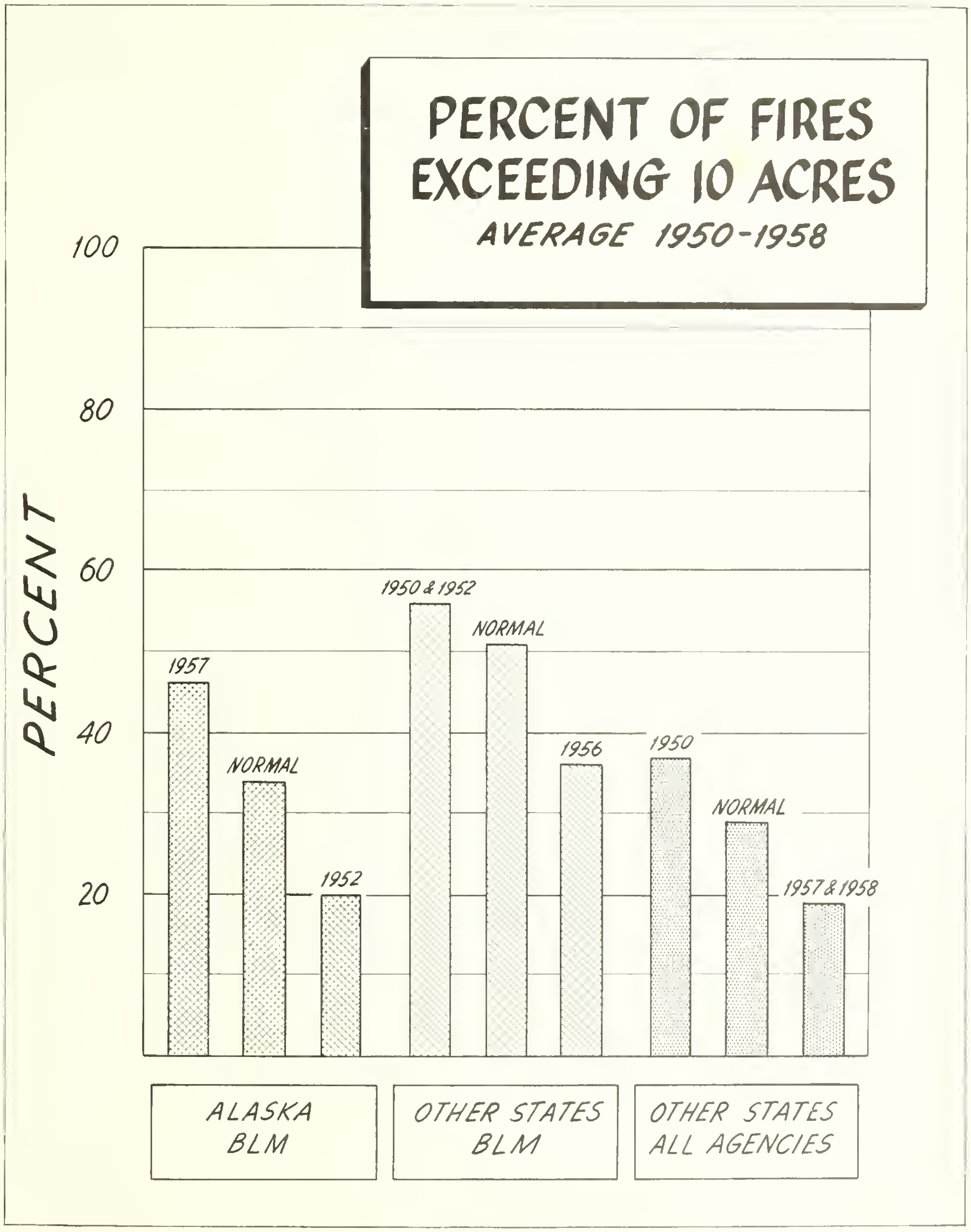

PERCENT OF FIRES
EXCEEDING 10 ACRES
AVERAGE 1950-1958
PERCENT
100
80
60
40
20
1957
NORMAL
1952
1950 & 1952
NORMAL
1956
1950
NORMAL
1957 & 1958
ALASKA
BLM
OTHER STATES
BLM
OTHER STATES
ALL AGENCIES

Figure 47

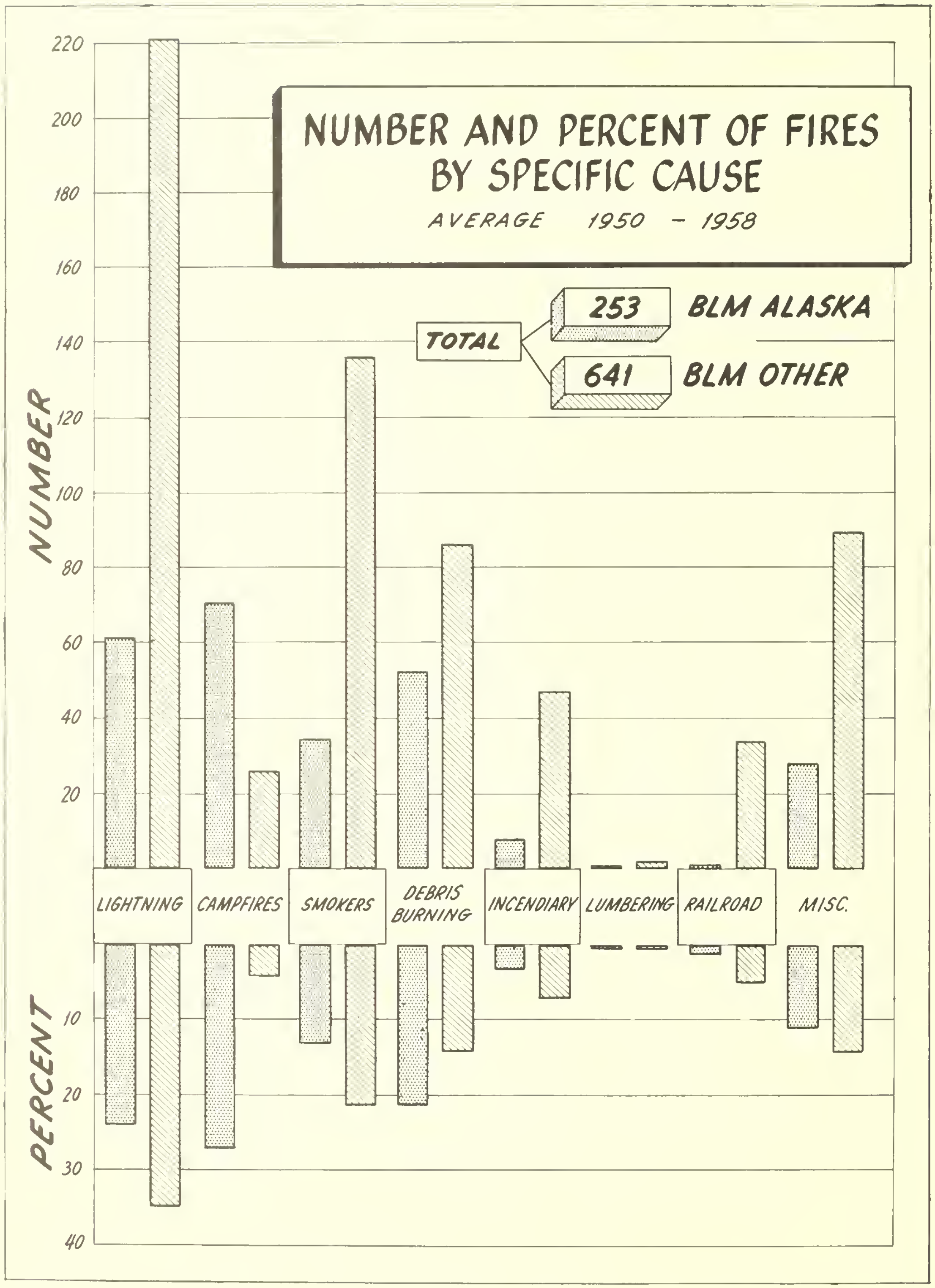

NUMBER AND PERCENT OF FIRES BY SPECIFIC CAUSE
AVERAGE 1950 - 1958
TOTAL
253 BLM ALASKA
641 BLM OTHER
NUMBER
PERCENT
220
200
180
160
140
120
100
80
60
40
20
10
20
30
40
LIGHTNING
CAMPFIRES
SMOKERS
DEBRIS BURNING
INCENDIARY
LUMBERING
RAILROAD
MISC.

Figure 48

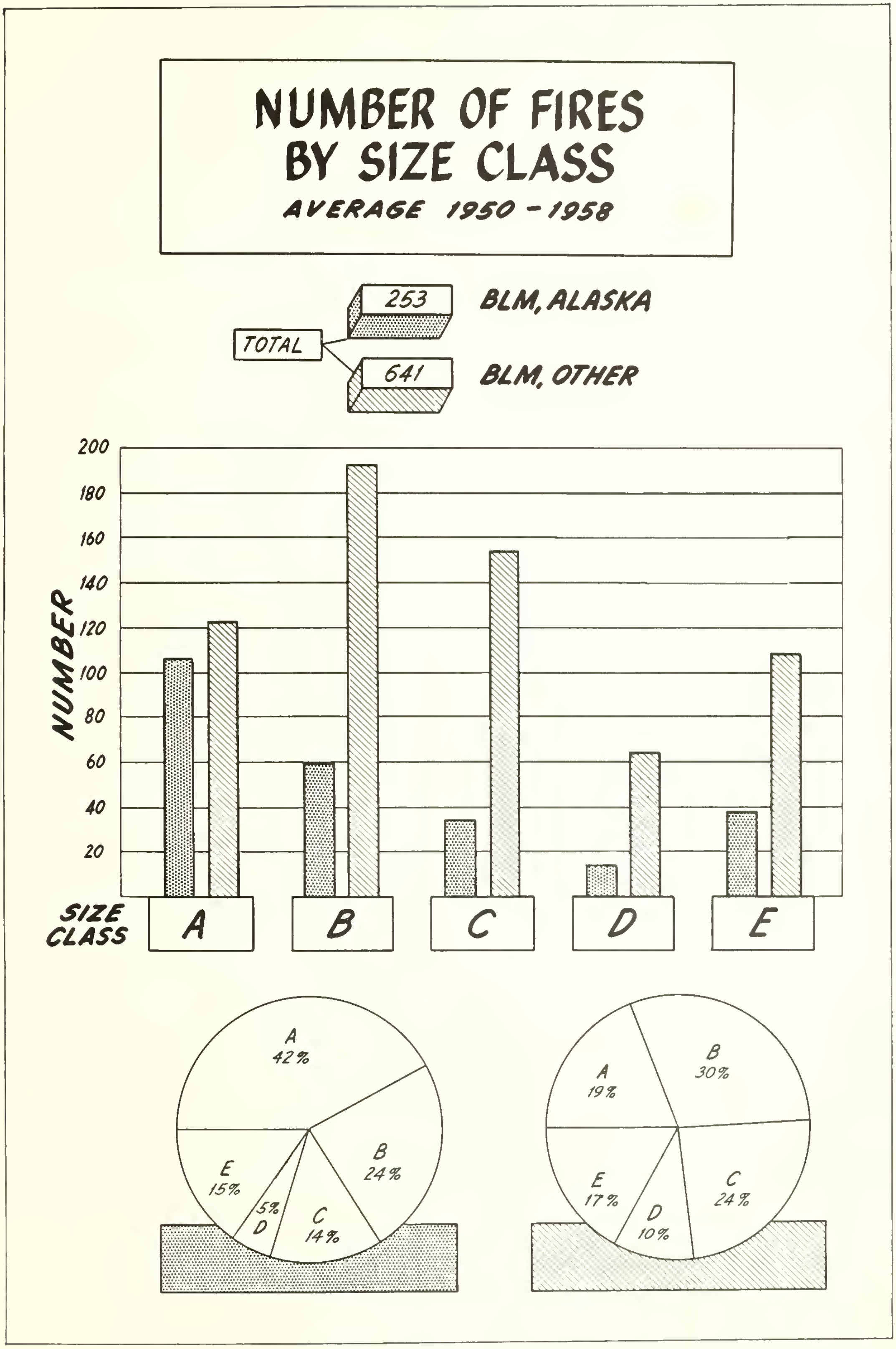
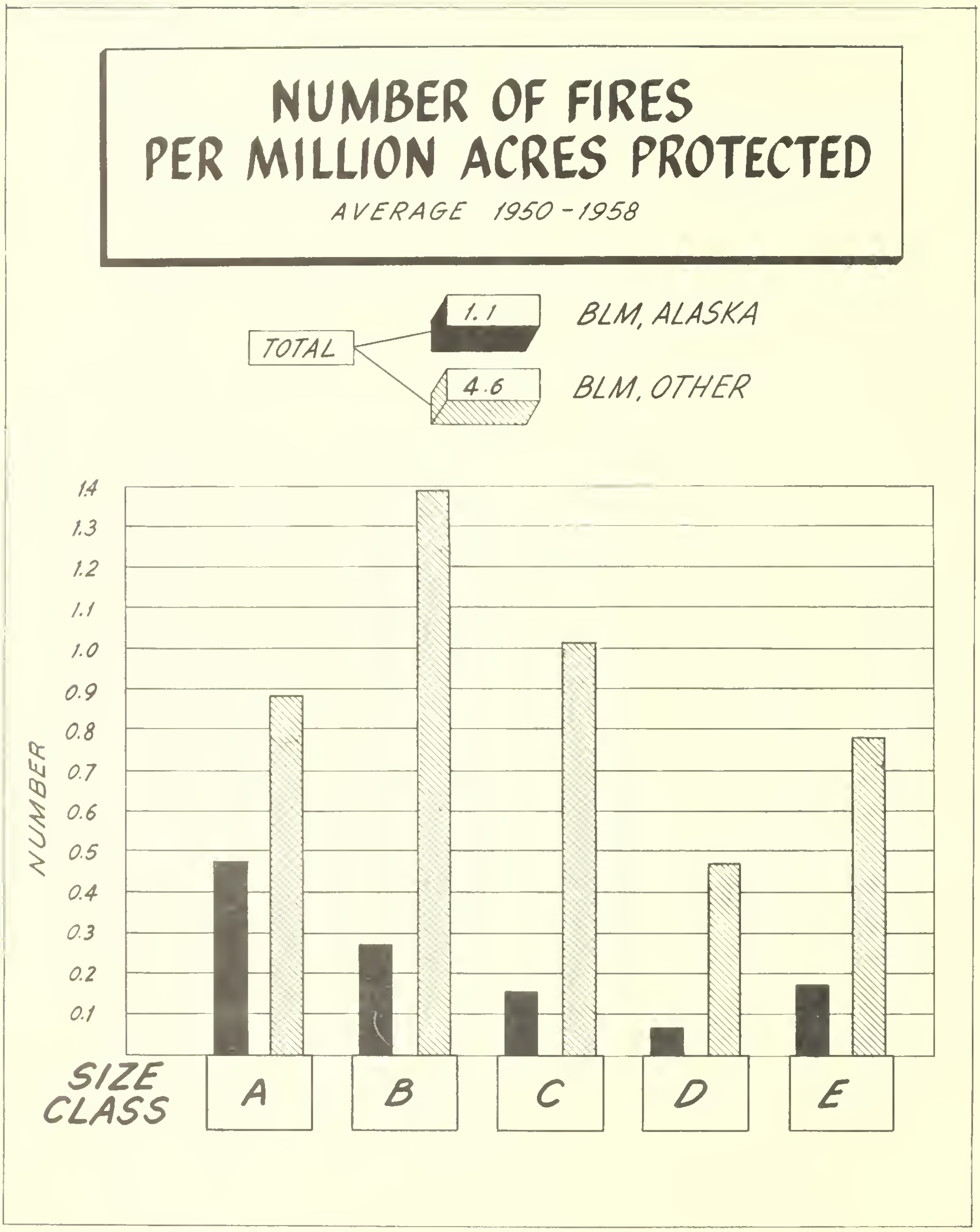

NUMBER OF FIRES
BY SIZE CLASS
AVERAGE 1950 - 1958
253
BLM, ALASKA
TOTAL
641
BLM, OTHER
200
180
160
140
120
100
80
60
40
20
NUMBER
SIZE CLASS
A
B
C
D
E
A 42%
B 24%
C 14%
5% D
E 15%
A 19%
B 30%
C 24%
D 10%
E 17%

Figure 49



NUMBER OF FIRES
PER MILLION ACRES PROTECTED
AVERAGE 1950-1958
TOTAL
1.1
BLM, ALASKA
4.6
BLM, OTHER
NUMBER
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
SIZE CLASS
A
B
C
D
E

Figure 50

The cover types in Alaska do not correspond to those in continental United States; therefore, no valid comparison of area burned can be made without modifying some terminology. In continental United States rate of spread is greatest in grass fuels. A large share of the lands protected by the Bureau of Land Management in continental United States is covered with grass; the next largest acreage is brushland. In Interior Alaska, grassland comprises a small percent of the total acreage; much of that is on the Kenai peninsula where lightning incidence is very low, accessibility is relatively good, and fire danger seldom becomes critical.

Tundra and related fuels are not included on fire reports; fires in tundra are arbitrarily classed in the "Other" fuel type category. Rate of spread in this complex is as great as, if not greater than, rate of spread in the grass type. The information in figure 51 would be more realistic if most of the BLM Alaska acreage that is now listed in "Other" fuels were placed in the "Grass" category.

Seventy-four percent of the acreage burned in Interior Alaska is in forest or tundralike fuels. Eighty-eight percent of the acreage burned on other BLM protected lands is in brush and grass fuels. Forty percent of the acreage burned in Interior Alaska is in forest fuels, compared with only 7 percent on other BLM protected land. A relatively greater strength-of-attack force is needed for controlling fires in forested land.

INTERIOR ALASKA, WITH SOUTHEASTERN ALASKA

Up to this point all of the statistics have referred only to Interior Alaska. The differences in weather factors and fire loads between the two sections of the State make this understandable. The brief tabulation below compares the precipitation patterns of Interior Alaska with those of southeastern Alaska; it reveals two entirely different climatic situations. Interior Alaska has been termed "the green desert," but southeastern Alaska approaches a rain forest condition.

Interior stations	Normal annual precipitation	Southeastern stations	Normal annual precipitation
	Inches		Inches
Fort Yukon	6.54	Seward	68.08
Fairbanks	11.92	Juneau	90.25
Anchorage	14.27	Sitka	96.33
Bethel	18.17	Ketchikan	151.93

Past fire records place nearly all the Alaska fire incidence and burned area within the Interior (table 14).

Abundance of precipitation in the southeast accounts for the heavy stands of Sitka spruce and western hemlock timber. Much of it is overmature: this indicates relative freedom from fire. But many stands in southeastern Alaska do show evidence of fire in their age and species composition.

Fire potential in the southeast increases as timber is cut. Large volumes of logging slash accumulate and expose the ground surface to insolation and rapid drying; this encourages growth of flammable grass and annual weeds. The number of people in and near the woods also increases as utilization increases.

The most urgent task is to reduce the annual burned area in Interior Alaska from the present 1,119,130 acres. However, the fire potential in the southeastern section must be realized; collection of certain elements of background information there will be of value to any fire research program that may ultimately be established.

WITHIN INTERIOR ALASKA

Lightning and Man-Caused Fires

Only 24 percent of all forest fires in Alaska are lightning caused, while 76 percent of the acreage burned is due to lightning fires (fig. 52). Inadequate storm detection and difficult accessibility contribute to the high area-to-incidence ratio. Probably the greatest fire control challenge is to reduce the acreage of lightning fires to approach the incidence percentage. Early detection and fast attack facilities will help bring the acreage burned into line with the number of fires.

Fires on Which No Suppression Action Was Taken

Several interesting but often confusing statistics result from comparing the group of fires on which suppression action was taken with the group that burned completely unrestricted. Already mentioned is the fact that control action cannot be taken on some fires because: (1) they are physically inaccessible; (2) they are so large when discovered that no reasonable force of men could stop them (economically inaccessible); (3) limited manpower makes it imperative to

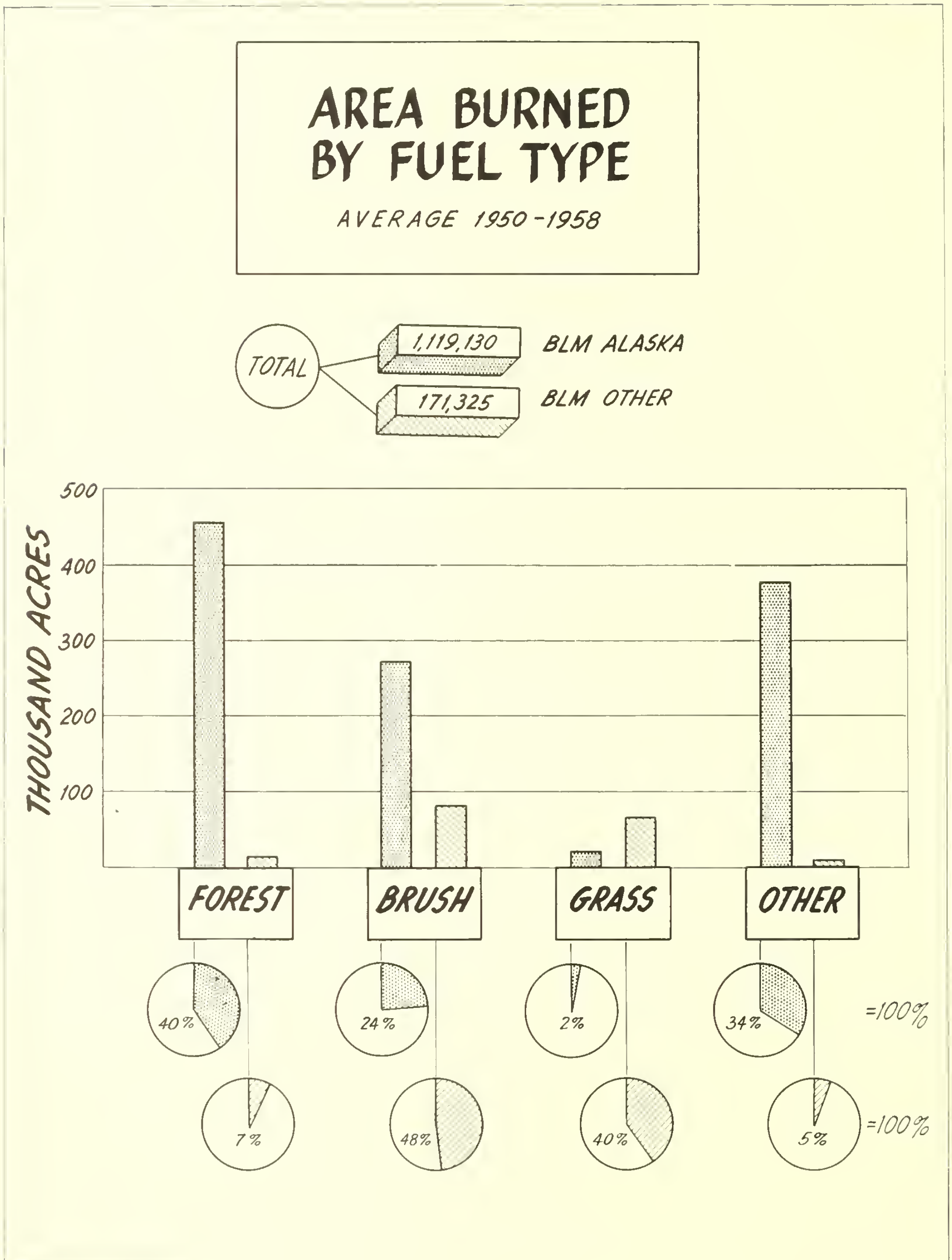
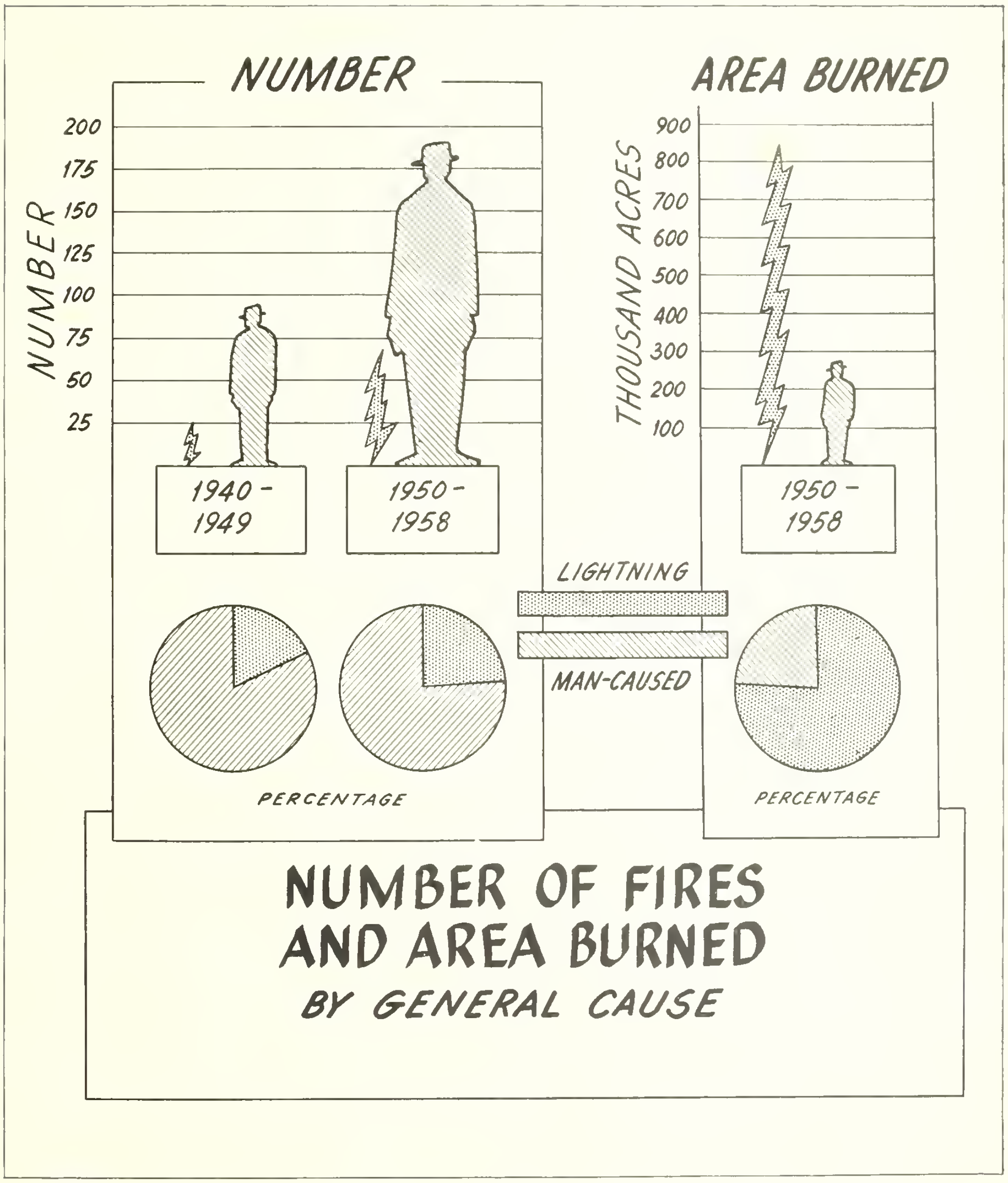

AREA BURNED
BY FUEL TYPE
AVERAGE 1950-1958
TOTAL
1,119,130
BLM ALASKA
171,325
BLM OTHER
THOUSAND ACRES
500
400
300
200
100
FOREST
BRUSH
GRASS
OTHER
40%
24%
2%
34%
=100%
7%
48%
40%
5%
=100%

Figure 51



NUMBER
AREA BURNED
NUMBER
200
175
150
125
100
75
50
25
THOUSAND ACRES
900
800
700
600
500
400
300
200
100
1940 - 1949
1950 - 1958
1950 - 1958
LIGHTNING
MAN-CAUSED
PERCENTAGE
PERCENTAGE
NUMBER OF FIRES AND AREA BURNED
BY GENERAL CAUSE

Figure 52

Table 14.—**Fire statistics, Interior versus Southeastern Alaska**

	Lightning				Man-caused				Total			
	Interior		Southeast		Interior		Southeast		Interior		Southeast	
	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
1940-49	200	no data	1	0+	938	no data	292	1,649	1,138	12,411,076	293	1,649
1950-58	546	7,665,726	3	1	1,734	2,406,442	234	5,738	2,280	10,072,168	237	5,739
1950-58 Av.	61	851,747	0.3	0+	193	267,382	26	638	253	1,119,130	26	638

Source: Southeast: National Forest Fire Reports, USDA, Forest Service.
Interior: Annual Reports of the Director (Statistical Appendix).

choose between fires when many start during a short period; and (4) under a general smoke pall some fires burn without being detected.

Thirty-three percent of all lightning fires are never attacked, while only 9 percent of man-caused fires are not; however, the actual number of no-action fires per year is about the same for both general causes. This 9 percent accounts for 68 percent of the area burned by man-caused fires.

A lightning fire usually is 10 times the size of a man-caused fire; but an average *no-action* lightning fire is only 1½ times the size of a *no-action* man-caused fire. Many lightning fires are held down in early stages by such elements of moderate weather as clouds, high humidity, and precipitation; this is not often true for man-caused fires. Table 15 and figure 53 contain the specific information for the above discussion.

Why an average no-action lightning fire is only slightly larger than an action lightning fire can lead to many conjectures. A partial explanation can be: (1) the more potentially dangerous fires are attacked first; (2) action not taken because known barriers may restrict the fires to small size; and (3) initial attack on some action fires occurs after they have become too large to control; they are subsequently abandoned — hence, large acreages appear on the action fire side of the ledger that otherwise would have been charged against no-action fires. The percentage of lightning fires upon which no action was taken has been materially reduced since 1956.

Table 15.—**Fires receiving suppression action**

Type of fire	Action status	Number	Total area burned		Average area per fire	
			Acres	Percent	Acres	Ratio
Lightning	No action	20	303,214		15,161	
	Action	41	549,574		13,404	
	Total	61	852,788	76	13,980	10
Man-caused	No action	17	181,514		10,677	
	Action	176	84,828		482	
	Total	193	266,342	24	1,380	1
Total		254	1,119,130		4,406	

Monthly Variation in Fire Frequency and Size

Lightning fires.—Virtually no lightning fires occur before mid-May or after the end of August. Eighty-eight percent of all lightning fires start during June and July. Class D fires are a very small percentage of the total number of lightning fires in any one month, but the number of Class E fires is consistently greater than that for any other class (fig. 54).

Man-caused fires.—The frequency pattern for man-caused fires deviates considerably from that of the lightning fire (fig. 54). For nearly all

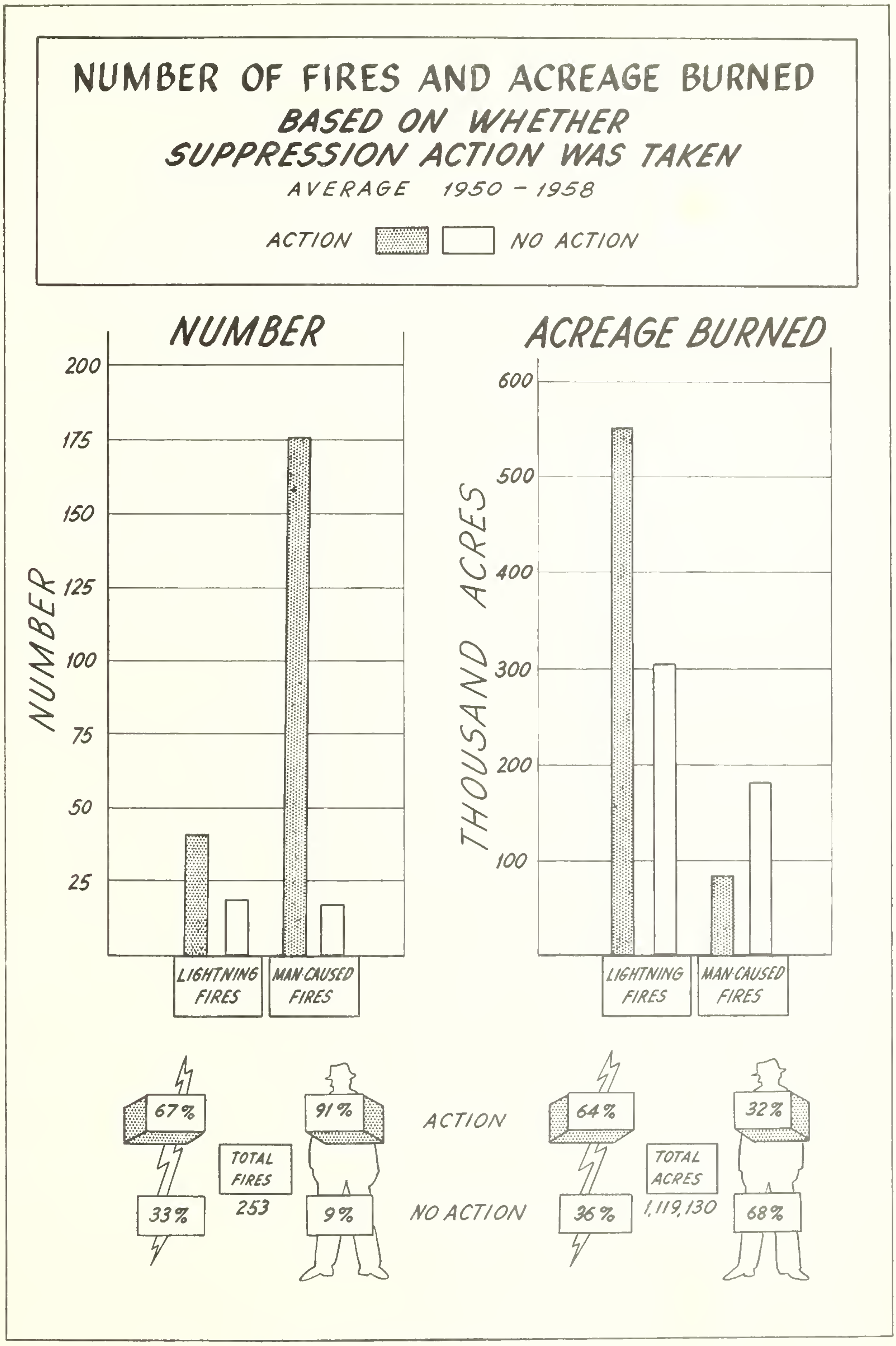

NUMBER OF FIRES AND ACREAGE BURNED
BASED ON WHETHER
SUPPRESSION ACTION WAS TAKEN
AVERAGE 1950 - 1958
ACTION
NO ACTION
NUMBER
ACREAGE BURNED
NUMBER
THOUSAND ACRES
LIGHTNING FIRES
MAN-CAUSED FIRES
LIGHTNING FIRES
MAN-CAUSED FIRES
67%
33%
91%
9%
TOTAL FIRES 253
64%
36%
32%
68%
TOTAL ACRES 1,119,130
ACTION
NO ACTION

Figure 53

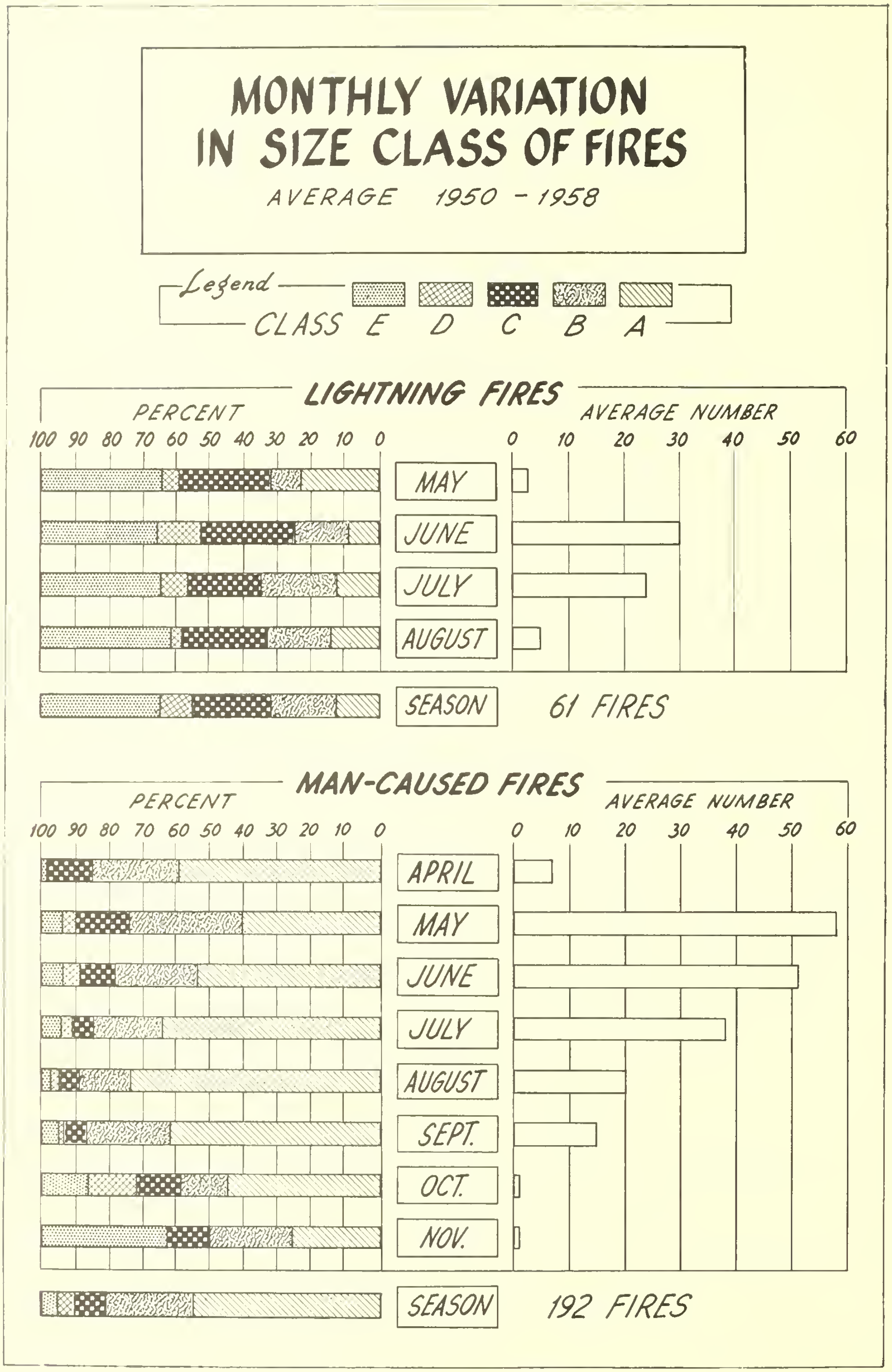

MONTHLY VARIATION IN SIZE CLASS OF FIRES
AVERAGE 1950 - 1958
Legend
CLASS E D C B A
LIGHTNING FIRES
PERCENT
100 90 80 70 60 50 40 30 20 10 0
AVERAGE NUMBER
0 10 20 30 40 50 60
MAY
JUNE
JULY
AUGUST
SEASON
61 FIRES
MAN-CAUSED FIRES
PERCENT
100 90 80 70 60 50 40 30 20 10 0
AVERAGE NUMBER
0 10 20 30 40 50 60
APRIL
MAY
JUNE
JULY
AUGUST
SEPT.
OCT.
NOV.
SEASON
192 FIRES

Figure 54

of the season the greatest percentage of the fires caused by man is Class A. Fifty-seven percent of the fires occur in May and June — a month earlier than for lightning fires; land-clearing operations are a major reason for this early peakload. Only a few fires occur in October and November, but a larger percentage of them reaches Class E size because the entire detection and control force has been drastically reduced by this time.

Acreage burned.—The record of actual acreage burned in each month (fig. 55) shows clearly that the small number of Class E fires during May, June, and July accounts for most of the total amount. Seventy-three percent of all acreage burned by lightning fires occurs in June. Seventy percent of all acreage burned by man-caused fires occurs in May. Lightning fires continue to burn much larger acreages in July than do man-caused fires; in fact, July lightning fires burn almost the same acreage as man-caused fires do in May.

Yearly Variation in Fire Frequency and Size

For the 9-season period studied, the generalization could be made that as the total number of fires increased, the number of Class E fires also increased, and the number of Class A fires decreased. This relationship is partly due to overloading of the fire control organization and partly due to many fires reaching such large size that no effective suppression action could be taken. The percentage of the Class B, C, and D fires does not vary greatly from year to year; the main difference in percentage is between Class A and Class E fires (fig. 56). The area-burned-per-fire record for 1957 — the worst year — and 1955 — the easiest year (fig. 46) — falls within this number-size class relationship.

Distribution of Fires

Fire control strategy cannot be planned properly without first knowing where and when fires are most likely to occur. Bases must be established and personnel deployed and shifted according to this knowledge. Data from the analysis of fires from 1950 through 1958 were insufficient to make detailed occurrence isograms for individual years or for separate size classes; however, figures 57 and 58 show the number of man-caused fires and lightning fires per million acres for this period.

Most man-caused fires burn near population centers and along the primary highways connecting these principal cities (fig. 57). Exceptions to this general rule are such towns as Tanana and Fort Yukon. No roads go near these towns, but in Alaska they are still centers of population or distribution points.

Distribution of lightning fires (fig. 58) appears somewhat similar to that for man-caused fires in respect to their apparent concentrations near the larger towns and along the primary highways—particularly around Fairbanks, Tanacross, and the connecting road. Other apparent centers of lightning fire frequency are near Kotzebue, Galena, McGrath, and between Eagle and Central along the Canadian border. The scatter of fires was so great that this table at best could show only an approximation.

If complete detection coverage were possible, the lightning fire isogram might appear considerably different. Over the past many years, detection and reporting have been almost entirely by such volunteers as airplane pilots, travelers, local residents, and miners. We now know that many lightning fires occur in areas for which the isogram indicates a low frequency. Some of these fires burn large areas, and some may combine with other fires and appear as only one for reporting purposes. Others burn and die out without being reported. Many fires do not spread beyond a very small size, and their existence is never known. Better detection and better reporting methods will no doubt change the pattern of the lightning fire isogram during the next few years. More information pertaining to fire distribution according to size class and distance from headquarters appears in chapter 8.

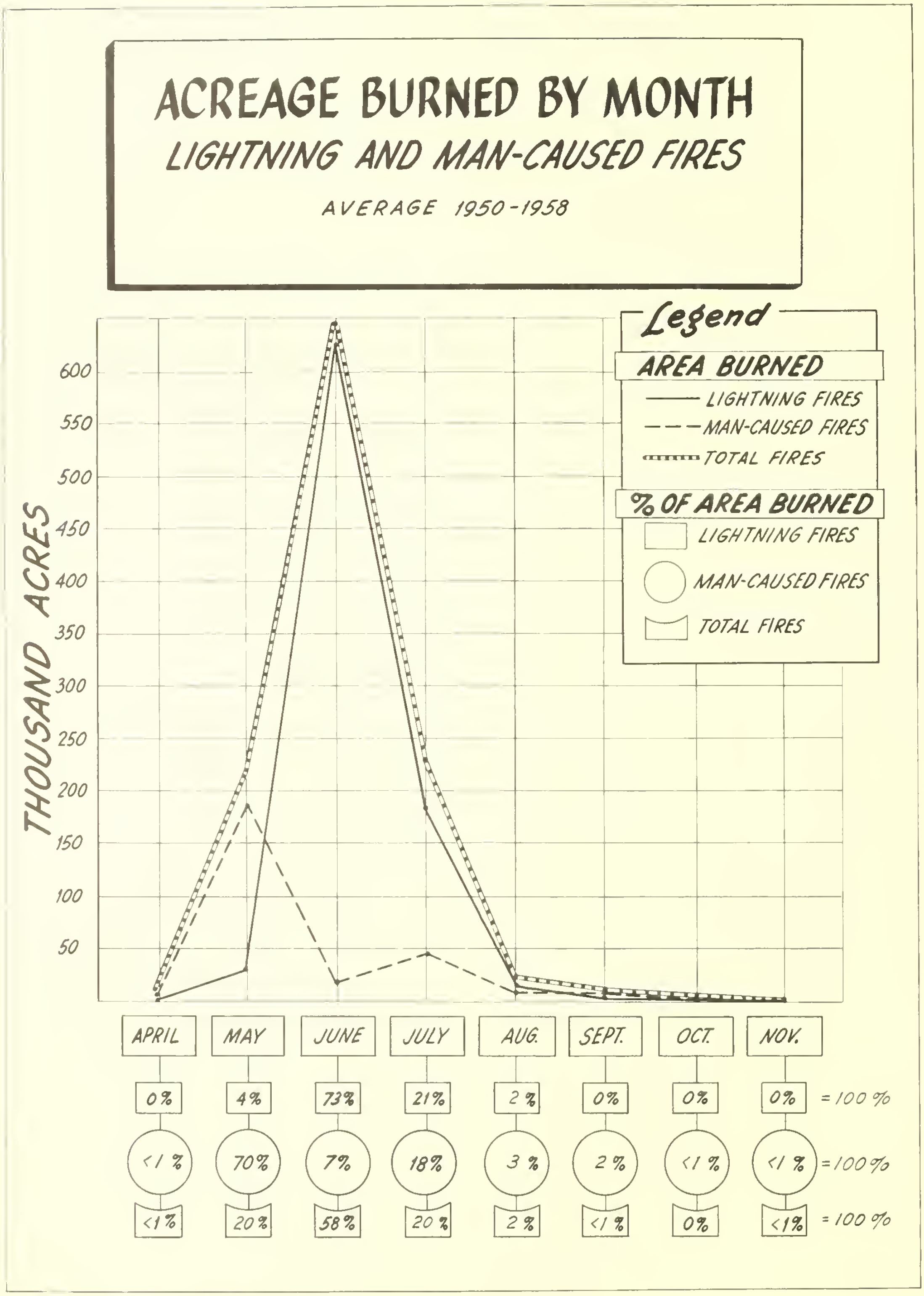

ACREAGE BURNED BY MONTH
LIGHTNING AND MAN-CAUSED FIRES
AVERAGE 1950-1958
Legend
AREA BURNED
LIGHTNING FIRES
MAN-CAUSED FIRES
TOTAL FIRES
% OF AREA BURNED
LIGHTNING FIRES
MAN-CAUSED FIRES
TOTAL FIRES
THOUSAND ACRES
600
550
500
450
400
350
300
250
200
150
100
50
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
0%
4%
73%
21%
2%
0%
0%
0%
= 100 %
<1 %
70%
7%
18%
3 %
2 %
<1 %
<1 %
= 100 %
<1%
20%
58%
20%
2%
<1%
0%
<1%
= 100 %

Figure 55

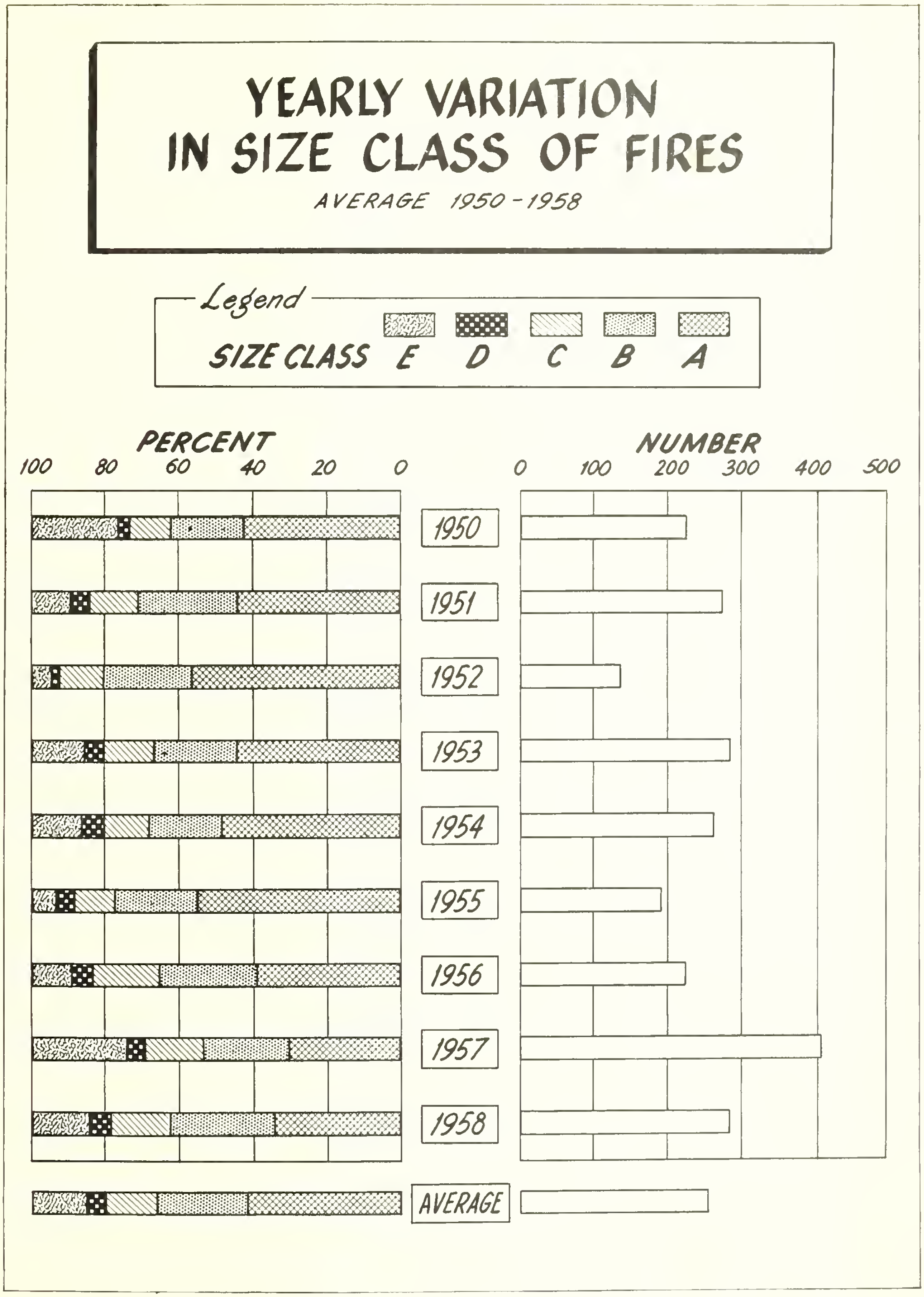

YEARLY VARIATION
IN SIZE CLASS OF FIRES
AVERAGE 1950-1958
Legend
SIZE CLASS E D C B A
PERCENT
100 80 60 40 20 0
NUMBER
0 100 200 300 400 500
1950
1951
1952
1953
1954
1955
1956
1957
1958
AVERAGE

Figure 56

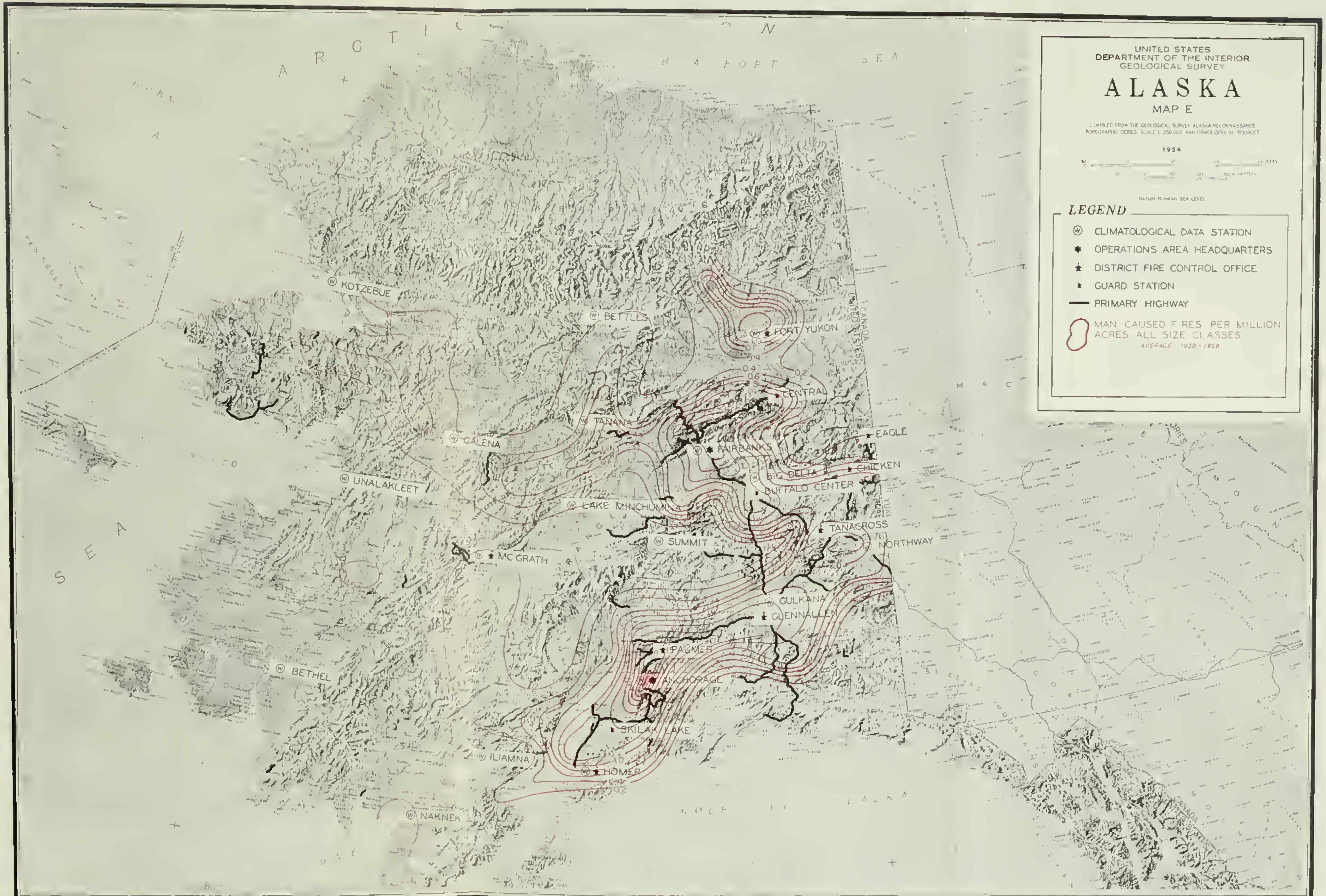

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
ALASKA
MAP E
1954
LEGEND
CLIMATOLOGICAL DATA STATION
OPERATIONS AREA HEADQUARTERS
DISTRICT FIRE CONTROL OFFICE
GUARD STATION
PRIMARY HIGHWAY
MAN-CAUSED FIRES PER MILLION ACRES ALL SIZE CLASSES
AVERAGE 1950-1958
KOTZEBUE
BETTLES
FORT YUKON
CENTRAL
TANANA
GALENA
FAIRBANKS
EAGLE
CHICKEN
BIG DELTA
BUFFALO CENTER
UNALAKLEET
LAKE MINCHUMINA
TANACROSS
NORTHWAY
SUMMIT
MC GRATH
GULKANA
GLENNALLEN
PALMER
ANCHORAGE
BETHEL
SKILAK LAKE
ILIAMNA
HOMER
NAKNEK
BEAUFORT SEA

Figure 57


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
ALASKA
MAP E
1954
LEGEND
CLIMATOLOGICAL DATA STATION
OPERATIONS AREA HEADQUARTERS
DISTRICT FIRE CONTROL OFFICE
GUARD STATION
PRIMARY HIGHWAY
LIGHTNING FIRES PER MILLION ACRES AVERAGE NUMBER PER YEAR, ALL SIZE CLASSES
1950 - 1958
KOTZEBUE
BETTLES
FORT YUKON
CENTRAL
TANANA
FAIRBANKS
EAGLE
CHICKEN
BIG DELTA
BUFFALO CENTER
NORTHWAY
UNALAKLEET
LAKE MINCHUMINA
SUMMIT
MC GRATH
GULKANA
GLENNALLEN
PALMER
ANCHORAGE
BETHEL
SKILAK LAKE
ILIAMNA
HOMER
NAKNEK

Figure 58

CHAPTER 7

FIRE CASE HISTORIES

Why do fires in Interior Alaska get so large so fast? What is the actual rate of perimeter and forward spread? What weather factors are associated with various rates of spread? And, is the rate of spread significantly different between fuel types?

Preliminary investigation of research needs showed an almost complete lack of recorded data in the form of weather, fuels, or behavior that would aid in answering these questions. In 1958 a case history study of fires in Interior Alaska was started. During that and the following year, two 2-man teams, equipped with portable fire-weather stations (fig. 59), gathered data from 19 fires; case histories of seven are presented here (fig. 60).

USFS

Figure 59. — Portable fire-weather station.

The most valuable data were collected during the free-burning period before control action altered the spread rate of the fires. Thus, data for several of the fires cover a period of only a few hours, even though the fires may have spread for a much longer time. Results of this study indicate that nearly all extreme behavior can be explained qualitatively but not quantitatively.

HEALY FIRE

The Healy fire burned 40,320 acres because of continual high winds. Healy is on the lee side of a major pass in the Alaska Range, between the Anchorage-Susitna River area and the Nenana River-Fairbanks area. Prevailing winds augment night downslope winds and override daytime upslope wind tendencies. Nonuniform topography downwind may also have caused erratic local winds and eddies.

The fire originated in a coal seam that had been smouldering for several years. At the time of discovery, midafternoon on July 4, 1958, it covered 50 acres. By 2300 it had increased to 100 acres, and was burning on steep, rocky terrain covered with black spruce, brush, and dense grass.

Excerpts from the narrative report of the fire indicate the influence of the continual high winds in thwarting early control:

> The wind made it almost impossible to do anything for about the first two weeks of the fire . . . ¾ of the time men on the ground couldn't keep ahead of the fire . . .
>
> After five inches of rain and four days since the last smoke, we felt reasonably safe and left the Healy wind tunnel.

Weather and behavior records collected by the team after its arrival on July 8 showed that the major runs occurred on July 9, 10, and 11, although relative humidity was rarely below 50 percent and burning index was around 20. The worst burning condition prevailed on July 26 (32 percent relative humidity, burning index 44);

however, since control was near there was no appreciable spread. One topographic feature hampering control of the fire was a bald mountain that caused the fire to split and form two heads. A note at the July 8/2200 reading indicates an interesting general wind situation: "The smoke is still being carried away by the fast surface winds, but as it reaches the flat country at the base of the mountain the smoke rises and forms huge cloud formations."

The fire was declared under control on August 1.

MURPHY DOME FIRE

No single factor can be pinpointed as the major cause of this fire that scorched 13,300 acres. Broken topography to the lee of a broad valley, cumulus clouds and even thunderstorms in the vicinity, and high burning indexes all contributed at various times. This lightning fire started on July 2, 1958, and covered 3 acres at discovery time the next morning. When initial attack forces arrived 5 hours later, it was at 500 acres, and by evening was 1,500 acres. The primary fuel at first attack was heavy black spruce, with a light understory of grass, brush, and deadwood. The fire burned through some birch and aspen stands, and near the top of Murphy Dome raced through a gradually thinning tundra cover.

Weather records show that either towering cumulus or mature thunderhead clouds were in the vicinity whenever the fire made a big run — a rather good indication of unstable air and downdraft conditions. The highest burning indexes (66 and 58) fell on the 2 days during which the greatest spread occurred — July 5 and 13.

Several features of topography apparently affected the erratic behavior of this fire. The wind directions recorded at the fire differ from those recorded at Fairbanks. Winds coming across the broad Tanana valley on both the western and southern sides of the fire area were broken by the mountains in which the fire burned. The northeast-southwest flowing Goldstream Creek and its steep tributaries further complicated the consistency of airflow. The whole topographic complex made it nearly impossible to predict the path of the fire.

The fire was declared controlled on July 21.

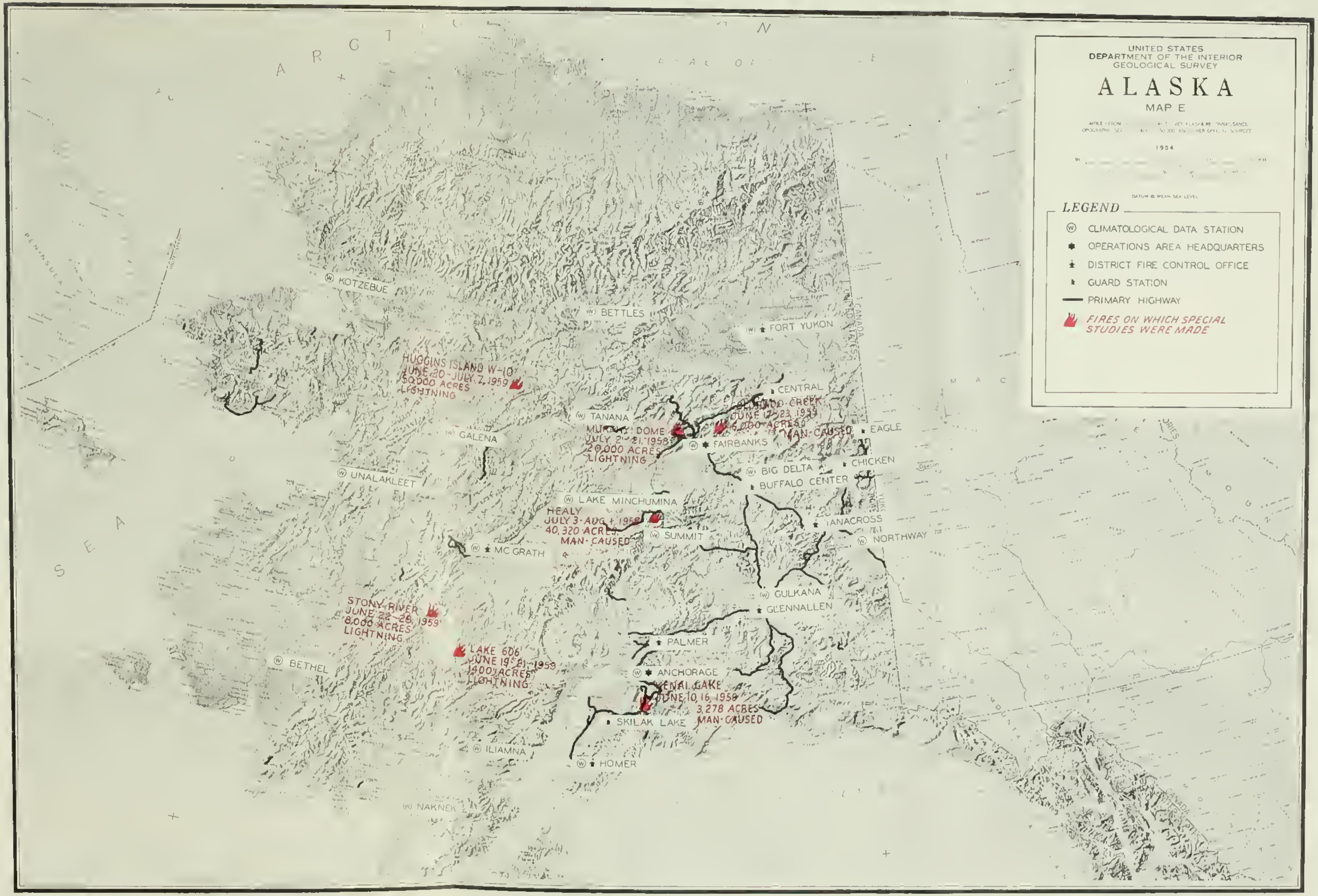
KENAI LAKE FIRE

Extremely steep and long, narrow canyons converging at the head of the lake cause strong winds that exhibit daily reversals in direction; 3,278 acres was burned on this fire, primarily as a result of these winds. Local night drafts could have been quite gusty and strong and from almost any direction during the time of the fire's rapid advance. The burning index, recorded at the lower end of Kenai Lake, climbed to 57 on the day of origin; this is critical for coastal Alaska.

Clearing fires from homestead preparation and right-of-way construction have caused hundreds of acres of forest land to go up in smoke over the past 5 decades. A right-of-way clearing fire in National Forest land along Kenai Lake was very small when discovered and first attacked on June 10, 1959. The point of origin was in a stand of white spruce where considerable moss was present; both the rate of spread and resistance to control were rated as high. By evening of June 13, the fire covered about 2,000 acres, extending along Kenai Lake for 7 miles and up a 75-percent slope for a mile or more. The major part of the fire burned in good quality black spruce timber. The fire had pretty well run out of fuel on the upper reaches of this steep mountainside, but it was burning at both the left and right ends. The condition of the fire at this time can best be described by quoting from the fire-behavior team's report:

> . . . the fire was burning at about 120 chains per hour. The fire was crowning in mostly black spruce timber with a northeast wind blowing at 10 miles per hour behind it. There were small spruce needles falling all over the ground as far as 2 miles ahead of the fire . . .

At 0800 on June 14, the 39 percent relative humidity and the 9 percent fuel moisture indicated afternoon burning conditions would be unusually bad. However, the fire made no particular big gains. Fair weather cumulus clouds were overhead from before 1600 until after 1800. At 1730 the wind shifted from a prevailing northeast direction to southwest, with a considerable increase in velocity. Line was lost at both ends of the fire and along the lakeshore



UNITED STATES
DEPARTMENT OF THE INTERIOR
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ALASKA
MAP E
LEGEND
CLIMATOLOGICAL DATA STATION
OPERATIONS AREA HEADQUARTERS
DISTRICT FIRE CONTROL OFFICE
GUARD STATION
PRIMARY HIGHWAY
FIRES ON WHICH SPECIAL STUDIES WERE MADE
KOTZEBUE
BETTLES
FORT YUKON
CENTRAL
TANANA
FAIRBANKS
EAGLE
GALENA
BIG DELTA
CHICKEN
BUFFALO CENTER
UNALAKLEET
LAKE MINCHUMINA
TANACROSS
SUMMIT
NORTHWAY
MC GRATH
GULKANA
GLENNALLEN
PALMER
BETHEL
ANCHORAGE
SKILAK LAKE
ILIAMNA
HOMER
NAKNEK
HUGGINS ISLAND W-10
JUNE 20 - JULY 7, 1959
50,000 ACRES
LIGHTNING
JUNE 17-23, 1959
MAN-CAUSED
DOME
JULY 2-21, 1958
20,000 ACRES
LIGHTNING
HEALY
40,320 ACRES
MAN-CAUSED
STONY RIVER
JUNE 22-28, 1959
8,000 ACRES
LIGHTNING
LAKE 606
JUNE 19-21, 1959
1400 ACRES
LIGHTNING
KENAI LAKE
JUNE 10-16, 1959
3,278 ACRES
MAN-CAUSED

Figure 60

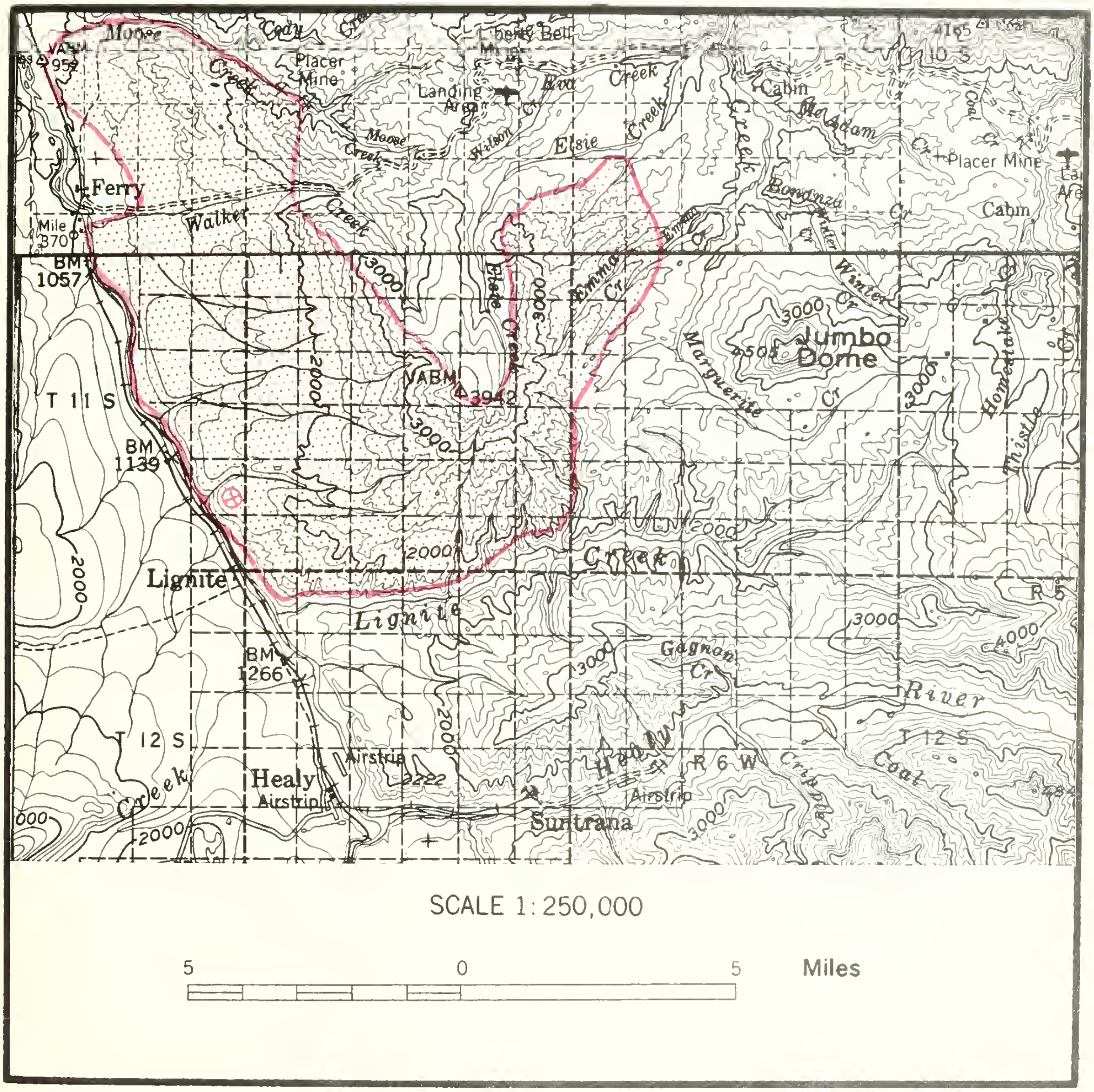


Figure 61. — Healy fire vicinity.

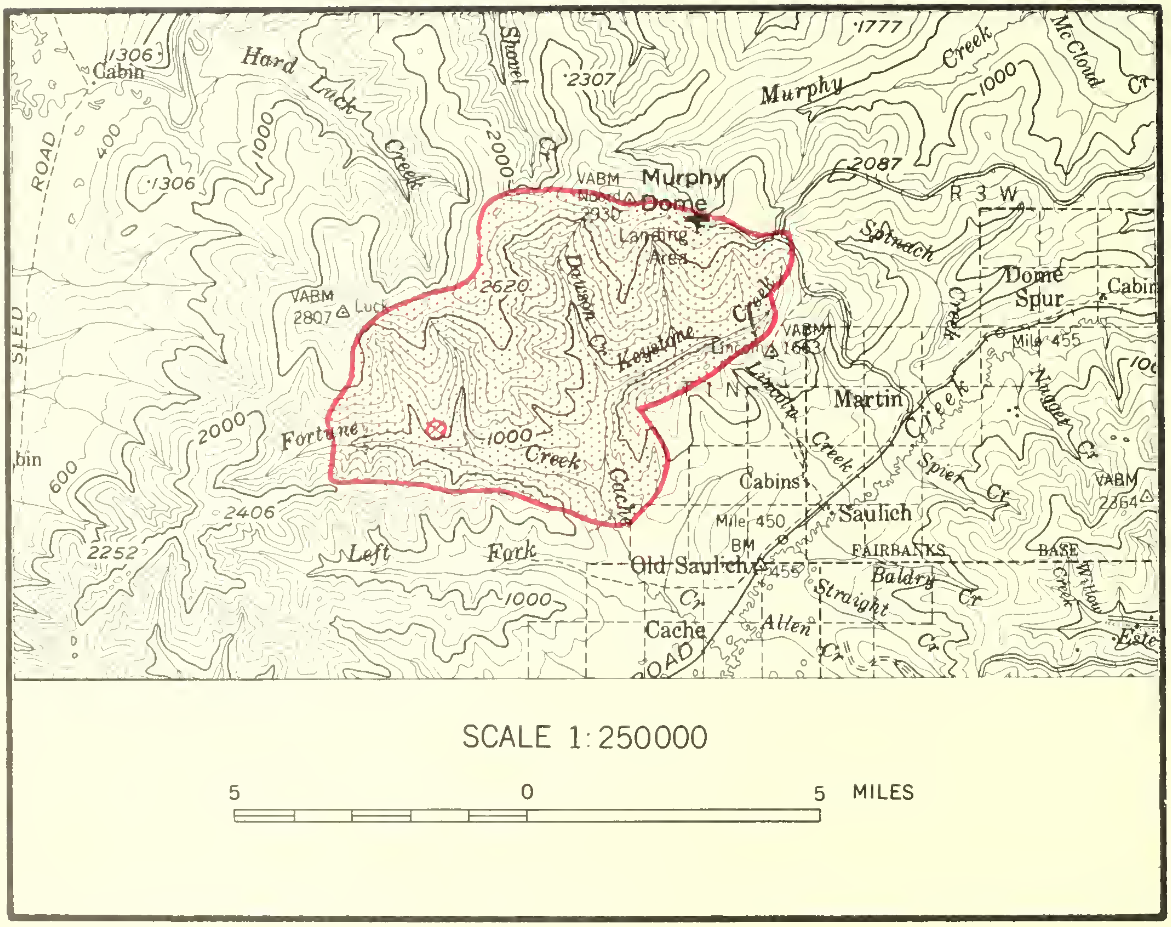


Figure 62. — Murphy Dome fire vicinity.

USFS

Figure 63. — Kenai Lake fire 1 year after it burned.

road, and many summer homes in the Snug Harbor vicinity were endangered. The fire became extremely active for a short while but slowed down as soon as the wind slackened. The wind shift on the fire may have been caused by a major shift in pressure patterns aloft; evidence for this might be the disappearance of small cumulus clouds from the area. A special fire-weather forecast could possibly have warned the fireboss that such a situation might occur.

This was the last significant advance of the fire; it was declared under control 2 days later.

COLORADO CREEK FIRE

Brisk winds, highly flammable fuels, steep topography, and unprecedented critical fire weather all contributed to the difficulties of predicting fire behavior and of taking adequate control measures on this 6,000-acre fire.

This fire is thought to have been set by an incendiarist on June 17, 1959. By early morning on June 18, 100 acres of muskeg had burned and burning was intense on each of the 3 days following ignition. Such critical fire-weather factors as those listed below were never before recorded in Interior Alaska:

Date	Fuel Moisture Stick	Fuel Moisture Slat	Temperature	Relative humidity
	Percent		Degrees F.	Percent
June 18	7.7	2.4	86	24
19	6.9	1.7		19
20	7.1	1.6	83	21

On June 18, a brisk gusty wind began by 0700 and persisted throughout the day. Before 1300, surface winds carried the smoke away near the surface; but after that time the column rose rapidly to extreme heights. Fair weather cumulus were present from 1300 on. By 1400 the fire was racing through muskeg at the rate of 60-chains-per-hour forward travel. Fast spread continued for about 2 hours.

On the morning of June 19 the sky was clear and wind speeded up to a maximum of 8 miles per hour. The fire jumped the control line and headed out at a rate of approximately 400 chains per hour. Black spruce became part of the fuel at the fire's head. The smoke column rose for several hundred feet, then flowed with the upper wind; however, as the day went on, the fire slowed down and the smoke column tended to toadstool; at this time the cirrus and

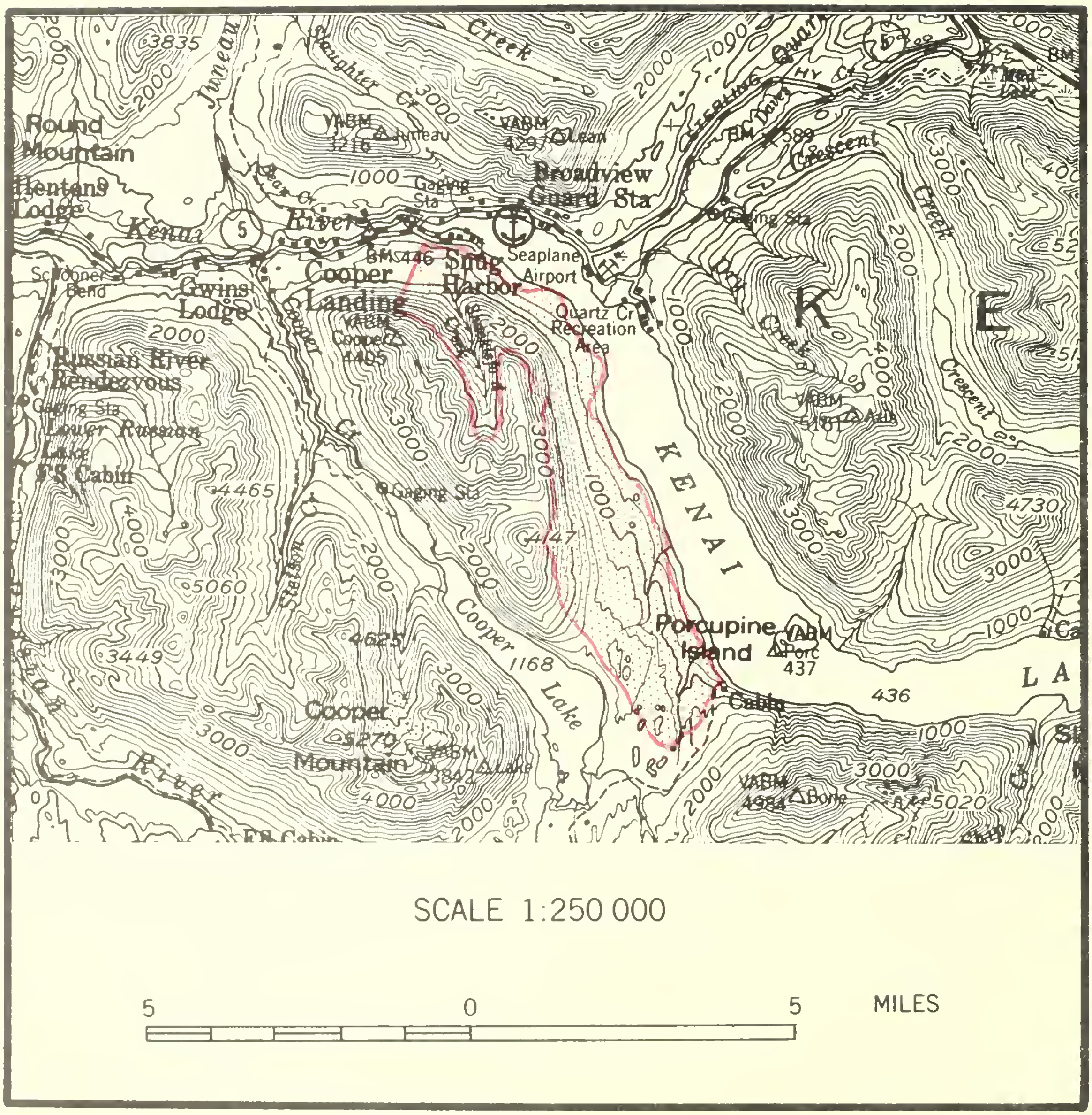


Figure 64. — Kenai Lake fire vicinity.

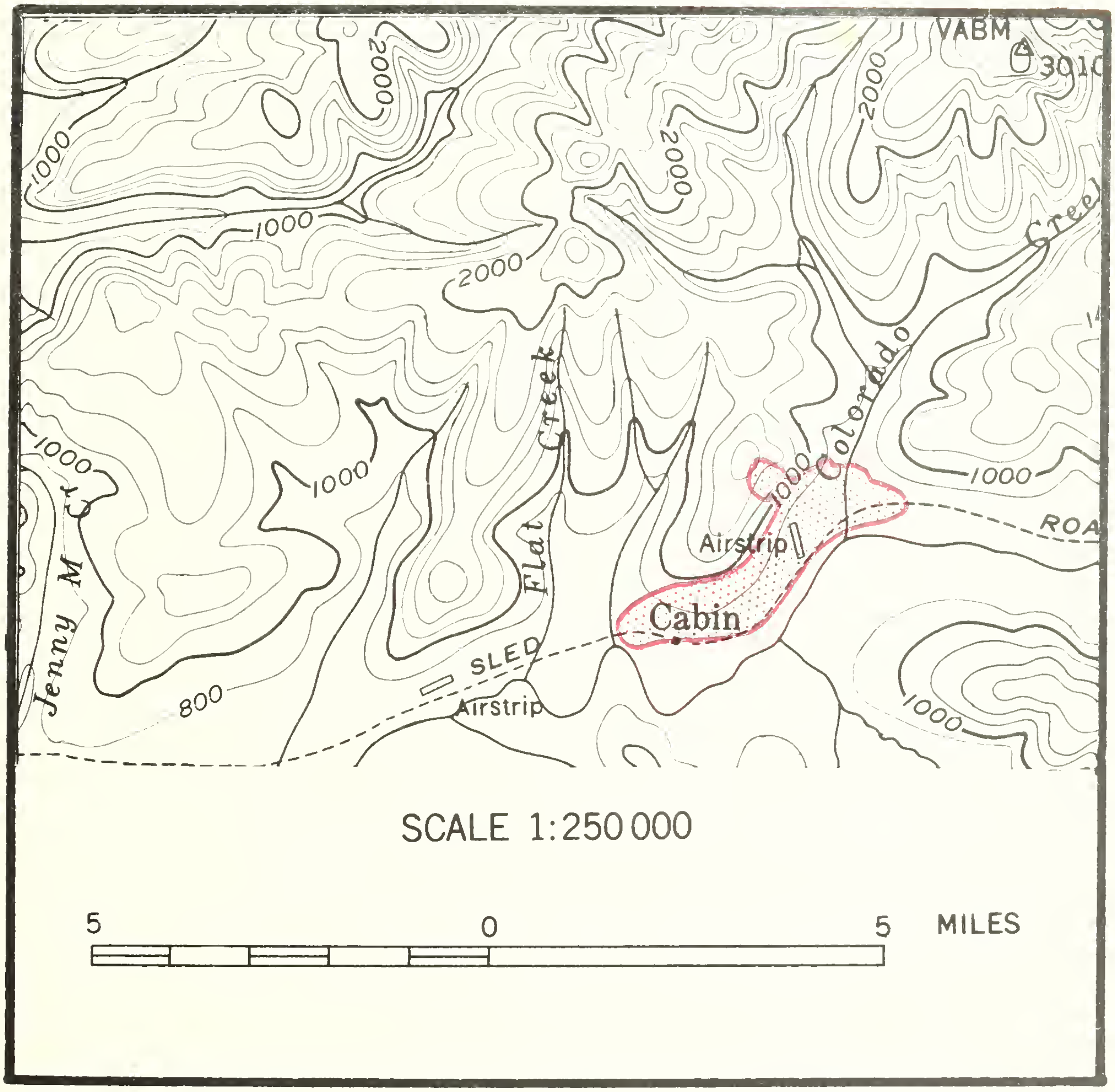


Figure 65. — Colorado Creek fire vicinity.

fair weather cumulus clouds did not appear to have much movement.

June 20 was another bad day. Altocumulus costellatus clouds (often a forerunner of thunderstorms and unstable air) were noticed from midnight until about 0900, but no cumulus development beyond fair weather stage followed. At 0800 altocumulus lenticularis appeared and the wind increased. At 1100 the fire jumped a wide control line and raced up a 90-percent slope through a black spruce stand at a rate of 140 chains per hour. After it burned out the large patch of black spruce it crept slowly in the surrounding birch stand. This midday action was the last period of rapid spread; the fire was declared under control by midafternoon June 23.

The entire 3-day period of record was characterized by temperatures about 10° F. above normal. Wind direction was predominantly from northeast on June 18, east on June 19, southeast on June 20, and east again on June 21. Average cloud cover was 0.7. Gusty winds caused some of the rapid advances by whipping backfires across the control lines. Presence of lenticular clouds on June 20 indicated high winds aloft. These, coupled with the combination of the local general wind direction of southeast and the normal afternoon tendency of wind to flow up-canyon in the side draws, may have helped the fire take advantage of local highly flammable fuel concentrations and race through these at unexpected times.

LAKE 606 FIRE

Thunderstorm downdrafts were the apparent causes for short separate periods of vicious behavior of this fire, which burned over 1,400 acres.

The Lake 606 fire was thought to have been started by lightning on June 19, 1959. It was discovered the afternoon of June 20 by patrol plane and was estimated to cover 30 acres. Initial attack forces arrived in the early morning of June 21 and soon found two fires totaling 100 acres; these burned together at 1400.

Thunderheads persisted in the vicinity during that afternoon. Fuel moisture of the sticks and slats was 10 and 7 percent, respectively; maximum temperature was 76, and the lowest relative humidity was 44 percent. Wind was from the north or northeast except at 1600 and 1700, when it came from the southwest with increased gustiness and velocity, up to 25 miles per hour.

The fire-behavior team mentioned it was difficult at this time to tell which end of the fire was the head and which was the rear. To quote their 1600 report:

> About 1530 lots of unusual things started happening. The wind was very variable. It could sometimes change direction completely and sometimes it was at a standstill. There were some whirlwinds all along the fire line . . . The smoke was rising fast and extremely high, becoming a part of a big toadstool directly overhead. It was impossible to determine atmospheric conditions from where we were because of the smoke. We did hear thunder in the SE.

At 1700 the report continued:

> Between 1600 and 1700 we had a very unusual big blowup on the fire. The smoke was rising extremely high and forming a big toadstool directly over the fire. The fire was completely out of control, burning at rate of about 4 chains per minute (240 chains per hour). It only burned about 30 minutes at this rate. At 1640 it began to rain and about 1715 the wind began to let up. At the two places on the fire where most of the activity was taking place there was small black spruce and lots of brush. The fire was sweeping through the trees and leaving the tundra and grass to burn later. At 1645 lightning appeared in the SE.

Rain stopped the fire at 1,400 acres.

Atmospheric instability and thunderhead downdrafts probably contributed heavily to the extreme behavior of the fire. Black spruce also appeared to be very conducive to crown fire behavior.

Fires behaving as this one did can easily become "killers." To prevent such possible tragic events a better understanding of the "whys" must be learned, supervisory personnel on fires

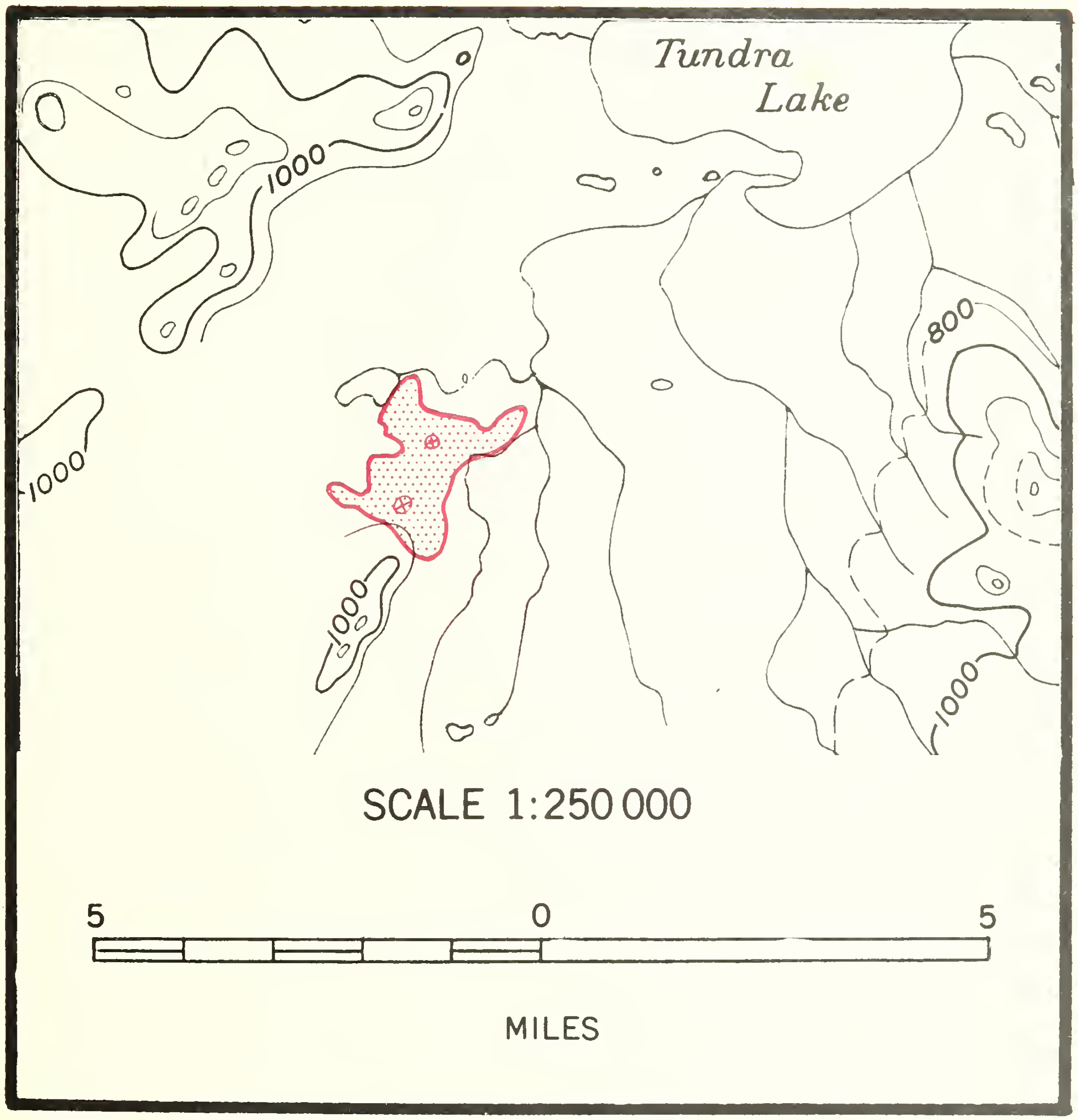


Figure 66. — Lake 606 fire vicinity.

must be trained to anticipate such behavior, and more reliable methods for prediction must be developed.

STONY RIVER FIRE

Unobstructed horizontal continuity of fuels had much to do with the rapid advance of this fire. Unexpected shift of wind direction and velocity could have resulted from mature cumulus clouds, but few were noted; possible passage of a frontal movement could also have contributed to the large final area of 8,000 acres.

The lightning fire started on June 22, 1959, and by the next afternoon it had spread to an estimated 5,000 acres.

The country was flat to rolling; surface weather conditions gave no outward indication of bad fire weather. The wind varied from 5 to 12 miles per hour and was gusty; but even so, the smoke column rose rapidly and formed a towering cumulus cloud. A change in the general atmospheric situation may have influenced a shift of wind at 1330 from northerly to southerly; the wind aloft caused crowning and a spread rate of 18 chains per hour. Towering cumulus clouds that were observed at 1315 could also have caused the wind shift and resultant fast spread. From 1550 until nearly midnight the surface wind blew from the west, but the clouds came from the southwest. In 9 hours' time the wind swung around clockwise about 270°. The greatest spread rate was 33 chains per hour at about 1700.

No extreme behavior occurred on June 24.

The fire spread both to the north and the south on June 25. Mature thunderheads developed by 0800 and persisted until noon, when only fair weather cumulus were reported. A trace of precipitation fell during each 2-hour period from 0800 through 1400; this indicated that thunderheads may have been present later into the day than the record showed. Winds were steady to gusty from 4 to 10 miles per hour from the northwest pushing the fire to the south, but at 1600 the wind shifted to a southwesterly direction and caused trouble on the north end of the fire. The smoke column first rose lazily and spread out gradually, but after 0900 the surface wind carried the smoke away before it rose. Locally u n s t a b l e atmospheric conditions may have accounted for most of the high rates of spread; fuel moisture, relative humidity, and burning index were mild all day. After June 25, the fire spread very little.

Coupled with a variety of weather conditions, the fuels — primarily black spruce — were capable of carrying the flame front with ease. The relatively flat rolling country with few obstructions also permitted the fire to travel unhindered.

From the limited information collected, it is hard to know whether the wind shifts were of local or general nature; however, upper air soundings at Bethel, 175 miles southwest of the fire, indicated a general southwesterly flow of air that was convectively stable at 1400 on June 24, in neutral equilibrium at 0200 on June 25; but at 1400 on June 25, layers of air were becoming convectively unstable.

The final area was 8,000 acres, about 5,000 acres of which burned on June 23.

HUGGINS ISLAND W-10 FIRE

Three major runs were observed on this fire. Steep slopes and heavy black spruce fuels were associated with all three. Brisk winds accelerated one of the runs, and thunderstorm cells influenced another. The fire was lightning caused on June 19, 1959, attacked on June 24 when it was already 4,500 acres, and abandoned on July 1. It finally burned out at an estimated size of 50,000 acres.

During June 25, both towering cumulus and altocumulus lenticularis clouds were present; some precipitation fell at 1630.

At about 2000 the fire, which had been crawling through tundra, reached a black spruce stand on a 75-percent slope and raced through it at about 90 chains per hour; the average spread for a whole hour was 45 chains. There was no special note of increased or erratic wind; no cumulus clouds were present; but the smoke column changed from rising lazily and spreading out, to being carried away by surface winds. This change in the smoke column characteristic may have been an important clue to the sudden rapid spread of the fire, but the changes in slope and fuel type were also pertinent to the cause. There might also have been a topographic influence on local wind flow at that time of day.

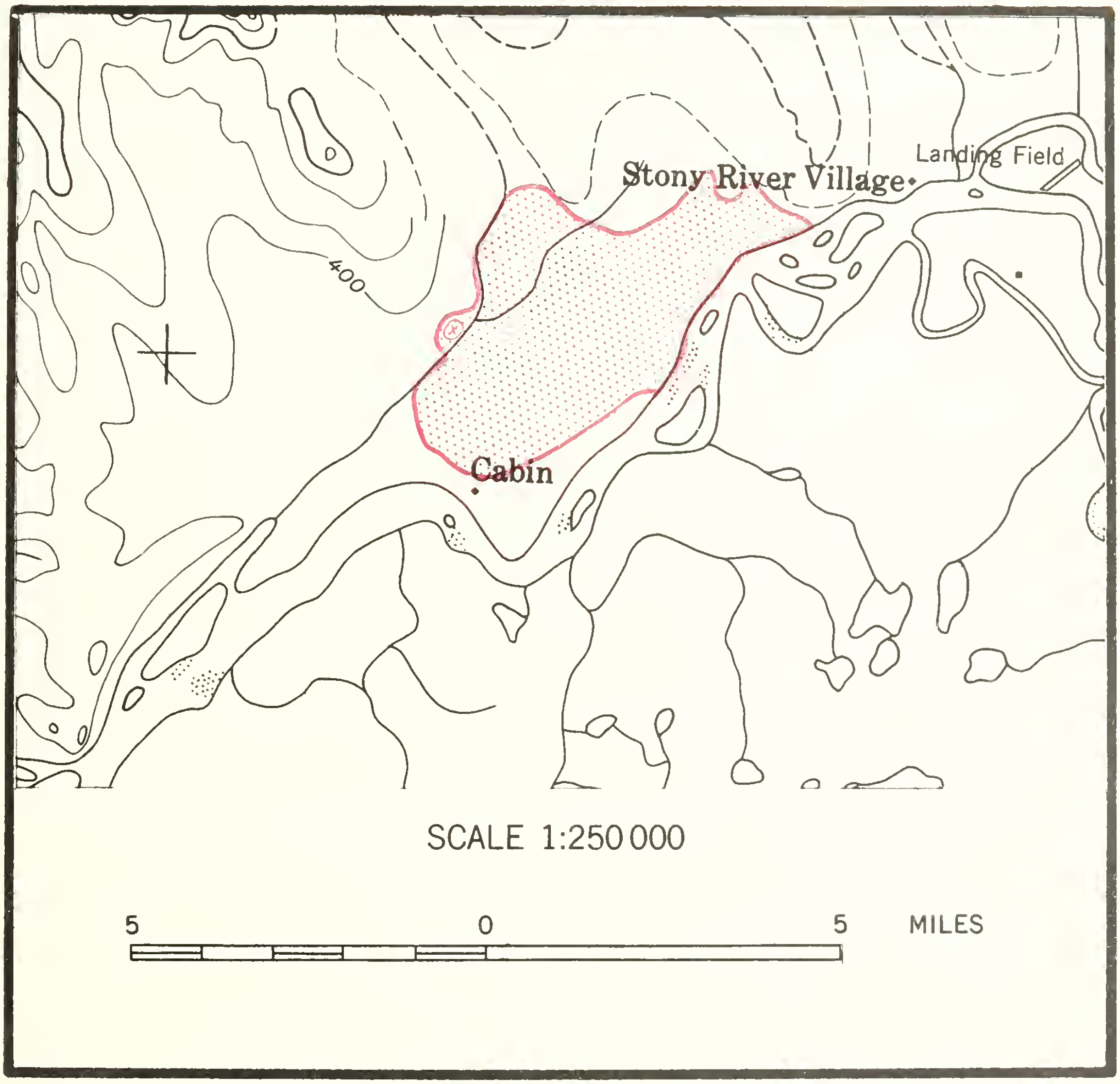


Figure 67. — Stony River fire vicinity.

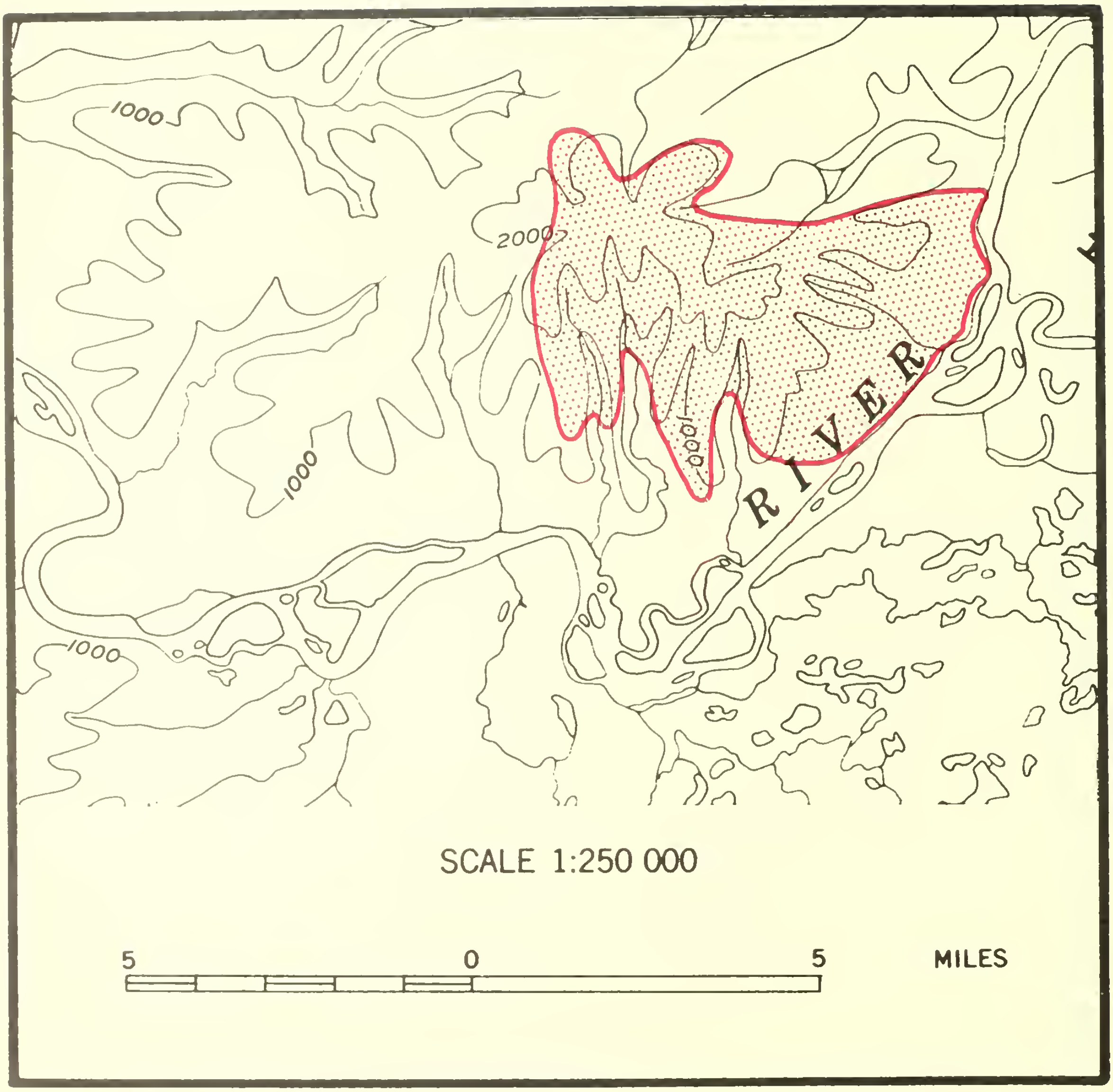


Figure 68. — Huggins Island W-10 fire vicinity.

On the morning of June 26, after a change from steady, light northeasterly wind to a variable wind, and under moderate fire-weather and clear-sky conditions, the fire began crowning at 80 chains per hour up a 75-percent slope containing black spruce. At 1000 all the weather conditions worsened, many dust devils occurred, cumulus clouds began to form, the smoke column rose rapidly and high, but the fire slowed to 20 chains per hour on a 35-percent slope, still in black spruce. The wind was now from the north and continued there all day. The fire continued to advance but not with extreme behavior characteristics.

At 1600, however, to quote the fire-behavior report, "A whole north-south wall of flame is moving west over a ridge at a fantastic rate — possibly a good 5 miles per hour. No warning — the whole ½ mile of flame started within 3 minutes." The smoke column continued to rise for some distance, then toadstooled. There had been no noticeable weather, fuel, or topographic change (21- to 50-percent slope) to cause this erratic behavior; however, the 1800 observation mentions fully mature thunderheads with virga in the vicinity. Maximum wind velocity at the weather station, though, was only 11 miles per hour. At 1930 the wind shifted from north to southeast, the fire subsided and remained quiet during the night. The fire was now about 13,000 acres in size.

Since the available firefighting crew was so small and the extended period of fire weather was so adverse, the fire was finally abandoned in late evening on July 1. More complete weather observations and intensive study of the atmospheric conditions might have led to a better explanation of the fire's rapid spread.

SUMMARY

Topography to windward of the Healy fire forms a saddle through which wind velocities are usually greatly increased. This fact is the major reason for the fast spread and difficult control of the fire.

The broken topographic complex on the lee side of a broad flat valley, high burning index, thunderstorms, and instability all contributed to the irregular and difficult time for predicting behavior of the Murphy Dome fire. One day the fire spread for several hours at a rate of 40 chains per hour.

Topography surrounding the Kenai Lake fire vicinity is extremely rugged and consists, in part, of steep canyons converging on the upper end of the lake. The resultant strong diurnal winds reverse their direction in morning and evening; altered atmospheric conditions also violently affect the wind pattern. The diurnal effect caused serious trouble on one day, and a front moving through caused considerable loss of line on another day.

The worst fire weather of all the fires reported here occurred on the Colorado Creek fire. The brisk winds that were altered by steep topography, highly flammable fuels, and generally critical fire weather all contributed to the difficulty of predicting fire behavior and taking appropriate control measures. A spread of 140 chains per hour in black spruce was recorded for a brief period.

The initial run of the Lake 606 fire was caused by strong winds. The greatest spread, however, was apparently caused by thunderstorm downdrafts and unstable atmospheric conditions.

Constant rapid spread of the Stony River fire was aided by unbroken horizontal fuel continuity and relatively unstable air associated with a frontal activity which changed the wind direction a total of 270 degrees. The fire traveled at a rate of 33 chains per hour at times.

Thunderstorm downdrafts may have caused a ½-mile section of the Huggins Island W-10 fire to advance briefly at a rate of 320 to 400 chains per hour. A local wind-topography-black spruce fuel situation may have caused another rapid advance of 45 to 90 chains per hour. A wind switch accompanied by local instability accounted for still another advance rate of 80 chains per hour. Rough topography, variable and gusty surface winds, evidence of high winds aloft, and local atmospheric instability all contributed to periods of extreme fire behavior.

From these case histories very few specific conclusions can be drawn. However, for the first time some systematic measure was made of the weather, topography, and fuel conditions during actual free-burning periods of wild fires in Interior Alaska. The results point up these things: (1) Most wildfire activity can be measured and explained; (2) more sophisticated methods will in the future add quantitative information to the predominantly qualitative data recorded in this study; and (3) the groundwork has been laid for answering the four questions at the beginning of this chapter.

CHAPTER 8
FIRE CONTROL

Timber losses have approximately balanced timber growth in unexploited Interior Alaska. Future demand to harvest part of the crop each year will require an increase in net growth to replace this removal. Besides, the national economy will demand a continuing increase in the future allowable cut.

How much should be spent to protect this important resource? Where is the breaking point between the ratio of loss and damage versus the cost of protection? No economic study has been made to ascertain just how much Alaska is worth in terms of what should be spent to protect it. Helmers (1960, p. 470) states, "Fires are so much a part of the summer scene that there is also the psychological problem of getting public recognition of the economical losses due to fire." A close review of the history of our resource protection effort and a good look at long-range needs show the necessity to materially reduce forest fire damage in Alaska.

Until July 1939, organized forest fire control in Alaska was nonexistent. Then the territory received $37,500 to establish the Alaska Fire Control Service. Early efforts were confined to suppression of man-caused fires within surface striking distance of Anchorage and Fairbanks.

Throughout development of an effective firefighting force, several major problems have persisted. The vast area and the contrastingly small, concentrated population have made early detection difficult; the lack of access to remote forest and range lands compounds the logistics of reaching fires and supplying crews. As tourist numbers increase, so does incidence of man-caused fires. An increasing awareness of the values at stake and of the need for better protection has mandated the fire control organization to use every means available to reduce the losses (Robinson 1960).

Since inception of the Alaska Fire Control Service, great strides have been made toward control of the major portion of forest fires in Alaska. Begun under the old General Land Office, the fire control organization is now operated as an integral part of the Bureau of Land Management, which has responsibilities for protection and management for more than 95 percent of the State's area. Protection of much of this land will remain the responsibility of the Bureau of Land Management for years to come even though the State will, within 25 years, assume title to more than 100 million acres.

In 1955 the Bureau of Land Management developed a comprehensive forestry program for Interior Alaska. The four major management objectives are: (1) multiple use management of the entire forest resource complex rather than timber management alone, (2) water resource protection and development, (3) increased utilization and development of the present timber resource, and (4) protection of the public's vested interest in the forest and range resources in Alaska from destruction or damage from fire, insects, and disease. None of the first three management objectives can be met with confidence until the fire protection organization can assure, within reasonable limits, a continuing forest cover. Robinson (1960) proposed a goal of not more than 100,000 acres of burned area per year. Basic barriers to early detection, attack, and control of fires must be identified and overcome.

FIRE CONTROL ORGANIZATION
PRESUPPRESSION

Regardless of the severity of any one fire season, a well-developed fire control organization containing basic personnel and equipment must be ready to handle an average bad season. Perhaps the job confronting fire control personnel for Interior Alaska can best be described by comparing it with another fire control group, Region 1 of the U.S. Forest Service:

	Region 1 USFS[1]	Interior Alaska BLM	Interior Alaska compared to Region 1
Acres protected	32,000,000	225,000,000	7 times
Acres burned	4,467	1,119,130	250 times
Number of fires	1,069	254	25 percent
Number of fires per million acres	33	1.1	3 percent
Fire personnel, man-years[2]	348	38	11 percent
Number people per square mile	4.9	.4	8 percent

[1]Montana, northern Idaho, northwest South Dakota, and northeast Washington.

[2]Regularly assigned positions including fire control aids.

Bases and Warehousing

Major operational bases and warehousing facilities are at Anchorage and Fairbanks, the only two cities capable of furnishing manpower, food, equipment, supplies, and services necessary for launching and supporting fire crews in the field. These are augmented by a few secondary permanently manned bases located at strategic support centers. In addition, several fireguard stations, manned seasonally, are situated from Skilak Lake on the Kenai Peninsula northward to Fort Yukon just north of the Arctic Circle.

The long time required to deliver many supplies (retardant chemicals for instance) makes it imperative to anticipate such needs as long as one season ahead of expected use.

Most equipment, tools, and supplies are packaged and stored in six-man units — a Grumman Goose load of firefighters. Development of new tools and equipment for fighting fires in the Alaskan fuel complex has lagged seriously. Dozers, tankers, and pumpers are used where available and where topography and soil along the fireline permit. Shovels and pulaskis are the old standbys for handtool work. New hand and power tools are urgently needed to help offset the relative scarcity of personnel, the difficulty of terrain, and the remoteness that gives fires such a headstart.

Dispatching

Most dispatching of men, equipment, and materials is handled at Anchorage and Fairbanks. Nearly all smokejumping and a major part of retardant chemical attack operations are controlled from Fairbanks. Dispatching involves considerable advance planning, preparation, and training. Even pilots of the contract retardant planes require orientation and training by the dispatcher staff. All aircraft use is controlled by the dispatcher and chief pilot in order to attain greatest value from each plane.

Effective dispatching depends upon a highly reliable communications system. Trunkline telephone service is excellent, but is limited to the large cities and to a few places of habitation along the main highways. All other communications are by radio. Airplanes need the most complex set of equipment as pilots depend on radio for navigation and safety as well as for tight control on fire missions. All stations and a large share of vehicles are radio-equipped: VHF-FM for air-ground work; VHF-FM and HF-AM for vehicle and station use.

Deployment of men and equipment during the fire season must be based upon information about fire occurrence. Since a large percentage of man-caused fires occurs in May and early June, men, tankers, dozers, and other ground equipment are aimed at control of fires near habitation centers and areas of agricultural development. Later, all the aircraft — whether for patrol, smokejumping, chemical attack, or supply — must be in constant readiness to attack lightning fires anywhere in the State.

Manpower

The supply of manpower in Alaska is small, and the distribution in respect to recruiting firefighters is poor. Even though Alaska's population has increased fourfold in the past 40 years, the 1960 census records a total of only 226,167 persons (four-fifths the population of Nevada). The tabulation below shows the uneven distribution of people; only about 100,000 persons reside outside of the Anchorage and Fairbanks vicinities, and many of these are in the southeast coastal area.

Climatic division	Geographic division	Approximate population
Maritime zone	Southeast, South Coast, Aleutians	56,000
Transition zone	Copper River, Cook Inlet, Bristol Bay, West Central (includes Anchorage)	106,000
Continental	Interior Basin (includes Fairbanks)	49,000
Arctic zone	Arctic Drainage	15,000

A small part of the regular fire control personnel are year-round employees, but most of the fire dispatching and overhead employees are seasonal. Most of them enter duty in April or May and remain until September. They are the well-trained nucleus that leads the attack on fires throughout the summer.

The actual firefighters come from two sources — Indian villages and the open labor market. The natives and Eskimos are excellent firefighters. Their villages are sufficiently scat-

A BLM

B BLM

C USFS

D USFS

E USFS

Figure 69. — Base facilities: A, fire headquarters, Fairbanks; B, smokejumper center, Fairbanks; C, dispatch room, Fairbanks; D, McGrath station; E, Skilak Lake guard station.

tered so that groups are often close to fires and can be recruited rapidly for early attack. They learn quickly and fit well into fireline organization. Also, they are physically able to stand backbreaking work for many days at a time. The pickup firefighters from the open labor market are of similar caliber to those found anywhere else; however, a few of them do return season after season and become topnotch workers.

Successful in western United States since World War II days, smokejumping began in Interior Alaska in 1959 with 16 jumpers. Setting up a smokejumper center in Fairbanks was a major undertaking. Everything from a loft-dormitory building to sewing machines, from acquiring a DC-3 to modifying the doors of a Grumman Goose had to be done to make the jumper force effective. Retraining dispatchers in new procedures and transportation methods was also necessary. Well-executed presuppression work in this new phase of fire control paid off when the actual suppression load began to increase.

Transportation

Of Alaska's 5,000 miles of highway, 3,000 are blacktopped, 2,000 are graveled. Private access roads go into homesteads, mining property, and recreational sites, but the actual mileage of these roads is very small. However, since most man-caused fires are along the highways or on homesteads (fig. 57), a far greater number of trucks, pickups, and tankers is used than one would suspect by looking at road data alone.

Aircraft are the hard core of the firefighting attack force. As one official put it, "The possibility for successful fire control started the day we received our three Grumman Gooses." These short-field amphibious planes can land on small lakes or sloughs close to fires; hence they are constantly used for patrolling, servicing and supplying, making initial and reinforcing attacks, and for smokejumping. Single engine, 4-place planes are kept busy on patrol, scouting, inspection, and administrative use. A Douglas C-47 (DC-3) is used primarily for smokejumpers; but it can also move equipment, supplies, and non-jumping firefighters. A P-51 fighter plane carries the observer for long-range detection and scouting; it is also used as lead plane for chemical retardant attack.

Charter and contract planes carry all the overload while the fire season is in full swing. At the peak of the season, one sees the usual assortment of larger chemical retardant application planes, several makes of helicopters, and both wheel and float type planes of the single engine, 4-place category. The numerous Alaskan commercial airlines furnish much of the heavier point-to-point hauling.

When fire conditions become critical and commercial equipment is no longer available, the military forces contribute many hours of flying. Heavy point-to-point hauling is done by planes in the C-123 class; helicopters — even the large double-rotor type — often do yeoman duty during crucial times.

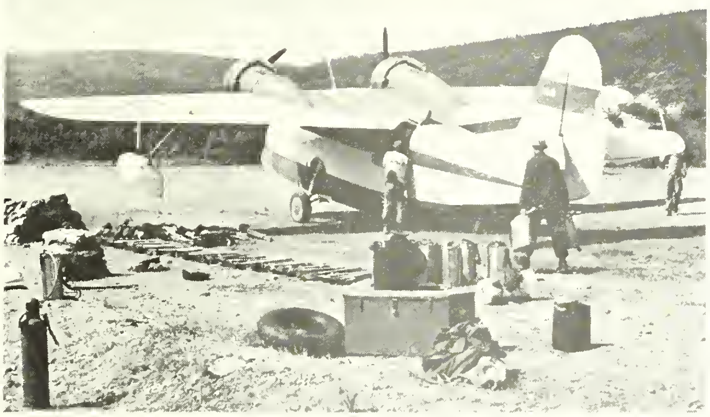
DETECTION[9]

The critical need for early detection of fires has been emphasized several times. A small crew can usually (not always by any means) handle a fire if they can attack before it begins to take over its own destiny. Prior to about 1957, aerial detection was limited for a practical reason: The attack force was not large enough to act on more than a small percentage of the fires; so there was no point in detecting all the fires that did start. The advent of retardants and smokejumpers now makes early detection of *all* fires imperative if these two new weapons are to be of maximum value.

All the means of detection credited above are somewhat haphazard, and at best are a poor substitute for a continuous, trained detection organization. The Bureau of Land Management has, since 1959, chartered a P-51, Mustang fighter plane to follow in the wake of thunderstorms in order to locate possible resultant fires. This procedure has helped early detection of many fires, but it has certain serious drawbacks: One plane cannot adequately patrol 150 million acres (the area of Montana and Idaho combined); an observer cannot locate all small fires from a fast-moving, high-flying plane; accurate

[9]Statistical analysis of time elapsed between origin of fires and their discovery proved unsuccessful because too many data were lacking on the fire reports. Only about one-third of the large (Class E) fires could be used; this fact presumably influenced the results to show that longer lags in discovery time did not result in larger fires. The question will have to remain a matter of conjecture until factual data are collected on the behavior of free-burning fires from the time of origin.

A USFS



B BLM

C USFS

Figure 70. — Transportation: A, foot travel is slow, often impossible; B, loading a Goose for fire run; C, air supply — Goose to small float plane.


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
ALASKA
MAP E
1954
DATUM IS MEAN SEA LEVEL
LEGEND
CLIMATOLOGICAL DATA STATION
OPERATIONS AREA HEADQUARTERS
DISTRICT FIRE CONTROL OFFICE
GUARD STATION
PRIMARY HIGHWAY
AREA OBSERVED BY COMMERCIAL AIRLINES
GREEN 1 - 10 FLIGHTS PER WEEK
BROWN 11 - 20 FLIGHTS PER WEEK
RED MORE THAN 20 FLIGHTS PER WEEK
SOURCE 1959 AIRLINE SCHEDULES
FORT YUKON
CENTRAL
EAGLE
CHICKEN
NORTHWAY
MC GRATH
LAKE MINCHUMINA
GULKANA
PALMER
SKILAK LAKE
HOMER

Figure 71

BLM

Figure 72. — Early detection of this small lightning fire will contribute to rapid control.

description and location of current thunderstorm cells or systems is not yet feasible; and, because of its speed such a plane is often diverted from its primary detection mission to be used for reconnaissance of going fires and for lead plane duties on retardant chemical attacks. The lighter planes which are also used occasionally for patrol are dispatched to lead plane duty whenever possible to permit the P-51 to continue its reconnaissance work.

Recent advances in development of electronic devices may make it possible to provide a reliable system for tracking storms, locating fires, and mapping going fires. Certain types of radar can identify mature thunderstorm cells. Sferics receivers are being developed to further determine whether an electrical disturbance is present (Battan· 1959). Airborne infrared mapping devices are now being investigated for use in the actual locating and mapping of fires (Hirsch 1962).

SUPPRESSION

Preparation for an expected bad fire season in Interior Alaska is a tremendous job, but it must be done thoroughly so that the subsequent suppression effort will be adequate.

Method of Attack

Fire control tactics in Interior Alaska are similar to those used elsewhere. Logistically, attack on fires accessible to motor vehicles is relatively simple. Initial attack on fires hundreds of miles from the source of supply requires ingenuity and wise use of every facility feasible. Except for longer time and distances involved, the following procedure follows closely those used in other States: As soon as a fire is reported, the dispatcher sends chemical retardant planes. At the same time he dispatches smokejumpers. Then, ground forces are sent to reinforce and relieve jumpers. Their travel may be by land plane to a small field, thence by amphibious plane to a body of water near the fire, and possibly by helicopter to the fireline. Subsequent loads of chemicals for tactical support are often ordered when conditions indicate the need.

As an example of the effectiveness of this type of rapid attack, some 1959 statistics follow: Of all fires upon which retardant was dropped, 35 percent was within 50 miles of the base, 43 percent between 50 and 100 miles, and 22 percent between 100 and 200 miles; an average of seven loads was dropped on each fire by planes traveling a mean one-way distance of 85 miles. The application of chemical checked the fires' spread to an extent that firefighters controlled 85 percent of them at the same size class as when the retardant was applied.

Smokejumpers in 1959 traveled as far as 472 miles to reach fires, but the average distance was 250 miles. Jumpers controlled 36 fires with an average force of five men per fire, and controlled 94 percent of them within the same size class as when attacked.

Distance Traveled to Fires

Analysis of individual fire reports showed only the following general relationships between distance traveled according to final fire size, and whether action was taken: Fifty-six percent of all reported fires occurred within 100 miles of headquarters. Sixty percent of action fires occurred within 100 miles compared to only 20 percent of those on which no action was taken. Only 12 percent of action fires occurred at distances greater than 200 miles compared with 39 percent for no-action fires. One-third of the fires larger than 300 acres are farther than 200 miles away from headquarters. More than two-thirds are farther than 100 miles away. This situation will always prevail simply because it takes

Table 16.—**Percent of fires controlled within each class of time lapse from initial attack by final size class**

(Av. 1950-58)

Final size class	Time lapse (hours) 0-1	1-2	2-3	3-6	6-12	12-24	24-48	48-72	72+
	Percent								
A	73	12	5	8	1	[1]	[1]	[1]	0
B	31	17	13	16	8	8	4	1	2
C	11	8	9	23	19	12	8	3	7
D	3	5	13	10	22	16	13	5	13
E	1	1	2	5	11	11	16	12	41
Av.	30	11	9	14	10	8	6	3	9

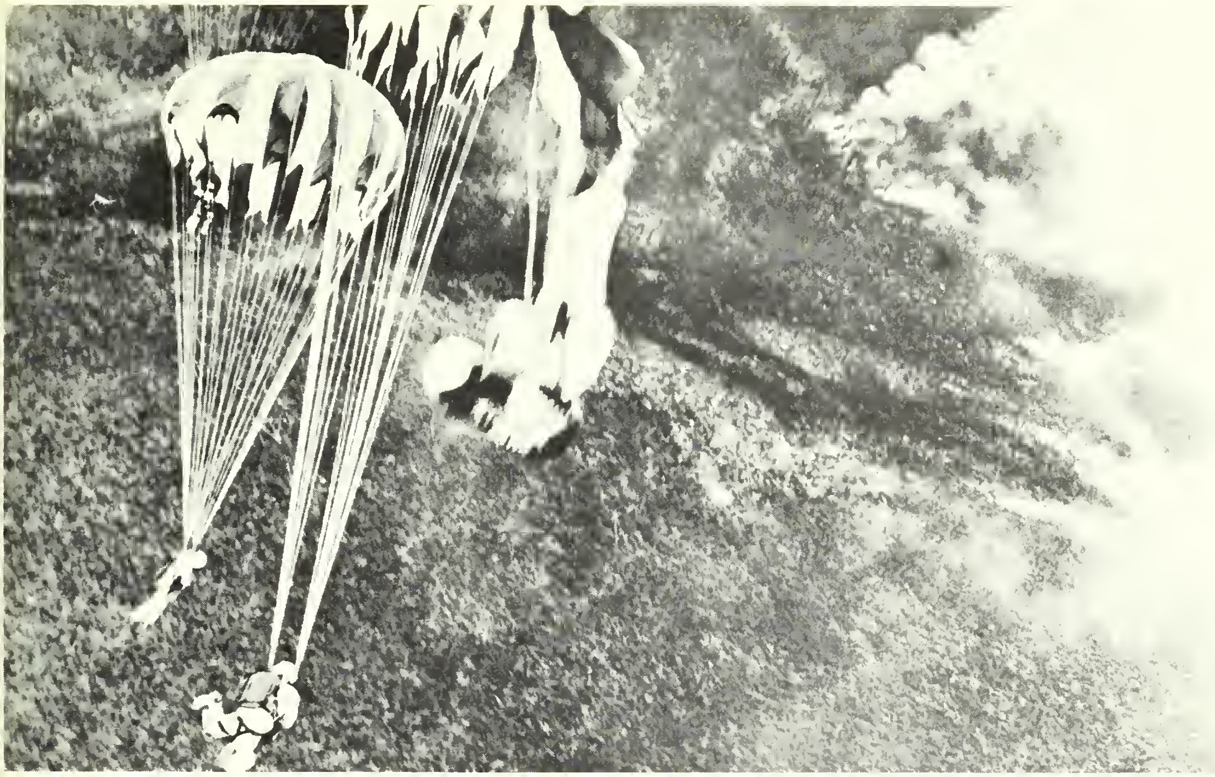
[1]Less than 1.0 percent.

longer to go greater distances. But when greater distance from headquarters is coupled with longer time between fire origin and detection, only larger fires yet can be expected. Again reduction of detection time would far more than pay its way.

Time From Attack to Control

Table 16 based on records of 986 fires confirms what one would expect to be the relation between the length of time required to control a fire and the final size of the fire; namely, the longer it takes to bring a fire under control, the larger the final acreage will be.

Figure 73. — Such large fires are difficult and expensive to control.



A USFS

B USFS

Figure 74. — Aerial fire attack: A, smokejumpers drop on Christian Village fire, 1960; thin diagonal line in upper right is strip of retardant; B, timely jumper attack may assure early control.

A BLM

B BLM

Figure 75. — Fighting fires: A, handline construction is still the mainstay; B, military equipment assists in emergencies.

The number of extra-period fires measures two things — effectiveness of the fire control organization, and severity of the fire season. An extra-period fire is one not controlled by 10 A.M. of the day following *discovery*. The BLM fire report data allowed only the following approximation to be attained: a fire not controlled within 24 hours from *initial attack*. With this in mind, the figures comparing Interior Alaska (1950-58) with Region 1, USFS (1954-60) are remarkably close.

Size of fire	Ratio of extra-period fires to total number of fires	
	Interior Alaska	Region 1 USFS
	Percent	
10 acres or less	4	6
More than 10 acres	36	35

However, if the Alaska data were based on the time between discovery and control, the percentage of extra-period fires, for the larger fires at least, would certainly be much greater in Alaska.

Forward Behavior of Fires at Time of Attack

The importance of early attack is illustrated in table 17. Usually fires with large final size are more violent in behavior at time of attack than small ones. Outstanding extremes in the spruce type are indicated by the fact that 70 percent of Class A fires are smoldering when attacked, but 47 percent of Class E fires are crowning when attacked. If fires could be reached while still small and before they start to run, the total control effort would be considerably lessened, as would also the loss and damage. That goal can never be completely reached, as some fires may begin running and crowning almost immediately after they start; however, this information about behavior must be kept in mind as an important factor in both fire control planning and dispatching.

Table 17.—**Forward behavior of fires in spruce type at time of initial attack by percent within each behavior class and by size classes**

(Av. 1950-58)

Final size class	Behavior				
	Smoldering	Creeping	Running	Spotting	Crowning
	Percent				
A	70	31	12	25	7
B	19	39	41	25	17
C	6	18	22	19	19
D	2	5	5	12	10
E	3	7	20	19	47

FIRE AS A MANAGEMENT TOOL

Use of fire in forest management is at times a controversial issue, but many protection and silvicultural objectives that could not be attained economically by any other means are being achieved through proper use of fire. Helmers (1960, p. 467) states, primarily in reference to southeastern Alaska, but possibly for many parts of Interior Alaska:

The possibility that fire can be used for silvicultural purposes is pure conjecture at this time. However, there is a need for reduction in slash volumes to reduce the physical impediment to regeneration as well as to reduce the fire danger in newly regenerated cutting. The seedbeds in cutover areas can be improved to advantage. These factors alone make controlled use of fire a tool worth investigation.

A USFS

B USFS

C USFS

Figure 76. — Use of fire: A, slash hazard, Kenai Peninsula; B, timber resource suffers from poor planning; C, example of current practice of windrowing slash resulting from land-clearing operations.

Lutz (1960) recognizes that fire properly used can, even in boreal forests, become a valuable silvicultural tool. He does not believe that the present forester or wildlife manager has sufficient knowledge ". . . to enable him to use prescribed burning on anything more than a purely experimental basis. There is a great opportunity and need for research on this problem" (p. 460). He also proposes investigating the use of fire to manipulate the position of the permafrost table for silvicultural benefit.

Ecological research performed within boreal forests in Sweden indicates results similar to those in Interior Alaska. Uggla (1958a), in comparing the effects of controlled fires and wildfire, states that controlled burns on slightly moist ground is the most efficient method of activating humus materials for natural seedbed preparation. He further states, "A feeble forest fire, on not too dry raw humus ground, can be compared with a controlled burning, but on poor, dry soils, uncontrolled forest fires can have devastating effects. . . . On such soils the activating effects of the fire soon disappear. Since also the addition of litter will be very inconsiderable for a long time, degeneration of the forest soil often results" (p. 5).

Prescribed burning techniques for safe and effective land clearing in the Fairbanks area were explored by Johnson (1958, 1959) and Gettinger and Johnson (1959); they found it quite feasible to obtain a good clear burn without endangering the surrounding woods, but only if certain sound practices were pursued.

As yet untapped are means for fully using fire as an effective tool in furthering forest management objectives. Research in fire and silviculture should aid in determining when and how fire should be used and when it should not be used.

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APPENDIX

Table 18.--Monthly and annual normal precipitation

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Interior Basin													
Bettles	0.73	0.39	0.88	0.37	1.05	1.18	1.37	3.09	2.25	1.44	0.69	0.57	14.01
Big Delta	.38	.16	.34	.28	.64	2.31	2.99	1.98	1.43	.50	.29	.33	11.63
Fairbanks	.99	.51	.58	.29	.74	1.37	1.92	2.26	1.21	.92	.63	.50	11.92
Fort Yukon	.38	.34	.28	.17	.32	.71	.96	1.28	.81	.57	.41	.29	6.52
Galena 1/	.77	.81	.74	.18	.63	1.69	2.69	2.84	2.4	.6	.6	.6	14.55
Lake Minchumina 2/													
McGrath	1.14	1.15	.98	.49	.94	2.06	2.32	3.63	2.41	1.67	1.09	1.25	19.13
Northway	.61	.34	.22	.35	.72	2.00	2.89	1.81	1.18	.49	.36	.37	11.34
Summit	1.01	1.33	1.32	.54	.98	2.13	3.38	3.37	3.35	1.89	1.43	1.52	22.25
Tanana	.81	.59	.58	.26	.73	1.26	2.39	2.89	1.99	1.05	.63	.57	13.75
Arctic Drainage													
Kotzebue	.47	.32	.27	.36	.33	.49	1.53	1.95	.94	.58	.43	.35	8.02
West Central													
Bethel	.90	.82	.92	.55	.89	1.20	2.29	4.02	3.01	1.75	.97	.85	18.17
Unalakleet 2/													
Cook Inlet													
Anchorage	.76	.58	.60	.40	.51	.89	1.55	2.56	2.71	1.87	1.00	.84	14.27
Homer	2.39	1.40	1.64	1.33	1.00	1.07	1.66	2.89	2.79	3.74	2.55	2.76	25.22
Bristol Bay													
Iliamna	1.20	.95	1.33	1.01	1.35	1.54	2.80	5.03	3.99	3.20	1.50	1.88	25.78
Naknek	.94	1.24	1.19	.83	1.28	1.52	3.10	4.14	3.49	2.73	1.30	1.21	22.97
Copper River													
Gulkana	.79	.42	.37	.21	.41	1.19	2.12	1.87	2.13	.74	.66	.79	11.70

1/ Data for Sept.-Dec. not given in climatological summary, but obtained through correspondence.
2/ Not sufficient records to establish a mean precipitation.

Source: U. S. Weather Bureau, Climatological Data, Annual Summary, 1958.

Table 19.--Percent of normal annual precipitation for the period March through August

Area	March	April	May	June	July	Aug.	Total precipitation March - August Percent	Total precipitation March - August Inches	Annual Inches
Interior Basin									
Bettles	6.3	2.6	7.5	8.4	9.8	22.1	56.7	7.94	14.01
Big Delta	2.9	2.4	5.5	19.9	25.7	17.0	73.4	8.54	11.63
Fairbanks	4.9	2.4	6.2	11.5	16.1	19.0	60.1	7.16	11.92
Ft. Yukon	4.3	2.6	4.9	10.9	14.8	19.6	57.1	3.72	6.52
Galena	5.1	1.3	4.3	11.6	18.6	19.5	60.4	8.77	14.52
Lake Minchumina	No record								
McGrath	5.1	2.6	4.9	10.8	12.1	19.0	54.5	10.42	19.13
Northway	1.9	3.1	6.3	17.6	25.6	16.0	70.5	7.99	11.34
Summit	5.9	2.4	4.5	9.6	15.2	15.1	52.7	11.72	22.25
Tanana	4.2	1.9	5.3	9.2	17.4	21.0	59.0	8.11	13.75
Arctic Drainage									
Kotzebue	3.3	4.5	4.1	6.1	19.2	24.3	61.5	4.93	8.02
West Central									
Bethel	5.1	3.0	4.9	6.5	12.6	22.1	54.2	9.85	18.17
Unalakleet	No record								
Cook Inlet									
Anchorage	4.2	2.8	3.6	6.2	10.9	17.9	45.6	6.51	14.27
Homer	6.5	5.3	4.0	4.2	6.6	11.4	38.0	9.59	25.22
Bristol Bay									
Iliamna	5.2	3.9	5.2	6.0	10.9	19.5	50.7	13.06	25.78
Naknek	5.2	3.6	5.6	6.6	13.5	18.0	52.5	12.06	22.97
Copper River									
Gulkana	3.2	1.8	3.5	10.2	18.1	16.0	57.7	6.17	11.70

Source: United States Weather Bureau, Climatological Data, Annual Summary, 1958.

Table 20.--Departure from 9-year average precipitation by number of days per month in each intensity class

1950

ANCHORAGE

	Precipitation in hundredths of an inch							
	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
				April				
Total	20	9	1	0	0	0		
Dep. from Av.	1.8	2.0	-2.7	-.9	-.1	-.1		
				May				
Total	16	12	3	0	0			0
Dep. from Av.	.2	1.2	-.4	-.6	-.3			-.1
				June				
Total	12	5	8	4	0	1		
Dep. from Av.	-2.4	-1.9	2.9	1.2	-.5	.7		
				July				
Total	8	12	7	3	1	0	0	
Dep. from Av.	-4.6	5.7	.9	-.3	-1.1	-.4	-.2	
				August				
Total	15	10	2	2	2	0	0	
Dep. from Av.	4.0	3.9	-5.2	-1.5	0	-1.1	-.1	

FAIRBANKS

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
				April				
Total	26	3	1	0				
Dep. from Av.	4.3	-2.7	-1.4	-.2				
				May				
Total	16	8	5	2	0	0		
Dep. from Av.	-1.1	-.1	8	.9	-.4	-.1		
				June				
Total	15	7	7	0	0	1	0	
Dep. from Av	2.5	-1.2	1.5	-2.3	-1.1	.8	-.2	
				July				
Total	13	2	10	3	2	1	0	
Dep. from Av.	-1.1	-4.2	4.0	4	1.0	0	-.1	
				August				
Total	17	5	5	3	1	0		
Dep. from Av.	5.9	-2.5	-3.2	-.4	.7	-.4	-.1	

GALENA

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
				April				
Total	19	6	2	1	2			
Dep. from Av.	1.2	-1.0	-2.5	.5	1.8			
				May				
Total	19	10	2	0	0	0		
Dep. from Av.	4.3	.2	-2.5	-1.6	-.3	-.1		
				June				
Total	11	7	8	3	0	1	0	
Dep. from Av.	-3.7	.3	2.2	1.1	-.4	.6	-.1	
				July				
Total	12	10	5	2	[illegible]	0		
Dep. from Av.	-1.0	3.6	-1.3	-1.1	.4	-.6		
				August				
Total	10	6	5	5	5	0		
Dep. from Av.	1.6	-.8	-2.1	-1.0	3.8	-1.5		

HOMER

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
				April				
Total	16	6	4	0	3	0	1	
Dep. from Av.	1.8	-.9	-1.4	-2.3	2.1	[illegible]	.9	
				May				
Total	13	11	5	2	0	0		
Dep. from Av.	-1.3	2.3	-1.0	.7	-.5	-.2		
				June				
Total	13	6	5	4	2	0		
Dep. from Av.	-2.1	-.4	.1	1.8	.7	-.1		
				July				
Total	10	9	10	1	1	0		
Dep. from Av.	-6.6	5.0	4.4	-2.4	0	-.4		
				August				
Total	18	4	3	4	2	0	0	
Dep. from Av.	4.0	.3	[illegible]	8	-.4	-1.5	-.2	

NORTHWAY

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
				April				
Total	23	[illegible]	1	0	0			
Dep. from Av.	3.0	-.7	-1.9	-.2	-.2			
				May				
Total	11	8	9	3	0	0		
Dep. from Av.	-4.9	.9	4.5	6	-.9	[illegible]		
				June				
Total	16	7	4	3	0	0		
Dep. from Av.	4.1	-.6	-1.8	.1	-1.0	-.8		
				July				
Total	7	8	6	5	[illegible]	0	2	
Dep. from Av.	-4.8	1.4	-1.0	1.4	1.7	-.3	1.6	
				August				
Total	[illegible]	8	6	1	0		0	
Dep. from Av.	4.3	.7	-1.8	-1.7	-1.4		-.1	

BIG DELTA

	Precipitation in hundredths of an inch							
	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
				April				
Total	25	2	3	0				
Dep. from Av.	3.8	-3.4	-.2	-.2				
				May				
Total	17	7	5	1	1	0	0	
Dep. from Av.	-2.8	1.5	1.5	-.4	.5	-.2	-.1	
				June				
Total	20	2	6	1	1	0	0	
Dep. from Av.	5.3	-3.8	.9	-1.2	-.2	-.6	-.4	
				July				
Total	14	4	7	2	1	3	0	
Dep. from Av.	-.3	-1.5	.4	.3	-.8	2.0	-.1	
				August				
Total	16	4	4	4	1	2		
Dep. from Av.	2.4	-2.0	[illegible]	1.5	-1.1	[illegible]		

FT. YUKON

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
				April				
Total	25	2	3	0	0			
Dep. from Av.	1.9	-1.5	.1	-.4	-.1			
				May				
Total	20	6	5	0	0			
Dep. from Av.	-2.8	.8	2.6	-.4	-.2			
				June				
Total	25	1	4	0	0	0		
Dep. from Av.	4.8	-2.6	-.7	-1.0	-.3	-.2		
				July				
Total	23	5	3	0	0			
Dep. from Av.	2.0	.7	-.7	-1.7	-.3			
				August				
Total	20	9	1	0	1	0		
Dep. from Av.	2.5	3.4	-3.9	-1.6	-.3	-.1		

GULKANA

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
				April				
Total	27	2	1	0				
Dep. from Av.	4.6	-2.2	-1.6	-.8				
				May				
Total	17	14	0	0	0			
Dep. from Av.	-2.3	6.6	-3.5	-.5	-.3			
				June				
Total	16	7	2	5	0	0		
Dep. from Av.	.2	1.8	-3.1	2.2	-.5	-.2		
				July				
Total	14	3	8	3	2	[illegible]	0	
Dep. from Av.	-1.5	.1	.6	[illegible]	1.5	-.8	-.1	
				August				
Total	19	7	[illegible]	1	1	0		
Dep. from Av.	[illegible]	[illegible]	-4.5	-1.9	[illegible]	[illegible]		

McGRATH

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
				April				
Total1/	19	[illegible]	2	3	0			
Dep. from Av.	.7	-1.3	-1.9	.9	-.2			
				May				
Total	17	7	5	2	0	0		
Dep. from Av.	1.9	-1.7	.2	.3	-.5	[illegible]		
				June				
Total	9	9	2	6	2	0	[illegible]	
Dep. from Av.	-1.0	-.6	3.9	2.8	1.4	-.4	1.7	
				July				
Total	9	8	4	4	[illegible]	[illegible]	0	
Dep. from Av.	[illegible]	1.9	[illegible]	[illegible]	[illegible]	-.6	-.2	
				August				
Total	10	3	9	3	4	2	[illegible]	
Dep. from Av.	2.4	[illegible]	.3	-2.6	1.2	.3	[illegible]	

See footnote at end of table.

Table 2[illegible].--Departure from [illegible]-year average precipitation by number of days per month in each intensity class--Continued

1953

ANCHORAGE

	Precipitation in hundredths of an inch							
	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	16	11	2	1	0	0		
Dep. from Av.	-2.2	4.[illegible]	-1.7	1	-.1	-.1		
May								
Total	15	11	2	2	1			0
Dep. from Av.	-.8	.2	-1.4	1.4	.7			-.1
June								
Total	17	6	4	3	0	0		
Dep. from Av.	2.6	-.9	-1.1	.2	-.5	-.3		
July								
Total	15	8	5	1	2	0	0	
Dep. from Av.	2.4	1.7	-1.1	-2.3	-.1	-.4	-.2	
August								
Total	8	3	7	5	5	3	0	
Dep. from Av.	-3.0	-3.1	-.2	1.5	3.0	1.9	-.1	

BIG DELTA

	Precipitation in hundredths of an inch							
	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	22	7	1	0				
Dep. from Av.	.8	1.6	-2.2	-.2				
May								
Total	12	6	9	2	1	1	0	
Dep. from Av.	-7.8	.5	5.5	.6	.5	.8	-.1	
June								
Total	14	3	7	3	2	0	1	
Dep. from Av.	-.7	-2.8	1.9	.8	.8	-.6	.6	
July								
Total	16	4	7	1	2	1	0	
Dep. from Av.	1.7	-1.5	.4	-.7	.2	0	-.1	
August								
Total	10	7	9	1	4	0		
Dep. from Av.	-3.6	1.0	3.0	-1.5	1.9	-.8		

FAIRBANKS

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	24	5	1	[illegible]				
Dep. from Av.	2.3	-.7	-1.4	-.2				
May								
Total	15	[illegible]	9	[illegible]	1	[illegible]		
Dep. from Av.	2.1	-2.1	4.8	-1.1	.6	-.1		
June								
Total	11	12	3	2	1	0	1	
Dep. from Av.	-1.5	3.[illegible]	-2.5	-.3	-.1	-.2	.8	
July								
Total	17	4	4	[illegible]	1	0	[illegible]	
Dep. from Av.	2.9	-2.2	-2.[illegible]	[illegible]	[illegible]	-1.[illegible]	-.1	
August								
Total	[illegible]	9	9	3	1		1	
Dep. from Av.	[illegible]	1.[illegible]	[illegible]	[illegible]	[illegible]	-.4	.9	

FT. YUKON

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	28	1	1	0	0			
Dep. from Av.	4.9	-2.5	-1.9	-.4	-.1			
May								
Total	26	4	1	0	0			
Dep. from Av.	3.2	-1.2	-1.4	-.4	-.2			
June								
Total	21	2	4	2	1	0		
Dep. from Av.	.8	-1.6	-.7	1.0	.7	-.2		
July								
Total	20	1	9	1	0			
Dep. from Av.	-1.[illegible]	-3.3	5.3	-.7	-.3			
August								
Total	19	5	4	1	2	0		
Dep. from Av.	1.5	-.6	-.9	-.6	.7	-.1		

GALENA

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	[illegible]	[illegible]	[illegible]	[illegible]				
Dep. from Av.	[illegible]	[illegible]	[illegible]	[illegible]	-.2			
May								
Total	[illegible]	11	4	[illegible]	[illegible]	1		
Dep. from Av.	-2.7	[illegible]	-.5	1.4	[illegible]	.9		
June								
Total	[illegible]	8	[illegible]	[illegible]	1	[illegible]	1	
Dep. from Av.	[illegible]	1.[illegible]	[illegible]	1.1	[illegible]	.4	.9	
July								
Total	[illegible]	[illegible]	[illegible]	1	1			
Dep. from Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
August								
Total	[illegible]	11			1	4		
Dep. from Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		

GULKANA

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	24	3	2	1				
Dep. from Av.	1.6	-1.2	-.6	.2				
May								
Total	18	9	4	0	0			
Dep. from Av.	-1.3	1.6	.5	-.5	-.3			
June								
Total	14	5	8	3	0	0		
Dep. from Av.	-2.2	-.2	2.9	.2	-.5	-.2		
July								
Total	17	6	2	5	1	0	0	
Dep. from Av.	1.5	3.1	-5.4	2.2	-.5	-.8	-.1	
August								
Total	8	7	11	2	2	1		
Dep. from Av.	-5.4	2.0	3.2	-.9	.7	.4		

HOMER

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	[illegible]	7	[illegible]	2	[illegible]			
Dep. from Av.	[illegible]		-2.4	[illegible]	[illegible]	[illegible]	[illegible]	
May								
Total	[illegible]	[illegible]	[illegible]	[illegible]	4	1		
Dep. from Av.	[illegible]	-.7	[illegible]	[illegible]	[illegible]	[illegible]		
June								
Total	[illegible]	[illegible]	[illegible]		2			
Dep. from Av.	[illegible]	[illegible]	[illegible]	2.2	.7	[illegible]		
July								
Total	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		
Dep. from Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-.4		
August								
Total	[illegible]	[illegible]	[illegible]	4	4	[illegible]	[illegible]	
Dep. from Av.	[illegible]	-.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

McGRATH

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	18	6	5	1	0	[illegible]		
Dep. from Av.	-.3	-.3	1.1	-.1	-.2	-.2		
May								
Total	7	14	4	4	1	1		
Dep. from Av.	-8.1	5.3	-.8	2.3	.5	.8		
June								
Total	9	11	8	1	0	1	0	
Dep. from Av.	-1.0	1.4	2.1	-2.2	-.6	.6	-.3	
July								
Total	[illegible]	5	6	3	1	0	0	
Dep. from Av.	4.3	-1.1	-1.0	.2	-1.6	-.6	-.2	
August								
Total	4	3	12	5	2	5	0	
Dep. from Av.	-3.6	-1.3	3.3	-.8	-.8	3.3	-.1	

NORTHWAY

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total 1/	[illegible]	7	[illegible]					
Dep. from Av.	[illegible]	[illegible]	[illegible]					
May								
Total	11	[illegible]		[illegible]	[illegible]			
Dep. from Av.	-4.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
June								
Total 1/	19	7	[illegible]	[illegible]				
Dep. from Av.	7.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
July								
Total	[illegible]	[illegible]	[illegible]	2	1	[illegible]	[illegible]	
Dep. from Av.	[illegible]	[illegible]		[illegible]	[illegible]	7	.4	
August								
Total	[illegible]	6	9	4	[illegible]		[illegible]	
Dep. from Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	

See footnote at end of table.

Table 20.--Departure from 9-year average precipitation by number of days per month in each intensity class--Continued

1954

ANCHORAGE

	Precipitation in hundredths of an inch							
	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
	April							
Total	25	4	1	0	0	0		
Dep. from Av.	6.8	-3.0	-2.7	-.9	-.1	-.1		
	May							
Total	17	10	4	0	0			0
Dep. from Av.	1.2	-.8	.6	-.6	-.3			-.1
	June							
Total	15	9	2	3	1	0		
Dep. from Av.	.6	2.1	-3.1	.2	.5	-.3		
	July							
Total	12	6	7	3	3	0	0	
Dep. from Av.	-.6	-.3	.9	-.3	.9	-.4	-.2	
	August							
Total	12	6	6	4	2	1	0	
Dep. from Av.	1.0	-.1	-1.2	.5	0	-.1	-.1	

FAIRBANKS

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
	April							
Total	22	8	0	0				
Dep. from Av.	.3	2.3	-2.4	-.2				
	May							
Total	24	4	2	1	0	0		
Dep. from Av.	6.9	-4.1	-2.2	-.1	-.4	-.1		
	June							
Total	14	8	2	3	3	0	0	
Dep. from Av.	1.5	-.2	-3.5	.7	1.9	-.2	-.2	
	July							
Total	13	6	4	5	1	1	1	
Dep. from Av.	-1.1	-.2	-2.0	2.4	0	0	.9	
	August							
Total	9	10	9	3	0	0	0	
Dep. from Av.	-2.1	2.5	.8	-.4	-.3	-.4	-.1	

GALENA

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
	April							
Total	23	4	2	1	0			
Dep. from Av.	5.2	-3.0	-2.5	.5	-.2			
	May							
Total	21	7	3	0	0	0		
Dep. from Av.	6.3	-2.8	-1.5	-1.6	-.3	-.1		
	June							
Total	21	2	4	2	1	0	0	
Dep. from Av.	6.3	-4.7	-1.8	.1	.6	-.4	-.1	
	July							
Total	10	10	3	3	4	1		
Dep. from Av.	3.0	3.6	-3.3	-.1	2.4	.4		
	August							
Total	8	7	6	9	1	0		
Dep. from Av.	-.4	.2	-1.1	3.0	-.2	-1.5		

HOMER

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
	April							
Total	23	6	1	0	0	0	0	
Dep. from Av.	8.8	-.9	-4.4	-2.3	-.9	-.2	-.1	
	May							
Total	15	9	5	2	0	0		
Dep. from Av.	.7	.3	-1.0	.7	-.5	-.2		
	June							
Total	18	10	1	1	0	0		
Dep. from Av.	2.9	3.6	-3.9	-1.2	-1.3	-.1		
	July							
Total	17	3	5	5	1	0		
Dep. from Av.	.4	-1.0	-.6	1.6	0	-.4		
	August							
Total	14	3	4	3	3	4	0	
Dep. from Av.	0	-.7	-2.0	-.2	.6	2.5	-.2	

NORTHWAY

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
	April							
Total	18	9	3	0	0			
Dep. from Av.	-2.0	2.3	.1	-.2	-.2			
	May							
Total	19	7	1	0	3	1		
Dep. from Av.	3.1	-.1	-3.5	-2.4	2.1	.8		
	June							
Total	7	9	8	4	1	1		
Dep. from Av.	-4.9	1.4	2.2	1.1	0	.2		
	July							
Total	7	11	10	2	1	0	0	
Dep. from Av.	-4.8	4.4	3.0	-1.6	-.3	-.3	-.4	
	August							
Total	17	6	6	1	1	0	0	
Dep. from Av.	5.3	-1.3	-1.8	-1.7	- 4	0	-.1	

BIG DELTA

	Precipitation in hundredths of an inch							
	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
	April							
Total	19	7	4	0				
Dep. from Av.	-2.2	1.6	.8	-.2				
	May							
Total	21	4	2	3	1	0	0	
Dep. from Av.	1.2	-1.5	-1.5	1.6	.5	-.2	-.1	
	June							
Total	13	8	4	1	2	1	1	
Dep. from Av.	-1.7	2.2	-1.1	-1.2	.8	.4	.6	
	July							
Total	12	5	10	1	2	1	0	
Dep. from Av.	-2.3	-.5	3.4	-.7	.2	0	-.1	
	August							
Total	16	7	3	3	2	0		
Dep. from Av.	2.4	1.0	-3.0	.5	-.1	-.8		

FT. YUKON

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
	April							
Total	27	2	1	0	0			
Dep. from Av.	3.9	-1.5	-1.9	-.4	-.1			
	May							
Total	28	1	2	0	0			
Dep. from Av.	5.2	-4.2	-.4	-.4	-.2			
	June							
Total	17	4	8	1	0	0		
Dep. from Av.	-3.2	.4	3.3	0	-.3	-.2		
	July							
Total	15	6	3	6	1			
Dep. from Av.	-6.0	1.7	-.7	4.3	.7			
	August							
Total	17	3	9	0	2	0		
Dep. from Av.	-.5	-2.6	4.1	-1.6	.7	-.1		

GULKANA

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
	April							
Total	30	0	0	0				
Dep. from Av.	7.6	-4.2	-2.6	-.8				
	May							
Total	19	6	5	0	1			
Dep. from Av.	-.3	-1.4	1.5	-.5	.7			
	June							
Total	18	4	5	2	1	0		
Dep. from Av.	1.8	-1.2	-.1	-.8	.5	-.2		
	July							
Total	14	2	10	1	4	0	0	
Dep. from Av.	-1.5	-.9	2.6	-1.8	2.5	-.8	-.1	
	August							
Total	16	3	7	4	1	0		
Dep. from Av.	2.6	-2.0	-.8	1.1	-.3	-.6		

McGRATH

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
	April							
Total	20	6	3	1	0	0		
Dep. from Av.	1.7	-.3	-.9	-.1	-.2	-.2		
	May							
Total	26	1	3	1	0	0		
Dep. from Av.	10.9	-7.7	-1.8	-.7	-.5	-.2		
	June							
Total	12	9	2	5	1	1	0	
Dep. from Av.	2.0	-.6	-3.9	1.8	.4	.6	-.3	
	July							
Total	10	8	6	0	4	3	0	
Dep. from Av.	-1.7	1.9	-1.0	-2.8	1.4	2.4	-.2	
	August							
Total	11	4	7	3	5	1	0	
Dep. from Av.	3.4	-.3	-1.7	-2.8	2.2	-.7	-.1	

See footnote at end of table.

Table 20.--Departure from 9-year average precipitation by number of days per month in each intensity class--Continued

1957

ANCHORAGE

	Precipitation in hundredths of an inch							
	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	[illegible]	3	1	0	0	0		
Dep. from Av.	[illegible]	1.	-2.7	-.9	-.1	-.1		
May								
Total	[illegible]	7	1					[illegible]
Dep. from Av.	7.[illegible]	[illegible]	-2.4	-.6	-.3			-.1
June								
Total	[illegible]	3	2	3	[illegible]	0		
Dep. from Av.	[illegible]	-4.9	-3.1	.2	-.5	-.2		
July								
Total	[illegible]	3	5	6	1	0	0	
Dep. from Av.	[illegible]4	3.3	-1.1	2.7	1.1	.4	.2	
August								
Total	[illegible]	2	8	3	[illegible]	[illegible]	[illegible]	
Dep. from Av.	[illegible]	-4.1	[illegible]	[illegible]	[illegible]	-.1	-.1	

FAIRBANKS

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	[illegible]	4	[illegible]					
Dep. from Av.	[illegible]	[illegible].7	[illegible]	[illegible]				
May								
Total	[illegible]	[illegible]	4	[illegible]				
Dep. from Av.	[illegible]	[illegible]	[illegible]	[illegible]	.4	[illegible]		
June								
Total	[illegible]	5	[illegible]	[illegible]				
Dep. from Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
July								
Total	[illegible]	[illegible]	4	[illegible]				
Dep. from Av.	[illegible]	[illegible].8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
August								
Total	[illegible]	[illegible]	[illegible]	2				
Dep. from Av.	4.3	[illegible]	[illegible]	[illegible].4	[illegible]	-.4	[illegible]	

GALENA

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	[illegible]	[illegible]	[illegible]	[illegible]				
Dep. from Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
May								
Total	[illegible]	[illegible]	2	[illegible]	[illegible]			
Dep. from Av.	[illegible]	-4	[illegible]	[illegible].4	[illegible]			
June								
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
Dep. from Av.	[illegible]	-4.7	[illegible]	[illegible].9	[illegible]	[illegible]	[illegible]	
July								
Total	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]		
Dep. from Av.	[illegible]	[illegible]	[illegible]	[illegible]	.4	[illegible]		
August								
Total	[illegible]	7	[illegible]	7	[illegible]	[illegible]		
Dep. from Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		

NOME

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	[illegible]	7	[illegible]	[illegible]				
Dep. from Av.	[illegible]	[illegible]	[illegible].4	.7		[illegible]	[illegible]	
May								
Total	[illegible]	[illegible]	[illegible]					
Dep. from Av.	4.7	[illegible]7	-4.[illegible]	.7	[illegible]	.2		
June								
Total	[illegible]	[illegible]	[illegible]					
Dep. from Av.	[illegible]	-4.4	[illegible].9	[illegible]	1.[illegible]	[illegible]		
July								
Total	17		[illegible]		1	[illegible]		
Dep. from Av.	[illegible]4	-4.[illegible]	.4	[illegible]	[illegible]	[illegible]		
August								
Total	19	1	[illegible]	[illegible]	[illegible]	[illegible]		
Dep. from Av.	[illegible]	-[illegible].7	-1.[illegible]	[illegible]	[illegible]	-1.[illegible]		

NORTHWAY

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	17	[illegible]	[illegible]					
Dep. from Av.	[illegible]	[illegible]	[illegible]		[illegible]			
May								
Total	[illegible]	[illegible]	7		[illegible]			
Dep. from Av.	[illegible]	-3.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
June								
Total	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		
Dep. from Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
July								
Total	14	3	9	1	[illegible]	[illegible]		
Dep. from Av.	[illegible]	[illegible]	[illegible]	-2.[illegible]	.7	.7	-.1	
August								
Total	Data missing							
Dep. from Av.								

BIG DELTA

	Precipitation in hundredths of an inch							
	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	19	5	6	0				
Dep. from Av.	-2.2	-.4	2.8	-.2				
May								
Total	23	6	2	0	0	0	0	
Dep. from Av.	3.2	.5	-1.5	-1.4	-.5	-.2	-.1	
June								
Total	18	6	2	3	1	0	0	
Dep. from Av.	3.3	.2	-3.1	.8	-.2	-.6	-.4	
July								
Total	16	4	7	1	2	1	0	
Dep. from Av.	1.7	-1.5	.4	-.7	.2	0	-.1	
August								
Total	18	5	4	1	2	1		
Dep. from Av.	4.4	-1.0	-2.0	-1.5	-.1	.2		

FT. YUKON

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	26	3	0	1	0			
Dep. from Av.	[illegible].9	[illegible]	[illegible].9	.6	-.1			
May								
Total	23	5	2	1	[illegible]			
Dep. from Av.	[illegible]	-.2	-.4	.6	-.2			
June								
Total	[illegible]	2	5		[illegible]			
Dep. from Av.	2.[illegible]	[illegible]	.3	[illegible]	[illegible]	[illegible]		
July								
Total	21	7	[illegible]	1	[illegible]			
Dep. from Av.		2.7	-[illegible].7	-.7	-.3			
August								
Total	[illegible]	5		0	1	[illegible]		
Dep. from Av.	4.[illegible]	.4	-[illegible].9	-1.6	-.3	[illegible]		

GULKANA

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	22	4	4	0				
Dep. from Av.	-[illegible]	-.2	1.4	-.8				
May								
Total	[illegible]	8	4	1	0			
Dep. from Av.	1.[illegible]	.6	.5	.5				
June								
Total	16	4	5	5	0			
Dep. from Av.	-[illegible]	-1.[illegible]	-.1	[illegible]				
July								
Total	17	1	[illegible]	4	[illegible]			
Dep. from Av.	1.5	-[illegible].9	1.4	1.2	[illegible]		[illegible]	-.1
August								
Total	[illegible]	3	3	3	0	[illegible]		
Dep. from Av.	[illegible]	[illegible]	-4.8	.1	-.[illegible]			

McGRATH

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	[illegible]	4	[illegible]					
Dep. from Av.	2.7	[illegible]	1.1	-1.1	[illegible]			
May								
Total	19	5	4	2	[illegible]	[illegible]		
Dep. from Av.	3.9	[illegible].7	-.8	.3	[illegible]	[illegible]		
June								
Total	19	6	3	2	0	[illegible]		
Dep. from Av.	9.0	-3.6	-2.9	-1.2	[illegible]	[illegible]	[illegible]	
July								
Total	14	8	6	3	[illegible]	[illegible]		
Dep. from Av.	2.3	1.9	-1.0	.2	[illegible]	[illegible]	[illegible]	
August								
Total	7	10	[illegible]	[illegible]	[illegible]			
Dep. from Av.	-.6	5.7	.7	.2	[illegible]	.7	[illegible]	

See footnote at end of table.

Table 20.--Departure from 9-year average precipitation by number of days per month in each intensity class--Continued

1958

ANCHORAGE

	Precipitation in hundredths of an inch							
	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	22	3	4	1	0	0		
Dep. from Av.	3.8	-4.0	.3	.1	-.1	-.1		
May								
Total	12	8	7	3	1			0
Dep. from Av.	-3.8	-2.8	3.6	2.4	.7			-.1
June								
Total	15	4	7	2	0	2		
Dep. from Av.	.6	-2.9	1.9	-.8	-.5	1.7		
July								
Total	8	6	9	2	3	2	1	
Dep. from Av.	-4.6	-.3	2.9	-1.3	.9	1.6	[illegible]	
August								
Total	12	6	7	5	1	0	1	
Dep. from Av.	1.0	-.1	-.2	1.5	-1.0	1.1	-.1	

BIG DELTA

	Precipitation in hundredths of an inch							
	0	Tr	1-.9	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	4	5	1	0				
Dep. from Av.	[illegible]	-.4	-2.[illegible]	-.2				
May								
Total	12	7	1	0	0	0	0	
Dep. from Av.	3.2	1	-3.5	-1.4	-.5	-.2	-.1	
June								
Total	17	[illegible]	[illegible]	1	1	0	0	
Dep. from Av.	2.3	[illegible]	-.1	1.[illegible]	-.2	-.1	-.4	
July								
Total	15	11	2	2	[illegible]	[illegible]		
Dep. from Av.	.7	[illegible]	-4.[illegible]	.3	-1.[illegible]	[illegible]	-.1	
August								
Total	15	11	2	3				
Dep. from Av.	1.4	5.0	-4.0	-.5	-2.1			

FAIRBANKS

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	21	7	2	0				
Dep. from Av.	-.7	[illegible]	-.4	-.2				
May								
Total	18	9	2	1	1	0		
Dep. from Av.	.9	9	-2.2	-.1	.6	-.1		
June								
Total	11	10	4	3	2	0	0	
Dep. from Av	-1.5	1.	-1.[illegible]	.7	.9	-.2	-.[illegible]	
July								
Total	13	10	5	1	1	1	[illegible]	
Dep. from Av.	-1.1	2.8	-1.0	-1.6		0	-.1	
August								
Total	9	12	8	2	2	0	[illegible]	
Dep. from Av.	-2.1	4.5	-.2	-1.4	-.3	-.4	-.1	

FT. YUKON

	0	Tr	1-.9	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	[illegible]	7	2	1				
Dep. from Av.	-4.[illegible]	[illegible]	-.9	.6	[illegible]			
May								
Total	21	[illegible]	3	1	[illegible]			
Dep. from Av.	1.[illegible]		.6	[illegible]	[illegible]			
June								
Total	22	2	4	2	[illegible]			
Dep. from Av.	1.[illegible]	-1.[illegible]	-.7	1.[illegible]	[illegible]	[illegible]		
July								
Total	11	[illegible]	1	1				
Dep. from Av.	.0	1.7	-2.7	[illegible]	7			
August								
Total	[illegible]	[illegible]	[illegible]	2				
Dep. from Av.	[illegible]	[illegible]	[illegible]	.4	7	[illegible]		

GALENA

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	19	6	5	0	0			
Dep. from Av.	1.2	-1.1	.5	-.5	-.3			
May								
Total	12	11	6	2	0	0		
Dep. from Av.	-2.7	1.2	1.5	.4	-.7	-.1		
June								
Total	9	4	12	3	1	1	0	
Dep. from Av.	-5.7	-2.7	6.2	1.1	.6	.5	.1	
July								
Total	Data missing							
Dep. from Av.								
August								
Total	Data missing							
Dep. from Av.								

GULKANA

	0	Tr	1-.9	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	17	[illegible]	[illegible]	0				
Dep. from Av.	-2.4	[illegible]	[illegible]	-.8				
May								
Total	12	12	3	2				
Dep. from Av.	-4.3	[illegible]	-.5	1.5	[illegible]			
June								
Total	22	1	3	1	0	[illegible]		
Dep. from Av.	5.[illegible]	-1.[illegible]	-3.1	-1.9	-.5			
July								
Total	14	4	8	3	1	1	0	
Dep. from Av.	-1.5	1.1	.6	.2	-.5	.2	-.1	
August								
Total	14	4	7	2	3	1		
Dep. from Av.	.6	-1.0	-.8	-.9	1.7	.4		

HOMER

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	17	4	4	5	0	0	0	
Dep. from Av.	2.8	2.9	-1.4	2.7	-.9	-.2	-.1	
May								
Total	8	8	12	2	1	0		
Dep. from Av.	-6.3	-.7	6.0	.7	.5	-.2		
June								
Total	11	9	4	5	1	0		
Dep. from Av.	-4.1	2.6	-.9	2.8	-.3	-.1		
July								
Total	14	3	6	5	2	1		
Dep. from Av.	-2.6	-1.0	.4	1.6	1.0	.6		
August								
Total	12	4	8	5	0	2	0	
Dep. from Av.	-2.0	.3	2.0	1.8	-2.4	.5	-.2	

McGRATH

	0	Tr	1-.9	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	20	8	1	0	1	0		
Dep. from Av.	1.7	1.7	-2.9	-1.1	.8	-.2		
May								
Total	12	10	3	1	0	0		
Dep. from Av.	-3.1	1.3	3.[illegible]	-.7	-.5	.2		
June								
Total	6	9	10	5	0	0	0	
Dep. from Av.	-4.0	-.6	4.1	1.8	-.6	-.4	-.3	
July								
Total	8	6	10	5	0	2	0	
Dep. from Av.	-3.7	-.1	3.0	2.2	-2.6	1.4	-.2	
August								
Total	6	2	12	6	4	1	0	
Dep. from Av.	-1.6	-2.3	3.3	.2	1.2	-.7	-.1	

NORTHWAY

	0	Tr.	01-09	10-25	26-49	50-99	1.00-1.99	2.00+
April								
Total	26	2	1	0	1			
Dep. from Av.	6.0	-4.7	1.9	-.2	.8			
May								
Total	16	7	4	3	1	0		
Dep. from Av.	.1	-.1	-.5	.6	.1	-.2		
June								
Total	23	1	4	2	0	0		
Dep. from Av.	11.1	-6.6	-1.8	-.9	-1.0	-.8		
July								
Total	13	6	9	1	1	1	0	
Dep. from Av.	1.2	-.6	2.[illegible]	-2.6	-.3	.7	-.4	
August								
Total	14	6	5	2	3		1	
Dep. from Av.	2.3	-1.3	-2.4	-.7	1.6		.9	

1/ Discrepancy in basic data.

Table 21.--Monthly precipitation and departure from normal

Area	January		February		March		April		May		June		July		August		September		October		November		December		Total		Apr.-Aug. Total	
	Amt	Dep	Amt	Dep	Amt	Dep	Amt	Dep	Amt	Dep	Amt	Dep	Amt	Dep	Amt	Dep	Amt	Dep	Amt	Dep	Amt	Dep	Amt	Dep	Amt	Dep	Amt	Dep
1950																												
Interior Basin																												
Big Delta	1.13	.84	.06	-.15	.69	.44	.07	-.28	.71	.00	.61	-1.82	3.37	.21	2.27	.41	.43	-.88	.69	.29	.53	.24	.26	.08	10.82	-.78	7.03	-1.17
Fairbanks	2.00	1.12	.25	-.25	.52	-.14	.03	-.28	.52	-.15	.86	-.56	2.50	.60	1.17	-1.00	.31	-.95	.51	-.36	.99	.31	.39	-.19	10.05	-1.85	5.08	-1.50
Fort Yukon	.68	.26	.06	-.35	.27	-.05	.07	-.19	.13	-.32	.07	-.73	.06	-.94	.32	-.91	.62	-.09	.50	-.14	.48	.10	.57	.26	3.83	-3.10	.65	-2.79
Galena	1.21	.63	.12	-.63	.18	-.63	.80	.66	.12	-1.33	1.88	.64	1.07	-1.60	2.58	-.25	1.87	.31	.26	-.36	.33	-.20	1.12	.23	11.54	-2.33	6.45	-1.58
McGrath	1.80	.68	.07	-1.23	.03	-1.11	.67	.28	.52	-.51	4.36	2.44	2.84	.46	2.82	-.76	2.13	-.29	.44	-1.42	.51	-.62	.98	-.32	17.17	-2.40	11.21	1.77
Northway	98	.38	.04	-.38	.11	-.15	.03	-.37	.99	.30	.58	-1.42	4.83	1.94	.39	-1.83	.54	-.90	.23	-.31	.31	-.04	.44	.06	9.47	-2.72	6.82	-.95
Cook Inlet																												
Anchorage	.83	-.01	Tr	-.67	.29	-.26	.04	-.37	.10	-.40	1.90	1.20	.97	-.66	.92	-1.68	1.07	-1.51	.52	-1.66	.26	-.78	1.71	.86	8.61	-5.94	3.93	-1.98
Homer	71	-1.98	.16	-1.41	1.08	-.77	2.75	1.48	.50	-.64	1.40	.38	1.02	-.74	1.34	-1.78	2.63	-2.84	2.36	-1.57	.08	-2.32	1.44	-1.37	15.47	-13.56	7.01	-.94
Copper River																												
Gulkana	86	-.03	.39	-.04	Tr	-.45	.06	-.37	Tr	-.47	.81	-.42	2.81	.70	.53	-1.33	1.75	.17	.44	-.42	.87	.22	.73	-.23	9.25	-2.67	4.21	-1.59
1953																												
Interior Basin																												
Big Delta	04	- 34	.30	.14	.16	-.18	.04	-.24	1.81	1.17	2.67	.36	2.05	-.94	1.77	.21	.63	-.80	.31	-.19	.03	-.26	.18	-.15	9.99	-1.64	8.34	.14
Fairbanks	.12	-.87	27	-.24	.20	-.38	.01	-.28	.64	-.10	1.85	.48	1.37	-.55	2.97	71	1.32	.11	.11	-.81	Tr	-.63	.13	-.37	8.99	-2.93	6.84	.26
Fort Yukon	.19	-.19	.22	-.12	.12	-.16	.01	-.16	.02	- 30	1.00	.29	.66	-.30	1.16	-.12	.89	.06	.45	-.12	.20	-.21	.67	.38	5.59	-.93	2.85	-.59
Galena	.10	-.67	1.03	.22	.20	-.54	.11	-.07	1.38	.75	2.15	.46	.69	-2.00	4.02	1.18	1.10	-1.27	.34	-.30	.21	-.43	.35	-.27	11.68	-2.94	8.35	.32
McGrath	.27	-.87	.97	-.18	.18	-.80	.24	-.25	1.98	1.04	1.12	-.94	1.15	-1.17	5.86	2.23	1.86	-.55	.33	-1.34	.21	-.88	.61	-.64	14.78	-4.35	10.35	.91
Northway	07	-.54	.06	-.28	.12	-.10	.11	-.24	1.35	.63	4.00	2.00	1.24	-1.65	2.12	.31	.95	-.23	.41	-.08	.07	-.29	.24	-.13	10.74	-.60	8.82	1.05
Cook Inlet																												
Anchorage	.20	-.56	.48	-.10	.21	-.39	.15	-.25	.76	.25	.57	-.32	1.14	-.41	5.06	2.50	1.85	-.86	.81	-1.06	.11	-.89	1.11	.27	12.45	-1.82	7.68	1.77
Homer	98	-1.41	3.57	2.17	21	-1.43	1.49	.16	2.04	1.04	.74	-.33	.16	-1.50	4.81	1.92	2.43	-.36	3.82	.08	2.74	.19	2.20	-.56	25.19	-.03	9.24	1.29
Copper River																												
Gulkana	18	-.61	.62	.20	.47	.10	.18	-.03	.18	-.23	.72	-.47	1.09	-1.03	2.08	.21	1.39	-.74	.71	-.03	.15	-.51	.92	.13	8.69	-3.01	4.25	-1.55
1954																												
Interior Basin																												
Big Delta	.48	.10	.05	-.11	.20	-.14	.13	-.15	1.15	.51	3.37	1.06	2.06	-.93	1.49	-.49	2.06	.63	.38	-.12	.19	-.10	.31	-.02	11.87	.24	8.20	.00
Fairbanks	.55	-.44	.21	-.30	.60	.02	Tr	-.29	.17	-.57	1.78	.41	3.22	1.30	.84	-1.42	1.82	.61	.08	-.84	.42	-.21	.48	-.02	10.17	-1.75	6.01	-.83
Fort Yukon	58	.20	.27	-.07	.28	.00	.01	-.16	.10	-.22	.41	-.30	1.26	.30	.92	-.36	.77	-.04	.41	-.16	.84	.43	.79	.50	6.64	.12	2.70	-.74
Galena	.19	-.58	.18	-.63	.35	-.39	.23	.05	.09	-.54	.95	-.74	2.81	.12	1.79	-1.05	1.87	-.50	.41	-.23	.45	-.19	.44	-.18	9.76	-4.86	5.87	-2.16
McGrath	.63	-.51	.28	-.87	1.04	.06	.29	-.20	.34	-.60	1.83	-.23	4.73	2.41	3.22	-.41	3.59	1.18	.73	-.94	1.85	.76	1.43	.18	19.98	.83	10.41	.97
Northway	.16	-.45	.15	-.19	.18	-.04	.14	-.21	1.52	.80	1.71	-.29	1.21	-1.68	.60	-1.21	.90	-.28	.21	-.28	.19	-.17	.51	.14	7.48	-3.86	5.18	-2.59
Cook Inlet																												
Anchorage	.56	-.20	18	-.40	.97	.37	.03	-.37	.15	-.36	.91	.02	2.08	.53	2.13	-.43	1.66	-1.05	2.02	.15	.93	-.07	1.00	.16	12.62	-1.65	5.30	-.61
Homer	1.12	-1.27	.76	-.64	1.93	.29	.01	-1.32	.43	-.57	.26	-.81	1.90	.24	4.13	1.24	1.47	-1.32	4.63	.89	2.44	-.11	1.34	-1.42	20.42	-4.80	6.73	-1.22
Copper River																												
Gulkana	33	-.46	.52	.10	.22	-.15	.00	-.21	.39	-.02	.69	-.50	1.94	-.18	1.48	-.39	1.75	-.38	.86	.12	.61	-.05	.84	.05	9.63	-2.07	4.50	-1.30
1957																												
Interior Basin																												
Big Delta	1.35	.97	1.33	1.17	.46	.12	.11	-.17	.03	-.61	1.05	-1.26	1.92	-1.07	1.65	-.33	.72	-.71	.63	.13	.09	-.20	.56	.23	9.90	-1.73	4.76	-3.44
Fairbanks	1.92	.93	.56	.05	.15	-.43	.08	-.21	.07	-.67	.21	-1.16	.40	-1.52	.40	-1.86	.47	-.74	.74	-.18	.30	-.33	.25	-.25	5.55	-6.37	1.16	-5.68
Fort Yukon	.56	.18	.38	.04	.22	-.06	.13	-.04	.23	-.09	.22	-.49	.27	-.69	.38	-.90	.58	-.23	.45	-.12	.49	.08	.26	-.03	4.17	-2.35	1.23	-2.21
Galena	1.10	.33	.79	-.02	.49	-.25	.17	-.01	.73	.10	.18	-1.51	1.40	-1.29	2.14	-.70	1.76	-.61	1.00	.36	1.63	.99	.49	-.13	11.88	-2.74	4.62	-3.41
McGrath	3.67	2.53	1.11	-.04	.72	-.26	.19	-.30	.82	-.12	.42	-1.64	.79	-1.53	1.21	-2.42	2.17	-.24	1.43	-.24	1.53	.44	.53	-.72	14.59	-4.54	3.43	6.01
Northway	43	-.18	.47	.13	.29	.07	.43	.08	1.21	.49	2.12	.12	2.51	-.38		Missing	data				.37	.01	.43	.06				
Cook Inlet																												
Anchorage	1.36	.60	67	.09	.20	-.40	.01	-.39	.02	-.49	.56	-.33	1.64	.09	2.02	-.54	3.21	.50	.93	-.94	1.51	.51	.36	-.48	12.49	-1.78	4.25	-1.66
Homer	.94	-1.45	.83	-.57	.42	-1 22	.76	-.57	.37	-.63	.09	-.98	2.26	.60	3.04	.15	4.30	1.51	3.63	-.11	6.00	3.45	2.35	-.41	24.99	-.23	6.52	-1.43
Copper River																												
Gulkana	.51	-.28	.49	.07	.09	-.28	.11	- 10	.42	.01	1.04	-.15	2.67	.55	.66	-1.21	3.41	1.28	1.56	.82	.51	-.15	.41	-.38	11.88	.18	4.90	-.90
1958																												
Interior Basin																												
Big Delta	.38	-.03	.06	-.10	.36	.02	.01	-.27	.08	-.56	.79	-1.52	1.07	-1.92	.96	-1.02	.75	-.68	.90	.40	.44	.15	.25	-.08	6.02	-5.61	2.91	-5.29
Fairbanks	31	-.68	.07	-.44	.24	-.34	.09	-.20	.57	-.17	1.01	-.36	1.42	-.50	.61	-1.65	.46	-.75	.84	-.08	.40	-.23	.41	-.09	6.43	-5.49	3.70	-3.14
Fort Yukon	.68	.30	07	-.27	.26	-.02	.15	-.02	.17	-.15	.39	-.32	.82	-.14	.97	-.31	.22	-.59	1.22	.65	1.17	.76	.34	.05	6.46	-.06	2.50	-.94
Galena	.80	.03	.21	-.60	.59	-.15	.11	-.07	.47	-.16	1.69	.00	3.53	.84	2.46	-.38		Missing	data								8.26	.23
McGrath	.36	-.78	.15	-.97	.64	-.34	.32	-.17	.44	-.50	1.10	-.96	2.88	.56	3.73	.10	2.95	.54	.81	-.86	.68	-.41	.17	-1.08	14.26	-4.87	8.47	-.97
Northway	.20	-.41	.18	-.16	.16	-.06	.43	.08	.76	.04	.51	-1.49	1.47	-1.42	2.94	1.13	1.07	-.11	1.05	.56	.32	-.04	.23	-.14	9.32	-2.02	6.11	-1.66
Cook Inlet																												
Anchorage	1.05	.29	.07	-.51	.19	-.41	.25	-.15	1.05	.54	2.19	1.30	4.44	2.89	1.67	-.89	1.31	-1.40	1.93	.06	1.41	.41	.54	-.30	16.10	1.83	9.60	3.69
Homer	3 74	1.35	.48	-.92	1.69	.05	.88	-.45	1.12	.12	1.12	.05	2.48	.82	2.89	.00	2.37	-.42	2.08	-1.66	4.72	2.17	1.05	-1.71	24.62	-.60	8.49	.54
Copper River																												
Gulkana	1.02	.23	.24	-.18	.33	-.04	.01	-.20	.33	-.08	.29	-.90	1.73	-.39	2.02	.15	1.10	-1.03	1.66	.92	.84	.18	.87	.08	10.44	-1.26	4.38	-1.42

Source: USWB Climatological Data, Alaska Annual Summary, for the years mentioned.

Table 22.--Precipitation intensity classes, according to frequency of occurrence by decades of the month

(Av. 1950-58)

ANCHORAGE

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
April								
1-10	5.8	2.0	2.0	0.1		0.1		
11-20	5.8	3.0	.7	.3	0.1			
21-30	6.6	2.0	1.0	.5				
Total	18.2	7.0	3.7	.9	.1	.1		
May								
1-10	5.8	2.8	1.3	.1	.1			
11-20	4.1	4.4	.9	.3	.1			.1
21-31	5.9	3.6	1.2	.2	.1			
Total	15.8	10.8	3.4	.6	.3			.1
June								
1-10	5.4	2.7	1.3	.6	.1			
11-20	4.4	1.9	2.0	1.2	.1	.3		
21-30	4.6	2.3	1.8	1.0	.3			
Total	14.4	6.9	5.1	2.8	.5	.3		
July								
1-10	4.3	2.0	1.9	.9	.8	.1		
11-20	4.1	2.3	1.8	1.0	.7		0.1	
21-31	4.2	2.0	2.4	1.4	.6	.3	.1	
Total	12.6	6.3	6.1	3.3	2.1	.4	.2	
August								
1-10	3.7	1.7	2.4	1.3	.4	.6		
11-20	4.9	1.9	2.4	.4	.4	.1		
21-31	2.4	2.5	2.4	1.8	1.2	.4	.1	
Total	11.0	6.1	7.2	3.5	2.0	1.1	.1	

BETHEL

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
April								
1-10	4.6	3.3	2.0	.2				
11-20	3.9	.2	3.1	.4	0.3			
21-30	3.1	.7	3.4	.7	.1			
Total	11.6	8.2	8.5	1.3	.4			
May								
1-10	4.7	2.9	1.6	.7	.1			
11-20	3.6	2.6	.9	.7	.2	0.1		
21-31	3.7	3.1	2.3	1.4	.3	.1		
Total	12.0	8.6	6.8	2.8	.6	.2		
June								
1-10	2.7	2.8	2.4	1.8	.3	.1		
11-20	3.0	3.3	2.0	1.2	.3	.1		
21-30	3.9	2.4	2.6	.8	.3			
Total	9.6	8.5	7.0	3.8	.9	.2		
July								
1-10	3.9	2.0	2.1	1.3	.7			
11-20	2.9	2.1	2.9	1.3	.8			
21-31	2.5	2.1	4.2	1.2	.7	.1	0.2	
Total	9.3	6.2	9.2	3.8	2.2	.1	.2	
August								
1-10	1.1	2.3	3.6	1.0	1.0	.6	.2	
11-20	2.4	1.2	2.9	2.0	.9	.7		.1
21-31	1.2	1.9	3.2	2.9	.8	.7	.3	
Total	4.7	5.4	9.7	5.9	2.7	2.0	.5	.1

BETTLES

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
April								
1-10	5.4	2.8	1.3	0.3	0.1			
11-20	6.8	1.9	1.1	.1	.1			
21-30	7.1	1.9	.9	.2				
Total	19.3	6.6	3.3	.6	.2			
May								
1-10	6.9	1.4	1.2	.4				
11-20	6.3	2.4	1.1	.3	.1			
21-31	5.2	3.8	1.3	.1	.4	0.1		
Total	18.4	7.6	3.6	.8	.5	.1		
June								
1-10	6.8	1.3	1.0	.8	.2			
11-20	4.4	3.2	1.1	.6	.2	.3	0.1	
21-30	4.8	2.3	1.9	.7	.2	.1		
Total	16.0	6.8	4.0	2.1	.6	.4	.1	
July								
1-10	5.1	1.9	2.1	.7	.1	.1		
11-20	6.3	2.1	1.0	.4	.2			
21-31	4.9	1.8	1.8	1.3	1.0	.2		
Total	16.3	5.8	4.9	2.4	1.3	.3		
August								
1-10	3.4	2.0	2.6	1.1	.8	.1		
11-20	3.4	2.9	1.6	.9	.9	.3		
21-31	3.4	2.7	2.0	1.2	.9	.6	.2	
Total	10.2	7.6	6.2	3.2	2.6	1.0	.2	

BIG DELTA

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
April								
1-10	6.7	1.9	1.4					
11-20	7.4	1.6	.8	.2				
21-30	7.1	1.9	1.0					
Total	21.2	5.4	3.2	.2				
May								
1-10	6.2	2.3	1.3	.2	0.1			
11-20	7.9	1.2	.3	.3	.1	.1		
21-31	5.7	2.0	1.9	.9	.3	.1	0.1	
Total	19.8	5.5	3.5	1.4	.5	.2	.1	
June								
1-10	6.8	1.9	1.1	.2	.1			
11-20	4.2	1.6	2.0	1.0	.7	.4	.1	
21-30	3.7	2.3	2.0	1.0	.4	.2	.3	
Total	14.7	5.8	5.1	2.2	1.2	.6	.4	
July								
1-10	5.4	1.7	1.7	.4	.3	.3	.1	
11-20	4.4	1.9	2.1	.3	.7	.4		
21-31	4.5	1.9	2.8	1.0	.8	.3		
Total	14.3	5.5	6.6	1.7	1.8	1.0	.1	
August								
1-10	4.7	2.1	1.8	.8	.3	.3		
11-20	4.4	2.0	1.9	.7	.8	.2		
21-31	4.5	1.9	2.3	1.0	1.0	.3		
Total	13.6	6.0	6.0	2.5	2.1	.8		

FAIRBANKS

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
April								
1-10	6.7	2.3	1.0					
11-20	7.4	1.8	.7	0.1				
21-30	7.6	1.6	.7	.1				
Total	21.7	5.7	2.4	.2				
May								
1-10	6.1	2.1	1.6	.3				
11-20	5.9	2.8	.9	.4				
21-31	5.1	3.2	1.7	.4	0.4	0.1		
Total	17.1	8.1	4.2	1.1	.4	.1		
June								
1-10	5.9	2.6	1.1	.2	.2			
11-20	2.9	3.4	2.1	.8	.6	.1	0.1	
21-30	3.7	2.2	2.3	1.3	.3	.1	.1	
Total	12.5	8.2	5.5	2.3	1.1	.2	.2	
July								
1-10	5.2	2.2	1.4	.9	.1	.2		
11-20	4.6	1.7	2.2	.6	.3	.6	.1	
21-31	4.3	2.3	2.4	1.1	.6	.2		
Total	14.1	6.2	6.0	2.6	1.0	1.0	.1	
August								
1-10	3.7	2.8	2.2	1.0	.1	.2		
11-20	4.6	2.6	2.1	.7				
21-31	2.8	2.1	3.9	1.7	.2	.2	.1	
Total	11.1	7.5	8.2	3.4	.3	.4	.1	

FT. YUKON

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
April								
1-10	6.9	1.6	1.4	0.1				
11-20	7.6	1.0	1.2	.2				
21-30	8.6	.9	.3	.1	0.1			
Total	23.1	3.5	2.9	.4	.1			
May								
1-10	7.3	1.2	1.2	.1	.1			
11-20	8.2	1.7	.3					
21-31	7.3	2.3	.9	.3	.1			
Total	22.8	5.2	2.4	.4	.2			
June								
1-10	7.9	1.1	.8	.1	.1			
11-20	6.9	.7	1.7	.6	.1	0.1		
21-30	5.4	1.8	2.2	.3	.1	.1		
Total	20.2	3.6	4.7	1.0	.3	.2		
July								
1-10	6.9	1.3	1.6	.4				
11-20	6.9	1.6	.9	.3	.2			
21-31	7.2	1.4	1.2	1.0	.1			
Total	21.0	4.3	3.7	1.7	.3			
August								
1-10	6.8	2.3	.7	.3	.1			
11-20	5.4	1.4	2.1	.4	.4	.1		
21-31	5.3	1.9	2.1	.9	.8			
Total	17.5	5.6	4.9	1.6	1.3	.1		

Table 2[illegible].--Precipitation intensity classes, according to frequency of occurrence by decades of the month--Continued

(Av. 1950-58)

GALENA

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
				April				
1-10	5.6	2.0	2.1	0.3	0.1			
11-20	6.0	2.7	1.2		.1			
21-30	6.2	2.3	1.2	.2				
Total	17.8	7.0	4.5	.5	.2			
				May				
1-10	5.9	2.9	.9	.3				
11-20	4.3	3.0	2.0	.4	.2			
21-31	4.5	3.9	1.6	.9	.1	0.1		
Total	14.7	9.8	4.5	1.6	.3	.1		
				June				
1-10	4.7	2.3	2.1	.4	.2	.2		
11-20	5.3	2.2	1.8	.7			0.1	
21-30	4.7	2.2	1.9	.8	.2	.2		
Total	14.7	6.7	5.8	1.9	.4	.4	.1	
				July				
1-10	4.0	2.4	2.1	1.1	.2	.1		
11-20	4.4	2.2	1.8	.6	.8	.2		
21-31	4.6	1.8	2.4	1.4	.6	.3		
Total	13.0	6.4	6.3	3.1	1.6	.6		
				August				
1-10	3.7	2.2	2.2	1.1	.6	.3		
11-20	2.8	2.8	2.0	1.8	.3	.3		
21-31	1.9	1.8	2.9	3.1	.3	.9		
Total	8.4	6.8	7.1	6.0	1.2	1.5		

GULKANA

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
				April				
1-10	7.3	1.1	1.3	0.1				
11-20	7.6	1.6	.6	.6				
21-30	7.5	1.5	.7	.1				
Total	22.4	4.2	2.6	.8				
				May				
1-10	6.2	2.8	.7	.3				
11-20	6.9	1.8	1.1	.1	0.1			
21-31	6.2	2.8	1.7	.1	.2			
Total	19.3	7.4	3.5	.5	.3			
				June				
1-10	7.2	1.2	1.1	.3	.1			
11-20	3.9	2.3	2.7	.9	.2			
21-30	5.1	1.7	1.3	1.6	.2	0.2		
Total	16.2	5.2	5.1	2.8	.5	.2		
				July				
1-10	5.8	.6	2.3	.4	.7	.1		
11-20	4.0	1.6	2.9	1.1	.2	.1	0.1	
21-31	5.7	.7	2.2	1.3	.6	.6		
Total	15.5	2.9	7.4	2.8	1.5	.8	.1	
				August				
1-10	5.7	1.1	1.7	.4	.9	.2		
11-20	4.2	2.0	2.9	.7	.2			
21-31	3.5	1.9	3.2	1.8	.2	.4		
Total	13.4	5.0	7.8	2.9	1.3	.6		

HOMER

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
				April				
1-10	5.0	1.9	2.0	0.9	.1	0.1		
11-20	4.4	2.2	1.8	.8	.6	.1	0.1	
21-30	4.8	2.8	1.6	.6	.2			
Total	14.2	6.9	5.4	2.3	.9	.2	.1	
				May				
1-10	5.3	2.7	1.4	.4	.1	.1		
11-20	4.2	2.6	2.5	.6	.2			
21-31	4.8	3.4	2.1	.3	.2	.1		
Total	14.3	8.7	6.0	1.3	.5	.2		
				June				
1-10	5.2	2.3	1.6	.6	.3			
11-20	4.2	2.4	2.0	.7	.6	.1		
21-30	5.7	1.7	1.3	.9	.4			
Total	15.1	6.4	4.9	2.2	1.3	.1		
				July				
1-10	5.2	1.4	1.7	1.6	.2			
11-20	5.4	1.3	2.0	.8	.1	.3		
21-31	6.0	1.3	1.9	1.0	.7	.1		
Total	16.6	4.0	5.6	3.4	1.0	.4		
				August				
1-10	4.9	1.1	1.8	.9	.8	.6		
11-20	5.1	1.2	1.8	1.2	.3	.3	.1	
21-31	4.0	1.4	2.4	1.1	1.3	.6	.1	
Total	14.0	3.7	6.0	3.2	2.4	1.5	.2	

ILIAMNA

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
				April				
1-10	5.1	2.2	1.8	0.6	0.2			
11-20	4.3	2.7	1.6	.7	.6	0.2		
21-30	4.8	2.9	1.4	.7	.2			
Total	14.2	7.8	4.8	2.0	1.0	.2		
				May				
1-10	4.7	2.6	1.8	.8	.1			
11-20	4.4	3.0	1.4	.8	.2	.1		
21-31	4.6	3.2	2.7	.6				
Total	13.7	8.8	5.9	2.2	.3	.1		
				June				
1-10	4.1	2.9	1.2	1.1	.7	.1		
11-20	4.2	2.3	2.2	.7	.4	.1		
21-30	4.3	2.1	1.8	1.1	.6	.1		
Total	12.6	7.3	5.2	2.9	1.7	.3		
				July				
1-10	4.0	1.2	2.7	1.3	.4	.3		
11-20	4.6	1.6	1.8	1.4	.4	.3		
21-31	4.8	1.7	2.1	1.1	.9	.4		
Total	13.4	4.5	6.6	3.8	1.7	1.0		
				August				
1-10	3.9	1.4	2.1	1.3	.3	.9		
11-20	3.3	1.8	2.0	1.1	.9	.6	0.3	
21-31	1.9	2.0	2.6	1.8	1.1	1.1	.6	
Total	9.1	5.2	6.7	4.2	2.3	2.6	.9	

KOTZEBUE

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
				April				
1-10	4.0	3.9	1.9	0.2				
11-20	5.4	2.7	1.9					
21-30	5.2	2.7	1.7	.4				
Total	14.6	9.3	5.5	.6				
				May				
1-10	6.1	2.2	1.7	.1				
11-20	5.4	2.0	2.1	.4				
21-31	5.6	3.9	1.1	.4				
Total	17.1	8.1	4.9	.9				
				June				
1-10	5.7	1.8	1.7	.9				
11-20	5.9	2.9	.8	.3	0.1			
21-30	4.4	2.8	2.2	.3	.1	0.1		
Total	16.0	7.5	4.7	1.5	.2	.1		
				July				
1-10	4.6	1.7	2.2	1.0	.3	.2		
11-20	5.9	2.3	.9	.7	.1	.1		
21-31	4.3	2.0	3.2	1.0	.3	.2		
Total	14.8	6.0	6.3	2.7	.7	.5		
				August				
1-10	2.1	2.5	2.3	1.0	1.1	.9		
11-20	2.7	2.7	2.2	1.2	.6	.7		
21-31	2.7	2.3	2.6	2.2	.7	.4	0.1	
Total	7.5	7.5	7.1	4.4	2.4	2.0	.1	

LAKE MINCHUMINA

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
				April				
1-10	6.4	2.3	1.2		0.1			
11-20	8.1	1.0	.8	0.1				
21-30	7.6	1.1	1.1	.2				
Total	22.1	4.4	3.1	.3	.1			
				May				
1-10	6.8	2.2	1.3	.3		0.1		
11-20	5.8	2.9	1.2	.1				
21-31	5.8	1.9	1.3	.9	.1	.3		
Total	18.4	7.0	3.8	1.3	.1	.4		
				June				
1-10	5.1	2.4	2.2	.2	.1			
11-20	3.6	2.9	1.4	1.7	.2	.1	0.1	
21-30	4.6	1.9	2.4	.8	.2	.1		
Total	13.3	7.2	6.0	2.7	.5	.2	.1	
				July				
1-10	5.0	2.4	1.1	1.0	.2	.2		
11-20	3.6	1.9	2.0	1.4	.7	.4		
21-31	3.2	2.1	3.8	1.3	.6	.1		
Total	11.8	6.4	6.9	3.7	1.5	.7		
				August				
1-10	3.5	2.2	2.9	1.2	.3			
11-20	4.3	2.0	1.3	1.4	.6	.2		0.1
21-31	2.2	2.8	3.1	1.3	.8	.7	.1	
Total	10.0	7.0	7.3	3.9	1.7	.9	.1	.1

Table 22.--Precipitation intensity classes, according to frequency of occurrence by decades of the month--Continued

(Av. 1950-58)

McGRATH

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
				April				
1-10	5.8	2.2	1.7	0.1		0.1		
11-20	6.6	1.7	1.1	.6	0.1	.1		
21-30	5.9	2.4	1.1	.4	.1			
Total	18.3	6.3	3.9	1.1	.2	.2		
				May				
1-10	5.6	2.9	1.2	.3				
11-20	4.7	2.7	1.8	.8	.1			
21-31	4.8	3.1	1.8	.6	.4	.2		
Total	15.1	8.7	4.8	1.7	.5	.2		
				June				
1-10	3.7	2.7	2.1	1.3			0.1	
11-20	2.7	3.3	2.2	.8	.6	.3	.1	
21-30	3.6	3.6	1.6	1.1		.1	.1	
Total	10.0	9.6	5.9	3.2	.6	.4	.3	
				July				
1-10	3.9	2.0	2.9	.4	.8			
11-20	3.7	2.1	1.4	1.6	.8	.2	.2	
21-31	4.1	2.0	2.7	.8	1.0	.4		
Total	11.7	6.1	7.0	2.8	2.6	.6	.2	
				August				
1-10	2.7	1.6	3.1	1.7	.4	.5		
11-20	3.3	1.4	2.3	1.4	1.2	.4		
21-31	1.6	1.3	3.3	2.7	1.2	.8	.1	
Total	7.6	4.3	8.7	5.8	2.8	1.7	.1	

NAKNEK

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
				April				
1-10	5.0	2.6	1.4	1.7	0.1			
11-20	4.0	2.1	2.7	.6	.2			
21-30	3.6	1.9	3.0	1.0	.1			
Total	12.6	6.6	7.1	3.3	.4			
				May				
1-10	4.0	2.8	2.3	.7	.2			
11-20	3.6	2.7	2.3	.9	.4	0.1		
21-31	3.4	3.6	1.9	1.9	.2			
Total	11.0	9.1	6.5	3.5	.8	.1		
				June				
1-10	3.4	2.8	2.2	.8	.6	.2		
11-20	2.9	2.8	2.9	1.4	.3	.2		
21-30	3.7	2.9	2.3	.4	.2			
Total	10.0	8.5	7.4	2.6	1.1	.4		
				July				
1-10	3.0	2.8	2.4	.9	.4	.3	0.1	
11-20	3.2	2.4	2.7	1.2	.2	.2		
21-31	3.4	2.8	3.1	1.0	.6	.3		
Total	9.6	8.0	8.2	3.1	1.2	.8	.1	
				August				
1-10	2.3	2.6	2.6	1.3	.7	.6		
11-20	2.1	2.9	2.4	1.6	.6	.3	.1	
21-31	2.0	.9	3.8	2.1	1.8	.2	.1	
Total	6.4	6.4	8.8	5.0	3.1	1.1	.2	

NORTHWAY

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
				April				
1-10	6.4	2.2	1.4					
11-20	7.3	2.1	.7		.1			
21-30	6.3	2.4	.8	0.2	.1			
Total	20.0	6.7	2.9	.2	.2			
				May				
1-10	5.6	2.2	1.6	.4	.2			
11-20	6.3	2.2	.9	.6				
21-31	4.0	2.7	2.0	1.4	.7	0.2		
Total	15.9	7.1	4.5	2.4	.9	.2		
				June				
1-10	4.6	3.1	1.7	.3	.1	.2		
11-20	4.3	2.4	1.8	.8	.7	.2		
21-30	3.0	2.1	2.3	1.8	.2	.4		
Total	11.9	7.6	5.8	2.9	1.0	.8		
				July				
1-10	4.6	1.6	2.1	1.2	.7			
11-20	3.2	2.2	2.6	1.2	.3	.1	0.3	
21-31	4.0	2.8	2.3	1.2	.3	.2	.1	
Total	11.8	6.6	7.0	3.6	1.3	.3	.4	
				August				
1-10	4.8	2.0	2.4	.4	.5			
11-20	3.2	2.4	2.3	1.5	.5		.1	
21-31	3.7	2.9	3.1	.8	.4			
Total	11.7	7.3	7.8	2.7	1.4		.1	

SUMMIT

Time of Day	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
				April				
1-10	5.3	1.7	2.2	0.7	0.1			
11-20	4.8	2.7	2.0	.4	.1			
21-30	5.4	2.6	1.8	.2				
Total	15.5	7.0	6.0	1.3	.2			
				May				
1-10	5.8	2.3	1.4	.3	.1	0.2		
11-20	4.2	3.4	1.8	.2	.3			
21-31	5.1	2.9	2.1	.7	.2			
Total	15.1	8.6	5.3	1.2	.6	.2		
				June				
1-10	4.9	2.6	1.1	1.1	.2	.1		
11-20	2.7	2.8	2.2	1.0	1.1	.2		
21-30	3.2	2.6	1.9	1.0	1.1	.2		
Total	10.8	8.0	5.2	3.1	2.4	.5		
				July				
1-10	3.8	2.7	2.2	.9	.4	.2		
11-20	3.3	2.2	1.7	1.2	1.4	.1		
21-31	3.7	1.4	1.4	2.0	1.4	.9	0.1	
Total	10.8	6.3	5.3	4.1	3.2	1.2	.1	
				August				
1-10	3.4	1.7	2.8	1.0	.6	.6		
11-20	3.4	1.9	2.3	1.3	.8	.2		
21-31	2.0	1.7	3.1	2.0	1.3	.6	.3	
Total	8.8	5.3	8.2	4.3	2.7	1.4	.3	

TANANA

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
				April				
1-10	6.3	2.6	0.9	0.2				
11-20	7.3	1.9	.7				0.1	
21-30	7.4	1.8	.7	.1				
Total	21.0	6.3	2.3	.3			.1	
				May				
1-10	6.5	2.6	.7	.2				
11-20	6.1	1.9	1.2	.3	0.2	0.1	.1	
21-31	5.9	2.7	1.6	.7	.2			
Total	18.5	7.2	3.5	1.2	.4	.1	.1	
				June				
1-10	6.2	2.1	1.2	.4	.1			
11-20	4.8	2.2	1.4	1.1	.1	.3		
21-30	4.9	2.3	1.6	.6	.6	.1		
Total	15.9	6.6	4.2	2.1	.8	.4		
				July				
1-10	5.3	1.9	1.8	.8	.2	.1		
11-20	5.3	1.9	1.3	.4	.9	.1		
21-31	4.9	2.1	1.2	1.7	1.0	.1		
Total	15.5	5.9	4.3	2.9	2.1	.3		
				August				
1-10	3.6	2.4	1.9	1.6	.2	.3		
11-20	4.0	2.3	2.3	.8	.4	.1		
21-31	3.2	1.6	2.8	1.6	1.0	.8	.1	
Total	10.8	6.3	7.0	4.0	1.6	1.2	.1	

UNALAKLEET

Time of Month	0	Tr.	.01-.09	.10-.25	.26-.49	.50-.99	1.0-1.99	2.0+
				April				
1-10	4.0	4.1	1.7	0.2				
11-20	5.4	3.3	1.0		0.2			
21-30	4.6	3.7	1.2	.6				
Total	14.0	11.1	3.9	.8	.2			
				May				
1-10	6.3	2.6	.6	.3	.2			
11-20	4.7	3.9	.8	.7				
21-31	4.3	5.4	1.1		.1			
Total	15.3	11.9	2.5	1.0	.3			
				June				
1-10	4.6	3.1	1.4	.4	.3	0.1		
11-20	3.8	4.4	.9	.8	.1			
21-30	4.6	3.6	1.1	.6	.1	.1		
Total	13.0	11.1	3.4	1.8	.5	.2		
				July				
1-10	4.4	3.6	.8	.9	.3			
11-20	3.8	2.7	2.[illegible]	1.1	.4	.1		
21-31	2.9	2.4	2.4	1.9	1.0	.3		
Total	11.1	8.7	5.2	3.9	1.7	.4		
				August				
1-10	1.9	1.8	2.8	1.4	1.2	.8	0.1	
11-20	2.1	2.3	2.1	1.6	1.0	.8	[illegible]	
21-31	2.1	2.0	2.9	2.0	1.1	.7	[illegible]	
Total	6.1	6.1	7.8	5.0	3.3	2.3	.4	

Source: United States Weather Bureau coded data.

Table 23.--Air temperature by hour of day, and number of days per month in each temperature class

(Av. 1950-58)

ANCHORAGE

Time of day	Temperature, degrees F. 1/ 30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	17.1	.7				
0900	15.6	10.1	0.4			
1200	10.8	15.9	2.2			
1500	9.0	16.8	3.6	0.2		
1800	13.3	14.6	.9	.1		
2100	19.0	6.2				
Av.	14.1	1[illegible].7	1.2	.1		
			May			
0300	13.7	10.1	.6			
0900	.2	19.2	1[illegible].9	.7		
1200		10.2	1[illegible].4	2.4		
1500		9.1	18.1	3.6	0.2	
1800	.1	15.4	12.8	2.7		
2100	[illegible]	24.[illegible]	4.8	.1		
Av.	2.[illegible]	15.7	10.9	1.6		
			June			
0300	.[illegible]	[illegible].3	1[illegible].6	.3		
0900		3.4	19.8	6.1	.7	
1200		1.4	15.9	11.4	1.2	0.1
1500		1.0	12.9	12.8	3.1	.2
1800		1.7	16.0	10.3	1.9	.1
2100		5.3	20.2	4.3	.2	
Av.	.1	5.2	15.9	7.5	1.2	.1
			July			
0300		[illegible].7	22.3	1.0		
0900			17.5	12.6	.9	
1200			9.7	17.0	4.3	
1500			8.0	16.7	6.0	.3
1800		.1	11.0	15.7	4.1	.1
2100		.2	21.2	9.4	.2	
Av.		1.3	14.9	12.1	2.6	.1
			August			
0300	.4	[illegible].6	21.2	.8		
0900		.6	21.3	9.0	.1	
1200			11.7	18.1	1.2	
1500		.1	8.3	19.8	2.8	
1800		.1	14.4	15.5	1.0	
2100	.1	[illegible]	24.0	4.9		
Av.	.1	1.9	16.8	11.4	.8	

BETHEL

Time of day	Temperature, degrees F. 30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	9.1	0.3				
0900	12.6	2.8				
1200	12.3	6.6	0.8			
1500	11.9	7.7	1.0			
1800	13.4	5.1	.9			
2100	11.8	1.9				
Av.	11.8	4.1	.4			
			May			
0300	19.2	7.4				
0900	9.7	13.8	5.7			
1200	6.1	11.6	11.0	1.3		
1500	4.4	12.2	11.2	2.3		
1800	5.8	13.4	9.2	2.0		
2100	9.2	15.8	3.9			
Av.	9.1	12.4	6.8	.9		
			June			
0300	3.8	20.2	6.0			
0900	.7	13.0	12.9	3.4		
1200	.1	7.3	13.2	8.4	1.0	
1500	.1	4.7	13.3	9.1	2.7	0.1
1800		5.2	13.7	8.6	2.4	.1
2100	.8	8.2	15.1	5.6	.3	
Av.	.9	9.8	12.4	5.8	1.1	
			July			
0300		14.1	16.9			
0900		5.2	18.6	6.8	.4	
1200		2.3	16.2	9.7	2.7	.1
1500		1.0	15.1	10.8	3.9	.2
1800		1.7	14.8	10.8	3.3	.4
2100		3.6	19.4	7.3	.7	
Av.		4.7	16.8	7.6	1.8	.1
			August			
0300	.3	14.7	16.0			
0900		6.1	23.1	1.8		
1200		1.6	23.1	5.6	.7	
1500		1.1	20.5	8.3	1.1	
1800		2.0	21.6	6.7	.7	
2100	.1	6.1	22.8	2.0		
Av.	.1	5.2	21.2	4.1	.4	

BETTLES

Time of day	Temperature, degrees F. 30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	2.9					
0900	7.6	1.2	0.1			
1200	11.0	4.6	.6			
1500	13.1	5.3	.7			
1800	11.2	3.6	.2			
2100	6.3	1.0				
Av.	8.7	2.6	.3			
			May			
0300	14.4	8.2	.6			
0900	6.3	12.6	8.7	1.3		
1200	4.3	10.8	10.4	4.4	0.1	
1500	3.2	9.8	11.0	5.7	.6	
1800	4.0	11.6	10.3	3.7	.7	
2100	8.4	11.7	7.0	1.1		
Av.	6.8	10.8	8.0	2.7	.2	
			June			
0300	2.8	15.8	11.3		.1	
0900	.1	3.3	12.3	13.4	.9	
1200	.1	1.8	8.7	12.5	6.9	
1500	.1	.8	7.6	10.2	9.7	1.6
1800	.1	1.6	7.4	12.3	8.0	.6
2100	.1	3.7	14.3	10.3	1.6	
Av.	.5	4.5	10.3	9.8	4.5	.4
			July			
0300	.9	14.4	14.4	1.3		
0900		2.1	13.5	11.7	3.7	
1200		.9	8.9	12.2	7.1	1.9
1500		.4	6.7	11.8	9.0	3.1
1800		.4	7.7	12.5	8.1	2.3
2100		1.6	16.4	10.8	1.9	.3
Av.	.1	3.3	11.3	10.0	5.0	1.3
			August			
0300	5.0	16.2	9.7	.1		
0900	.2	8.6	17.2	5.0		
1200	.1	3.4	14.7	10.7	2.1	
1500	.1	2.0	13.2	11.7	4.0	
1800		3.6	14.2	10.0	3.2	
2100	.8	12.2	15.4	2.6		
Av.	1.0	7.7	14.1	6.7	1.5	

BIG DELTA

Time of day	Temperature, degrees F. 30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	8.9	1.2				
0900	12.6	7.8	1.1	[illegible].2		
1200	8.4	13.[illegible]	[illegible].3	.8		
1500	8.9	12.2	3.1	.8	0.1	
1800	11.[illegible]	9.9	1.0	.7		
2100	14.9	2.[illegible]	.4			
Av	10.9	7.[illegible]	1.3	.4		
			May			
0300	13.2	12.9	1.6			
0900	2.3	9.8	15.8	2.7	.2	
1200	1.6	6.6	15.1	6.9	.8	
1500	1.3	5.7	15.6	7.2	.9	
1800	[illegible].3	9.[illegible]	13.[illegible]	5.3	.6	
2100	4.4	17.7	7.2	.7		
Av.	4.2	1[illegible].4	11.4	3.8	.4	
			June			
0300	.8	14.8	13.2	1.2		
0900		2.4	10.2	13.9	3.4	
1200		.9	7.8	12.5	7.6	1.2
1500		.6	8.1	11.4	7.7	2.2
1800		1.4	8.8	13.2	5.2	1.4
2100		4.3	16.1	8.6	1.0	
Av.	.1	4.1	10.7	10.1	4.2	.8
			July			
0300		7.0	19.3	4.7		
0900		.9	10.2	14.7	5.1	.1
1200		.6	4.6	14.4	9.4	2.0
1500		.4	5.1	13.2	9.3	3.0
1800		.9	6.9	13.5	8.3	1.4
2100		1.3	14.6	13.5	1.6	
Av		1.9	10.1	12.3	5.6	1.1
			August			
0300	[illegible]	14.7	12.6	1.4		
0900		4.1	13.7	11.4	1.8	
1200		1.4	9.0	13.0	7.2	
1500		1.2	9.0	11.8	8.0	1.0
1800		1.6	14.2	10.1	4.7	.2
2100	.1	7.0	16.1	7.6	.2	
Av.	.4	5.0	12.4	9.2	3.7	.3

FAIRBANKS

Time of day	Temperature, degrees F. 30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	7.2	0.7	0.2			
0900	12.0	7.4	1.3	0.2		
1200	8.0	11.6	4.0	1.0		
1500	7.0	12.6	4.4	1.1		
1800	9.0	11.6	3.0	.8		
2100	14.0	4.0	1.0			
Av.	9.5	8.0	2.3	.5		
			May			
0300	15.0	10.9	2.2			
0900	2.3	8.3	14.6	5.4	0.1	
1200	.8	5.9	12.3	10.9	1.0	
1500	1.0	3.8	11.9	12.3	1.8	0.1
1800	1.2	5.4	14.0	8.8	1.2	.1
2100	3.7	13.7	12.2	1.0	.2	
Av.	4.0	8.0	11.2	6.4	.7	
			June			
0300	1.3	11.9	15.7	1.1		
0900		.3	10.6	14.2	4.8	.1
1200		.3	5.3	13.4	9.2	1.8
1500			4.2	11.9	10.9	3.0
1800		.3	5.6	13.5	8.3	2.3
2100		1.2	11.9	13.8	3.0	.1
Av.	.2	2.3	8.9	11.3	6.1	1.2
			July			
0300	.1	9.0	20.6	1.3		
0900		.4	9.2	16.0	5.3	.1
1200		.3	3.3	12.9	11.4	3.1
1500			3.8	11.2	11.9	4.1
1800			5.0	11.9	10.8	3.3
2100		.2	12.1	16.2	2.4	.1
Av.		1.6	9.0	11.6	7.0	1.8
			August			
0300	2.1	15.3	12.9	.7		
0900	.1	2.6	15.9	11.6	.8	
1200		.7	8.2	14.5	7.2	.4
1500		.4	7.8	12.5	9.1	1.2
1800		1.0	11.1	11.4	6.9	.6
2100	.1	5.3	17.9	7.7		
Av.	.4	4.2	12.3	9.7	4.0	.4

FT. YUKON

Time of day	Temperature, degrees F. 30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	2.8	0.1				
0900	6.9	2.7	0.3			
1200	9.7	5.1	2.0			
1500	9.7	7.2	2.2	0.1		
1800	data missing					
2100	7.9	2.3				
Av.	7.4	3.5	.9			
			May			
0300	12.1	9.2	1.0			
0900	6.4	8.7	10.3	2.2	0.3	
1200	3.9	8.7	10.4	6.4	1.0	
1500	3.0	6.7	10.7	8.9	1.4	0.1
1800	data missing					
2100	6.2	7.7	11.7	4.0	.2	
Av.	6.3	8.2	8.8	4.3	.6	
			June			
0300	1.4	10.9	15.8	1.9		
0900		2.1	8.7	14.6	4.6	
1200		.6	5.6	13.7	9.4	.7
1500		.2	4.7	11.8	12.1	1.2
1800	data missing					
2100	.1	1.2	8.3	14.7	5.6	.1
Av.	.3	3.0	8.6	11.4	6.3	.4
			July			
0300	.7	5.4	20.6	4.3		
0900		.9	5.9	16.2	7.3	.7
1200		.3	2.9	12.0	12.9	2.7
1500		.2	2.3	10.9	13.3	3.6
1800	data missing					
2100	.1	.3	3.6	17.9	8.3	.8
Av.	.2	1.4	7.1	12.3	8.4	1.6
			August			
0300	3.4	11.4	15.4	.8		
0900		4.4	13.5	11.0	2.1	
1200		1.7	8.3	13.0	7.2	.8
1500		1.3	7.4	12.0	9.0	1.3
1800	data missing					
2100		5.2	12.4	11.3	2.1	
Av.	.7	4.8	11.4	9.6	4.1	.4

Table 23.--Air temperature by hour of day, and number of days per month in each temperature class--Continued

(Av. 1950-58)

GALENA

Time of day	Temperature, degrees F. 30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	6.1	.2				
0900	9.0	2.4				
1200	9.9	6.6	0.9			
1500	10.6	7.6	1.2	0.2		
1800	11.2	6.4	1.0	.1		
2100	10.3	2.6	.3			
Av.	9.5	4.3	.6	.1		
			May			
0300	14.0	11.1	1.0			
0900	3.8	13.4	10.3	1.2		
1200	2.7	7.8	14.2	5.0	0.2	
1500	2.3	7.3	12.4	7.6	.7	
1800	2.8	7.9	12.1	7.0	.4	
2100	3.7	12.4	11.0	2.2		
Av.	4.9	10.0	10.2	3.8	.2	
			June			
0300	.9	12.6	15.6	.9		
0900	.1	3.2	15.5	10.1	1.1	
1200		1.0	9.7	13.2	5.7	0.4
1500		.3	7.0	13.1	8.2	1.4
1800		.7	8.1	13.0	7.1	1.1
2100		1.4	12.6	13.3	2.6	.1
Av.	.2	3.2	11.4	10.6	4.1	.5
			July			
0300		6.4	22.5	2.1		
0900		1.0	14.0	13.1	2.9	
1200		.2	8.8	13.0	7.8	1.2
1500		.2	6.2	13.0	9.0	2.6
1800		.2	7.0	13.0	8.6	2.2
2100		.6	13.1	13.4	3.9	
Av.		1.4	11.9	11.3	5.4	1.0
			August			
0300	1.4	11.0	18.1	.5		
0900		5.0	20.6	5.4		
1200		2.2	16.2	11.2	1.4	
1500		1.4	13.2	13.9	2.4	.1
1800		1.9	15.3	11.4	2.4	
2100	.1	3.4	21.9	5.5	.1	
Av.	.2	4.2	17.6	8.0	1.0	

GULKANA

Time of day	Temperature, degrees F. 30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	5.6					
0900	16.0	6.0	0.4			
1200	11.7	13.8	1.9	0.3		
1500	11.1	13.9	2.3	.7		
1800	16.1	8.2	1.3	.1		
2100	14.2	1.3				
Av.	12.4	7.2	1.0	.2		
			May			
0300	21.3	4.0				
0900	1.9	16.1	12.0	1.0		
1200	.7	10.0	14.9	5.0	0.4	
1500	.7	11.0	14.0	4.7	.6	0.1
1800	1.4	16.9	9.8	2.6	.2	.1
2100	10.3	16.9	2.9	.3		
Av.	6.0	12.5	8.9	2.3	.2	
			June			
0300	6.9	19.1	4.0			
0900		2.8	13.7	12.1	1.4	
1200		1.3	8.8	12.2	7.1	.6
1500		1.3	7.9	11.2	8.2	1.4
1800		2.7	10.7	11.2	4.4	1.0
2100		9.8	14.8	4.6	.8	
Av.	1.2	6.2	10.0	8.5	3.6	.5
			July			
0300	2.0	19.2	9.8			
0900		2.3	10.2	15.7	2.8	
1200		.7	5.3	14.1	8.4	2.0
1500		.6	6.0	12.4	8.4	3.6
1800		1.2	7.7	13.8	6.0	2.3
2100		4.1	18.4	7.9	.6	
Av.	.3	4.7	9.6	10.7	4.4	1.3
			August			
0300	4.7	20.1	5.3			
0900	.1	4.1	17.8	8.9	.1	
1200		1.1	10.2	14.1	5.6	
1500		1.2	8.8	13.8	6.2	1.0
1800		3.0	14.3	9.4	3.9	.4
2100	.7	11.0	16.4	2.9		
Av.	.9	6.8	12.1	8.2	2.6	.2

HOMER

Time of day	Temperature, degrees F. 30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	16.2	1.2				
0900	17.6	10.3	0.1			
1200	12.[illegible]	16.7	.7			
1500	11.6	16.6	1.1			
1800	17.3	10.[illegible]	.2			
2100	21.1	2.[illegible]				
Av.	15.9	9.7	.4			
			May			
0300	18.4	9.9				
0900	1.2	25.7	4.1			
1200	.6	22.3	7.9	0.2		
1500	.9	23.2	6.8	.1		
1800	2.1	26.1	2.8			
2100	9.2	21.3	.3			
Av.	5.4	21.4	3.6	.1		
			June			
0300	6.4	20.9	2.6	.1		
0900		10.3	17.4	2.1	0.2	
1200		6.4	21.0	2.2	.4	
1500		6.4	20.7	2.6	.3	
1800		10.0	17.7	2.1		
2100	.2	19.3	10.1	.4		
Av.	1.1	12.2	14.9	1.6	.2	
			July			
0300	2.6	21.1	7.3			
0900		.9	24.0	5.9	.2	
1200		.1	21.8	8.4	.7	
1500		.7	20.5	9.4	.4	
1800		1.1	23.2	6.7		
2100		7.8	22.8	.4		
Av.	.4	5.3	20.0	5.1	.2	
			August			
0300	2.1	16.1	12.2	.6		
0900		.8	24.5	5.7		
1200		.2	21.5	9.2	.1	
1500			22.7	8.2	.1	
1800		.2	26.8	4.0		
2100	.2	9.4	21.0	.4		
Av.	.4	4.4	21.5	4.7		

ILIAMNA

Time of day	Temperature, degrees F. 30-39	40-49	50-59	60-29	70-79	80-89
			April			
0300	14.6					
0900	16.9	5.0	0.1			
1200	14.6	10.2	.7			
1500	15.6	9.6	.7			
1800	18.4	5.6	.1			
2100	18.3	.4				
Av.	16.4	5.1	.3			
			May			
0300	23.0	5.6				
0900	7.7	19.3	3.7	0.1		
1200	4.0	17.1	9.4	.4		
1500	3.7	16.9	9.3	1.0		
1800	6.6	19.3	4.8	.3		
2100	17.1	12.8	.7			
Av.	10.4	15.2	4.6	.3		
			June			
0300	4.2	23.5	2.0	.3		
0900	.3	11.9	14.6	2.8	0.4	
1200		7.4	16.2	5.1	1.0	0.3
1500		7.1	13.8	6.8	2.0	.3
1800	.1	9.9	12.9	5.1	1.6	.4
2100	.5	17.6	9.9	1.7	.3	
Av.	.8	12.9	11.6	3.6	.9	.2
			July			
0300		18.3	12.7			
0900		2.7	20.6	7.4	.3	
1200		1.7	15.5	11.0	2.8	
1500		1.3	14.5	11.0	3.9	.3
1800		1.6	17.9	8.2	3.3	
2100		6.0	21.1	3.9		
Av.		5.3	17.0	6.9	1.7	.1
			August			
0300	.6	12.1	18.3			
0900		2.2	23.7	5.0	.1	
1200		.6	18.4	11.0	1.0	
1500		.4	17.2	11.6	1.7	.1
1800		1.1	21.9	7.2	.8	
2100	.1	5.6	24.0	1.3		
Av.	.1	3.7	20.6	6.0	.6	

KOTZEBUE

Time of day	Temperature, degrees F. 30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	2.8					
0900	4.4					
1200	8.1	0.1				
1500	9.1	.1				
1800	6.9					
2100	4.3					
Av.	5.9					
			May			
0300	16.6	1.4				
0900	16.0	5.9	1.1	0.1		
1200	15.1	8.4	1.0	.3		
1500	15.8	9.0	1.2	.1		
1800	16.9	7.1	.6	.1		
2100	17.7	3.4	.2			
Av.	16.4	5.9	.7	.1		
			June			
0300	11.7	13.2	4.2	.2		
0900	9.3	12.6	6.3	1.2	0.4	
1200	7.1	12.8	8.0	1.8	.3	
1500	5.3	12.3	10.0	2.1	.3	
1800	6.7	11.5	9.7	2.1		
2100	8.7	11.7	8.3	1.3		
Av.	8.1	12.3	7.8	1.4	.2	
			July			
0300	1.0	12.0	16.7	1.3		
0900	.3	10.6	14.9	4.6	.6	
1200		6.4	16.6	7.1	.8	0.1
1500		5.6	15.3	8.4	1.7	
1800	.1	6.2	15.5	8.3	.9	
2100	.2	7.9	17.8	5.0	.1	
Av.	.3	8.1	16.1	5.8	.7	
			August			
0300	1.7	15.6	13.6	.1		
0900	.2	9.8	18.2	2.8		
1200		8.2	18.7	3.8	.3	
1500		6.6	19.4	4.6	.4	
1800	.1	7.3	20.0	3.4	.2	
2100	.4	11.8	18.0	.8		
Av.	.4	9.9	18.0	2.6	.1	

LAKE MINCHUMINA

Time of day	Temperature, degrees F. 30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	6.9	0.6				
0900	11.8	3.8	.8			
1200	11.4	9.4	1.2	0.3		
1500	10.3	10.4	2.2	.4		
1800	12.1	8.0	1.5	.3		
2100	13.8	2.9	.7			
Av.	11.0	5.8	1.1	.2		
			May			
0300	14.4	11.6	1.0			
0900	3.4	13.9	10.8	2.0		
1200	2.0	8.8	14.2	5.4	0.3	
1500	1.8	7.8	14.7	6.[illegible]	.7	
1800	2.6	10.1	13.6	4.[illegible]	.4	
2100	4.2	15.8	8.9	.9	.1	
Av.	4.7	11.3	10.6	3.0	.2	
			June			
0300	1.3	14.1	13.0	1.6		
0900		2.6	13.4	11.3	2.7	
1200		1.2	8.2	13.7	6.6	0.3
1500		1.0	6.7	15.1	7.0	.2
1800		.9	9.8	13.5	5.7	.1
2100		3.9	16.0	8.7	1.4	
Av.	.2	4.0	11.2	10.6	3.9	.1
			July			
0300	.1	8.2	20.5	2.2		
0900		.8	12.9	12.9	4.3	.1
1200		.6	8.3	13.1	7.1	1.9
1500		.3	6.3	13.0	8.4	3.0
1800		.3	8.4	12.7	7.8	1.8
2100		1.4	15.8	11.1	2.7	
Av.		1.9	12.1	10.8	5.1	1.1
			August			
0300	1.3	13.6	15.4	.7		
0900		4.4	18.2	8.0	.4	
1200		2.2	13.3	12.1	3.4	
1500		1.3	11.5	13.3	4.6	.3
1800		1.8	16.1	10.3	2.7	.1
2100	.2	6.6	18.0	6.2		
Av.	.3	5.0	15.4	8.4	1.8	.1

Table [illegible].--Air temperature by hour of day, and number of days per month in each temperature class--Continued

(Av. 1950-58)

[illegible]

Time of day	30-39	40-49	50-59	60-69	70-79	80-89
			April			
[illegible]	[illegible]	0.4				
[illegible]	[illegible]	4.?	[illegible]			
[illegible]	[illegible]	11.?	1.9	.?		
[illegible]	[illegible]	1?.?	?.?	.?		
[illegible]	[illegible]	?.?	1.?	.?		
[illegible]	[illegible]	?.7	.?			
Av.	[illegible]	[illegible]	[illegible]	.2		
			May			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Av.	[illegible]	?0.4	[illegible]	[illegible]		
			June			
[illegible]	[illegible]	14.?	[illegible]	[illegible]		
[illegible]	[illegible]	9	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	9.4	1?.?	1.9	[illegible]	
[illegible]	[illegible]	15.2	[illegible]	.4		
Av.	[illegible]	11.3	9.9	[illegible]	[illegible]	
			July			
[illegible]	[illegible]	18.?	9			
[illegible]	[illegible]	19.4	?.1	[illegible]		
[illegible]		?.?	14.4	[illegible]	[illegible]	
[illegible]		?	12.?	[illegible]	[illegible]	
[illegible]		[illegible]	1?.5	[illegible]	[illegible]	
[illegible]	[illegible]	1?.?	?.7	?.4		
Av.	[illegible]	[illegible]	9	4	[illegible]	
			August			
[illegible]	[illegible]	14.?	[illegible]			
[illegible]	[illegible]	?.?	?.?			
[illegible]	[illegible]	?.9	?.?	.7		
[illegible]	[illegible]	?.4	1?.?	4.1	[illegible]	
[illegible]	[illegible]	[illegible]	?.7	?.?	[illegible]	
[illegible]	[illegible]	[illegible]	?.			
Av.	[illegible]	[illegible]	7.?	[illegible]		

[illegible]

Time of day	30-39	40-49	50-59	60-69	70-79	80-89
			April			
[illegible]	[illegible]	0.9				
[illegible]	[illegible]	7.2	.			
[illegible]	[illegible]	11.2	..			
[illegible]	[illegible]	12.?	..?	.1		
[illegible]	[illegible]	10.?	.9			
[illegible]	[illegible]	?.0	.1			
Av.	[illegible]	7.?	.?			
			May			
[illegible]	[illegible]	[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	14.7	1?.?	..1		
[illegible]	[illegible]	?.7	1?.?	2.2		
[illegible]	[illegible]	17.7	?.?	.9		
[illegible]	1.9	?.9	..?			
Av.	7.4	15.7	?.?	.7		
			June			
[illegible]	[illegible]	2?.?	?.?	.1		
[illegible]	[illegible]	1?.?	15.?	2.4	.?	
[illegible]	[illegible]	?.?	15.?	7.?	..?	.2
[illegible]	[illegible]	?.7	14.5	9.1	...	.?
[illegible]	[illegible]	?.3	15.3	?.?	1.?	.3
[illegible]	[illegible]	1?.1	13.3	1.3	.3	
Av.	1	?.?	12.8	4.4	.9	.2
			July			
[illegible]	[illegible]	[illegible]	1?.?	.1		
[illegible]	[illegible]	?	2.?	5.7	.?	
[illegible]	[illegible]	[illegible]	14.?	1?.1	?.7	.?
[illegible]	[illegible]	[illegible]	1?.?	1?.?	4.1	1.?
[illegible]	[illegible]	1.4	15.?	10.4	?.?	.1
[illegible]	[illegible]	?.7	21.1	4.2		
Av.	[illegible]	.2	1?.?	7.7	1.7	.?
			August			
[illegible]	[illegible]	13.3	17.7	.7		
[illegible]	[illegible]	1.9	2?.?	5.2	.1	
[illegible]	[illegible]	.2	17.?	11.7	1.1	
[illegible]	[illegible]	.4	14.?	12.9	2.8	.1
[illegible]	[illegible]	.6	19.?	9.4	1.2	
[illegible]	[illegible]	?.?	2?.?	2.7		
Av.	[illegible]	.4	19.5	7.1	.9	

NORTHWAY

Time of day	30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	2.7	0.1				
0900	14.?	4.9	0.7			
1200	11.8	11.4	1.6	0.6		
1500	12.0	11.4	2.0	.4		
1800	14.2	6.8	.9	.3		
2100	10.0	1.4	.2			
Av.	10.9	6.0	.9	.2		
			May			
0300	17.2	6.6				
0900	2.9	12.1	13.9	1.8	0.1	
1200	.3	8.4	15.1	5.6	.4	
1500	1.1	8.2	15.1	5.2	.7	
1800	2.8	11.2	13.9	2.7	.4	
2100	9.7	16.3	?.6	.2		
Av.	5.8	10.5	10.3	2.7	.3	
			June			
0300	.	17.?	1?.?	.?		
0900	.2	2.3	1?.9	14.3	2.2	0.1
1200		1.?	?.9	13.5	7.2	.6
1500		1.6	7.0	13.9	6.9	.6
1800		1.9	10.6	12.6	4.6	.?
2100	.1	5.8	17.6	6.3	.2	
Av.	.3	5.2	10.5	10.2	3.5	.?
			July			
0300	.4	14.?	16.3	.3		
0900		1.?	10.2	15.2	4.3	
1200		.4	5.8	14.1	9.6	1.?
1500		.4	5.3	13.8	9.6	1.9
1800		.6	9.0	13.0	7.2	1.1
2100	.1	2.3	18.8	8.7	1.1	
Av.	.1	3.2	10.9	10.8	5.3	.7
			August			
0300	?.1	8.1	5.1	.1		
0900	.2	5.1	15.1	8.8	1.8	
1200		2.4	8.6	14.9	5.1	
1500		1.8	10.1	12.4	6.5	.2
1800		4.2	13.3	10.0	3.4	.1
2100	1.1	12.4	14.6	2.9		
Av.	1.1	7.7	11.1	8.2	2.8	.1

[illegible]

Time of day	30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	[illegible]	.1				
0900	[illegible]	[illegible]				
1200	[illegible]	4.	.3			
1500	[illegible]	4.4	.?			
1800	[illegible]	2.3	.1			
2100	[illegible]	.?				
Av.	9.?	2.1	.1			
			May			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
[illegible]	9	[illegible]	[illegible]	7		
[illegible]	[illegible]	[illegible]	?.1	7	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	
[illegible]	?7.7	[illegible]				
Av.	[illegible]	?.9	[illegible]			
			June			
[illegible]	[illegible]	1?.?	?.7			
0900	[illegible]	1?.?	1?.?	4.?	.?	
1200	[illegible]	7.4	1?.?	7.7	?.1	
1500	.4	?.?	1?.?	8.3	2.7	
1800	.7	?.?	11.?	7.1	1.4	
2100	?.9	1?.?	10.9	2.3	.1	
Av.	?.?	11.?	10.1	5.0	1.1	
			July			
[illegible]		2?.?	?.3			
[illegible]		9.?	1?.3	6.3	.?	
[illegible]		4.?	14.5	8.8	?.1	
[illegible]		3.?	?.1	?0.?	4.1	0.?
[illegible]		5.1	14.?	7.8	3.?	
[illegible]	[illegible]	11.7	1?.1	4.1		
Av.	[illegible]	9.5	1?.?	6.?	1.8	
			August			
[illegible]	[illegible]	?1.7	3.6			
[illegible]	?7	14.?	13.1	2.6		
[illegible]	[illegible]	7.?	16.9	5.?	.9	
[illegible]		?.9	16.8	5.4	1.6	
[illegible]	[illegible]	9.5	15.8	4.4	.4	
[illegible]	[illegible]	18.3	10.8	.6		
Av.	[illegible]	1?.1	1?.?	3.1	.5	

TANANA

Time of day	30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	4.2	0.6				
0900	10.3	4.0	0.8			
1200	10.4	7.6	2.0	0.3		
1500	9.6	8.8	2.7	.7		
1800	12.2	5.7	1.4	.2		
2100	10.4	2.0	.2			
Av.	9.5	4.8	1.2	.2		
			May			
0300	14.?	9.9	.?			
0900	4.1	10.1	12.9	2.8		
1200	2.?	7.1	?.8	7.4	.8	
1500	2.1	6.2	12.9	8.3	1.1	0.1
1800	2.1	7.7	13.3	6.3	.8	
2100	?.?	13.1	8.9	1.1		
Av.	5.?	9.0	10.2	4.3	.4	
			June			
0300	3.1	14.5	11.2	1.1	.1	
0900		1.4	12.2	13.0	3.4	
1200		.7	7.0	12.9	8.6	.8
1500		.3	4.8	13.4	9.2	2.3
1800		.7	6.4	14.8	7.1	1.0
2100		3.0	14.4	10.8	1.8	
Av.	.5	3.5	9.3	11.0	5.0	.7
			July			
0300	1.7	12.9	15.1	1.3		
0900		.7	11.0	14.9	4.3	.1
1200		.4	5.9	13.1	9.8	1.8
1500		.1	5.0	13.1	10.0	2.8
1800		.3	5.8	13.9	9.0	2.0
2100		1.1	13.9	13.7	2.3	
Av.	.3	2.6	9.4	11.7	5.9	1.1
			August			
0300	3.9	14.9	10.8	.7		
0900	.2	5.0	16.2	9.6		
1200	.1	1.6	12.3	13.3	3.7	
1500		1.3	11.2	13.0	5.2	.3
1800		2.4	13.9	12.0	2.7	
2100	1.1	8.2	17.4	4.3		
Av.	.9	5.6	13.6	8.8	1.9	.1

UNALAKLEET

Time of day	30-39	40-49	50-59	60-69	70-79	80-89
			April			
0300	7.6	0.4				
0900	11.2	2.3				
1200	12.4	4.4	0.2			
1500	12.4	4.9	.2			
1800	11.7	2.9				
2100	10.3	.6				
Av.	10.9	2.6	.1			
			May			
0300	16.9	7.6	.2			
0900	9.8	12.9	5.3	0.9		
1200	8.1	13.7	5.7	1.9		
1500	9.0	11.8	6.8	1.7	0.1	
1800	10.1	11.0	7.0	.9		
2100	14.2	10.7	2.6			
Av.	11.4	11.3	4.6	.9		
			June			
0300	4.9	18.0	7.0		.1	
0900	1.6	8.8	15.6	3.6	.3	0.1
1200	1.2	6.9	15.6	4.4	.8	.1
1500	1.2	6.9	15.6	5.0	1.2	.1
1800	1.8	7.2	16.3	3.6	1.0	.1
2100	2.2	10.3	16.0	1.4	.1	
Av.	2.2	9.7	14.4	3.0	.6	.1
			July			
0300	.7	10.6	18.9	.8		
0900		2.1	18.3	9.7	.9	
1200		1.2	17.6	10.4	1.8	
1500		1.0	17.7	11.1	1.2	
1800		1.3	19.6	9.1	1.0	
2100		2.8	23.5	4.7		
Av.	.1	3.2	19.3	7.6	.8	
			August			
0300	1.3	13.1	16.3	.3		
0900		4.0	23.9	3.0	.1	
1200		2.3	21.3	6.8	.6	
1500		2.1	21.2	7.0	.6	.1
1800		2.8	23.1	4.7	.4	
2100	.6	7.2	22.1	1.1		
Av.	.3	5.3	21.3	3.8	.3	

1/ Temperature frequencies below 30° F. were not compiled. All stations in April and May, and Kotzebue in June had temperatures below 30° F.

Source: United States Weather Bureau coded data.

Table 24.--Normal relative humidity according to time of day

Station	Percent relative humidity																			
	April				May				June				July				August			
	0200	0800	1400	2000	0200	0800	1400	2000	0200	0800	1400	2000	0200	0800	1400	2000	0200	0800	1400	2000
Galena	70	72	62	68	77	65	51	58	76	64	49	54	82	73	59	64	85	82	65	75
Northway	78	62	49	68	81	55	43	61	83	60	48	61	87	67	50	66	89	71	52	75
McGrath	77	70	55	66	82	66	49	60	84	67	50	59	88	75	57	66	92	86	66	79
Fairbanks	74	63	47	61	77	57	42	55	82	62	45	57	88	70	52	66	91	78	57	77
Anchorage	75	67	53	67	77	64	50	63	75	68	57	65	85	74	62	72	86	78	65	77
Naknek 1/	86	80	64	78	86	73	58	75	88	78	59	72	91	82	60	75	92	86	64	81
Bethel	87	84	74	83	89	79	64	74	90	80	64	70	[illegible]	87	69	77	96	93	77	87

1/ 3 years of data only

Source: United States Weather Bureau. Local climatological data, Alaska, 1958.

Table 25 Relative humidity percent by hour of day, and number of days in each temperature class

(Av. 1950-58)

ANCHORAGE

Time of day	10-19	20-29	30-39	40-49	50+
		April			
0300		.1		1.3	28.6
900		.2	1.1	5.0	23.7
1200		.2	3.2	9.3	17.3
1500		.6	4.3	9.0	16.1
1800		.2	2.2	6.1	21.5
2100	.1		.7	1.8	27.4
Av.		.2	1.9	5.4	22.5
		May			
0300			.1	.7	30.2
0900		.2	1.6	6.3	22.9
1200		[illegible]	4.7	11.6	14.1
1500		1.1	6.7	10.2	13.0
1800		.7	2.6	8.3	19.4
2100		.1	.6	2.9	27.4
Av.		.4	2.7	6.7	21.2
		June			
[illegible]				.3	29.7
[illegible]			.3	2.6	27.1
[illegible]		.4	1.1	5.6	22.9
[illegible]		.6	1.6	8.4	19.4
[illegible]			1.6	6.4	22.0
[illegible]			.3	1.4	28.3
Av.		.2	.8	4.1	24.9
		July			
[illegible]					31.0
[illegible]				1.7	29.3
[illegible]			.4	4.6	[illegible]
[illegible]		[illegible]	.9	5.3	[illegible]
[illegible]			[illegible]	4.1	26.1
[illegible]			.2	.6	30.2
[illegible]			.4	2.7	27.9
		August			
[illegible]				.1	30.9
[illegible]				.8	[illegible]
[illegible]			.4	2.7	27.9
[illegible]		[illegible]	.7	4.0	[illegible]
[illegible]			.2	2.6	28.2
[illegible]				.3	[illegible]
[illegible]			.2	1.8	29.0

BETHEL

Time of day	10-19	20-29	30-39	40-49	50+
		April			
0300					30.0
0900				0.1	29.9
1200			0.1	1.2	28.7
1500			.1	1.2	28.7
1800				.8	29.2
2100					30.0
Av.				.6	29.4
		May			
0300					31.0
0900			.1	.7	30.2
1200		0.2	.8	4.4	25.6
1500		.3	1.8	4.8	24.1
1800	0.1	.1	.8	3.4	26.6
2100		.1	.1	.7	30.1
Av.		.1	.6	2.3	28.0
		June			
0300				.1	29.9
0900				.6	29.4
1200			1.3	2.4	26.3
1500		.4	1.6	4.4	23.6
1800		.2	.8	4.1	24.9
2100				.6	29.4
Av.		.1	.6	2.0	27.3
		July			
0300					31.0
0900				.1	30.9
1200			.1	2.3	28.6
1500			.8	3.6	26.6
1800			.8	2.8	27.4
2100				.1	30.9
Av.			.3	1.5	29.2
		August			
0300					31.0
0900					31.0
1200				.2	30.6
1500			.1	.6	30.3
1800			.1	.7	30.2
2100					31.0
Av.				.3	30.7

BETTLES

Time of day	10-19	20-29	30-39	40-49	50+
		April			
0300			0.1	0.2	29.7
0900			.1	2.9	27.0
1200			.9	4.2	24.9
1500			.7	4.8	24.5
1800			.1	3.4	26.5
2100			.1	.6	29.3
Av.			.3	2.7	27.0
		May			
0300		0.1		.3	30.7
0900			.6	5.2	25.2
1200		.2	3.4	6.8	20.6
1500		.8	3.6	7.4	19.2
1800		.7	3.4	6.9	20.0
2100			.9	3.9	26.2
Av.		.3	2.0	5.1	23.6
		June			
0300				.4	29.6
0900		.1	1.9	5.1	22.9
1200		.2	5.1	8.1	16.6
1500		1.8	6.2	6.4	15.6
1800		2.2	4.7	5.6	17.5
2100		.3	1.8	2.8	25.1
Av.		.8	3.3	4.7	21.2
		July			
0300				.1	30.9
0900				1.8	29.2
1200		.1	2.8	6.9	21.2
1500		1.1	4.6	6.3	19.0
1800		.9	3.9	6.0	20.2
2100			.7	1.3	29.0
Av.		.4	2.0	3.7	24.9
		August			
0300					31.0
0900				.1	30.9
1200			.3	2.0	28.7
1500			.6	4.0	26.4
1800			.8	1.3	28.9
2100					31.0
Av.			.3	1.2	29.5

[illegible]

Time of day	[illegible]	20-29	30-39	40-49	50+
		April			
[illegible]			.1	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	7.7	[illegible]
[illegible]		[illegible]	4.1	[illegible]	[illegible]
[illegible]		[illegible]	4.9	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			.4	[illegible]	[illegible]
Av.		[illegible]	2.4	[illegible]	[illegible]
		May			
[illegible]		[illegible]	.8	1.9	[illegible]
0900		[illegible]	[illegible]	9.7	13.2
[illegible]	[illegible]	[illegible]	9.9	9.0	8.1
[illegible]	[illegible]	[illegible]	[illegible]	7.2	8.6
[illegible]		[illegible]	[illegible]	6.9	[illegible]
2100			1.8	7.6	21.6
Av.		[illegible]	[illegible]	7.1	15.5
		June			
[illegible]		[illegible]	.3	1.8	27.8
0900		.9	4.3	7.1	17.7
1200	[illegible]	[illegible]	6.8	8.9	11.5
1500	.1	4.1	[illegible]	7.8	11.2
1800	[illegible]	[illegible]	5.8	7.8	14.1
2100		.1	2.0	5.3	22.6
Av.	[illegible]	[illegible]	4.3	6.4	17.5
		July			
0300		.1	.2	1.2	29.5
0900		.1	1.6	6.6	22.7
1200		[illegible]	5.2	8.3	15.9
1500	.1	[illegible]	6.7	7.7	14.3
1800		.9	5.4	7.2	17.5
2100		.2	1.4	3.0	26.4
Av.		.8	3.4	5.7	21.1
		August			
[illegible]			.1	1.4	29.5
[illegible]			.7	4.4	25.9
[illegible]		.3	4.2	8.0	15.5
[illegible]		.4	5.3	8.7	16.6
1800		.3	2.2	6.6	21.9
2100			.7	2.8	27.5
Av.		.2	2.2	5.3	23.3

FAIRBANKS

Time of day	10-19	20-29	30-39	40-49	50+
		April			
0300			0.1	[illegible]	29.2
0900		0.2	2.4	6.2	21.2
1200		1.2	4.3	9.7	[illegible]
1500		2.3	6.1	8.8	12.8
1800		.7	4.3	8.9	16.1
2100			.4	3.2	26.3
Av.		.7	2.9	6.3	20.1
		May			
0300				1.0	30.0
0900		.6	7.0	8.7	14.6
1200	0.3	[illegible]	8.4	8.4	8.8
1500	.4	6.3	10.3	7.3	6.6
1800	.7	3.7	8.8	9.4	8.4
2100		.6	1.0	5.7	23.8
Av.	.2	[illegible]	5.9	6.8	15.4
		June			
0300			.3	.9	28.8
0900	.1	.6	3.7	7.1	18.5
1200	.1	2.9	7.7	8.7	10.6
1500	.7	4.4	7.9	8.1	8.9
1800	.4	3.0	7.2	7.9	11.5
2100			1.9	4.4	23.7
Av.	.2	1.8	4.8	6.2	17.0
		July			
0300					31.0
0900		.1	1.2	4.0	25.7
1200		1.7	5.2	7.0	17.1
1500	.3	3.2	6.0	6.3	15.2
1800		2.2	5.2	7.0	16.6
2100			.6	1.0	29.4
Av.	.1	1.2	3.0	4.2	22.5
		August			
0300					31.0
0900			.1	1.2	29.7
1200		.6	2.1	6.7	21.6
1500		.9	5.6	6.9	17.6
1800			1.4	6.1	23.5
2100				.1	30.9
Av.		.3	1.5	3.5	25.7

FT. YUKON

Time of day	10-19	20-29	30-39	40-49	50+
		April			
0300			0.1	0.4	28.5
0900			.1	4.3	25.6
1200			1.4	6.7	21.9
1500		0.1	2.8	6.9	20.2
1800		Data missing			
2100			.6	2.0	26.6
Av.		.0	1.0	4.1	24.6
		May			
0300		.1	.1	1.4	29.4
0900		.3	2.2	7.9	20.6
1200		.6	5.1	10.6	14.7
1500		1.3	6.8	10.1	12.8
1800		Data missing			
2100		.2	1.9	5.8	23.1
Av.		.5	3.2	7.2	20.1
		June			
0300		.1	1.0	4.0	24.9
0900		.1	3.9	8.4	17.6
1200		.4	6.0	10.4	13.2
1500		1.0	6.7	12.0	10.3
1800		Data missing			
2100		.3	2.3	6.7	20.7
Av.		.4	4.0	8.3	17.3
		July			
0300			.2	1.3	29.5
0900		.2	2.2	8.2	20.4
1200		.6	3.3	12.0	15.1
1500		.7	4.9	10.7	14.7
1800		Data missing			
2100		.4	2.2	5.7	22.7
Av.		.4	2.5	7.6	20.5
		August			
0300				.2	30.8
0900			.7	2.6	27.7
1200		.1	.9	8.7	21.3
1500		.2	1.9	8.9	20.0
1800		Data missing			
2100			.3	1.8	28.9
Av.		.1	.8	4.4	25.7

Table 25.--Relative humidity percent by hour of day and number of days in each temperature class--Continued

(Av. 19[illegible])

GALENA

Time of day	10-19	20-29	30-39	40-49	50+
April					
0300					30.0
0900				0.9	29.1
1200		0.2	0.4	4.2	25.2
1500		.2	1.4	4.7	23.7
1800			1.2	3.7	25.1
2100			.1	.6	29.3
Av.		.1	.5	2.3	27.1
May					
0300				1.0	30.0
0900		.8	2.1	6.0	22.1
1200	0.1	1.8	6.7	7.1	15.3
1500	.4	2.9	6.9	7.0	13.8
1800	.3	2.6	5.6	7.9	14.6
2100		.4	3.3	6.2	21.1
Av.	.1	1.4	4.1	5.9	19.5
June					
0300				.3	29.7
0900		.4	1.6	4.3	23.7
1200	.1	1.8	4.2	9.1	14.8
1500	.4	2.9	4.8	8.1	13.8
1800	.2	2.9	4.9	6.8	15.2
2100		1.1	3.2	3.7	22.0
Av.	.1	1.5	3.1	5.4	19.9
July					
0300					31.0
0900			.5	2.8	27.7
1200		.4	2.6	7.4	20.6
1500		1.2	4.9	7.4	17.5
1800		.6	5.2	6.4	18.8
2100			.6	2.2	28.2
Av.		.4	2.3	4.4	23.9
August					
0300					31.0
0900				.8	30.2
1200		.1	1.0	2.8	27.1
1500		.4	2.1	.8	25.9
1800		.1	1.2	2.4	27.3
2100				.9	30.1
Av.		.1	.7	1.6	28.6

GULKANA

Time of day	10-19	20-29	30-39	40-49	50+
April					
0300			0.2	0.1	29.7
0900			.1	3.9	26.0
1200		0.1	2.6	9.4	17.9
1500		.6	3.2	10.0	16.2
1800		.2	.9	6.1	22.[illegible]
2100		.1		.9	29.0
Av.		.2	1.2	5.0	23.6
May					
0300			.1	.1	30.8
0900	0.1	.7	.9	9.0	19.3
1200	.2	2.6	7.[illegible]	7.9	13.3
1500	.2	3.8	8.0	7.3	11.7
1800	.2	1.4	4.9	7.3	17.2
2100			.4	[illegible].4	28.[illegible]
Av.	.1	1.4	3.7	5.7	2[illegible].4
June					
0300				.1	29.9
0900		.2	1.6	8.3	18.9
1200	.2	3.4	7.4	8.7	1[illegible].3
1500	.9	4.8	8.2	6.6	9.5
1800	.3	3.2	5.4	8.4	12.7
2100		.1	1.4	4.6	23.9
Av.	.2	2.0	4.2	6.1	17.5
July					
0300					31.0
0900				1.9	29.1
1200		.9	4.8	8.3	17.0
1500	.1	2.3	6.7	8.3	13.6
1800		2.2	4.4	6.6	17.8
2100			.3	2.6	28.1
Av.		.9	[illegible].7	4.6	2[illegible].8
August					
0300					31.0
0900				1.9	29.1
1200		.4	[illegible]	6.1	22.[illegible]
1500		.9	4.[illegible]	8.1	17.4
1800		.9	[illegible].3	4.1	23.7
2100				.3	30.7
Av.		.4	1.5	3.4	25.7

HOMER

Time of day	10-19	20-29	30-39	40-49	50+
April					
0300			0.2	.4	29.4
0900		0.1	.6	1.3	28.0
1200			.3	1.7	28.0
1500			.8	2.4	26.8
1800		.1	.3	1.3	28.3
2100	0.1			.8	29.1
Av.			.4	1.3	28.3
May					
0300				.1	30.9
0900			.1	.6	30.3
1200				1.4	29.6
1500		.1	.1	1.0	29.8
1800				.6	30.4
2100				.1	30.9
Av.				.6	30.4
June					
0300					30.0
0900			.1		29.9
1200		.1		.4	29.5
1500		.1	.1	.2	29.6
1800				.4	29.6
2100					30.0
Av.				.2	29.8
July					
0300					31.0
0900				.1	30.9
1200				.2	30.8
1500			.3	.1	30.6
1800				.2	30.8
2100					31.0
Av.			.1	.1	30.8
August					
0300					31.0
0900			.1		30.9
1200				.3	30.7
1500			.2	[illegible]	30.6
1800				.1	30.9
2100					31.0
Av.			.1	.1	30.8

ILIAMNA

Time of day	10-19	20-29	30-39	40-49	50+
April					
0300				0.1	29.9
0900			0.2	.3	29.5
1200			.2	1.1	28.7
1500			.1	1.1	28.8
1800				.2	29.8
2100				.1	29.9
Av.			.1	.5	29.4
May					
0300					31.0
0900				.6	30.4
1200		0.1	.1	1.8	29.0
1500	0.1	.1	.8	1.2	28.8
1800		.1	.2	1.0	29.7
2100				.3	30.7
Av.		.1	.2	.8	29.9
June					
0300				.1	29.9
0900		.1		.2	29.7
1200		.1	.7	1.2	28.0
1500		.1	1.1	3.9	24.9
1800		.2	.9	2.4	26.5
2100			.2	.7	29.1
Av.		.1	.5	1.4	28.0
July					
0300					31.0
0900				.7	30.3
1200			.3	1.6	29.1
1500		.1	.7	2.8	27.4
1800			.7	2.2	28.1
2100				.1	30.9
Av.			.3	1.2	29.5
August					
0300					31.0
0900				.1	30.9
1200			.1	.9	30.0
1500		.1		1.3	29.6
1800			.1	.6	30.3
2100				.1	30.9
Av.				.5	30.5

KOTZEBUE

Time of day	10-19	20-29	30-39	40-49	50+
April					
0300			0.1	.1	29.8
0900				.1	29.9
1200					30.0
1500		0.2		.4	29.4
1800		.1		.1	29.8
2100					30.0
Av.		.1		.1	29.8
May					
0300					31.0
0900			.1	.7	30.2
1200			.2	.8	30.0
1500			.1	1.0	29.9
1800				.1	30.9
2100					31.0
Av.			.1	.4	30.5
June					
0300					[illegible]
0900			.4	[illegible]	[illegible]
1200			.3	.7	29.0
1500		.1	.3	.4	29.2
1800			.1	.6	29.3
2100				.3	29.7
Av.			.2	.4	29.4
July					
0300					31.0
0900					31.0
1200				.8	30.2
1500			.1	.9	30.0
1800				.3	30.7
2100				.1	30.9
Av.				.4	30.6
August					
0300					31.0
0900				.2	30.8
1200		.1		.2	30.7
1500			.1	[illegible]	30.8
1800				.3	30.7
2100					31.0
Av.				.1	30.9

LAKE MINCHUMINA

Time of day	10-19	20-29	30-39	40-49	50+
April					
0300			.2	1.4	29.4
0900		0.1	[illegible]	2.7	27.0
1200		.6	2.1	5.9	21.4
1500		.6	3.3	5.9	20.[illegible]
1800		.2	2.0	7.4	20.4
2100			.8	3.8	26.0
Av.		.2	1.4	4.[illegible]	24.0
May					
0300			.1	.9	30.0
0900		.3	1.4	7.[illegible]	22.3
1200		1.4	6.2	8.8	14.6
1500		3.4	4.4	10.0	13.2
1800	0.2	1.3	4.6	8.1	16.8
2100		.3	1.6	6.2	22.9
Av.		1.1	[illegible]	[illegible]	[illegible]
June					
0300				1.[illegible]	[illegible].4
0900			1.4	[illegible]	[illegible].3
1200		2.0	5.[illegible]	[illegible].1	14.1
1500	.1	2.3	7.8	[illegible]	13.5
1800		.9	4.7	7.[illegible]	17.1
2100		.1	1.3	4.4	24.[illegible]
Av.		.9	3.5	5.7	19.9
July					
0300				[illegible]	[illegible].7
0900		.1	.7	2.8	27.4
1200		.4	3.4	5.9	[illegible].3
1500		1.1	5.4	[illegible].7	17.8
1800		.2	4.6	5.[illegible]	[illegible].3
2100			.8	2.7	27.5
Av.		.3	2.5	4.0	24.[illegible]
August					
0300					[illegible]
0900				.7	[illegible]
1200			.2	[illegible]	27.[illegible]
1500		.1	.3	4.1	[illegible]
1800			.1	[illegible]	[illegible]
2100				[illegible]	[illegible]
Av.			[illegible]	1.9	[illegible]

Table 39.--Relative humidity percent by hour of day, and number of days in each temperature class--Continued

(Av. 1950-58)

McGRATH

Time of day	Relative humidity percent 10-19	20-29	30-39	40-49	50/
April					
[illegible]				0.1	[illegible]
[illegible]				[illegible]	27.7

NAKNEK

Time of day	Relative humidity percent 10-19	20-29	30-39	40-49	50/
April					
[illegible]					[illegible]
[illegible]				0.[illegible]	29.4
[illegible]			.9	[illegible].4	[illegible].7

NORTHWAY

Time of day	Relative humidity percent 10-19	20-29	30-39	40-49	50/
April					
0300			0.2	0.2	29.6
0900	0.1	0.2	2.1	1.[illegible]	23.3
1200		1.1	5.9	9.1	15.9
1500	.1	1.1	4.6	[illegible].1	14.1
1800	.1	[illegible]	[illegible]	[illegible]	22.4
2100			.1	[illegible]	[illegible]
Av.	[illegible]	[illegible]	2.[illegible]	[illegible]	[illegible]
May					
0300			.1	.1	30.[illegible]
0900	.1	.9	6.[illegible]	[illegible].1	15.6
1200	.4	[illegible].8	8.4	7.0	11.4
1500	.3	4.9	8.3	[illegible].7	10.[illegible]
1800	.2	[illegible].5	5.3	7.4	15.[illegible]
2100		.1	.2	1.9	25.7
Av.	.[illegible]	1.[illegible]	4.9	[illegible]	[illegible]
June					
0300					[illegible]
0900		[illegible]	3.2	9.0	17.2
1200	.1	1.9	[illegible]	7.6	[illegible]
1500	[illegible]	[illegible]	[illegible]	7.6	11.7
1800	[illegible]	.9	[illegible]	[illegible].8	15.[illegible]
2100			.4	[illegible].9	26.7
Av.	[illegible]	.9	4.5	5.[illegible]	18.9
July					
0300					[illegible]
0900		[illegible]	1.7	[illegible]	[illegible]
1200		1.4	5.7	[illegible]	14.[illegible]
1500	[illegible]	2.1	[illegible].1	[illegible]	13.7
1800	[illegible]	1.2	3.8	7.[illegible]	18.7
2100			.2	1.6	29.[illegible]
Av.		.3	2.9	5.4	21.9
August					
0300					31.[illegible]
0900			.1	[illegible].4	17.5
1200		[illegible]	3.[illegible]	9.8	17.8
1500		[illegible]	4.5	9.4	16.3
1800		[illegible]	[illegible]	5.4	24.4
2100					31.0
Av.		.2	1.5	4.7	24.6

[illegible]

Time of day	Relative humidity percent 10-19	20-29	30-39	40-49	50/
April					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Time of day	Relative humidity percent 10-19	20-29	30-39	40-49	50/
April					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

UNALAKLEET

Time of day	Relative humidity percent 10-19	20-29	30-39	40-49	50/
April					
[illegible]				[illegible]	29.7
[illegible]			.4	[illegible]	[illegible].7
Av.			[illegible]	[illegible]	29.[illegible]
June					
[illegible]					29.[illegible]
Av.			.4	.9	[illegible]

Source: United States Weather Bureau coded data.

Table 26.--Sunrise, sunset, and duration of daylight

Date	Fort Yukon, Alaska				Anchorage, Alaska				Missoula, Montana			
	Time of sunrise	Time of sunset	Duration of daylight		Time of sunrise	Time of sunset	Duration of daylight		Time of sunrise	Time of sunset	Duration of daylight	
			Hrs	Mins			Hrs	Mins			Hrs	Mins
April 1	0456	1836	13	40	0524	1843	13	19	0616	1905	12	49
11	0416	1911	14	55	0452	1910	14	18	0556	1919	13	23
21	0335	1947	16	12	0422	1935	15	13	0538	1933	13	55
May 1	0255	2025	17	30	0351	2002	16	11	0521	1946	14	25
11	0213	2105	18	52	0323	2029	17	06	0506	1959	14	53
21	0128	2150	20	22	0258	2055	17	57	0454	2012	15	18
June 1	0033	2252	22	19	0236	2119	18	43	0445	2023	15	38
11	1/SAH	SAH	24	00	0222	2135	19	13	0441	2031	15	50
21	SAH	SAH	24	00	0218	2143	19	25	0441	2034	15	53
July 1	SAH	SAH	24	00	0225	2140	19	15	0444	2035	15	51
11	0034	2252	22	18	0240	2127	18	47	0452	2030	15	38
21	0129	2200	20	31	0301	2107	18	06	0503	2022	15	19
Aug. 1	0216	2115	18	59	0329	2040	17	11	0515	2009	14	54
11	0257	2034	17	37	0355	2012	16	17	0528	1954	14	26
21	0333	1952	16	19	0421	1942	15	21	0540	1937	13	57
Sept. 1	0412	1908	14	56	0448	1907	14	19	0555	1916	13	21
11	0445	1828	13	43	0514	1836	13	22	0608	1857	12	49
21	0518	1748	12	30	0538	1804	12	26	0621	1836	12	15

1/ SAH - Sun above horizon all day.

Source: United States mimeographed data.

Table 27.--Wind direction by hour of day, and number of days per month in each direction class

(Av. 1950-58)

A[illegible]

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
0300	5.9	2.7	2.3	2.9	4.2	1.7	1.7	2.2	6.4
0900	7.3	6.3	.7	.6	2.4	1.7	4.0	5.4	1.6
1200 1/	6.2	2.6	1.0	1.6	2.7	2.3	4.8	7.4	.8
1500	5.6	1.9	1.1	2.2	4.0	2.2	5.9	6.8	.3
1800 1/	4.4	1.6	.7	2.4	4.9	3.7	4.4	5.9	1.3
2100	3.8	2.7	2.0	4.1	6.3	2.9	1.9	2.7	3.6
Av.	5.5	3.0	1.3	2.3	4.1	2.4	3.8	5.1	2.3
					May				
0300	2.7	2.2	2.7	5.8	7.8	1.4	1.0	2.0	5.4
0900	4.3	2.2	.6	2.4	3.9	2.2	6.0	8.2	1.2
1200	3.2	.8	.6	3.6	5.9	2.4	7.0	6.7	.8
1500	1.6	.8	.7	4.9	9.0	2.2	6.6	4.9	.3
1800	1.7	.1	.3	5.7	9.1	3.2	5.4	4.7	.8
2100	1.8	1.7	.3	5.4	11.0	3.4	1.9	1.7	3.8
Av.	2.6	1.3	.9	4.6	7.8	2.5	4.6	4.7	2.0
					June				
0300	1.3	2.2	1.4	3.1	8.2	4.0	1.3	1.6	6.9
0900	4.0	2.1	.6	1.3	3.0	2.9	6.7	8.4	1.0
1200	3.3	.4	.3	2.0	3.7	2.2	8.9	8.8	.4
1500	2.6	.4	.1	2.4	5.8	3.2	9.0	6.3	.2
1800	2.0	.6	.2	3.6	6.7	5.3	7.2	4.2	.2
2100	1.7	.9	1.0	4.1	9.9	4.2	2.9	1.4	3.9
Av.	2.5	1.1	.6	2.8	6.2	3.6	6.0	5.1	2.1
					July				
0300	1.9	2.8	2.4	3.6	7.0	1.9	1.3	1.1	9.0
0900	4.9	2.2	.8	1.8	[illegible]	3.1	6.7	6.4	2.0
1200	3.9	2.0	.2	2.0	1.9	2.6	9.7	7.8	1.0
1500 1/	3.3	1.0	.2	2.1	3.0	3.8	8.7	7.4	.8
1800	[illegible]	.7	.4	3.1	4.4	4.9	7.7	5.6	1.2
2100	1.9	.7	1.3	5.1	7.6	4.6	2.3	2.1	5.3
Av.	[illegible]	1.6	.9	3.0	4.5	[illegible]	6.0	5.1	3.2
					August				
0300	[illegible]	2.9	[illegible]	4.4	5.0	1.1	.8	1.3	9.1
0900	[illegible]	3.8	.9	1.3	4.4	2.7	3.1	4.8	3.4
1200	5.8	4.0	.7	1.6	2.2	3.2	4.0	8.2	1.3
1500	4.1	2.2	.4	.4	3.9	[illegible]	7.2	[illegible]	1.8
1800	[illegible]	2.0	.7	2.6	5.9	[illegible]	5.4	[illegible]	[illegible]
2100	2.2	1.0	[illegible]	6.0	6.7	[illegible]	1.6	1.6	6.0
Av.	4.1	2.6	1.5	3.0	4.7	2.6	3.7	4.8	4.0

BETHEL

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
0300	5.2	3.1	3.4	2.6	3.2	1.8	1.1	6.9	2.7
0900	4.6	3.4	4.1	2.9	3.3	1.6	2.1	6.0	2.0
1200	5.6	1.8	3.3	3.4	3.9	1.8	2,3	7.5	.4
1500	5.0	1.7	3.4	3.1	3.6	2.1	2.0	8.4	.7
1800	5.2	1.8	3.3	3.2	3.4	1.7	2.6	8.2	.6
2100	4.5	2.1	3.4	2.8	3.8	1.1	2.4	7.9	2.0
Av.	5.0	2.3	3.5	3.0	3.5	1.7	2.1	7.5	1.4
					May				
0300	4.1	3.1	6.0	3.3	3.4	1.9	1.2	5.7	2.3
0900	4.0	3.1	6.8	5.0	4.1	1.8	2.3	3.6	.3
1200	3.9	3.2	4.7	4.9	4.8	2.2	1.9	5.2	.2
1500	3.9	1.6	4.5	3.6	6.1	2.0	2.1	6.6	.6
1800	4.2	1.6	4.2	3.9	4.8	2.4	3.1	6.6	.2
2100	4.0	2.0	4.8	3.7	3.8	1.8	3.3	6.3	1.3
Av.	4.0	2.4	5.2	4.1	4.5	2.0	2.3	5.7	.8
					June				
0300	2.2	1.7	3.9	4.4	4.9	3.4	1.8	5.9	1.8
0900	2.4	2.9	3.2	4.3	6.6	3.1	2.0	4.8	.7
1200	3.1	2.0	3.6	3.0	6.9	4.1	3.2	4.0	.1
1500	2.6	2.1	2.3	2.3	7.0	4.7	2.7	5.9	.4
1800	2.6	1.6	2.2	2.3	5.8	4.3	5.0	6.0	.2
2100	2.0	1.6	2.6	1.8	6.1	4.7	5.2	5.1	1.0
Av.	2.5	2.0	3.0	3.0	6.2	4.0	3.3	5.3	.7
					July				
0300	2.6	1.7	2.2	3.6	6.7	3.0	2.6	5.5	3.1
0900	3.3	3.2	2.4	3.1	8.0	3.2	2.1	4.4	1.3
1200	2.9	1.6	2.3	2.8	9.5	3.4	2.8	5.0	.7
1500	2.4	2.1	1.7	1.6	9.5	5.2	3.0	5.2	.3
1800	2.6	1.3	1.9	1.9	7.7	6.2	3.8	4.6	1.0
2100	1.8	1.3	1.6	2.0	6.8	6.7	4.9	4.7	1.2
Av.	2.6	1.9	2.0	2.5	8.0	4.6	3.2	4.9	1.3
					August				
0300	2.0	1.6	3.3	4.4	6.9	4.1	2.4	3.5	2.8
0900	1.9	2.6	3.2	4.3	7.2	5.1	2.3	3.0	1.4
1200	2.6	2.4	[illegible]	3.4	9.6	3.9	2.2	3.6	.7
1500	2.6	2.6	1.8	3.0	9.0	5.6	2.9	3.4	.2
1800	1.4	2.1	1.3	3.1	8.1	5.1	3.3	5.2	.4
2100	1.9	1.7	1.1	3.6	8.2	4.9	3.0	3.6	3.0
Av.	2.1	2.3	2.2	3.6	8.2	4.8	2.7	3.7	1.4

BETTLES

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
0300	8.0	0.5	0.4	1.9	0.8	0.2	2.0	12.2	4.0
0900	7.6	2.0	.2	3.0	1.4	.4	2.7	8.3	[illegible]
1200	6.0	4.3	1.7	4.7	2.4	1.3	1.6	3.8	4.2
1500	5.6	4.8	2.9	5.7	2.7	1.3	1.2	2.2	3.6
1800	5.2	5.1	2.0	4.0	1.6	1.1	2.0	2.9	6.1
2100	7.1	1.9	1.0	1.9	1.3	.6	3.0	6.9	6.3
Av.	6.6	3.1	1.4	3.5	1.7	.8	2.1	6.0	4.6
					May				
0300	5.6	1.4	.3	1.9	1.4	.9	3.6	10.2	5.7
0900	7.6	3.1	1.9	4.3	2.7	2.7	1.4	2.7	4.6
1200	4.9	4.2	3.8	4.8	3.7	3.2	2.0	2.1	2.3
1500	4.4	4.9	4.0	4.2	2.9	3.3	3.0	1.9	2.4
1800	4.7	5.3	4.2	3.8	2.8	4.0	1.6	2.4	2.2
2100	5.9	4.2	2.8	3.4	1.3	2.4	2.4	5.0	3.6
Av.	5.5	3.9	2.8	3.7	2.5	2.8	2.3	4.0	3.5
					June				
0300	5.3	.7	1.3	4.9	1.8	1.0	1.9	6.3	6.8
0900	3.3	.9	2.0	3.7	5.0	6.0	2.2	3.0	3.9
1200	3.0	1.4	2.1	3.7	5.9	6.2	2.0	2.3	3.4
1500	3.0	1.7	2.3	3.6	3.7	8.4	1.9	2.0	3.4
1800	3.0	1.2	2.4	3.4	4.2	8.4	2.6	2.9	1.9
2100	4.1	1.2	2.0	3.8	4.0	5.4	1.9	2.8	4.8
Av.	3.6	1.2	2.0	3.9	4.1	5.9	2.1	3.2	4.0
					July				
0300	3.1	.7	2.0	8.6	2.2	.7	.8	6.2	6.7
0900	4.0	.4	.9	6.0	6.2	4.0	2.0	2.6	4.9
1200	1.8	.9	1.9	4.8	6.6	8.0	1.0	1.7	4.3
1500	1.7	1.2	1.0	3.9	7.7	9.4	1.9	1.4	2.8
1800	1.4	.9	.8	5.7	6.7	9.2	2.3	1.7	2.3
2100	2.2	.6	1.3	5.4	6.2	5.3	1.1	3.3	5.6
Av.	2.4	.8	1.3	5.8	5.9	6.1	1.5	2.8	4.4
					August				
0300	4.3	.7	1.3	6.9	1.7	.7	1.6	8.4	5.4
0900	5.2	1.4	1.7	5.3	5.9	2.0	.8	3.9	4.8
1200	3.7	2.0	1.6	4.3	7.0	5.3	2.2	2.0	2.9
1500	2.4	2.0	[illegible]	3.9	8.0	5.6	2.0	1.8	3.3
1800	3.1	1.6	2.1	3.8	8.1	5.0	1.9	2.0	3.4
2100	4.1	1.1	2.4	6.0	4.2	1.9	1.8	2.3	7.2
Av.	3.8	1.5	1.9	5.0	5.8	3.4	1.7	3.4	4.5

[illegible] DELTA

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
[illegible]	.2	[illegible]	3.7	2.1	7.1	7.0	3.1	[illegible]	5.6
[illegible]	1.6	2.2	9.3	.9	3.3	1.2	5.0	1.2	5.3
[illegible]	1.6	1.8	7.0	1.2	4.6	1.8	4.8	2.1	5.1
[illegible]	1.1	1.8	5.6	1.1	5.0	2.7	6.6	1.9	4.2
[illegible]	.6	1.0	4.6	1.7	5.6	5.2	6.8	[illegible]	[illegible]
[illegible]		.8	4.1	1.0	7.3	8.8	4.3	.6	3.1
[illegible]	.8	1.4	5.8	1.3	5.5	4.4	5.1	1.4	4.3
					May				
[illegible]	.1	.4	3.0	1.7	7.9	10.0	1.9	.2	5.8
0900	[illegible]	2.0	6.1	1.7	6.0	[illegible]	[illegible]	[illegible]	3.0
1200	.7	2.2	4.4	1.6	8.1	3.1	[illegible]	1.1	1.9
[illegible]	1.6	2.8	[illegible]	2.0	9.7	3.7	5.0	1.8	1.0
[illegible]	1.7	1.8	3.6	1.1	[illegible]	3.6	4.2	3.0	1.9
[illegible]	.4	1.6	[illegible]	1.8	10.7	7.0	3.1	1.0	3.3
[illegible]	1.5	2.0	3.7	1.6	8.8	5.1	3.4	[illegible]	2.8
					June				
[illegible]	.1	.4	1.8	1.8	7.1	[illegible]	2.8	.2	4.0
[illegible]	[illegible]	3.0	3.4	1.1	3.3	3.2	6.4	3.7	2.9
[illegible]	[illegible]	2.7	2.3	.9	3.2	3.6	7.1	4.3	2.8
[illegible]	[illegible]	[illegible]	1.9	1.3	6.2	[illegible]	6.9	4.4	[illegible]
[illegible]	[illegible]	1.0	2.2	1.0	6.9	4.9	5.8	4.2	2.3
[illegible]	.7	1.1	.8	.8	7.8	[illegible]	4.3	.8	[illegible]
Av	1.3	[illegible]	2.1	1.2	5.8	6.1	5.5	2.9	3.0
					July				
[illegible]	[illegible]	.2	1.7	.6	6.6	10.6	4.1	.2	6.9
[illegible]	[illegible]	2.8	[illegible]	[illegible]	3.4	[illegible]	6.0	4.2	4.2
[illegible]	[illegible]	2.7	2.1	.8	4.2	[illegible]	5.9	5.1	3.7
[illegible]	[illegible]	1.7	[illegible]	.6	6.0	3.0	6.1	5.8	2.4
[illegible]	[illegible]	2.0	1.7	1.0	5.7	4.0	6.0	6.0	2.4
[illegible]	[illegible]	1.0	1.7	1.2	7.6	9.0	5.2	.8	4.4
Av	[illegible]	1.7	[illegible]	.7	5.6	5.4	5.6	3.7	[illegible]
					August				
[illegible]	[illegible]	.9	3.4	2.7	5.8	7.4	3.1	.3	7.2
[illegible]	[illegible]	2.9	8.4	.8	3.3	2.2	4.6	3.3	3.8
[illegible]	[illegible]	2.8	6.6	1.6	4.8	[illegible]	3.6	3.1	2.7
[illegible]	[illegible]	2.9	4.4	1.4	6.1	2.1	4.6	4.1	2.6
[illegible]	1.7	1.9	2.6	1.2	7.1	3.7	4.9	3.1	4.6
[illegible]	[illegible]	.2	1.9	1.3	11.3	7.9	3.7	.3	4.2
Av.	1.5	1.9	4.6	1.5	6.4	4.4	4.1	2.4	4.2

FAIRBANKS

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
0300	8.3	3.6	1.7	.6	[illegible]	2.0	1.2	2.8	9.1
0900	1.9	4.6	4.7	2.9	2.6	2.0	1.4	1.9	8.0
1200	1.6	2.7	4.0	5.6	5.3	3.0	2.1	1.1	4.6
1500	2.3	2.3	2.7	5.1	5.4	3.6	3.4	1.8	3.4
1800	5.3	3.4	1.7	1.4	3.9	4.0	2.7	3.6	4.0
[illegible]	11.2	3.1	[illegible]	.7	1.0	3.0	2.0	3.6	4.4
Av.	5.1	3.7	2.6	2.7	3.2	2.9	2.1	2.5	5.6
					May				
0300	9.7	4.2	1.9	.4	1.6	1.8	1.0	4.4	6.0
0900	2.1	3.3	6.4	2.8	3.6	5.3	2.1	1.8	3.6
1200	2.0	[illegible]	4.1	4.8	5.2	4.6	3.0	3.3	1.2
1500	2.6	4.4	3.9	2.7	4.1	5.5	3.8	2.8	1.2
1800	3.7	4.9	3.4	1.7	2.4	5.4	4.7	3.4	1.4
2100	8.7	3.3	1.6	1.1	1.2	4.8	2.1	4.8	3.4
Av.	4.8	3.8	3.6	[illegible]	3.0	4.6	2.8	3.4	2.8
					June				
0300	6.9	2.7	2.2	.8	1.9	3.4	1.9	2.3	7.9
0900	1.3	3.0	3.0	2.4	3.9	6.9	2.3	2.4	4.8
1200	1.4	1.7	3.0	2.4	2.9	8.2	5.2	2.9	2.3
1500	1.7	2.8	1.9	1.6	3.3	7.7	6.3	2.7	2.0
1800	3.0	2.8	1.7	1.7	2.8	7.7	5.3	2.9	2.1
2100	4.9	2.0	1.2	.9	3.0	6.0	4.9	3.3	3.8
Av.	3.2	2.5	2.2	1.6	3.0	6.6	4.3	2.8	3.8
					July				
0300	5.2	5.0	1.9	.8	1.6	3.9	1.4	2.3	8.9
0900	1.2	3.2	2.7	3.7	4.5	6.7	2.8	.9	5.3
1200	1.4	1.6	2.4	2.8	4.9	9.1	4.6	1.9	2.3
1500 1/	1.3	2.1	1.4	2.2	3.6	6.0	8.6	2.4	2.0
1800	2.1	1.4	1.1	2.3	2.7	8.9	7.3	2.4	2.8
2100	4.9	1.3	1.4	.9	3.0	6.1	3.7	4.3	5.4
Av.	2.7	2.4	1.8	2.1	3.4	6.8	4.7	2.4	4.4
					August				
0300	5.2	4.6	1.7	1.0	2.1	3.2	1.7	4.1	7.4
0900 1/	2.2	4.4	5.2	2.8	2.2	3.8	2.2	1.3	6.1
1200	.9	2.4	3.7	4.0	4.1	6.2	3.2	2.1	4.4
1500	2.7	2.4	2.4	3.0	3.0	7.2	5.1	2.1	3.1
1800	4.2	2.6	1.9	1.1	1.8	8.2	4.3	3.2	3.7
2100	8.0	1.6	.9	.7	1.8	5.2	2.9	6.0	3.9
Av.	3.9	3.0	2.6	2.1	2.5	5.6	3.2	3.1	4.8

FT. YUKON

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
0200	2.6	15.6	1.8	1.0	.6	3.2	1.4	1.0	1.8
0900	2.7	14.5	2.6	.8	.9	3.9	3.9	.4	.3
1200	2.4	15.3	2.2	.3	.8	4.3	3.9	.8	.0
1500	1.9	13.9	2.4	.8	.6	5.7	3.9	.7	.1
1700 2/	1.5	13.0	3.5	1.0	.6	4.8	3.8	.9	.0
2000 2/	2.7	15.0	2.3	.6	1.1	3.2	2.2	1.6	.4
Av.	2.3	14.6	2.5	.8	.8	4.2	3.2	.9	.4
					May				
0200	.9	18.9	1.8	.6	1.1	4.4	1.7	.3	1.3
0900	1.6	15.4	2.3	.6	.8	5.3	4.2	.7	.1
1200	1.3	14.1	2.1	1.1	.7	6.6	4.0	1.0	.1
1500	1.1	14.0	2.0	1.7	1.1	5.7	4.4	1.0	.0
1700 3/	1.1	14.8	1.6	1.8	1.0	4.6	4.6	.9	.0
2000	1.6	15.8	2.0	.9	.9	4.2	4.0	1.2	.4
Av.	1.3	15.5	2.0	1.1	.9	5.1	3.8	.8	.3
					June				
0200	1.2	10.9	1.7	1.7	2.0	6.7	3.2	1.2	1.4
0900	1.7	9.1	1.7	1.2	1.7	7.9	5.7	.9	.1
1200	1.0	7.3	1.8	1.2	2.0	7.9	6.9	1.9	.0
1500	1.2	8.3	1.0	1.0	1.6	7.0	8.3	1.6	.0
1700	1.0	8.7	1.6	1.4	1.6	6.4	7.3	1.9	.1
2000	1.6	9.1	1.2	1.7	1.6	6.8	6.1	1.7	.2
Av.	1.3	8.9	1.5	1.4	1.8	7.1	6.2	1.5	.3
					July				
0200	1.2	6.8	1.7	1.3	1.9	8.0	6.7	1.6	1.8
0900 1/	1.4	7.2	1.2	.6	2.4	10.0	6.2	1.0	.0
1200	.8	5.0	1.3	1.3	2.8	9.7	8.4	1.7	.0
1500	.8	5.1	1.1	1.2	2.1	8.7	9.7	2.2	.1
1700	.3	3.7	1.0	1.1	2.4	8.5	10.7	3.0	.3
2000	1.6	4.2	1.8	1.3	2.8	7.9	8.7	2.0	.7
Av.	1.0	5.3	1.4	1.1	2.4	7.6	8.4	1.9	.5
					August				
0200	.7	7.0	3.6	.8	2.0	8.6	4.2	1.1	3.0
0900	1.2	7.1	2.0	1.0	3.0	8.9	5.5	2.1	.2
1200	1.3	6.1	1.8	1.8	2.9	8.5	6.8	1.8	.0
1500	.7	5.6	2.1	1.9	1.9	7.4	9.0	2.1	.3
1700	1.0	5.6	2.4	1.1	2.6	6.6	8.3	3.0	.4
2000	1.1	7.1	2.7	1.1	2.6	8.7	4.7	2.3	.7
Av.	1.0	6.4	2.4	1.3	2.5	8.1	6.4	2.1	.8

[illegible] footnotes at end of table.

Table 27 --Wind direction by hour of day, and number of days per month in each direction [illegible]--continued

(Av 1950-58)

GALENA

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
0300	9.7	0.8	3.1	2.3	1.2	0.9	0.8	2.2	9.0
0900	9.4	1.4	4.4	1.7	1.0	2.2	1.2	1.8	6.9
1200[4]/	11.3	1.4	4.4	1.3	2.3	2.4	.6	1.9	3.3
1500[5]/	12.3	1.9	4.0	1.2	2.4	2.4	1.0	.8	1.8
1800[4]/	12.9	2.8	4.4	.9	2.3	1.6	.8	1.3	1.9
2100	13.3	1.9	3.6	1.2	1.6	1.1	.8	1.8	4.7
Av.	11.5	1.7	4.0	1.4	1.8	1.8	.9	1.6	4.6
					May				
0300	7.1	1.4	3.6	3.3	1.1	1.8	1.4	3.4	7.9
0900	7.0	1.4	4.4	2.0	3.2	3.9	2.1	3.2	3.8
1200	7.4	1.7	4.3	2.8	4.1	3.7	2.6	2.2	2.2
1500	7.3	2.8	5.6	1.8	3.7	3.4	2.1	2.0	2.3
1800	8.3	2.0	5.1	2.6	2.7	2.9	2.2	2.3	2.8
2100	9.0	4.4	3.0	1.4	3.4	2.9	1.0	1.8	4.1
Av.	7.7	2.3	4.3	2.3	3.0	3.1	1.9	2.5	3.9
					June				
0300	3.8	.8	2.1	2.9	2.9	5.3	2.0	2.0	8.2
0900	4.2	1.1	2.2	1.8	2.6	6.0	3.4	3.0	5.6
1200	3.6	1.1	2.1	1.7	3.2	7.6	2.6	3.8	4.3
1500	3.2	1.3	2.6	1.9	2.7	7.8	3.2	4.1	3.2
1800	3.8	1.0	1.4	2.1	3.3	6.3	3.1	5.2	3.8
2100	4.6	2.3	1.2	.9	3.7	5.3	2.9	3.4	5.7
Av.	3.9	1.3	1.9	1.9	3.0	6.4	2.9	3.6	5.1
					July				
0300	2.1	.6	2.3	2.4	4.2	5.3	4.2	1.0	8.9
0900	2.1	.2	2.4	1.6	4.0	5.8	2.3	2.2	10.4
1200	1.9	.4	2.2	2.1	5.6	5.2	3.9	3.8	5.9
1500	2.2	.8	1.5	1.2	4.1	7.5	4.0	3.8	5.9
1800	3.0	.8	1.6	1.6	4.5	7.0	3.9	3.2	5.4
2100	3.3	1.0	1.5	1.5	4.6	7.8	2.1	2.0	7.2
Av.	2.4	.6	1.9	1.7	4.5	6.5	3.4	2.7	7.3
					August				
0300	3.0	.6	4.1	5.3	3.2	4.5	1.8	.9	7.6
0900	1.9	1.0	4.3	4.5	3.3	4.8	1.8	1.6	7.8
1200	2.8	1.0	3.2	4.5	5.9	4.6	1.8	3.0	4.2
1500	2.8	.8	4.2	3.6	5.2	5.9	2.9	2.5	3.1
1800	2.6	1.0	3.1	2.8	4.9	6.9	1.8	2.8	5.1
2100	3.0	.9	4.3	3.5	4.6	5.0	1.2	2.0	6.5
Av.	2.7	.9	3.9	4.0	4.5	5.3	1.9	2.1	5.7

GULKANA

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
0300	2.9	0.7	0.3	5.6	1.9	1.9	5.6	4.7	6.4
0900	2.8	.6	1.6	9.6	2.6	1.6	2.8	2.6	5.6
1200	2.4	1.3	1.7	11.2	2.4	1.6	3.4	2.2	3.8
1500	3.2	2.4	1.2	9.3	3.9	2.8	2.7	1.6	2.9
1800	3.0	.7	.7	9.3	3.6	1.6	5.2	3.6	2.3
2100[1]/	2.8	1.3	1.7	8.6	2.3	1.3	4.2	3.3	3.2
Av.	2.8	1.2	1.2	8.9	2.8	1.8	4.0	3.0	4.1
					May				
0300	1.9	1.0	1.4	9.8	4.4	2.3	2.2	1.6	6.4
0900	1.7	2.2	2.4	13.8	3.3	2.9	1.7	1.1	1.9
1200	2.2	1.4	2.6	13.0	4.8	2.9	2.2	1.3	.6
1500	2.7	.9	1.8	13.0	4.7	3.9	1.9	1.3	.8
1800	2.1	2.1	.9	9.6	5.8	4.8	2.2	2.3	1.2
2100	2.3	1.3	1.4	12.4	4.3	2.4	3.1	1.9	1.9
Av.	2.2	1.5	1.8	11.9	4.6	3.2	2.2	1.5	2.1
					June				
0300	1.1	.6	1.6	9.1	5.6	3.0	1.8	2.1	5.1
0900	1.7	1.1	3.1	11.8	3.9	3.1	1.7	2.2	1.4
1200	2.3	1.1	3.3	10.0	5.8	4.0	1.8	1.1	.6
1500	1.8	1.2	3.1	10.0	5.2	3.9	2.2	2.2	.4
1800	2.8	.9	1.8	10.1	4.0	4.9	2.6	2.2	.7
2100	2.0	.6	1.3	10.1	4.8	3.4	2.4	3.8	1.6
Av.	2.0	.9	2.4	10.2	4.9	3.7	2.0	2.3	1.6
					July				
0300	.9	.6	1.2	8.0	7.3	4.0	1.8	2.3	4.9
0900	2.3	.8	4.1	12.0	4.2	2.4	1.4	1.2	2.6
1200	2.0	1.8	3.6	12.8	3.0	2.1	1.7	3.0	1.0
1500	2.8	.9	4.2	12.0	3.4	3.3	2.1	1.1	1.2
1800	3.1	1.3	2.3	11.8	4.4	2.0	1.2	2.9	2.0
2100	2.2	.8	1.9	11.4	4.2	3.0	2.0	3.2	2.3
Av.	2.2	1.0	2.9	11.4	4.4	2.8	1.7	2.3	2.3
					August				
0300	1.6	.9	.7	7.4	5.7	4.3	1.6	2.6	6.2
0900	2.8	1.4	2.2	12.1	3.9	3.2	1.4	1.0	3.0
1200	3.2	1.0	3.0	11.4	5.0	2.0	1.4	1.8	2.2
1500	3.2	1.3	3.3	12.2	3.9	3.2	1.7	1.2	1.0
1800	3.0	1.4	1.3	11.9	5.1	2.3	2.2	1.4	2.4
2100	2.2	.7	2.0	11.4	4.2	1.9	2.8	2.1	3.7
Av.	2.7	1.1	2.1	11.1	4.6	2.8	1.8	1.7	3.1

HOMER

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
0300	6.3	7.0	2.1	0.6	0.9	2.0	0.6	1.7	8.8
0900	1.3	7.5	4.8	3.9	2.8	4.2	.0	.6	4.9
1200	1.6	4.2	3.2	2.2	5.3	10.4	.6	.2	2.3
1500	1.8	3.4	2.4	2.2	3.8	12.3	1.4	.9	1.8
1800	1.8	3.4	2.4	2.3	2.2	8.9	2.7	2.2	4.1
2100	3.5	4.9	2.3	.9	.9	4.1	2.3	2.3	8.8
Av.	2.7	5.1	2.9	2.0	2.6	7.0	1.3	1.3	5.1
					May				
0300	4.7	8.2	1.8	.9	1.2	1.2	1.3	1.5	9.8
0900	.8	2.7	4.8	4.6	6.5	8.8	1.0	.1	1.7
1200	.4	2.3	3.9	3.4	5.1	12.9	2.2	.1	.7
1500	.9	1.9	3.7	3.1	3.7	14.5	2.0	.6	.6
1800	.9	2.4	3.1	3.7	2.6	14.0	2.3	.7	1.3
2100	1.8	4.0	1.9	3.2	1.4	6.4	3.9	1.3	7.1
Av.	1.6	3.6	3.2	3.2	3.4	9.6	2.1	.8	3.5
					June				
0300	3.4	6.3	1.2	1.1	1.1	1.7	1.9	1.6	11.7
0900	.4	.8	2.4	2.8	5.1	13.4	2.3	.6	2.2
1200	.6	1.0	2.2	1.1	4.9	17.6	1.9	.3	.4
1500	.1	.9	1.7	2.0	2.9	17.6	3.7	.3	.8
1800	.4	1.1	1.3	2.0	4.5	16.2	2.9	.3	1.3
2100	1.7	2.1	1.7	1.2	1.7	8.5	5.2	1.3	6.6
Av.	1.1	2.0	1.8	1.7	3.4	12.5	3.0	.7	3.8
					July				
0300	4.1	6.6	1.1	.2	.9	2.0	1.7	.3	14.1
0900	.4	3.2	1.7	1.9	5.6	9.4	1.9	.9	6.0
1200	1.0	2.9	.9	.7	2.4	17.6	2.0	.2	3.3
1500	.2	3.0	.9	1.6	3.1	15.1	2.9	.6	3.6
1800	.2	.8	1.3	1.9	1.9	18.2	4.0	.3	2.4
2100	2.0	2.4	.8	.9	1.6	5.4	3.9	3.0	11.0
Av.	1.3	3.2	1.1	1.2	2.6	11.3	2.7	.9	6.7
					August				
0300	4.4	7.7	1.4	1.9	.4	2.0	.6	.9	11.7
0900	1.1	3.9	5.2	3.0	3.6	5.9	1.7	.2	6.4
1200	.7	1.9	1.4	2.2	5.4	14.8	2.0	.2	2.4
1500	.6	1.8	1.4	1.9	3.6	15.5	2.8	.3	3.1
1800	.8	1.4	1.8	1.9	2.9	13.0	3.3	1.3	4.6
2100	3.7	5.0	1.2	2.0	1.1	4.7	1.7	1.1	10.5
Av.	1.9	3.6	2.1	2.2	2.8	9.3	2.0	.7	6.4

ILIAMNA

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
0300	8.2	3.0	6.4	1.0	0.0	0.9	3.9	2.6	4.0
0900	4.9	1.7	8.0	3.7	1.2	1.6	3.0	2.2	3.7
1200	1.9	1.1	8.0	4.4	3.0	3.6	3.2	2.4	2.4
1500	.9	.8	7.6	4.9	3.0	3.9	4.2	2.9	1.8
1800	1.7	1.3	6.3	4.0	2.3	3.6	5.4	2.4	3.0
2100	2.8	2.3	6.1	2.8	.7	1.5	4.3	4.6	4.9
Av.	3.4	1.7	7.1	3.5	1.7	2.5	4.0	2.8	3.3
					May				
0300	4.8	2.3	10.0	1.4	.3	1.2	3.8	2.4	4.8
0900	1.8	.6	11.7	9.5	1.6	2.3	1.7	.6	1.2
1200	.7	.4	11.0	9.3	4.3	2.3	1.7	.7	.6
1500	.8	.2	10.7	9.7	4.0	2.0	2.0	.9	.7
1800	.2	.3	10.4	9.3	4.1	2.6	1.7	1.3	1.1
2100	.8	1.2	11.3	3.7	1.1	2.1	4.4	1.3	5.1
Av.	1.5	.8	10.8	7.2	2.6	2.1	2.6	1.2	2.2
					June				
0300	3.0	1.8	7.0	1.8	.3	2.9	5.7	2.8	4.7
0900	.7	.8	7.0	8.2	2.4	5.3	2.9	1.0	1.7
1200	.7	.1	6.7	9.1	3.8	6.1	1.7	1.4	.4
1500	.4	.1	7.9	8.3	4.2	5.8	1.3	1.6	.4
1800	.6	.0	7.6	8.0	3.9	5.4	2.4	1.7	.4
2100	1.0	1.0	8.0	4.9	2.0	3.3	5.5	1.6	2.7
Av.	1.1	.6	7.4	6.7	2.8	4.8	3.2	1.7	1.7
					July				
0300	2.6	1.6	6.2	2.0	.1	3.2	6.7	1.9	6.7
0900	1.3	.3	7.0	6.9	3.0	6.9	2.9	.6	2.1
1200	.9	.4	5.6	8.8	4.0	6.8	2.2	1.0	1.3
1500	.8	.0	5.1	9.4	4.9	7.1	1.7	1.3	.7
1800	.3	.4	5.8	7.3	4.2	6.1	3.2	2.0	1.7
2100	.9	.9	6.0	4.2	1.8	3.2	6.8	2.1	5.1
Av.	1.1	.6	6.0	6.4	3.0	5.6	3.9	1.5	2.9
					August				
0300	4.6	1.8	5.1	2.2	.7	2.6	5.5	3.2	5.3
0900	2.2	1.9	6.8	4.8	1.2	4.4	5.0	1.6	3.1
1200	1.2	.6	7.1	6.4	3.3	5.6	3.3	1.8	1.7
1500	.6	.4	5.6	8.4	3.2	6.4	3.4	1.4	1.6
1800	.9	.4	8.1	6.4	2.2	6.4	3.1	1.9	1.6
2100	1.2	1.2	6.8	4.4	1.7	3.4	5.4	2.5	4.4
Av.	1.8	1.0	6.6	5.4	2.0	4.8	4.3	2.1	3.0

KOTZEBUE

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
0300	3.8	5.5	7.3	3.0	1.7	3.4	3.7	0.6	1.0
0900	2.7	4.4	6.8	3.8	1.6	2.9	4.6	1.2	[illegible]
1200	1.8	3.1	7.5	3.6	1.6	3.8	5.7	[illegible]	[illegible]
1500	2.4	2.8	7.4	3.1	1.3	4.0	6.6	1.6	.8
1800	2.6	3.3	6.7	2.3	2.0	[illegible]	6.4	1.2	.9
2100	3.2	4.2	7.5	2.1	2.6	3.0	4.9	1.3	1.2
Av.	2.8	3.9	7.2	3.0	1.8	3.6	5.3	1.2	1.2
					May				
0300	3.2	7.0	6.1	1.7	1.2	4.0	4.8	1.7	1.3
0900	3.0	2.9	6.7	1.9	2.3	6.8	4.7	2.3	.4
1200	2.2	2.0	5.4	2.2	2.2	7.1	8.5	1.2	.2
1500	2.2	2.3	4.6	1.7	1.0	6.8	9.7	2.1	.6
1800	2.6	3.4	4.1	1.3	1.3	[illegible]	9.2	2.7	1.1
2100	3.6	5.1	4.8	1.4	1.6	5.8	7.2	1.6	1.9
Av.	2.8	3.8	5.3	1.7	1.6	5.6	7.4	1.9	.9
					June				
0300	2.4	3.0	2.7	2.4	2.7	6.0	8.8	1.4	.6
0900	1.2	.4	1.4	3.1	4.2	9.4	8.8	1.4	.1
1200	.8	.0	1.9	2.4	2.7	9.1	11.6	1.4	.1
1500	.6	.2	1.1	2.3	1.8	6.9	14.7	2.2	.2
1800	1.3	.9	.9	1.9	2.1	5.3	14.9	2.4	.3
2100	1.7	2.2	2.1	[illegible]	2.7	4.7	[illegible]	2.1	.3
Av.	1.3	1.1	1.7	2.4	2.7	6.9	11.8	1.8	.3
					July				
0300	1.7	2.1	3.7	4.3	[illegible]	4.7	8.1	[illegible]	.8
0900	.7	.1	2.4	4.9	4.7	7.8	8.1	2.0	.3
1200	.1	.4	.8	5.0	5.1	7.0	11.7	.9	.0
1500	1.0	.2	1.2	4.6	3.7	4.8	13.1	1.7	.7
1800	1.3	.8	2.0	3.7	2.6	4.3	14.0	1.6	.7
2100	1.1	1.6	2.6	3.3	2.1	5.4	10.9	2.1	.9
Av.	1.0	.9	2.1	4.3	3.6	5.7	11.0	1.8	.6
					August				
0300	3.1	2.9	6.3	4.6	2.3	3.2	6.3	1.7	.6
0900	1.9	1.1	6.9	4.6	4.4	2.9	6.8	2.1	.3
1200	.6	.9	4.9	5.1	4.8	5.5	7.5	1.7	.0
1500	.2	.9	3.8	5.6	3.9	4.4	[illegible]	[illegible]	.2
1800	.9	2.4	4.2	4.7	3.7	3.1	9.0	2.3	.7
2100	1.8	3.4	4.8	4.2	3.0	[illegible]	7.0	2.9	.9
Av.	1.4	1.9	5.2	4.8	3.7	3.7	[illegible]	2.1	.4

LAKE MINCHUMINA

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
0300	2.8	7.7	1.3	0.6	0.6	2.6	3.0	2.0	9.4
0900	.8	4.1	7.1	2.0	2.1	4.7	1.4	1.1	6.7
1200	1.0	4.9	9.3	2.7	2.4	[illegible]	[illegible]	.2	4.0
1500	1.7	4.9	9.0	3.2	2.1	3.0	1.1	1.1	3.9
1800	3.1	10.0	4.1	.2	.8	2.4	2.2	2.4	4.8
2100	6.1	[illegible]	1.4	.0	.3	2.0	2.0	2.8	5.0
Av.	2.6	7.0	5.4	1.4	1.4	2.2	1.8	1.6	5.6
					May				
0300	3.4	6.2	2.2	.4	.8	1.6	2.9	3.4	9.1
0900	.8	4.4	10.4	3.7	2.2	5.4	.8	1.1	2.2
1200	1.4	4.8	9.1	4.1	2.9	4.8	1.8	.7	1.4
1500	1.4	4.7	7.8	2.5	2.8	5.6	3.0	1.7	1.4
1800	3.4	8.2	3.6	.6	.6	5.9	3.6	2.0	3.1
2100	6.2	6.4	1.0	.2	.6	3.6	4.9	4.2	3.9
Av.	2.8	5.8	5.7	1.9	1.7	4.6	2.8	2.2	3.5
					June				
0300	2.8	2.4	1.0	.1	.6	6.3	4.7	2.0	10.1
0900	.7	4.1	6.7	3.0	3.4	6.0	3.2	.9	1.4
1200	.8	3.0	6.4	3.1	3.3	7.8	2.8	1.6	1.2
1500	1.3	4.4	4.8	1.9	2.7	9.4	2.7	2.0	.8
1800	2.7	4.6	1.4	1.1	1.6	8.0	5.0	3.7	1.9
2100	4.0	3.2	.4	.0	.4	6.0	6.7	6.0	3.2
Av.	2.1	3.6	3.4	1.5	[illegible]	7.4	[illegible]	2.7	3.1
					July				
0300	[illegible]	1.6	.6	.2	.6	6.7	5.6	3.2	10.7
0900	.3	2.2	4.2	3.1	3.6	9.8	2.9	.9	4.0
1200	.6	1.7	5.3	4.4	2.3	9.7	3.1	1.7	2.1
1500	.8	3.2	4.4	3.0	3.2	9.1	4.1	1.9	1.3
1800	1.9	2.3	2.1	.7	1.8	9.9	4.8	2.3	4.2
2100	3.3	2.6	.6	.2	.8	6.6	7.1	4.6	5.2
Av.	1.4	2.4	2.9	2.0	2.1	8.6	4.6	2.4	4.6
					August				
0300	2.8	2.0	.7	.6	1.0	5.1	4.3	3.1	11.3
0900	.3	3.8	5.0	2.1	2.8	7.6	2.8	1.3	5.3
1200	.6	1.1	6.7	2.4	2.3	8.2	3.7	.8	2.7
1500	.4	2.9	6.0	1.6	1.6	8.2	4.1	1.6	3.6
1800	1.1	2.8	2.8	.8	1.2	6.3	4.6	2.4	8.0
2100	1.7	3.3	1.1	.2	1.7	5.2	6.0	3.9	5.9
Av.	[illegible]	[illegible]	[illegible]	1.3	1.8	6.8	4.2	2.2	6.1

See footnotes at end of table.

Table [illegible] Wind direction by hour of day, and number of days per month [illegible] each direction class—Continued

(Av. 1950-58)

[illegible]

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					May				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					June				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.4	4.4	4.1	[illegible]	3.9
					July				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.[illegible]
					August				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NAB[illegible]

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
[illegible]	[illegible]	[illegible]	[illegible]	3.6	[illegible]	[illegible]	1.7	3.7	[illegible]
[illegible]	[illegible]	4.	[illegible]	3.4	[illegible]	[illegible]	1.2	3.7	3.1
[illegible]	4.[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	1.9	5.6	[illegible]
[illegible]	4.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.6	.9
[illegible]	4.[illegible]	[illegible]	4.[illegible]	.2	3.1	[illegible]	3.9	4.8	1.[illegible]
[illegible]	4.4	[illegible]	2.7	[illegible]	[illegible]	[illegible]	2.2	4.3	4.9
Av.	4.5	[illegible]	[illegible]	2.9	[illegible]	[illegible]	2.3	4.5	3.0
					May				
[illegible]	[illegible]	4.4	4.[illegible]	4.4	4.[illegible]	1.6	.7	.7	7.[illegible]
[illegible]	[illegible]	.4	6.7	5.4	4.[illegible]	[illegible]	1.3	1.8	3.4
[illegible]	[illegible].7	2.9	[illegible]	3.9	4.[illegible]	[illegible]	[illegible]4	2.0	1.7
[illegible]	[illegible]	1.9	7.7	4.2	5.4	.7	3.3	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	6.8	3.7	4.8	4.4	4.3	2.0	1.1
[illegible]	[illegible]	[illegible].1	5.1	4.1	5.7	3.3	3.0	1.1	4.0
Av.	[illegible]	[illegible]	6.4	4.6	4.8	2.8	2.5	1.7	[illegible]
					June				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.9	[illegible]
[illegible]	[illegible]	[illegible]	4.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.7	4.[illegible]
[illegible]	[illegible]	[illegible]	4.4	4.[illegible]	5.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	4.5	3.4	5.[illegible]	[illegible]	5.[illegible]	2.2	[illegible]
[illegible]	[illegible]	[illegible]	4.0	2.7	5.8	5.8	7.[illegible]	.8	.9
[illegible]	[illegible]	[illegible]	4.3	[illegible]	8.0	6.[illegible]	3.6	1.1	2.4
Av.	[illegible]	[illegible].5	4.2	3.8	6.5	4.6	3.5	1.5	2.9
					July				
[illegible] [1/]	1	[illegible]4	2.2	3.9	9.1	2.2	2	1.1	7.4
[illegible]	[illegible]	[illegible]	[illegible].7	3.4	[illegible]	4.2	1.6	1.8	4.2
[illegible]	[illegible].4	[illegible]	[illegible].7	3.0	[illegible].2	5.4	4.4	[illegible].6	3.[illegible]
[illegible]	1.4	[illegible]	4.1	2.[illegible]	6.9	5.6	6.1	2.3	1.6
[illegible]	[illegible].3	[illegible]	3.	2.6	6.3	[illegible]	8.2	[illegible].8	.8
[illegible]	.8	[illegible]	[illegible].8	2.[illegible]	8.5	7.4	[illegible]	.9	4.0
Av.	1.5	[illegible]	2.9	3.[illegible]	7.8	5.[illegible]	4.[illegible]	1.6	3.5
					August				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.7	[illegible]	1.1	.7	6.[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.4	[illegible]	[illegible]	[illegible]	3.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.9	[illegible]	[illegible]	2.0	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.4	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.3
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.7	2.9

NORTHWAY

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
0300	.2	1.2	2.9	3.6	2.7	1.3	2.1	4.4	11.6
0900	.8	1.6	4.8	5.1	1.1	.9	2.7	5.8	7.2
1200	1.[illegible]	1.7	3.8	5.1	1.9	2.6	2.0	5.4	5.7
1500	1.2	1.1	3.1	5.[illegible]	2.0	1.9	[illegible]	7.6	4.3
1800	[illegible]	[illegible]	[illegible]	2.4	.7	2.1	3.7	8.3	[illegible]
2100	1.7	.9	3.[illegible]	2.7	1.3	[illegible]	3.4	6.1	8.1
Av.	[illegible]	1.2	3.4	4.1	1.[illegible]	1.9	3.[illegible]	[illegible]	7.3
					May				
0300	.6	.6	[illegible]	3.[illegible]	1.1	1.4	3.0	4.3	13.2
0900	2.8	1.2	2.[illegible]	4.0	2.8	2.9	3.9	[illegible]	3.9
1200	3.9	1.9	1.9	4.3	3.1	3.8	4.4	5.9	1.8
1500	3.0	.7	2.6	2.7	2.7	3.7	4.2	9.8	1.6
1800	3.3	.8	2.2	1.8	2.1	2.8	6.6	9.3	2.1
2100	1.8	1.2	1.6	1.0	1.6	3.3	5.6	6.8	8.1
Av.	2.6	1.1	2.4	2.9	2.2	3.0	4.6	7.1	5.1
					June				
0300	.4	.1	1.4	1.8	2.2	3.8	4.1	5.5	10.7
0900	[illegible].7	1.1	1.6	2.[illegible]	2.3	1.9	5.3	9.0	3.4
1200[illegible]	3.3	1.1	1.7	2.[illegible]	4.[illegible]	1.5	4.6	8.1	2.0
1500	3.9	1.2	1.4	2.4	2.1	2.4	7.1	8.2	1.3
1800	3.0	1.6	1.7	2.2	2.[illegible]	1.9	7.[illegible]	8.3	2.3
2100	1.3	1.2	1.7	.9	1.9	3.8	6.7	7.5	5.0
Av.	2.4	1.0	1.6	2.1	2.4	2.6	5.8	7.8	4.1
					July				
0300	.2	.6	2.4	2.2	1.6	3.1	5.2	5.4	10.3
0900	2.3	1.0	2.4	3.0	1.3	2.0	5.1	[illegible].9	3.0
1200[7]	2.0	1.0	1.3	3.1	2.2	2.4	4.1	9.9	2.8
1500	3.0	1.5	[illegible].4	2.1	1.8	2.8	4.5	10.1	2.2
1800[illegible]	3.[illegible]	.4	1.[illegible]	1.8	1.7	3.1	6.[illegible]	9.3	3.2
2100	[illegible]	.7	1.2	1.0	2.3	3.3	6.8	7.0	7.1
Av.	2.0	.9	1.9	2.2	1.8	2.8	5.4	8.8	4.8
					August				
0300	.4	.4	3.5	[illegible].9	2.5	1.4	4.9	4.1	10.9
0900	1.8	[illegible].1	4.0	5.9	2.6	1.5	3.[illegible]	6.[illegible]	2.9
1200	1.1	1.4	2.9	4.5	3.2	2.9	4.4	[illegible].0	2.6
1500	[illegible].0	1.4	1.[illegible]	3.[illegible]	1.4	2.6	6.0	7.1	3.9
[illegible]	[illegible].1	1.1	1.2	2.2	2.2	3.8	7.[illegible]	6.5	5.2
[illegible]	1.0	.1	[illegible].0	1.6	1.8	3.0	6.5	5.0	10.0
Av.	1.4	1.1	2.[illegible]	3.5	2.3	2.5	5.5	6.2	5.9

[illegible]

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					May				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					June				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					July				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					August				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
[illegible]	[illegible]	4.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	1.4	13.8
[illegible]	[illegible]	[illegible]	9[illegible]	[illegible]	.4	[illegible].4	[illegible].9	.8	7.3
[illegible]	[illegible]	4.[illegible]	[illegible].4	2.4	[illegible]	1.4	[illegible].4	[illegible].2	5.[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].4	4.4
[illegible]	[illegible]	[illegible]7	[illegible]	9	[illegible]	[illegible]	[illegible]	2.8	3.3
[illegible]	[illegible]	[illegible]	4.[illegible]	[illegible]	[illegible]	[illegible]	1.9	[illegible]	[illegible].4
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.9	1.9	7.1
					May				
[illegible]	[illegible]	3.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	1.[illegible]	17.9
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.4	1.[illegible]	1.[illegible]	5.7
[illegible]	[illegible]	[illegible]	[illegible]	4.[illegible]	[illegible]	5.9	2.2	2.0	2.7
[illegible]	[illegible]	4.[illegible]	.7	3.[illegible]	1.[illegible]	4.[illegible]	[illegible].9	[illegible].9	3.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.[illegible]	2.4	4.4
[illegible]	[illegible]	[illegible]	4.	4	[illegible]	[illegible]	[illegible]	4.0	9.0
Av.	[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.2	[illegible]
					June				
[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	13.3
[illegible]	[illegible]	[illegible]7	4.[illegible]	[illegible].7	[illegible]	[illegible]	[illegible].9	1.2	6.7
[illegible]	[illegible]	1[illegible]	5.[illegible]	[illegible].7	[illegible]1	[illegible]	4.2	1.[illegible]	4.2
[illegible]	[illegible]	[illegible]	4.[illegible]	2	[illegible]	[illegible]	[illegible]	1.[illegible]	3.4
[illegible]	[illegible]	[illegible]	.7	1.4	[illegible]	[illegible]	[illegible]	[illegible]	5.2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.[illegible]
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.1
					July				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					August				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

UNALAKLEET

Time of day	N	NE	E	SE	S	SW	W	NW	Calm
					April				
[illegible]30[illegible]	0.4	5.6	11.5	2.2	1.7	2.3	0.7	1.[illegible]	4.4
[illegible]900	.0	5.6	7.3	[illegible]	[illegible].4	3.9	2.6	[illegible]	[illegible].8
12[illegible]	[illegible]	3.9	6.4	[illegible].4	[illegible].1	[illegible]	3.9	5.[illegible]	2.7
15[illegible]	.7	4.4	5.4	1.3	[illegible]	[illegible]	[illegible].9	[illegible]	[illegible].4
18[illegible]	1.[illegible]	4.1	[illegible].5	1.[illegible]	[illegible]	[illegible].7	2.3	5.[illegible]	[illegible].7
2100	.7	6.7	8.[illegible]	[illegible]	[illegible]	3.[illegible]	[illegible]	[illegible]	[illegible]
Av.	.8	5.0	7.[illegible]	1.[illegible]	[illegible]	3.[illegible]	[illegible].3	[illegible].7	[illegible]
					May				
0300	.4	7.9	1[illegible].6	.9	1.7	[illegible].4	[illegible]	[illegible]	[illegible]
0900	.2	3.7	7.1	1.[illegible]	[illegible]	[illegible].7	4.4	4.[illegible]	1.7
1200	.4	2.4	5.1	[illegible]	1.7	5.[illegible]	4.5	8.4	[illegible].1
1500	.9	2.4	5.0	1.[illegible]	[illegible]	4.4	4.4	1[illegible].7	1.[illegible]
1800	.9	4.4	4.4	1.[illegible]	[illegible]	[illegible].9	2.9	[illegible]	[illegible].9
[illegible]	2.1	[illegible]	5.8	[illegible]	[illegible]	4.0	1.[illegible]	[illegible]	5.[illegible]
Av.	.8	4.[illegible]	6.[illegible]	[illegible]	[illegible]	4.2	[illegible]	[illegible]	3.0
					June				
0300	.0	4.[illegible]	10.3	1.6	1.7	5.0	2.8	.8	3.0
0900	0	1.9	2.1	1.2	[illegible]	8.4	5.9	4.9	2.3
1200	1	.9	1.4	1.1	[illegible].6	6.3	[illegible].6	5.1	.9
1500	.4	.8	1.[illegible]	1.0	1.[illegible]	[illegible].7	[illegible].7	[illegible].3	1.2
1800	1.[illegible]	1.4	1.[illegible]	.[illegible]	3.2	6.[illegible]	[illegible].4	7.0	1.9
[illegible]	1.[illegible]	2.[illegible]	[illegible].9	[illegible]	[illegible].7	7.[illegible]	4.8	[illegible]	4.[illegible]
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].5	[illegible]	[illegible]	5.4	[illegible]
					July				
[illegible]	[illegible]	[illegible]	[illegible].4	[illegible]	7	[illegible].9	1.[illegible]	[illegible].9	4.[illegible]
[illegible]	[illegible]	.3	[illegible].7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].7	[illegible].4	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.7	[illegible]	[illegible]	[illegible]
[illegible]	7	[illegible]	[illegible]	[illegible].4	[illegible]	7.0	7.0	[illegible]	1.[illegible]
[illegible]	[illegible]	1.9	[illegible]	[illegible]	[illegible]	[illegible]	4.[illegible]	[illegible]	4.7
Av.	[illegible]	1.1	[illegible]	[illegible]	[illegible]	7.[illegible]	[illegible]	[illegible]	.4
					August				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.4	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Table 28.--Wind velocity by hour of day, and number of days per month in each velocity class

(Av. 1950-58)

ANCHORAGE

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			Wind velocity, m.p.h.			
			April			
0300	14.8	9.8	4.2	1.1	0.1	
0900	8.3	13.9	5.8	2.0		0.1
1200	4.8	12.4	10.7	1.8	.2	.1
1500	3.7	11.7	10.1	4.1	.2	.2
1800	8.4	11.4	6.2	3.4	.6	
2100	12.4	9.3	6.0	2.1	.1	.1
Av.	8.7	11.4	7.2	2.4	2	.1
			May			
0300	14.6	9.7	4.3	2.0	.3	.1
0900	4.8	14.4	8.1	3.1	.6	
1200	2.7	8.7	12.7	5.8	1.0	.1
1500	1.2	5.[illegible]	13.6	7.7	1.6	.1
1800	2.8	8.8	10.3	8.1	1.0	
2100	10.9	8.9	5.7	5.2	.3	
Av.	6.2	9.4	9.2	5.3	.8	.1
			June			
0300	15.8	9.9	2.9	1.0	.4	
0900	6.2	14.1	6.0	1.6	.1	
1200	3.2	10.9	11.7	3.6	.6	
1500	1.8	9.8	12.4	4.6	1.4	
1800	4.1	9.2	10.1	6.0	.6	
2100	12.9	8.3	4.3	3.9	.6	.1
Av.	7.3	10.4	8.2	3.5	.6	
			July			
0300	17.9	8.4	3.3	1.4		
0900	7.3	14.6	7.7	1.3	.1	
1200	5.2	12.1	11.1	2.2	.4	
1500	3.6	12.0	11.0	3.7	.7	
1500	6.4	12.0	8.3	3.7	.6	
2100	14.1	9.3	4.2	3.1	.3	
Av.	9.1	11.4	7.6	2.6	.3	
			August			
0300	1[illegible].6	7.9	2.6	1.6	.2	.1
0900	10.[illegible]	12.9	5.6	1.7		
1200	6.0	14.4	8.[illegible]	1.4	.3	.1
1500	5.6	13.5	[illegible].9	2.7	.3	
1800	10.9	10.6	7.1	2.0	.3	.1
2100	14.7	9.9	4.0	2.1	.2	.1
Av.	11.1	11.5	6.2	1.9	.2	.1

BETHEL

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			Wind velocity, m.p.h.			
			April			
0300	4.1	9.7	.7	6.6	[illegible].6	0.[illegible]
0900	3.1	6.9	10.7	7.6	1.3	.4
1200	1.0	6.3	9.6	9.2	3.[illegible]	.[illegible]
1500	.9	4.6	11.0	9.6	3.2	.7
1800	1.2	6.3	11.2	8.8	1.7	.[illegible]
2100	3.7	8.5	10.4	5.3	1.7	.4
Av.	2.[illegible]	7.1	10.3	7.[illegible]	2.[illegible]	.5
			May			
0300	3.7	11.0	11.9	3.9	.4	.1
0900	1.[illegible]	7.7	12.0	7.8	1.6	.1
1200	.9	5.[illegible]	11.4	[illegible].4	[illegible].1	4
1500	.9	3.6	13.2	10.8	2.3	.2
1800	.6	5.3	13.3	9.9	1.7	.2
2100	2.7	9.8	11.7	5.8	.9	.1
Av.	1.8	7.2	12.2	8.1	1.5	.2
			June			
0300	2.9	11.1	12.6	3.3	.1	
0900	1.7	6.4	14.5	6.6	.7	.[illegible]
1200	1.0	6.0	14.2	7.3	[illegible].2	.3
1500	.9	6.3	13.4	8.6	.[illegible]	
1800	.6	4.4	14.3	9.7	1.[illegible]	
2100	1.7	9.4	12.7	5.8	.3	.1
Av.	1.5	7.2	13.6	6.9	.7	1
			July			
0300	4.9	11.5	9.4	4.8	.4	
0900	1.8	10.2	11.8	6.2	.9	.1
1200	1.6	8.2	13.0	6.7	1.3	.2
1500	1.1	7.4	12.6	8.2	1.6	.1
1800	1.4	6.9	13.6	9.3	.[illegible]	
2100	2.4	10.9	13.1	4.1	.4	.1
Av.	2.2	9.2	12.2	6.4	.9	.1
			August			
0300	3.8	10.7	10.7	5.1	.[illegible]	.1
0900	2.4	7.3	12.7	6.7	1.9	
1200	.9	7.3	12.1	7.7	[illegible].6	.[illegible]
1500	1.3	7.1	11.9	7.7	[illegible].9	.1
1800	1.2	8.4	12.4	7.9	1.0	.1
2100	4.2	10.0	10.2	5.7	.9	
Av.	2.3	8.5	11.7	6.8	1.6	.[illegible]

BETTLES

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			Wind velocity, m.p.h.			
			April			
0300	6.0	11.5	[illegible]	1.9	0.2	0.1
0900	6.1	9.3	10.8	3.7		.1
1200	7.3	10.1	8.7	3.7	.2	
1500	7.7	9.6	8.7	3.7	.3	
1800	9.7	9.2	8.1	2.6	.4	
2100	9.[illegible]	[illegible]	8.3	1.8	.1	.1
Av.	7.7	[illegible]	9.1	[illegible].9	[illegible]	.1
			May			
0300	[illegible]	11.8	9.[illegible]	[illegible]	.1	
0900	7.[illegible]	[illegible]	11.[illegible]	[illegible]	[illegible]	[illegible]
1200	[illegible]	11.3	[illegible]	[illegible]		
1500	[illegible]	9.6	[illegible]	[illegible]		[illegible]
1800	4.7	12.[illegible]	11.[illegible]	[illegible].4		
2100	7.9	[illegible].4	[illegible]	1.[illegible]		
Av.	6.[illegible]	11.[illegible]	[illegible]	[illegible]		
			June			
0300	12.[illegible]	10.7	[illegible]	[illegible]		
0900	[illegible]	[illegible]	[illegible]			
1200	[illegible]	[illegible]	[illegible]	[illegible]		
1500	[illegible]	[illegible]7	[illegible]	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]4	[illegible]5	[illegible]		
2100	[illegible]	[illegible]	[illegible]	[illegible]		
Av.	7.[illegible]	[illegible]	[illegible].9			
			July			
0300	[illegible]	4.3	[illegible].9	[illegible]		
0900	[illegible]	[illegible]6	9.1	[illegible]		
1200	7[illegible]	8.6	[illegible].7	[illegible].4		
1500	5.9	9.1	[illegible]	4.4		
1800	[illegible]	10.6	[illegible].9	5.0		
2100	9.7	14.0	6.3	.9		
Av.	[illegible]	11.4	8.9	2.8		
			August			
0300	[illegible]	[illegible]	9.[illegible]	[illegible]		
0900	[illegible]	[illegible]	10.7	1[illegible]		
1200	[illegible]	[illegible]	[illegible]	[illegible]		
1500	[illegible]	[illegible].9	[illegible]	[illegible]		
1800	[illegible]	12.[illegible]	9.[illegible]			
2100	1[illegible]	13.1	[illegible].4	1.1		
Av.	7.[illegible]	11.[illegible]	[illegible]	1.[illegible]		

BIG DELTA

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			Wind velocity, m.p.h.			
			April			
0300	9.1	11.4	4.2	2.2	1.1	2.0
0900	7.9	7.7	6.0	3.1	2.1	3.2
1200	6.8	6.4	6.7	4.6	2.7	2.8
1500	6.0	5.7	8.1	5.2	2.8	2.2
1800	4.7	8.0	10.5	3.9	1.8	1.1
2100	6.0	10.6	8.2	2.3	.8	2.1
Av.	6.7	8.3	7.3	3.6	1.9	2.2
			May			
0300	9.1	11.8	5.3	2.0	1.0	1.3
0900	6.1	10.2	6.2	4.0	2.7	1.8
1200	3.8	9.5	7.2	6.3	2.0	2.2
1500	2.4	7.1	9.9	6.3	2.9	2.4
1800	3.8	7.8	9.9	4.7	2.4	2.4
2100	5.8	11.6	6.7	3.4	1.6	1.9
Av.	5.2	9.7	7.5	4.4	2.1	2.1
			June			
0300	6.4	14.2	7.4	1.0	.1	.9
0900	4.8	12.6	7.9	3.4	.7	.6
1200	5.1	10.6	8.6	4.2	.4	1.1
1500	3.7	10.3	9.3	4.8	.6	1.3
1800	4.3	10.3	10.4	3.8	.8	.4
2100	7.0	12.3	7.2	2.8	.3	.4
Av.	5.2	11.7	8.5	3.3	.5	.8
			July			
0300	10.2	13.1	5.8	.9	.6	.4
0900	7.6	14.3	6.2	1.9	.4	.6
1200	6.2	13.0	8.1	2.0	.9	.8
1500	4.9	11.8	8.9	3.0	1.7	.7
1800	5.9	11.6	8.7	2.9	1.0	.9
2100	6.9	14.0	6.9	1.6	1.0	.6
Av.	7.0	13.0	7.4	2.0	.9	.7
			August			
0300	10.9	12.8	4.8	.8	.9	.8
0900	7.6	10.6	8.0	2.4	1.4	1.0
1200	5.6	12.0	7.7	2.3	1.8	1.6
1500	5.7	9.6	9.3	3.9	1.3	1.2
1800	7.8	13.2	5.4	2.2	1.4	1.0
2100	7.9	11.9	7.0	2.2	1.0	1.0
Av.	7.6	11.7	7.0	2.3	1.3	1.1

FAIRBANKS

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			Wind velocity, m.p.h.			
			April			
0300	16.1	7.9	5.3	.7		
0900	14.1	8.2	5.4	2.2	.1	
1200	9.2	10.5	6.6	3.3	.3	0.1
1500	8.8	10.3	6.7	4.0	.2	
1800	7.7	9.5	8.8	3.8	.2	
2100	9.0	13.1	6.2	1.6	.1	
Av.	10.5	9.9	6.5	2.6	.2	
			May			
0300	13.9	10.1	6.0	1.0		
0900	8.9	11.4	7.1	3.3	.3	
1200	4.9	9.6	9.6	6.2	.6	1
1500	4.7	9.2	10.0	6.1	.9	.1
1800	3.9	8.4	12.4	5.9	4	
2100	8.2	12.0	9.0	1.8		
Av.	7.4	10.1	9.0	4.1	.4	
			June			
0300	16.3	8.8	4.2	.7		
0900	10.4	9.3	6.7	3.1	.4	.1
1200	6.4	9.5	8.8	4.7	.4	.2
1500	5.2	8.1	10.5	5.1	1.0	.1
1800	4.7	10.3	9.9	4.1	.8	.2
2100	7.7	13.1	7.2	1.9	.1	
Av.	8.5	9.9	7.9	3.2	.4	.1
			July			
0300	17.7	9.9	2.7	.7		
0900	12.6	10.7	6.3	1.3	.1	
1200	6.2	12.3	9.3	3.1	.1	
1500	4.7	11.0	10.5	4.6	.2	
1800	7.8	10.9	8.9	2.9	.4	.1
2100	12.9	11.9	5.4	.7	.1	
Av.	10.3	11.1	7.2	2.2	.2	
			August			
0300	17.1	10.6	2.4	.9		
0900	13.3	10.8	5.7	1.2		
1200	9.2	11.4	8.3	2.0	.1	
1500	6.9	12.6	8.4	2.8	.3	
1800	7.9	15.1	6.7	1.2	.1	
2100	10.0	14.0	6.6	.3	.1	
Av.	10.7	12.4	6.4	1.4	.1	

FT. YUKON

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			Wind velocity, m.p.h.			
			April			
0300 1/	3.6	11.3	10.0	3.4	[illegible]	
0900	1.4	11.1	9.9	6.0	1.6	
1200	.8	9.4	11.3	6.7	1.6	0.[illegible]
1500	1.[illegible]	9.9	11.1	6.4	1.4	.1
1800	Data missing					
2100 1/	2.[illegible]	11.1	10.3	3.6	1.7	.[illegible]
Av.	1.8	10.6	10.5	5.2	1.4	.1
			May			
0300	1.6	12.4	12.6	3.6	.8	
0900	.9	8.9	11.7	7.9	1.6	
1200	.6	7.6	[illegible]	8.6	1.9	1
1500	.9	6.9	13.4	8.1	1.3	.4
1800	Data missing					
2100	1.3	10.3	11.1	5.9	2.2	.2
Av.	1.1	9.2	12.2	6.8	1.6	.1
			June			
0300	3.1	13.4	10.7	2.4	.4	
0900	1.4	11.2	9.2	6.7	1.4	.1
1200	.4	8.2	12.4	6.7	2.1	.2
1500	.6	7.2	13.7	6.3	1.8	.4
1800	Data missing					
2100	1.3	11.4	10.1	5.9	1.1	.2
Av.	1.4	10.2	11.2	5.6	1.4	.[illegible]
			July			
0300	5.3	14.9	7.4	3.0	.4	
0900	2.2	12.6	9.3	5.4	1.4	.1
1200	2.2	8.8	10.9	6.8	2.0	.[illegible]
1500	1.4	8.2	12.2	6.9	2.1	.[illegible]
1800	Data missing					
2100	3.2	12.9	9.1	4.2	1.6	
Av.	2.9	11.4	9.8	5.2	1.5	.[illegible]
			August			
0300	4.6	16.1	8.0	1.6	.7	
0900	2.0	12.1	10.1	5.2	1.[illegible]	1
1200	1.0	10.3	10.9	6.8	1.[illegible]	4
1500	1.1	9.2	11.7	7.0	1.7	[illegible]
1800	Data missing					
2100	3.3	13.3	9.4	4.1	.[illegible]	1
Av.	2.4	12.2	10.0	4.9	1.3	[illegible]

1/ Minor data discrepancy

Table 28.--Wind velocity by hour of day and number of days per month in each velocity class--Continued

(Av. 1950-58)

GALENA

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			April			
0300	11.0	7.7	7.0	3.3	0.6	0.4
0900	9.0	5.6	7.5	5.3	1.8	.8
1200	5.3	5.6	9.5	6.3	2.4	.9
1500	2.9	5.3	9.9	9.5	1.8	.6
1800	3.4	5.1	12.2	7.8	1.2	.3
2100	6.9	[illegible]	11.4	4.9	.8	.4
Av.	6.4	5.8	9.6	6.2	1.4	.6
			May			
0300	[illegible]	[illegible]	7.8	2.2		.1
0900	5.6	7.8	11.1	5.8	.7	
1200	3.6	7.3	10.6	8.0	1.4	.1
1500	4.3	6.2	11.4	7.3	1.6	.2
1800	4.1	6.6	10.5	8.2	1.6	
2100	6.4	8.0	12.3	3.9	.4	
Av.	[illegible]	7.5	10.6	5.9	.9	.1
			June			
0300	[illegible]	8.2	8.1	2.2	.2	.1
0900	[illegible]	7.6	8.8	4.9	.8	.3
1200	[illegible]	[illegible]	9.5	5.0	1.7	.4
1500	[illegible]	6.7	10.8	5.7	1.6	.3
1800	[illegible]	5.7	11.8	5.9	1.4	.4
2100	[illegible]	[illegible]	11.6	3.8	.6	.1
Av.	7.1	6.9	10.1	4.6	1.0	.3
			July			
0300	[illegible]	9.4	7.8	2.8	.4	
0900	[illegible]	5.9	6.6	4.9	.9	.4
1200	[illegible]	9.0	7.6	5.2	1.6	.4
1500	[illegible]	7.2	9.5	4.8	2.2	.5
1800	[illegible]	7.6	8.9	6.4	1.2	.1
2100	[illegible]	[illegible]	7.9	2.5	.9	
Av.	9.1	[illegible]	8.1	4.4	1.2	.2
			August			
0300	[illegible]	[illegible]	9.2	2.6	[illegible]	.2
0900	[illegible]	[illegible]	9.9	5.6	1.2	.4
1200	[illegible]	[illegible]	11.4	5.0	[illegible]	.9
1500	[illegible]	7.4	[illegible]	5.0	[illegible]	.6
1800	[illegible]	7.1	10.7	4.1	[illegible]	.6
2100	[illegible]	[illegible]	9.2	3.8	[illegible]	
Av.	7.2	7.1	10.2	4.4	1.7	.4

GULKANA

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			April			
0300	11.4	10.6	4.4	2.3	0.9	0.4
0900	11.1	7.4	4.7	3.7	1.8	1.3
1200	8.9	6.4	4.4	5.7	2.6	2.0
1500	5.9	6.6	7.3	6.0	3.0	1.2
1800	4.1	8.7	10.0	5.0	1.4	.8
2100	7.6	10.3	7.6	2.9	1.2	.4
Av.	8.2	8.3	6.4	4.3	1.8	1.0
			May			
0300	11.4	9.8	5.4	3.6	.8	
0900	7.1	7.0	6.8	5.8	3.1	1.2
1200	2.4	8.7	7.7	6.2	4.4	1.6
1500	2.1	6.6	8.7	7.3	4.7	1.6
1800	2.4	8.2	10.0	6.1	3.1	1.2
2100	5.2	11.4	9.1	4.0	1.2	.1
Av.	5.1	8.6	8.0	5.5	2.9	.9
			June			
0300	9.7	11.1	5.9	3.0	.3	
0900	4.7	10.2	8.2	4.3	2.0	.6
1200	3.0	8.2	8.7	6.2	2.7	1.2
1500	3.0	7.6	7.3	8.1	2.9	1.1
1800	2.1	7.3	9.7	7.3	3.3	.3
2100	5.2	10.2	9.2	3.6	1.7	.1
Av.	4.6	9.1	8.2	5.4	2.1	.6
			July			
0300	12.4	11.1	5.8	1.3	.4	
0900	6.6	10.2	8.7	3.6	1.6	.3
1200	4.9	8.3	8.8	4.8	3.3	.9
1500	3.7	9.2	8.9	4.9	3.4	.9
1800	4.3	9.2	7.7	6.7	2.7	.4
2100	5.6	11.3	9.1	4.0	1.0	
Av.	6.2	9.9	8.2	4.2	2.1	.4
			August			
0300	11.5	10.3	5.4	3.0	.6	.2
0900	6.4	10.3	7.7	4.2	1.7	.7
1200	5.0	9.5	6.9	5.4	2.6	1.6
1500	3.9	8.8	7.7	6.6	2.8	1.2
1800	5.1	10.9	8.2	4.2	2.2	.4
2100	7.0	11.6	6.5	4.4	1.3	.2
Av.	6.5	10.2	7.1	4.7	1.8	.7

HOMER

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			April			
0300	16.7	7.4	3.4	1.8	0.4	0.1
0900	11.6	9.2	6.1	2.2	.6	.3
1200	6.1	6.9	10.6	5.7	.4	.3
1500	5.0	6.8	10.4	6.7	1.0	.1
1800	8.5	8.2	8.6	3.8	.7	.1
2100	16.0	6.9	2.8	3.9	.4	
Av.	10.6	7.6	7.0	4.0	.6	.2
			May			
0300	18.5	8.7	2.7	.7	.3	.1
0900	6.2	11.4	8.7	4.2	.2	.1
1200	3.1	6.2	12.9	8.4	.4	
1500	2.2	5.7	12.1	10.1	.8	.1
1800	4.0	10.1	12.1	4.4	.3	.1
2100	14.6	7.7	6.4	2.0	.2	.1
Av.	8.1	8.3	9.1	5.0	.4	.1
			June			
0300	20.6	6.2	2.0	1.1	.1	
0900	5.7	11.0	9.6	3.3	.4	
1200	2.9	6.6	12.3	7.4	.8	
1500	2.9	5.4	12.9	8.1	.7	
1800	5.1	8.4	13.4	2.8	.3	
2100	13.7	11.3	4.4	.4	.2	
Av.	8.4	8.3	9.1	3.8	.4	
			July			
0300	22.9	5.6	2.0	.4	.1	
0900	10.0	11.1	7.6	2.1	.1	.1
1200	4.6	5.9	12.6	7.3	.6	
1500	4.7	6.9	11.6	7.6	.2	
1800	6.6	9.0	13.0	2.2	.1	.1
2100	19.1	8.0	3.1	.7	.1	
Av.	11.3	7.7	8.4	3.4	.2	
			August			
0300	20.4	6.6	2.7	1.3		
0900	13.4	10.2	5.0	2.4		
1200	5.7	7.7	12.7	4.8	.1	
1500	6.3	6.4	12.3	5.8	.2	
1800	10.3	9.1	9.2	2.4		
2100	18.9	6.9	3.8	1.0	.3	
Av.	12.5	7.8	7.6	3.0	.1	

ILIAMNA

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			April			
0300	7.2	9.3	6.8	3.8	1.9	1.0
0900	7.6	6.2	[illegible]	3.9	2.7	1.9
1200	[illegible]	[illegible]	[illegible]	4.6	2.7	2.2
1500	[illegible]	5.1	[illegible]	6.4	[illegible]	1.7
1800	[illegible]	7.4	[illegible]	5.2	1.4	1.6
2100	9.6	7.9	[illegible]	3.3	2.3	1.1
Av.	[illegible]	7.2	7.8	4.5	2.3	1.6
			May			
0300	[illegible]	[illegible]	5.6	4.7	1.7	.6
0900	4.1	[illegible]	7.6	6.3	3.8	1.2
1200	1.7	[illegible]	9.8	9.3	4.7	1.7
1500	1.8	3.9	8.6	10.7	4.8	1.2
1800	2.8	5.9	9.6	9.0	2.8	.9
2100	9.6	6.9	5.9	4.8	3.0	.8
Av.	4.7	6.4	7.8	7.5	3.5	1.1
			June			
0300	9.5	8.2	5.6	5.1	1.4	.2
0900	4.1	6.7	8.0	8.0	2.6	.6
1200	1.4	5.3	9.0	8.9	4.3	1.1
1500	.9	3.6	9.4	10.3	4.3	1.0
1800	1.6	4.3	9.1	10.8	3.6	.6
2100	7.6	6.6	7.2	7.1	.9	.6
Av.	4.2	5.8	8.0	8.4	2.9	.7
			July			
0300	11.4	8.7	6.7	3.4	.8	
0900	4.8	9.5	9.1	6.1	1.4	.1
1200	2.4	8.2	9.7	9.4	1.2	.1
1500	1.8	6.0	11.3	9.3	2.3	.3
1800	4.1	6.7	10.4	8.2	1.4	.2
2100	9.2	7.6	9.1	4.1	.8	.2
Av.	5.6	7.8	9.4	6.7	1.3	.2
			August			
0300	8.0	8.9	7.6	4.7	1.6	.2
0900	5.8	7.7	9.3	5.3	2.1	.8
1200	3.8	7.0	9.4	7.4	2.4	1.0
1500	2.8	4.8	10.3	9.8	2.3	1.0
1800	2.6	7.2	10.8	8.1	2.2	.1
2100	8.3	8.0	6.3	6.1	2.0	.3
Av.	5.2	7.3	8.9	6.9	2.1	.6

KOTZEBUE

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			April			
0300	3.4	5.9	8.0	6.9	2.7	3.1
0900	3.6	6.0	7.0	5.6	4.0	3.6
1200	2.1	7.0	7.3	5.8	4.4	3.4
1500	1.4	6.6	8.1	6.4	4.2	3.3
1800	1.8	7.2	7.9	6.8	3.6	2.7
2100	2.9	6.8	7.4	6.6	3.4	2.9
Av.	2.6	6.6	7.6	6.3	3.7	3.2
			May			
0300	3.3	[illegible]	9.6	5.8	2.1	1.2
0900	1.6	7.1	9.7	7.9	3.3	1.4
1200	1.6	5.6	11.1	7.7	3.7	1.3
1500	1.7	6.0	11.2	7.8	2.9	1.4
1800	2.4	6.8	9.2	8.4	3.1	1.1
2100	4.1	6.3	9.7	7.3	2.8	.8
Av.	2.4	6.8	10.1	7.5	3.0	1.2
			June			
0300	1.9	7.0	9.8	8.2	2.4	.7
0900	.6	4.1	13.3	7.5	2.7	1.8
1200	.4	4.2	10.7	9.1	3.8	1.8
1500	.9	5.1	8.3	9.4	4.7	1.6
1800	1.1	4.9	9.3	9.0	4.4	1.3
2100	2.0	5.6	9.7	8.4	3.7	.6
Av.	1.2	5.1	10.2	8.6	3.6	1.3
			July			
0300	1.1	5.2	9.2	9.8	4.7	1.0
0900	.6	4.3	9.6	10.0	5.1	1.4
1200	.4	3.4	11.3	9.1	5.1	1.7
1500	1.0	4.3	9.3	9.0	4.7	2.7
1800	1.2	4.1	8.7	9.0	6.0	2.0
2100	1.6	4.1	9.9	8.4	5.3	1.7
Av.	1.0	4.2	9.7	9.2	5.1	1.8
			August			
0300	1.0	4.4	8.9	9.8	5.6	1.3
0900	1.0	2.8	8.8	9.7	6.8	1.9
1200	.6	2.9	9.2	9.7	6.8	1.8
1500	.9	3.4	8.3	10.4	6.3	1.7
1800	1.2	3.9	9.4	9.4	5.4	1.7
2100	1.7	4.3	9.4	9.7	4.9	1.0
Av.	1.1	3.6	9.0	9.8	6.0	1.5

LAKE MINCHUMINA

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			April			
0300	17.3	6.8	4.2	1.6	0.1	
0900	14.2	8.7	5.0	1.7	.4	
1200	9.3	12.6	5.4	2.4	.2	0.1
1500	10.0	10.9	7.0	1.7	.4	
1800	10.3	10.2	7.1	2.1	.3	
2100	11.6	10.1	6.1	1.8	.4	
Av.	12.1	9.9	5.8	1.9	.3	
			May			
0300	16.5	9.0	3.6	1.8	.1	
0900	7.8	14.7	6.0	2.1	.4	
1200	4.6	14.1	9.1	2.7	.4	.1
1500	6.7	13.7	6.8	3.3	.4	.1
1800	8.8	11.4	6.9	3.1	.6	.2
2100	10.4	12.4	6.8	1.3		.1
Av.	9.1	12.5	6.6	2.4	.3	.1
			June			
0300	16.3	9.2	3.6	.6	.3	
0900	7.2	13.0	7.1	2.1	.4	.2
1200	4.3	13.6	7.8	2.8	1.3	.2
1500	3.7	12.4	8.4	3.8	1.6	.1
1800	6.1	11.0	7.7	3.8	1.3	.1
2100	8.3	12.6	6.6	2.2	.3	
Av.	7.6	12.0	6.8	2.6	.9	.1
			July			
0300	18.0	8.3	3.1	1.3	.3	
0900	9.7	12.7	5.3	2.6	.7	
1200	6.1	14.1	7.2	2.9	.7	.1
1500	5.9	13.3	8.1	2.7	1.0	
1800	10.1	10.1	6.3	4.3	.2	
2100	11.6	11.7	6.0	1.4	.3	
Av.	10.3	11.7	6.0	2.5	.5	
			August			
0300	15.9	9.9	4.1	1.1		
0900	11.6	12.0	4.7	2.4	.3	
1200	6.7	13.7	6.3	3.2	1.0	.1
1500	6.7	12.6	6.9	3.3	1.1	.4
1800	12.2	9.2	6.4	2.4	.6	.2
2100	12.3	11.2	5.7	1.7	.1	
Av.	10.9	11.4	5.7	2.4	.5	.1

Table 28.--Wind velocity by hour of day and number of days per month in each velocity class--Continued

([illegible])

McGRATH

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			April			
0300	19.3	6.9	2.8	[illegible]	.2	
0900	14.1	8.0	6.8	1.1		
1200	6.3	12.2	8.2	3.2	.1	
1500	5.2	9.3	11.5	3.8	.2	
1800	6.4	11.0	10.7	1.9		
2100	14.9	9.4	6.4	.3		0.1
Av.	11.0	9.3	7.7	1.9	.1	
			May			
0300	19.3	8.6	2.9	.2		
0900	9.3	10.7	9.2	1.2		
1200	4.3	11.0	10.8	4.8	.1	
1500	2.7	10.4	12.9	4.6	.2	.2
1800	4.8	10.6	11.3	4.1	.2	
2100	12.2	11.4	6.1	1.3		
Av.	8.8	10.4	8.9	2.8	.1	
			June			
0300	18.1	8.4	2.8	.7		
0900	8.6	11.6	7.2	2.6		
1200	5.8	9.9	10.6	3.4		.1
1500	4.4	11.3	9.2	4.8	.7	
1800	4.4	10.8	11.4	3.2	.2	
2100	9.7	12.3	6.3	1.6	.1	
Av.	8.5	10.7	8.0	2.7	.1	
			July			
0300	18.9	8.1	3.1	.7	.2	
0900	12.4	10.4	6.3	1.9		
1200	5.2	12.9	9.6	3.0	.3	
1500	3.8	13.0	10.8	3.2	.2	
1800	4.1	14.3	10.1	2.2	.3	
2100	11.2	12.5	6.1	1.0	.2	
Av.	9.3	11.8	7.7	2.0	.2	
			August			
0300	18.2	8.9	3.1	.7	.1	
0900	11.9	10.2	6.3	2.3	.2	.1
1200	8.2	10.9	9.6	3.0	.2	
1500	6.6	11.1	10.4	2.7	.1	.1
1800	9.3	11.5	8.4	1.4	.3	.1
2100	15.2	9.9	4.1	1.2	.6	
Av.	11.6	10.2	7.0	1.9	.2	.1

NAKNEK

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			April			
0300	8.9	[illegible]	7.1	[illegible]	[illegible]	[illegible]
0900	5.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1200	2.1	4.9	9.9	[illegible]	[illegible]	[illegible]
1500	2.2	4.1	[illegible]	9.3	3.9	[illegible]
1800	2.7	[illegible]	[illegible]	7.3	[illegible]	[illegible]
2100	7.1	[illegible]	7.7	4.6	[illegible]	1.1
Av.	4.7	[illegible]	[illegible]	6.2	[illegible]	[illegible]
			May			
0300	3.9	[illegible]	[illegible]	[illegible]	.4	.9
0900	4.7	5.7	7.7	[illegible]	[illegible]	[illegible]
1200	2.7	5.4	[illegible]	7.9	[illegible]	[illegible]
1500	1.8	[illegible]	9.1	9.3	[illegible]	[illegible]
1800	[illegible]	4.2	[illegible]	[illegible]	4.1	[illegible]
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.2
Av.	4.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			June			
0300	7.9	[illegible]	[illegible]	[illegible]	[illegible]	.9
0900	[illegible]	[illegible]	9.1	[illegible]	[illegible]	[illegible]
1200	3.9	5.4	10.8	[illegible]	[illegible]	[illegible]
1500	[illegible]	[illegible]	9.9	8.4	[illegible]	[illegible]
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2100	3.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	5.7	[illegible]	[illegible]		1.1
			July			
0300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
0900	[illegible]	8.1	[illegible]	[illegible]	[illegible]	
1200	[illegible]	6.7	[illegible]	[illegible]	[illegible]	[illegible]
1500	2.4	[illegible]	[illegible]	[illegible]	.7	
1800	1.3	[illegible]	[illegible]	[illegible]	[illegible]	
2100	6.6	[illegible]	[illegible]	[illegible]	[illegible]	
Av.	[illegible]	7.4	[illegible]	[illegible]	[illegible]	
			August			
0300	7.6	[illegible]	9.7	4.6	[illegible]	[illegible]
0900	3.7	7.2	11.4	5.6	[illegible]	[illegible]
1200	[illegible]	[illegible]	11.7	7.9	[illegible]	[illegible]
1500	[illegible]	[illegible]	[illegible]	9.4	[illegible]	[illegible]
1800	2.4	[illegible]	10.4	[illegible]	[illegible]	[illegible]
2100	6.2	[illegible]	9.7	[illegible]	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NORTHWAY

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			April			
0300	[illegible]	9.7	[illegible]	1.4	[illegible]	
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1200	[illegible]	[illegible]	[illegible]	[illegible]	.4	
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1800	[illegible]	[illegible]	[illegible]	1.9	[illegible]	
2100	[illegible]	[illegible]	[illegible]	1.3	[illegible]	
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
			May			
0300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1200	[illegible]	7.9	[illegible]	[illegible]	[illegible]	
1500	[illegible]	7.0	[illegible]	[illegible]	[illegible]	
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
			June			
0300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
			July			
0300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1500	[illegible]	[illegible]	[illegible]	[illegible]	4	
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
			August			
0300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

SUMMIT

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			April			
0300	10.1	6.4	7.4	4.7	1.2	0.2
0900	7.8	4.4	9.1	6.6	2.1	
1200	8.1	5.6	9.7	5.4	.9	.3
1500	6.7	7.6	9.2	5.6	[illegible]	.1
1800	8.8	6.1	9.5	4.7	.8	.1
2100	9.4	6.3	8.7	4.1	1.4	.1
Av.	8.5	6.1	8.9	5.2	1.2	.1
			May			
0300	13.4	7.8	6.9	2.6	.3	
0900	5.3	7.0	12.0	5.8	.9	
1200	2.3	5.3	13.7	8.3	1.4	
1500	2.6	6.6	12.6	7.7	1.2	.3
1800	5.0	7.3	12.4	5.1	.9	.3
2100	9.7	8.4	9.3	3.1	.4	.1
Av.	6.4	7.1	11.2	5.4	.8	.1
			June			
0300	10.1	9.8	7.9	1.8	.4	
0900	3.7	7.0	13.1	5.9	.3	
1200	3.0	5.6	14.0	5.6	1.8	
1500	2.1	5.0	11.0	9.6	2.3	
1800	1.3	6.1	10.7	10.1	1.6	.2
2100	5.6	9.6	11.2	3.2	.4	
Av.	4.3	7.2	11.3	6.0	1.2	
			July			
0300	11.1	9.8	7.4	2.6	.1	
0900	5.9	8.7	10.8	4.9	.7	
1200	5.0	7.3	11.8	5.8	1.1	.1
1500	2.9	6.0	12.4	8.7	1.0	
1800	3.8	5.0	13.6	7.2	1.4	
2100	5.9	10.2	11.8	2.8	.3	
Av.	5.8	7.8	11.3	5.3	.8	
			August			
0300	13.8	6.2	7.3	3.0	.6	.1
0900	6.4	8.0	11.0	4.7	.9	
1200	4.7	5.9	11.8	8.0	.6	
1500	4.1	6.1	10.3	9.3	1.2	.1
1800	4.6	6.8	13.1	5.9	.6	.1
2100	10.6	9.0	8.6	2.4	.4	
Av.	7.4	7.0	10.3	5.5	.7	.1

TANANA

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			April			
0300	14.9	7.7	5.9	1.3	0.2	0.1
0900	8.4	5.6	10.0	5.4	.6	
1200	5.7	6.3	11.3	6.4	.3	
1500	5.2	5.5	13.5	4.9	.6	.2
1800	3.9	8.6	12.3	4.1	1.0	.1
2100	9.2	9.5	8.0	2.6	.6	.1
Av.	7.9	7.2	10.2	4.1	.5	.1
			May			
0300	18.9	6.9	4.0	1.2		
0900	6.2	8.6	10.0	5.8	.4	
1200	3.4	9.3	11.3	6.1	.9	
1500	4.1	7.3	12.9	5.9	.8	
1800	5.8	7.7	10.2	7.1	.2	
2100	10.4	11.7	6.1	2.7	.1	
Av.	8.1	8.6	9.1	4.8	.4	
			June			
0300	14.3	9.9	5.0	.7	.1	
0900	7.4	7.6	11.1	3.7	.2	
1200	4.7	8.1	11.8	5.1	.3	
1500	4.2	9.1	11.7	4.8	.1	.1
1800	5.9	10.1	9.4	4.2	.3	.1
2100	10.3	10.3	7.8	1.4	.2	
Av.	7.8	9.2	9.5	3.3	.2	
			July			
0300	18.0	9.3	3.3	.4		
0900	9.0	10.2	9.7	2.0	.1	
1200	16.0	8.8	3.3	2.8	.1	
1500	5.6	9.2	14.1	2.0	.1	
1800	7.9	8.6	12.1	2.4		
2100	13.1	11.4	5.7	.8		
Av.	11.6	9.6	8.0	1.7	.1	
			August			
0300	13.1	11.9	5.3	.7		
0900	7.1	10.6	11.4	1.9		
1200	4.6	10.0	13.9	2.4	.1	
1500	5.6	7.9	15.2	2.1	.2	
1800	8.8	10.8	9.3	1.9	.2	
2100	11.2	12.0	6.8	1.0		
Av.	8.4	10.5	10.3	1.7	.1	

UNALAKLEET

Time of day	0-3	4-7	8-12	13-18	19-24	25+
			April			
0300	5.6	6.7	7.0	6.2	3.4	[illegible]
0900	4.9	5.8	[illegible]	5.1	4.1	[illegible]
1200	3.4	6.4	[illegible]	7.0	3.9	[illegible]
1500	[illegible]	6.7	[illegible]	6.8	[illegible]	[illegible]
1800	3.6	7.4	[illegible]	6.2	[illegible]	[illegible]
2100	5.3	8.3	7.2	5.0	[illegible]	[illegible]
Av.	4.3	6.9	7.7	6.1	3.5	[illegible]
			May			
0300	6.1	7.6	10.3	5.9	[illegible]	
0900	2.4	7.0	9.9	7.8	[illegible]	[illegible]
1200	1.8	4.7	13.1	7.4	4.3	[illegible]
1500	1.7	4.7	10.6	9.7	2.7	[illegible]
1800	4.0	6.6	10.9	7.2	1.7	[illegible]
2100	5.9	9.3	11.0	3.9	.8	.1
Av.	3.6	6.6	10.8	7.0	2.4	.6
			June			
0300	3.8	10.6	10.7	4.2	.6	.1
0900	3.2	8.3	12.2	4.7	1.3	[illegible]
1200	1.4	5.6	13.3	7.6	1.7	.4
1500	1.6	6.0	12.4	7.1	2.3	.6
1800	2.6	6.9	13.2	6.1	1.2	
2100	5.3	11.0	9.9	3.3	.4	.1
Av.	[illegible]	8.1	[illegible]	5.5	1.2	.2
			July			
0300	5.0	8.3	10.1	5.2	[illegible]	.4
0900	3.0	7.6	10.1	7.3	2.2	[illegible]
1200	1.2	5.0	[illegible]	9.4	2.4	[illegible]
1500	1.0	5.3	12.4	10.2	1.4	.7
1800	2.4	7.1	[illegible]	6.9	1.0	[illegible]
2100	6.4	8.4	9.2	4.8	1.6	[illegible]
Av.	3.2	6.9	11.2	7.3	1.8	[illegible]
			August			
0300	4.6	8.6	10.5	5.0	1.9	.4
0900	3.2	6.3	11.4	6.9	2.4	.8
1200	1.7	6.4	9.8	9.2	3.1	.8
1500	2.1	6.0	11.9	8.3	1.9	.8
1800	5.2	7.4	11.3	4.4	2.1	.6
2100	6.6	7.8	11.0	3.3	1.4	.9
Av.	3.9	7.1	11.0	6.2	2.1	.7

Source: United States Weather Bureau coded data.

Table 29.--Amount of [illegible] cover by hour of [illegible] per [illegible] days per month in each cover class

[illegible]

[illegible] (first station, name illegible)

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	17.7
[illegible]	[illegible]	[illegible]	18.9
[illegible]	[illegible]	4.2	[illegible]
[illegible]	[illegible]	4.7	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
May–August	[illegible]	[illegible]	[illegible]

BETHEL

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	11.4	3.2	15.2
0900	7.	2.9	20.1
1200	6.2	2.9	20.9
1500	6.7	4.7	18.7
1800	8.4	3.4	18.1
2100	8.8	4.3	16.8
Av.	8.1	3.6	18.3
May			
[illegible]	6.3	3.9	[illegible]
[illegible]	[illegible]	[illegible]	21.9
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	23.1
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	21.2
Av.	4.8	[illegible]	[illegible]
June			
[illegible]	4.4	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	7.2	[illegible]
[illegible]	3.9	4.4	[illegible]
[illegible]	4.4	3.6	[illegible]
[illegible]	4.3	4.1	21.6
Av.	[illegible]	3.8	[illegible]
July			
[illegible]	[illegible]	2.3	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	26.2
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	22.9
Av.	3.3	[illegible]	24.7
August			
[illegible]	2.2	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.4	[illegible]	[illegible]
[illegible]	2.4	[illegible]	[illegible]
Av.	[illegible]	2.4	27.1

BEETLES

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	13.6	4.2	12.2
0900	11.0	4.4	14.6
1200	11.7	3.9	14.5
1500	[illegible]	4.3	[illegible]
1800	11.4	5.3	[illegible]
2100	14.3	4.7	[illegible]
Av.	12.3	4.5	13.2
May			
0300	10.1	5.8	15.1
0900	10.1	[illegible]	14.7
1200	7.6	[illegible]	15.2
1500	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]	16.3
2100	9.3	[illegible]	[illegible]
Av.	[illegible]	7.0	15.3
June			
0300	7.9	6.4	16.7
0900	[illegible]	8.1	15.
1200	5.1	[illegible]	15.9
1500	4.6	[illegible]	14.8
1800	6.9	[illegible]	[illegible]
2100	7.8	5.9	13.3
Av.	6.5	8.7	14.8
July			
0300	[illegible]	[illegible]	18.0
0900	[illegible]	5.9	19.7
1200	4.7	[illegible]	[illegible]
1500	3.9	[illegible]	[illegible]
1800	4.7	[illegible]	[illegible]
2100	[illegible]	[illegible]	[illegible]
Av.	5.4	6.9	18.7
August			
0300	[illegible]	[illegible]	[illegible]
0900	4.1	[illegible]	[illegible]
1200	3.2	[illegible]	[illegible]
1500	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]	19.9
2100	[illegible]	[illegible]	[illegible]
Av.	4.1	5.4	[illegible]

BIG DELTA

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	12.	4.9	[illegible]
0900	8.7	[illegible]	15.3
1200	8.7	6.7	14.7
1500	7.8	7.0	15.2
1800	7.8	5.9	16.4
2100	11.9	6.3	[illegible]
Av.	9.5	6.1	14.4
May			
0300	7.9	7.2	15.9
0900	6.9	8.2	15.9
1200	4.8	8.4	17.8
1500	3.6	8.2	18.9
1800	4.4	7.0	19.6
2100	7.6	7.2	16.2
Av.	5.9	7.7	17.4
June			
0300	[illegible]	6.2	18.7
0900	[illegible]	5.3	18.3
1200	5.8	7.7	16.6
1500	5.2	6.7	18.1
1800	5.0	6.9	18.1
2100	4.7	8.0	17.3
Av.	5.3	6.8	17.9
July			
0300	5.9	5.4	19.7
0900	6.6	5.7	18.8
1200	6.3	7.2	17.3
1500	5.9	7.6	17.6
1800	6.9	6.4	17.7
2100	5.4	7.6	18.0
Av.	6.2	6.6	18.2
August			
0300	6.7	4.8	19.6
0900	6.7	5.6	19.8
1200	6.8	7.7	[illegible]
1500	4.6	7.7	18.8
1800	4.8	6.6	19.4
2100	6.3	5.6	19.1
Av.	5.6	6.3	19.1

FAIRBANKS

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	12.2	4.0	13.8
0900	9.6	4.6	15.9
1200	9.8	4.4	15.1
1500	[illegible]	4.1	15.3
1800	9.3	4.3	16.3
2100	12.1	4.1	13.8
Av.	10.6	4.3	15.1
May			
0300	9.8	4.3	16.9
0900	7.8	5.3	17.9
1200	5.0	5.3	20.7
1500	4.7	5.4	20.9
1800	[illegible]	5.1	20.2
2100	8.0	5.9	17.1
Av.	6.8	5.2	19.0
June			
0300	5.4	5.6	18.9
0900	6.1	4.9	18.8
1200	5.1	5.8	19.1
1500	3.7	7.2	19.1
1800	4.6	6.6	18.9
2100	6.0	5.9	18.1
Av.	5.2	6.0	18.8
July			
0300	5.4	4.6	21.0
0900	6.6	4.3	19.9
1200	5.6	5.8	19.7
1500	6.0	5.3	19.7
1800	6.6	5.3	19.1
2100	6.3	5.1	19.4
Av.	6.1	5.1	19.8
August			
0300	5.1	4.3	21.6
0900	4.8	3.0	23.2
1200	4.7	4.6	21.8
1500	2.7	6.1	22.2
1800	3.9	[illegible]	22.1
2100	4.7	5.1	21.2
Av.	4.3	4.7	22.0

FT. YUKON

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	16.2	1.9	11.0
0900	11.5	4.9	14.0
1200	12.1	5.4	13.0
1500	11.9	4.8	14.0
1800	11.9	4.7	13.0
2100	14.7	2.8	12.0
Av.	13.1	4.1	12.8
May			
0300	16.0	4.8	10.2
0900	13.1	4.8	13.0
1200	10.8	7.0	13.2
1500	9.8	7.8	13.4
1800	[illegible]	7.6	12.8
2100	12.3	[illegible]	11.8
Av.	12.1	6.5	12.4
June			
0300	11.7	6.9	11.4
0900	9.9	7.4	12.7
1200	7.9	9.4	12.7
1500	6.9	8.7	14.4
1800	6.1	8.5	15.4
2100	9.2	7.6	13.2
Av.	8.6	8.1	13.3
July			
0300	12.4	5.9	12.7
0900	10.0	5.4	15.6
1200	6.6	7.9	16.3
1500	6.2	8.6	16.2
1800	7.4	9.1	14.4
2100	9.4	6.4	15.1
Av.	8.7	7.2	15.1
August			
0300	10.4	5.6	15.0
0900	8.7	5.2	17.1
1200	6.3	9.3	15.3
1500	5.1	9.8	16.1
1800	5.1	8.1	17.8
2100	8.9	6.0	15.9
Av.	7.4	7.3	16.3

GALENA

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April–June	[illegible]	[illegible]	[illegible]
July			
0300	4.5	5.0	21.5
0900	[illegible]	5.4	21.4
[illegible]	[illegible]	5.2	21.9
[illegible]	4.	5.5	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
August			
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

GULKANA

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
[illegible]	[illegible]	4.4	11.0
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	15.4
[illegible]	7.9	[illegible]	17.8
[illegible]	8.1	6.2	15.7
[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	[illegible]	14.3
May			
[illegible]	[illegible]	[illegible]	16.3
[illegible]	[illegible]	[illegible]	18.9
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	4.8	[illegible]
[illegible]	[illegible]	[illegible]	18.7
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
June			
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	17.3
Av.	[illegible]	[illegible]	[illegible]
July			
0300	[illegible]	4.9	17.6
0900	7.9	5.0	18.1
1200	[illegible]	6.8	18.0
1500	5.7	7.1	15.2
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	4.7	[illegible]
Av.	[illegible]	[illegible]	[illegible]
August			
[illegible]	[illegible]	5.9	17.9
[illegible]	[illegible]	4.6	19.7
[illegible]	6.1	5.8	19.1
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	5.7	[illegible]

HOMER

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
[illegible]	[illegible]	3.9	[illegible]
[illegible]	[illegible]	4.1	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	3.8	[illegible]
[illegible]	[illegible]	4.8	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	3.9	[illegible]
May			
[illegible]	[illegible]	4.1	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	21.1
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	4.7	[illegible]
Av.	[illegible]	4.7	[illegible]
June			
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	19.4
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	4.7	17.8
Av.	6.6	4.9	18.5
July			
0300	8.7	4.1	18.2
0900	8.2	5.1	17.7
1200	7.6	5.7	17.8
1500	[illegible]	5.0	17.1
1800	[illegible]	[illegible]	17.9
2100	[illegible]	[illegible]	16.8
Av.	[illegible]	5.0	17.6
August			
[illegible]	[illegible]	2.4	21.7
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	5.4	4.4	21.1
[illegible]	[illegible]	[illegible]	21.2
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]

ILIAMNA

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
[illegible]	10.7	3.9	15.4
[illegible]	8.1	4.4	17.6
[illegible]	9.2	4.4	16.3
[illegible]	[illegible]	4.4	16.0
[illegible]	[illegible]	5.6	15.7
[illegible]	[illegible]	4.1	[illegible]
Av.	9.5	4.5	[illegible]
May			
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	6.2	19.4
[illegible]	[illegible]	7.1	[illegible]
[illegible]	[illegible]	6.2	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]
June			
[illegible]	[illegible]	4.2	[illegible]
[illegible]	5.2	[illegible]	[illegible]
[illegible]	4.9	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	18.1
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	4.7	[illegible]	18.3
Av.	5.2	5.8	19.0
July			
0300	5.8	3.9	21.3
0900	5.0	3.7	22.3
1200	4.3	4.8	21.9
1500	5.8	5.4	19.6
1800	6.2	5.8	[illegible]
[illegible]	5.4	6.2	19.3
Av.	5.4	5.0	20.6
August			
0300	5.3	3.0	22.7
[illegible]	2.8	4.4	23.8
[illegible]	1.9	5.3	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	6.1	[illegible]
[illegible]	[illegible]	5.7	[illegible]
Av.	[illegible]	5.2	[illegible]

KOTZEBUE

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	10.8	3.6	15.7
[illegible]	9.1	3.8	17.2
1200	10.2	3.8	16.0
1500	11.0	3.6	15.4
1800	11.1	3.9	14.9
2100	12.2	2.3	15.3
Av.	10.7	3.5	15.8
May			
[illegible]	9.6	3.0	18.4
[illegible]	9.7	4.2	17.1
[illegible]	10.4	4.7	15.9
[illegible]	[illegible]	4.7	15.9
[illegible]	12.	3.	15.1
[illegible]	11.9	[illegible]	[illegible]
Av.	10.7	4.0	[illegible]
June			
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	4.4	[illegible]
[illegible]	9.7	5.	[illegible]
[illegible]	[illegible]	4.4	[illegible]
[illegible]	8.2	4.6	16.9
Av.	8.2	4.5	17.3
July			
0300	3.9	3.0	24.1
0900	4.2	2.7	24.1
1200	5.8	4.3	20.9
1500	6.2	5.1	19.7
1800	6.1	4.4	20.3
2100	6.2	[illegible]	21.1
Av.	5.4	3.9	21.7
August			
0300	3.4	2.0	25.6
[illegible]	3.4	2.0	[illegible]
[illegible]	[illegible]	2.3	23.7
[illegible]	3.9	[illegible]	23.1
[illegible]	4.7	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Av.	4.1	[illegible]	24.1

LAKE MINCHUMINA

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	12.9	3.6	13.6
0900	11.2	3.8	15.0
1200	10.2	4.2	15.6
1500	8.6	4.1	17.3
1800	8.7	4.2	17.1
2100	13.1	3.1	13.8
Av.	10.8	3.8	15.4
May			
0300	8.0	[illegible]	16.9
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	17.4
Av.	7.2	[illegible]	17.8
June			
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	17.9
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	3.4	[illegible]	[illegible]
[illegible]	4.7	[illegible]	[illegible]
Av.	4.6	6.2	19.2
July			
0300	6.6	4.7	19.8
0900	7.0	3.1	20.9
1200	5.4	4.8	20.7
1500	4.9	5.4	20.7
1800	4.9	5.9	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Av.	5.7	[illegible]	20.3
August			
0300	5.7	[illegible]	[illegible]
0900	[illegible]	[illegible]	[illegible]
1200	3.2	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	4.1	[illegible]

Table 29.--Amount of cloud cover by hour of day, and number of days per month in each cover class--Continued

(Av. 1950-58)

McGRATH

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	10.7	[illegible]	15.8
0900	9.6	4.6	15.9
1200	9.7	4.2	16.1
1500	8.6	5.4	16.0
1800	8.6	4.6	16.9
2100	11.1	4.1	14.8
Av.	9.7	4.4	15.9
May			
0300	7.2	5.1	18.7
0900	7.8	4.2	19.0
1200	5.4	4.9	20.7
1500	4.3	5.9	20.8
1800	5.2	5.1	20.7
2100	7.3	4.4	19.2
Av.	6.2	4.9	19.9
June			
0300	5.1	4.7	20.2
0900	5.3	3.9	20.8
1200	4.1	5.1	20.8
1500	3.7	4.6	21.6
1800	3.7	5.5	20.6
2100	5.3	4.6	20.1
Av.	4.5	4.8	20.7
July			
0300	4.1	3.5	22.7
0900	5.9	3.6	21.6
1200	4.2	5.0	21.8
1500	3.7	5.1	22.2
1800	4.3	3.4	23.2
2100	4.3	3.7	23.0
Av.	4.5	4.1	22.4
August			
0300	3.7	[illegible]	24.1
0900	3.0	1.9	26.1
1200	2.2	3.8	25.0
1500	1.7	3.4	25.9
1800	2.6	3.4	24.0
2100	4.0	3.6	23.4
Av.	3.0	3.2	24.8

NAKNEK

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	10.2	[illegible]	16.6
0900	[illegible]	[illegible]	19.4
1200	6.1	3.8	20.1
1500	5.2	[illegible]	19.2
1800	6.9	4.4	18.7
2100	9.8	4.6	15.7
Av.	7.5	4.2	18.3
May			
0300	5.3	4.1	21.6
0900	[illegible]	3.3	24.3
1200	[illegible]	5.4	23.2
1500	[illegible]	4.9	24.1
1800	[illegible]	5.7	[illegible]
2100	[illegible]	[illegible]	19.7
Av.	3.2	[illegible]	[illegible]
June			
0300	3.3	[illegible]	22.3
0900	2.7	4.0	[illegible]
1200	3.1	[illegible]	23.2
1500	2.9	5.4	21.7
1800	3.6	5.2	21.2
2100	3.8	4.9	22.3
Av.	3.2	4.6	22.2
July			
0300	2.8	[illegible]	25.2
0900	3.3	2.2	25.4
1200	3.2	3.4	24.3
1500	2.9	4.2	23.9
1800	3.1	5.0	22.9
2100	3.4	4.2	23.3
Av.	3.1	3.7	24.2
August			
0300	3.3	2.8	24.9
0900	[illegible]	[illegible]	27.4
1200	1.4	3.6	26.0
1500	1.1	4.3	25.6
1800	2.1	4.9	24.0
2100	2.4	4.9	23.7
Av.	[illegible]	2.7	25.3

NORTHWAY

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	8.4	4.6	[illegible]
0900	[illegible]	4.7	[illegible]
1200	7.3	5.4	[illegible]
1500	7.1	5.5	17.6
1800	6.9	5.3	17.8
2100	10.1	4.1	15.8
Av.	[illegible]	4.9	17.0
May			
0300	7.8	[illegible]	[illegible]
0900	4.1	[illegible]	[illegible]
1200	[illegible]	5.9	22.3
1500	[illegible]	4.7	24.0
1800	[illegible]	4.9	[illegible]
2100	5.0	5.6	20.4
Av.	[illegible]	5.7	21.7
June			
0300	[illegible]	4.3	21.9
0900	4.9	5.3	19.9
1200	[illegible]	7.3	[illegible]
1500	2.9	[illegible]	[illegible]
1800	3.1	5.1	21.8
2100	[illegible]	4.7	21.8
Av.	3.4	5.3	21.3
July			
0300	3.4	5.7	[illegible]
0900	4.9	[illegible]	19.7
1200	4.3	6.4	20.2
1500	3.3	7.3	20.3
1800	4.2	5.9	20.9
2100	4.8	5.3	20.9
Av.	4.2	6.2	20.6
August			
0300	4.4	4.5	[illegible]
0900	4.6	4.9	[illegible]
1200	3.4	[illegible]	21.5
1500	2.1	7.2	[illegible]
1800	[illegible]	[illegible]	21.2
2100	[illegible]	[illegible]	19.3
Av.	[illegible]	5.9	[illegible]

SUMMIT

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	[illegible]	4.3	14.3
0900	9.9	3.7	16.4
1200	9.7	3.3	17.0
1500	7.4	4.8	17.8
1800	8.1	5.1	16.8
2100	10.3	4.3	15.3
Av.	9.5	4.2	16.3
May			
0300	[illegible]	3.7	20.1
0900	[illegible]	4.6	19.8
1200	[illegible]	7.6	18.0
1500	5.4	6.2	19.3
1800	6.1	6.2	18.7
2100	7.7	5.2	18.0
Av.	6.4	5.6	19.0
June			
0300	4.6	3.9	21.6
0900	4.0	3.9	22.1
1200	[illegible]	4.9	22.3
1500	[illegible]	5.8	20.9
1800	3.3	6.7	20.0
2100	4.2	5.3	20.4
Av.	3.7	5.1	21.2
July			
0300	5.7	3.2	22.1
0900	5.1	3.2	22.6
1200	4.4	4.9	21.7
1500	4.1	5.7	21.2
1800	5.0	4.0	22.0
2100	6.3	3.7	20.9
Av.	5.1	4.1	21.8
August			
0300	4.2	4.1	22.7
0900	2.9	2.9	25.2
1200	2.6	4.0	24.4
1500	[illegible]	3.1	24.9
1800	3.1	3.7	24.2
2100	4.8	3.3	22.9
Av.	3.4	[illegible]	24.1

TALANA

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	[illegible]	[illegible]	[illegible]
0900	11.9	5.7	[illegible]
1200	[illegible]	4.8	13.1
1500	10.9	4.9	14.1
1800	10.6	6.4	13.0
2100	14.2	4.8	11.0
Av.	12.2	5.3	[illegible]
May			
0300	10.9	6.8	13.6
0900	9.1	6.2	15.7
1200	7.1	7.6	16.3
1500	5.9	8.3	16.8
1800	7.8	5.4	17.2
2100	9.0	7.4	[illegible]
Av.	8.3	6.9	15.8
June			
0300	7.1	8.3	14.6
0900	6.7	8.3	15.0
1200	4.8	8.2	17.0
1500	3.2	10.2	16.6
1800	4.7	8.7	16.7
2100	5.0	8.6	16.5
Av.	5.2	8.7	16.1
July			
0300	8.2	4.3	18.4
0900	6.2	6.4	18.3
1200	4.7	6.8	19.6
1500	4.2	6.0	20.8
1800	3.9	7.1	20.0
2100	4.6	7.1	19.3
Av.	5.3	6.3	19.4
August			
0300	5.2	3.8	22.0
0900	3.4	5.4	22.1
1200	3.1	5.4	22.4
1500	2.3	5.4	23.2
1800	3.8	6.0	21.3
2100	6.1	4.1	[illegible]
Av.	4.0	5.0	[illegible]

UNALAKLEET

Time of day	Cloud cover (tenths) 0-3	4-7	8-10
April			
0300	[illegible]	3.4	[illegible]
0900	7.8	4.4	[illegible]
1200	[illegible]	5.1	[illegible]
1500	9.8	3.8	16.5
1800	8.9	4.1	[illegible]
2100	10.8	4.6	14.7
Av.	[illegible]	[illegible]	[illegible]
May			
0300	7.9	5.1	[illegible]
0900	8.7	5.0	[illegible]
1200	7.4	5.9	17.7
1500	6.9	6.2	[illegible]
1800	7.1	6.2	17.7
2100	[illegible]	5.4	17.3
Av.	7.7	5.6	17.7
June			
0300	5.3	4.6	20.1
0900	5.4	5.6	19.0
1200	5.4	6.2	18.3
1500	5.7	6.2	18.1
1800	5.4	6.6	19.0
2100	5.7	5.3	[illegible]
Av.	5.5	5.8	18.7
July			
0300	3.3	5.7	[illegible]
0900	3.2	4.8	[illegible]
1200	3.7	6.1	[illegible]
1500	4.2	6.6	[illegible]
1800	4.1	6.0	20.9
2100	3.9	5.9	21.2
Av.	3.7	5.9	21.4
August			
0300	3.0	3.1	24.9
0900	2.7	3.1	25.2
1200	2.4	3.4	25.1
1500	2.4	3.4	25.1
1800	2.4	3.4	25.1
2100	3.2	3.8	[illegible]
Av.	2.7	3.4	24.9

Source United States Weather Bureau coded data.

			June			
0300				.1	.8	29.1
0900		.1			1.2	28.7
1200					.9	29.1
1500					1.0	29.0
1800					1.4	28.6
2100				.1	1.2	28.7
Av.					1.1	28.9
			July			
0300	0.1	.4	.3	.6	1.3	28.3
0900		.3	.3	.6	2.0	27.8
1200	.1	.2	.3	.7	1.6	28.1
1500	.1	.1	.2	.9	2.1	27.6
1800		.2	.2	.2	1.7	28.7
2100		.1	.6	.7	1.3	28.3
Av.	.1	.2	.3	.6	1.7	28.1
			August			
0300	.1	.2	.1	.6	1.6	[illegible].4
0900		.1		.7	2.[illegible]	27.6
1200		.1	.1	[illegible]	1.8	28.9
1500				.4	1.[illegible]	29.3
1800				.1	.6	30.3
2100	.1		.2	.2	1.4	29.1
Av.		.1	.1	.4	1.5	2[illegible].9

See footnote at end of table.

Table [illegible].--Visibility distance by hour of day, and number of days per month in each distance class--Continued

GALENA

Time of day	Visibility in miles: 0-1/8	3/16-3/8	1/2-3/4	1-2-1/2	3-6	7+
			April			
0300		0.1		0.6	1.4	27.9
0900			0.1	1.0	1.1	27.8
1200			.2	.6	.7	28.5
1500			.1	.2	.7	29.0
1800				.6	.4	29.0
2100				.8	.8	28.4
Av.			.1	.6	.9	28.4
			May			
0300	[illegible]			.4	.2	30.3
0900			.1	.2	.3	30.4
1200				.2	.1	30.7
1500			.1	.2		30.7
1800			.1	.2		30.7
2100				.3	.1	[illegible]
Av.			.1	.2	.1	[illegible]
			June			
0300		.1	.1	[illegible]	[illegible]	[illegible]
0900				.2	1.[illegible]	28.4
1200				.4	.9	28.7
1500			.1	[illegible]	.7	28.9
1800			.2	.2	1.[illegible]	28.2
2100			.1	[illegible]	[illegible]	28.9
Av.			.1	[illegible]	.9	28.7
			July			
0300		.4	.5	1.[illegible]	.9	27.9
0900		.6		1.[illegible]	1.[illegible]	27.7
1200		.5		1.[illegible]	[illegible]	28.9
1500			.4	1.2	1.4	28.0
1800	.1		.4	[illegible]	1.5	29.4
2100	.1	.4	.2	[illegible]	[illegible]	27.9
Av.		.3	.3	[illegible]	1.3	28.[illegible]
			August			
0300	.1		.1	.1	1.6	29.1
0900			.1	.4	1.6	28.9
1200				.9	.8	29.3
1500				.5	.6	29.9
1800				.4	.2	30.4
2100				.4	1.2	29.4
Av.				.5	1.0	29.5

GULKANA

Time of day	Visibility in miles					
			April			
0300	[illegible]					
0900	[illegible]					
1200	[illegible]					
1500	[illegible]					
1800	[illegible]					
2100	[illegible]					
Av.	[illegible]					
			May			
0300	[illegible]					
0900	[illegible]					
1200	[illegible]					
1500	[illegible]					
1800	[illegible]					9
2100	[illegible]					9
Av.	[illegible]					
			June			
0300	[illegible]					
0900	[illegible]					
1200	[illegible]					
1500	[illegible]					
1800	[illegible]					
2100	[illegible]					
Av.	[illegible]					
			July			
0300	[illegible]					
0900	[illegible]					
1200	[illegible]					
1500	[illegible]					
1800	[illegible]					
2100	[illegible]					
Av.	[illegible]					
			August			
0300	[illegible]			.1		[illegible]
0900				.1		[illegible]
1200	[illegible]					
1500	[illegible]					9
1800	[illegible]					
2100	[illegible]					
Av.	[illegible]					

ILIAMNA

Time of day	Visibility in miles: 0-1/8	3/16-3/8	1/2-3/4	1-2-1/2	3-6	7+
			April			
0300	0.2		0.2	0.9	[illegible]	[illegible]
0900	.1		.4	.7	1.3	27.4
1200	.1		.1	.8	.9	28.1
1500		0.1	.4	.6	1.1	27.[illegible]
1800		.1	.4	1.[illegible]	.8	27.4
2100	.1	.1	.4	1.2	1.3	27.0
Av.	.1	.1	.3	.9	1.2	27.4
			May			
0300	.1	.1	.1	.8	.7	29.2
0900				.2	.7	30.1
1200			.1	.2	.4	30.[illegible]
1500			.1	.1	.3	30.[illegible]
1800				.2	.1	30.7
2100				.2	.4	30.4
Av.			.1	.2	.4	30.[illegible]
			June			
0300	.3	.1	.2	.6	.6	28.2
0900		.1		.3	.8	28.8
1200				.1	.3	29.6
1500					.1	29.9
1800					.3	29.7
2100					.6	29.4
Av.	.1			.2	.4	29.3
			July			
0300	.2	.4	.8	1.7	2.2	25.7
0900		.1	.4	.9	2.0	27.6
1200			.1	.3	1.2	29.4
1500			.1	1.1	1.1	28.7
1800	.1			.4	1.0	29.5
2100	.1		.1	.7	[illegible]	29.3
Av.	.1	.1	.2	.8	1.4	28.4
			August			
0300	.1	.2	.3	1.8	3.1	25.5
0900				1.3	1.9	27.8
1200		1		.9	1.2	27.8
1500		.1	.1	1.1	1.9	27.8
1800		.1	.3	.9	1.4	28.3
2100		.1	.3	1.4	1.4	27.8
Av.		.1	.2	1.2	1.8	27.7

KOTZEBUE

Time of day	Visibility in miles: 0-1/8	3/16-3/8	1/2-3/4	1-2-1/2	3-6	7+
			April			
0300	[illegible]	[illegible]	0.7	[illegible]	[illegible]	[illegible]
0900	[illegible]	[illegible]	1.[illegible]	[illegible]	[illegible]	[illegible]
1200	[illegible]	[illegible]	[illegible]	[illegible]	.4	[illegible]
1500	[illegible]	[illegible]	[illegible]	[illegible]	.4	[illegible]
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			May			
0300	.4	.4	[illegible]	[illegible]	[illegible]	[illegible]
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1200	.1	.1	[illegible]	[illegible]	[illegible]	[illegible]
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]	[illegible]	[illegible]	.4	[illegible]
2100	.1	.2	.1	[illegible]	.4	[illegible]
Av.	.1	.2	.4	[illegible]	[illegible]	[illegible]
			June			
0300	.7	.1	.4	1.1	.6	[illegible]
0900	.1	.1	.4	1.6	.7	27.[illegible]
1200	.1		.3	1.2	.6	27.8
1500	.1	.2	.3	.9	.4	28.1
1800	.4	.1	.6	[illegible]	.3	28.[illegible]
2100	.2	.6	.8	.6	.7	27.[illegible]
Av.	.3	.2	.5	1.0	.5	27.5
			July			
0300	.4	.2	[illegible]	1.[illegible]	1.2	27.[illegible]
0900	.2		.7	.8	1.2	28.1
1200			[illegible]	1.[illegible]	.8	29.[illegible]
1500			.1	.7	.9	[illegible]
1800	.1	.1	.2	[illegible]	1.1	29.[illegible]
2100	.2	.1	.1	.8	.7	29.[illegible]
Av.	.1	.1	[illegible]	[illegible]	1.1	[illegible]
			August			
0300	.2	.1	.3	[illegible]	[illegible]	[illegible]
0900			.2	1.[illegible]	[illegible]	[illegible]
1200			.1	.4	[illegible]	[illegible]
1500			.2	.4	[illegible]	[illegible]
1800			.4	[illegible]	1.4	[illegible]
2100			.1	[illegible]	1.1	[illegible]
Av.			[illegible]	.7	1.[illegible]	[illegible]

* See footnote at end of table.

Table 3[illegible].--Visibility distance by hour of day, and number of days per month in each distance class--Continued

([illegible] 1960-68)

[illegible]

Time of day	0-1/8	3/16-3/8	1/2-3/4	1-2-1/2	3-6	7+
			April			
0300	[illegible]	[illegible]	0.1	.6	[illegible]	[illegible]
0900	[illegible]	[illegible]	.1	.8	.1	[illegible]
1200	[illegible]	[illegible]	.1	[illegible]	[illegible]	[illegible]
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2100	[illegible]	[illegible]	[illegible]	.4	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			May			
0300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			June			
0300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0900	[illegible]	[illegible]	[illegible]	[illegible]	.4	[illegible]
1200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			July			
0300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29.[illegible]
1500	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	29.0
1800	[illegible]	[illegible]	[illegible]	.4	1.[illegible]	29.0
2100	[illegible]	.1	[illegible]	.7	[illegible]	29.4
Av.	[illegible]	[illegible]	[illegible]	.6	1.[illegible]	[illegible]
			August			
0300	[illegible]	[illegible]	.2	[illegible]	.4	[illegible]
0900	[illegible]	[illegible]	[illegible]	[illegible]	.1	27.9
1200	[illegible]	[illegible]	[illegible]	[illegible]	.7	[illegible]
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]	[illegible]	[illegible]	.7	[illegible]
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Time of day	0-1/8	3/16-3/8	1/2-3/4	1-2-1/2	3-6	7+
			April			
0300	[illegible]	[illegible]	[illegible]	.1	1.8	25.3
0900	[illegible]	[illegible]	[illegible]	1.[illegible]	[illegible]	26.[illegible]
1200	[illegible]	[illegible]	[illegible]	[illegible]	1.8	27.1
1500	[illegible]	[illegible]	[illegible]	1.4	1.2	27.2
1800	[illegible]	[illegible]	[illegible]	1.3	[illegible]	27.8
2100	[illegible]	[illegible]	[illegible]	1.1	1.4	27.1
Av.	[illegible]	[illegible]	[illegible]	[illegible]	1.7	26.8
			May			
0300	[illegible]	[illegible]	[illegible]	.7	[illegible]	26.4
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29.7
1200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29.5
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30.4
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30.5
2100	[illegible]	[illegible]	[illegible]	.4	[illegible]	29.7
Av.	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	29.4
			June			
0300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28.9
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28.1
Av.	[illegible]	[illegible]	.1	[illegible]	[illegible]	27.7
			July			
0300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27.2
1200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1500	[illegible]	[illegible]	[illegible]	.4	[illegible]	[illegible]
1800	[illegible]	[illegible]	[illegible]	.4	[illegible]	28.0
2100	[illegible]	[illegible]	[illegible]	1.3	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]	.9	[illegible]	[illegible]
			August			
0300	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NORTHWAY

Time of day	0-1/8	3/16-3/8	1/2-3/4	1-2-1/2	3-6	7+
			April			
0300	0.1	0.1	0.1	0.7	[illegible]	[illegible]
0900			.3	.8	[illegible]	[illegible]
1200		.1	.1	.7	[illegible]	[illegible]
1500				.7	[illegible]	[illegible]
1800	.1		.1	.3	[illegible]	[illegible]
2100			.2	.2	[illegible]	[illegible].7
Av.			.1	.6	.5	[illegible].8
			May			
0300	.1	.1		.6	1.0	29.2
0900			.1	.1	1.2	[illegible]9.6
1200				.1	.3	30.6
1500				.2		30.8
1800				.1		3[illegible].9
2100					.4	30.6
Av.				.2	.5	[illegible].3
			June			
0300	.2	.1		.1	.8	28.5
0900				.1	.6	29.3
1200					.6	29.4
1500		.1		.1	.4	29.4
1800					.7	29.3
2100				.1	.7	29.2
Av.				.1	.7	29.3
			July			
0300		.1	.2	.7	.9	29.1
0900				.4	1.3	29.3
1200			.1	.4	.9	29.6
1500				.6	[illegible]	29.8
1800				.3	.6	30.1
2100				.4	.8	29.8
Av.			.1	.5	.8	29.6
			August			
0300	.4	.2	.5	.4	.8	28.7
0900				[illegible]	1.4	29.4
1200				[illegible]	.6	30.2
1500					.8	30.2
1800				.1	.6	30.4
2100					.8	30.2
Av.	[illegible]		.1	[illegible]	.8	29.8

[illegible]

Time of day	0-1/8	3/16-3/8	1/2-3/4	1-2-1/2	3-6	7+
			April			
0300	[illegible]	[illegible]	.2	1.[illegible]	[illegible]	[illegible]
0900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			May			
0300	[illegible]	[illegible]	[illegible]	.4	[illegible]	[illegible]
0900	[illegible]	[illegible]	.1	[illegible]	[illegible]	[illegible]
1200	[illegible]	[illegible]	[illegible]	.7	[illegible]	[illegible]
1500	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			June			
0300	[illegible]	[illegible]	[illegible]	.9	[illegible]	[illegible]
0900	[illegible]	[illegible]	[illegible]		.3	29.6
1200	[illegible]	[illegible]	.1		.1	29.8
1500					.4	29.6
1800					.6	29.4
2100				.2	.7	29.1
Av.				.2	.5	29.3
			July			
0300	[illegible]	[illegible]	.6	1.3	2.9	25.2
0900				.1	1.1	29.8
1200					.9	30.1
1500				.1	.7	30.[illegible]
1800				.2	1.7	29.5
2100		.1		.4	1.6	28.9
Av.		[illegible]	[illegible]	.4	1.4	28.9
			August			
0300	[illegible]	[illegible]	.7	1.2	2.1	26.9
0900			.1	.2	1.1	29.6
1200	[illegible]			.1	.9	29.8
1500					1.1	29.9
1800			[illegible]	.2	1.1	29.6
2100				[illegible]	2.2	28.2
Av.	[illegible]		[illegible]	.4	1.4	29.0

[illegible]UA

Time of day	0-1/8	3/16-3/8	1/2-3/4	1-2-1/2	3-6	7+
			April			
0300	[illegible]	[illegible]	[illegible]	.3	1.[illegible]	28.6
0900	[illegible]	[illegible]	.1	[illegible]	[illegible]	28.[illegible]
1200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28.7
1500	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	27.9
1800	[illegible]	[illegible]	[illegible]	[illegible]	.4	29.6
2100	[illegible]	[illegible]	[illegible]	[illegible]	.2	29.6
Av.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29.0
			May			
0300	[illegible]	[illegible]	[illegible]	[illegible]	.4	30.1
0900	[illegible]	[illegible]	[illegible]	[illegible]	.8	30.1
1200	[illegible]	[illegible]	[illegible]	[illegible]	.7	30.3
1500	[illegible]	[illegible]	[illegible]	[illegible]	.2	30.7
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30.6
2100	[illegible]	[illegible]	[illegible]	.1	[illegible]	30.6
Av.	[illegible]	[illegible]	[illegible]	.1	[illegible]	30.4
			June			
0300	[illegible]	[illegible]	[illegible]	[illegible]	1.4	28.3
0900	[illegible]	[illegible]	[illegible]	.1	1.7	28.1
1200				.2	1.2	28.6
1500				.4	.7	28.9
1800			[illegible]	.1	.9	28.9
2100			.1	.1	.8	29.0
Av.			.1	.2	1.1	28.6
			July			
0300	[illegible]		.1	1.2	1.3	28.3
0900			[illegible]	.9	1.2	27.5
1200			.4	.7	2.1	27.8
1500			.3	.9	.9	28.9
1800			[illegible]	.6	1.7	28.4
2100			[illegible]	.6	1.6	28.6
Av.			[illegible]	.8	1.6	28.3
			August			
0300	[illegible]	[illegible]	[illegible]	[illegible]	1.9	27.7
0900		[illegible]		.7	2.6	27.4
1200			[illegible]	.5	1.4	28.9
1500				[illegible]	1.4	29.4
1800					.3	30.7
2100				.1	1.3	29.6
Av.			[illegible]	.4	1.5	29.0

[illegible]NALAKLEET

Time of day	0-1/8	3/16-3/8	1/2-3/4	1-2-1/2	3-6	7+
			April			
0300	0.1	0.4	0.4	1.[illegible]	0.9	27.1
0900	.1	[illegible]	.1	1.[illegible]	1.[illegible]	[illegible]7.[illegible]
1200	.1	.1	.3	.6	.6	[illegible]8.[illegible]
1500			.2	.6	.9	28.[illegible]
1800	.1	.1	.1	1.[illegible]	[illegible]	[illegible]
2100		.4	.4	.3	1.0	27.9
Av.	.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]7.9
			May			
0300		.2	.6	1.0	1.[illegible]	28.2
0900		[illegible]	.1	1.3	1.0	28.4
1200			.1	.4	.6	29.9
1500		.2		.8	.3	29.7
1800	.3	.2	.2	.1	.6	29.6
2100	.[illegible]	.2	.4	.4	.1	29.6
Av.	.1	.2	.2	.7	.6	29.2
			June			
0300	.2	.3	.3	1.0	1.0	27.2
0900	.1	.1	.1	.8	.7	28.2
1200	.1		.3	.9	.6	28.1
1500	.1	.1	.2	.3	.7	28.6
1800		.1	.2	.9	.1	28.7
2100	.2	.1	.2	.7	.7	28.1
Av.	.1	.1	.2	.8	.6	28.2
			July			
0300			.1	.9	.3	29.7
0900				.8	1.6	28.6
1200				.8	1.4	28.8
1500	.1		.1	.6	.9	29.3
1800	.2		.1	.6	.6	29.5
2100			.2	.7	.3	29.8
Av.	.1		.1	.7	.8	29.3
			August			
0300			.3	1.1	1.4	28.2
0900		.1		1.6	1.7	28.0
1200				.8	1.0	29.2
1500	.1		.1	.6	1.2	29.0
1800			.1	.9	1.3	28.7
2100		.1	.2	1.3	1.0	28.4
Av.			.1	1.1	1.2	28.6

1/ Minor data discrepancy

Source: United States Weather Bureau coded data.

Table 31.--Height of ceiling by [illegible] of day, [illegible]

(Av. [illegible])

ANCHORAGE

Time of day	Ceiling in hundreds of feet: 0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
April										
0300		0.1		0.4	1.1	0.9	2.3	6.7	3.8	14.7
0900			0.2	.8	.3	.8	1.3	7.1	3.7	15.8
1200				.3	1.0	.4	1.7	8.4	2.7	15.5
1500				.6	.3	1.3	2.4	8.1	2.7	14.6
1800				.6	.9	1.1	2.0	8.8	2.6	14.0
2100				.2	1.3	.8	2.3	8.9	2.9	13.6
Av.		.0	.0	.5	.8	.9	2.0	6.0	3.1	14.7
May										
0300			.1	.1	.7	.7	2.9	13.2	2.7	10.6
0900			.1		1.0	.7	3.4	10.3	2.9	12.6
1200					.6	.4	3.7	10.3	4.1	11.9
1500					.4	.9	3.8	11.6	3.0	11.3
1800					.4	.6	3.3	13.2	2.9	10.6
2100					.7	.7	3.0	11.7	3.8	11.1
Av.			.0	.0	.6	.7	3.4	11.7	3.2	11.4
June										
0300			.1	.8	.9	.9	5.0	8.6	3.8	9.9
0900				.2	2.2	1.9	3.1	7.7	4.4	10.5
1200				.2	.7	1.6	3.4	8.4	3.9	11.8
1500					.3	.7	2.6	10.2	3.4	12.8
1800				.2	.3	.8	2.4	9.0	4.6	12.7
2100				.2	.4	1.0	2.8	9.4	4.7	11.5
Av.			.0	.3	.8	1.2	3.2	8.9	4.1	11.5
July										
0300			.1	.4	1.8	1.6	4.4	10.8	1.4	10.5
0900				1.4	2.7	1.7	2.1	8.6	2.3	12.2
1200				.7	2.0	1.2	2.4	8.2	3.7	12.8
1500				.4	1.2	.9	3.2	8.9	3.3	13.1
1800				.3	.9	.9	3.4	10.7	2.6	12.2
2100			.1	.4	.7	1.3	3.7	10.0	2.8	12.0
Av.			.0	.6	1.6	1.3	3.2	9.5	2.7	12.1
August										
0300		.3	.2	.2	1.1	1.0	4.3	13.6	1.9	8.4
0900		.1	.2	1.0	1.6	1.0	3.6	11.4	2.7	9.4
1200				.7	.9	.9	3.2	10.9	4.1	10.3
1500				.2	.8	.7	3.3	11.6	3.2	11.2
1800				.6	.6	.4	4.2	10.8	3.7	10.7
2100		.1	.1		1.0	.9	4.8	11.7	2.4	10.0
Av.		.1	.1	.4	1.0	.8	3.9	11.7	3.0	10.0

BETHEL

Time of day	Ceiling in hundreds of feet: 0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
April										
0300		[illegible]	[illegible]	[illegible]	[illegible]	3.1	[illegible]	[illegible]	[illegible]	14.0
0900		[illegible]	[illegible]	[illegible]	3.3	1.8	[illegible]	[illegible]	1.9	12.7
1200			[illegible]	[illegible]	[illegible]	2.2	[illegible]	[illegible]	1.2	12.2
1500		.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.7	12.8
1800		.2	[illegible]	[illegible]	2.1	[illegible]	[illegible]	[illegible]	[illegible]	13.2
2100		.1	[illegible]	[illegible]	1.1	[illegible]	[illegible]	[illegible]	1.7	13.5
Av.		.2	[illegible]	[illegible]	2.8	[illegible]	[illegible]	[illegible]	2.2	13.1
May										
0300	0.1	.4	.4	1.9	3.3	1.8	[illegible]	[illegible]	1.9	9.1
0900			.2	4.9	[illegible]	.8	[illegible]	[illegible]	[illegible]	9.7
1200				1.3	[illegible]	4.2	[illegible]	[illegible]	1.9	8.5
1500				.8	4.3	[illegible]	[illegible]	[illegible]	1.7	9.5
1800			.1	.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.7
2100				.9	3.0	[illegible]	5.1	[illegible]	1.4	12.1
Av.	.0	.1	.1	1.8	[illegible]	2.7	5.7	[illegible]	1.9	9.9
June										
0300		.8	1.1	3.0	2.4	3.0	5.1	4.9	1.4	8.3
0900			.1	4.6	6.4	2.9	3.1	5.1	1.7	6.1
1200			.2	1.8	6.4	4.3	4.6	4.0	1.6	7.1
1500				.8	4.7	4.9	5.9	4.3	1.4	8.0
1800				1.1	3.0	4.6	6.7	4.2	2.1	8.3
2100				1.1	2.7	3.5	5.3	5.1	1.9	10.4
Av.		.1	.2	2.1	4.3	3.9	5.1	4.6	1.7	8.0
July										
0300	.1	.1	.9	5.8	5.2	1.9	5.0	4.9	1.1	6.0
0900			1.2	8.3	4.9	1.8	2.6	4.6	1.9	5.8
1200			.2	5.0	6.8	4.6	3.2	4.2	1.4	5.6
1500				3.2	7.1	4.3	4.2	4.3	1.6	6.3
1800			.1	3.3	5.0	3.9	4.9	3.8	2.4	7.6
2100			.6	3.4	3.9	2.6	4.3	5.6	1.9	8.7
Av.	.0	.0	.5	4.8	5.5	3.3	4.0	4.6	1.7	6.7
August										
0300		1.0	1.4	5.0	4.6	4.6	5.2	3.6	1.2	4.4
0900		.3	1.2	9.7	6.6	2.7	3.2	3.7	.8	2.8
1200			.4	6.3	8.3	4.2	3.9	3.8	.7	3.4
1500			.1	5.1	6.8	6.4	4.3	3.8	1.3	3.2
1800			.6	4.6	5.3	3.9	5.4	4.7	1.2	5.3
2100			.8	5.5	5.4	3.7	3.8	4.8	1.4	5.6
Av.		.2	.8	6.0	6.2	4.2	4.3	4.1	1.1	4.1

BETTLES

Time of day	Ceiling in hundreds of feet: 0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
April										
0300				0.2	1.0	1.3	1.8	6.9	2.0	16.8
0900				.3	.7	.8	1.9	5.7	2.7	17.9
1200					.8	.7	1.7	5.0	3.1	18.7
1500				.2	.6	1.0	2.4	4.3	2.4	19.1
1800				.1	.7	1.0	1.3	4.7	2.2	20.0
2100				.1	.3	.8	1.3	5.7	3.1	18.7
Av.				.2	.7	.9	1.7	5.4	2.6	18.5
May										
0300			0.1	.2	.4	.7	2.0	10.6	1.7	15.3
0900				.1	.7	1.2	2.3	6.8	1.9	18.0
1200		0.1		.1	.4	.8	3.8	7.4	2.7	15.7
1500				.2	.4	.4	2.9	10.1	3.2	13.8
1800					.3	.8	1.9	9.7	3.2	15.1
2100					.8	.2	1.5	9.1	3.6	15.8
Av.		.0	.0	.1	.5	.7	2.4	9.0	2.7	15.6
June										
0300					.3	.7	1.1	10.3	1.8	15.8
0900				.3	.7	1.2	2.3	8.0	2.6	14.9
1200					1.0	.6	3.2	9.3	2.0	13.9
1500				.2	.3	1.0	3.4	8.0	2.3	14.8
1800					.6	1.0	1.7	8.2	3.3	15.2
2100				.1	.3	.3	.9	9.5	2.6	16.3
Av.				.1	.5	.8	2.1	8.9	2.4	15.2
July										
0300				.6	1.0	1.1	3.0	9.3	1.8	14.2
0900				.3	2.4	1.6	3.1	7.3	2.7	13.6
1200				.3	1.9	1.3	4.7	8.0	2.2	12.6
1500				.1	1.3	.4	4.7	9.1	1.8	13.6
1800				.1	.8	1.3	2.4	9.4	1.3	15.7
2100				.1	.9	1.1	2.3	9.0	1.6	16.0
Av.				.2	1.4	1.1	3.4	8.7	1.9	14.3
August										
0300		.2		1.3	1.4	1.3	4.4	12.0	1.3	9.1
0900		.1		1.6	3.3	2.2	4.3	8.1	2.2	9.2
1200				.8	2.2	3.0	4.8	7.9	3.6	8.7
1500				.4	1.1	3.1	3.7	10.3	2.3	10.1
1800				.2	1.6	1.8	3.2	10.3	1.9	12.0
2100				.1	1.1	2.1	3.0	10.8	2.0	11.9
Av.		.1		.7	1.8	2.2	3.9	9.9	2.2	10.2

BIG DELTA

Time of day	Ceiling in hundreds of feet: 0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
April										
0300				0.2	0.8	0.6	2.2	3.8	4.8	17.6
0900				.3	1.6	.9	1.4	2.4	3.7	19.7
1200					1.1	1.1	1.9	2.9	3.4	19.6
1500					.7	1.2	3.0	2.1	4.0	19.0
1800					.8	.8	1.4	2.9	4.2	17.9
2100				.2	.4	.6	1.8	3.3	3.7	20.0
Av.				.1	.9	.9	2.0	3.1	4.0	19.0
May										
0300				.2	.8	.8	2.7	5.7	5.2	15.6
0900				.4	.9	1.0	2.4	3.1	4.2	19.0
1200				.1	1.0	.8	4.1	5.0	3.9	16.1
1500				.1	.7	.7	3.7	5.8	4.4	15.6
1800				.1	.8	.6	1.7	5.9	5.9	15.1
2100				.2	.7	.7	2.1	6.1	4.4	16.8
Av.				.2	.8	.8	2.8	5.3	4.7	16.4
June										
0300				.3	.7	.8	2.2	7.7	4.3	14.4
0900				.2	1.3	1.2	2.2	5.3	[illegible]	15.5
1200				.1	.8	1.7	2.2	4.7	[illegible]	16.0
1500				.3	.2	1.1	2.7	7.3	4.6	[illegible]
1800				.1		.8	2.9	5.4	5.2	15.6
2100					.4	.8	2.7	7.1	4.1	14.6
Av.				.2	.6	1.0	[illegible]	6.2	4.4	15.0
July										
0300			0.1	.8	1.7	.7	3.7	7.8	3.7	12.5
0900				1.1	2.9	.9	2.0	4.7	5.0	14.4
1200				.4	1.8	.9	1.8	5.6	5.1	[illegible]
1500				.1	1.0	.9	3.1	5.7	5.0	15.6
1800				.3	.8	.7	2.2	6.9	4.7	[illegible]
2100				.1	.4	1.2	3.0	8.0	3.8	14.5
Av.			.0	.5	1.4	.8	2.6	[illegible]	4.5	14.8
August										
0300			.1	.7	1.2	1.7	5.1	7.4	[illegible]	11.9
0900				1.4	2.9	.9	1.2	5.4	4.8	14.4
1200				.9	2.0	.9	[illegible]	4.4	4.7	16.2
1500				.6	.8	1.1	1.9	5.1	5.9	15.6
1800				.1	.6	1.0	1.1	8.1	5.3	14.5
2100				.3	.9	1.3	2.9	8.4	4.9	[illegible]
Av.			.0	.7	1.4	1.1	2.5	6.5	4.8	14.0

Table [illegible] — [illegible] ceiling [illegible] days [illegible] each ceiling class (continued)

[illegible]

Hour									
	Ceiling in hundreds of feet								
	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim
April									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
May									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
July									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
August									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Hour									
	Ceiling in hundreds of feet								
	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim
April									
[illegible]			.2	1.0	.8	.2	7.1	.9	18.8
[illegible]			.6	.6	.9	1.2	3.9	2.2	20.6
[illegible]			.6	.6	1.3	.8	[illegible]	1.9	22.0
[illegible]				.7	1.6	1.2	3.6	3.1	19.8
[illegible]			[illegible]	.6	1.0	.9	3.5	2.2	20.6
[illegible]			[illegible]	.7	1.1	.6	4.8	1.7	19.8
Av.			.4	.7	1.1	.8	4.2	2.0	20.3
May									
[illegible]			.3	.7	1.0	[illegible]	6.8	1.0	[illegible]
[illegible]			.3	1.0	1.3	1.4	4.6	2.4	20.0
[illegible]			.6	.6	1.6	1.9	5.5	1.9	18.9
[illegible]			[illegible]	.2	1.0	2.4	5.6	1.6	19.9
[illegible]			.4	.5	.9	1.6	5.5	1.5	20.1
[illegible]			.4	.9	.1	.9	6.1	2.1	20.4
Av.			.4	.6	1.	1.5	5.7	1.6	20.0
June									
[illegible]				.7	.9	.4	7.0	1.4	19.6
[illegible]			.6	1.0	.7	1.0	5.0	2.9	18.8
[illegible]			.3	.6	[illegible]	1.9	4.6	2.3	19.0
[illegible]			.1	.6	[illegible]	2.3	5.0	1.3	19.4
[illegible]			.1	.8	1.2	2.6	5.5	.8	19.0
[illegible]			.4	.3	.8	1.1	6.6	1.8	19.0
Av.			.2	.7	1.0	1.6	5.6	1.8	19.1
July									
[illegible]	.1		.2	.3	1.2	.8	8.0	1.4	18.5
[illegible]			[illegible]	2.0	[illegible]	[illegible]	5.4	2.9	17.9
[illegible]			[illegible]	2.6	[illegible]	[illegible]	3.1	2.3	18.3
[illegible]			.1	1.6	1.6	3.6	6.5	1.8	15.8
[illegible]			.4	1.1	[illegible]	2.6	6.6	2.4	16.9
[illegible]			[illegible]	.8	1.8	1.2	9.1	2.0	15.9
Av.	[illegible]		[illegible]	[illegible]	1.5	2.1	6.4	2.1	17.2
August									
[illegible]			[illegible]	[illegible]	1.7	2.0	8.7	1.8	15.2
[illegible]			.7	[illegible]	1.	2.1	6.8	1.9	16.8
[illegible]			[illegible]	1.1	[illegible]	3.1	5.7	1.7	16.8
[illegible]			.1	[illegible]	1.5	[illegible]	6.6	1.8	15.8
[illegible]			.4	1.1	1.0	2.6	[illegible]	2.4	16.9
[illegible]			[illegible]	1.0	1.7	1.2	8.7	1.7	16.5
Av.			[illegible]	[illegible]	1.6	2.4	7.2	1.9	16.3

[illegible]

Hour									
	Ceiling in hundreds of feet								
	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim
April									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
May									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
June									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
July									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
August									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]A

Hour										
	Ceiling in hundreds of feet									
	[illegible]	[illegible]	[illegible]	[illegible]	10-19	20-29	30-49	50-95	96-199	Unlim
April										
[illegible]				[illegible]	[illegible]	.2	[illegible]	4.0	3.4	20.5
[illegible]					[illegible]	.2	1.0	3.0	.1	20.0
[illegible]				[illegible]	[illegible]	.4	1.9	4.3	4.6	18.3
[illegible]				[illegible]	[illegible]	.7	1.6	6.1	[illegible]	15.9
[illegible]					.1	.8	3.2	4.1	4.6	17.1
[illegible]					.8	.2	2.1	3.7	3.4	19.8
Av.					.4	.4	1.8	4.2	4.4	18.6
May										
[illegible]				[illegible]	[illegible]	.8	3.0	6.8	3.7	16.3
[illegible]			[illegible]	[illegible]	.8	.4	1.9	7.1	5.2	15.2
[illegible]				.2	.4	.4	3.4	12.1	3.6	10.8
[illegible]					.7	.8	3.6	12.1	3.3	10.5
[illegible]					[illegible]	.9	2.3	10.1	4.1	13.3
[illegible]					.3	.4	3.3	7.8	3.8	15.4
Av.				.1	.5	.6	2.9	9.3	4.0	13.6
June										
[illegible]		[illegible]			.6	.1	2.0	7.4	3.9	15.7
[illegible]				[illegible]	.7	.4	1.4	5.9	5.2	16.2
[illegible]					.6	.3	2.2	9.2	3.8	13.9
[illegible]					[illegible]	1.0	3.3	9.1	3.6	12.7
[illegible]					[illegible]	.1	2.2	9.0	3.8	14.6
[illegible]					.2	.4	2.0	8.3	3.0	16.1
Av.		[illegible]		[illegible]	.1	.4	2.2	8.2	3.9	14.9
July										
[illegible]		[illegible]	[illegible]	.2	[illegible]	.7	4.0	9.0	3.1	[illegible]
900				[illegible]	.9	[illegible]	2.1	6.8	5.1	14.5
[illegible]				[illegible]	.6	.4	2.9	9.7	3.7	13.5
150[illegible]				[illegible]	[illegible]	.6	2.9	9.6	2.6	13.8
[illegible]				.1	[illegible]	.3	2.4	10.5	4.3	13.2
[illegible]				.3	.1	.7	2.6	[illegible]	2.2	14.8
Av.		[illegible]	[illegible]	.2	.4	.7	2.8	9.3	3.7	13.9
August										
[illegible]	.1	[illegible]	.2	.1	.4	1.1	2.1	9.2	4.4	12.1
[illegible]90			.1	.3	1.1	.9	1.7	8.4	5.6	12.9
1200				.3	1.0	.3	[illegible]	8.7	[illegible]	13.4
1500				.2	.8	.4	2.7	[illegible]	4.8	13.8
1800				.2	.7	.4	3.2	9.1	[illegible]	13.4
2100			[illegible]	.1	.6	1.0	3.2	[illegible]	[illegible]	13.9
Av.	[illegible]	.1	[illegible]	.2	.8	.7	2.7	[illegible]	4.6	[illegible]

Table 31.--Height of ceiling by hour of day, and number of days per month in each height class--Continued

(Av. 1950-58)

HOMER

Time of day	0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
					Ceiling in hundreds of feet					
					April					
0300		0.2	0.1	0.4	2.3	2.9	6.9	3.4	0.8	13.0
0900			.2	.8	2.2	2.3	5.8	4.2	1.7	12.8
1200			.1	.4	2.0	1.9	6.6	4.6	1.1	13.3
1500			.1	.9	2.3	1.9	7.1	3.8	1.6	12.3
1800				.6	1.2	2.7	7.0	3.7	1.4	13.4
2100		.1	.1	.6	2.1	2.1	6.3	3.9	1.2	13.6
Av.		.1	.1	.6	2.0	2.3	6.6	3.9	1.3	13.1
					May					
0300		.3		.2	.8	2.8	9.4	6.0	1.4	10.1
0900				.2	.9	1.6	9.0	6.7	2.6	10.0
1200					1.2	1.2	9.3	7.0	2.2	10.1
1500				.1	.6	2.7	10.1	6.1	2.0	9.4
1800					1.7	3.6	9.0	5.2	1.3	10.2
2100					1.0	3.1	8.8	4.3	1.7	11.1
Av.		.1		.1	1.0	2.5	9.3	5.9	1.9	10.2
					June					
0300		.1	.2	.3	1.1	2.3	7.3	6.7	1.8	10.2
0900				.3	1.1	1.1	7.4	6.8	2.1	11.2
1200					.8	1.0	8.1	6.7	1.9	11.5
1500					.4	1.0	7.2	6.8	2.1	12.5
1800					.3	.4	9.3	5.8	2.8	11.4
2100			.1		.4	.7	9.0	6.1	1.9	11.8
Av.			.1	.1	.7	1.1	8.0	6.5	2.1	11.4
					July					
0300	0.1	.4	.1	.3	1.6	1.3	7.7	5.9	1.8	11.8
0900					.3	1.0	8.6	5.9	1.9	13.3
1200					.3	1.0	7.8	7.0	1.7	13.2
1500			.2		.9	.8	6.7	7.1	1.6	13.7
1800			.1	.2	.8	1.3	7.0	6.8	1.8	13.0
2100		.1	.3	.1	.6	1.3	6.7	6.8	1.1	14.0
Av.	.0	.1	.1	.1	.8	1.1	7.4	6.6	1.6	13.2
					August					
0300	.1	.2	.4	.1	1.3	.7	10.8	6.8	1.1	9.5
0900			.1	.2	1.2	1.6	9.7	7.2	1.9	9.1
1200				.1	.7	1.3	11.9	5.2	1.6	10.2
1500					.9	1.0	10.3	7.0	2.1	9.7
1800			.3		.7	.4	11.9	5.6	1.8	10.3
2100		.1	.1	.2	.7	.9	11.2	5.4	1.2	11.2
Av.	.0	.1	.1	.1	.9	1.0	11.0	6.2	1.6	10.0

ILIAMNA

Time of day	0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
					Ceiling in hundreds of feet					
					April					
0300	.1	0.1	.1	0.8	2.0	2.8	4.3	5.2	[illegible]	[illegible]
0900			.1	.8	3.0	2.2	4.9	5.3	[illegible]	[illegible]
1200				.6	2.6	1.6	4.8	[illegible]	[illegible]	15.0
1500		.1	[illegible]	.6	2.0	1.9	3.9	[illegible]	[illegible]	[illegible]
1800			.1	1.1	2.1	1.8	4.2	5.0	[illegible]	14.5
2100		.2	.1	.9	2.0	1.3	5.1	4.9	.8	14.6
Av.	.0	.1	.1	.8	2.3	1.9	4.5	5.0	1.1	[illegible]
					May					
0300	.2	.1	.1	.8	[illegible]	2.4	8.0	8.7	.9	8.6
0900				.7	2.0	2.2	6.2	7.4	1.9	10.6
1200				.9	.8	1.6	6.6	9.0	1.3	10.8
1500				[illegible]	1.1	.7	6.8	7.7	1.9	[illegible]
1800				[illegible]	.9	.8	7.4	8.1	1.8	11.7
2100				.2	1.4	2.3	7.4	8.3	1.2	[illegible]
Av.	.0	.0	[illegible]	.6	1.2	1.7	7.1	[illegible]	1.5	10.7
					June					
0300		.3	.1	1.4	1.3	1.7	6.9	7.8	[illegible]	[illegible]
0900			.2	1.1	2.6	1.9	5.9	7.7	1.0	9.7
1200				.6	1.4	1.7	7.1	7.7	[illegible]	[illegible]
1500					.4	1.2	7.5	7.9	[illegible]	[illegible]
1800				.1	.6	1.2	[illegible]	[illegible]	[illegible]	[illegible]
2100				.4	.8	1.0	6.8	9.1	[illegible]	[illegible]
Av.		.1	.1	.6	1.2	1.4	[illegible]	[illegible]	[illegible]	10.6
					July					
0300	.2	.4	.7	[illegible]	2.0	1.7	8.7	[illegible]	[illegible]	9.4
0900		.2	.6	2.0	3.8	1.9	[illegible]	[illegible]	[illegible]	[illegible]
1200		.1		[illegible]	2.6	2.1	[illegible]	[illegible]	[illegible]	[illegible]
1500			.1	1.0	1.4	1.8	6.8	[illegible]	[illegible]	[illegible]
1800		.1	.1	.7	1.3	1.7	[illegible]	9.1	.8	[illegible]
2100				.8	1.7	.6	7.7	7.7	1.6	10.7
Av.	.0	.1	.2	1.3	2.1	1.6	7.1	[illegible]	[illegible]	10.1
					August					
0300		.6	.8	1.9	3.6	2.0	8.1	[illegible]	1.1	7.6
0900			[illegible]	[illegible]	[illegible]	2.1	6.9	7.7	[illegible]	[illegible]
1200			.2	1.1	[illegible]	2.3	7.9	8.6	1.9	[illegible]
1500			.1	1.2	[illegible]	[illegible]	7.7	[illegible]	1.6	[illegible]
1800			[illegible]	1.0	1.9	1.4	7.3	[illegible]	1.9	[illegible]
2100		.1	.4	1.2	2.1	2.4	8.0	7.8	1.7	[illegible]
Av.		.1	[illegible]	1.6	2.6	[illegible]	7.8	7.6	1.6	7.4

KOTZEBUE

Time of day	0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
					Ceiling in hundreds of feet					
					April					
0300		0.1	0.1	1.3	2.1	1.6	3.9	4.4	1.7	14.8
0900	0.1	.3	.4	1.4	1.6	1.2	3.7	4.9	1.0	15.4
1200	.1		.1	1.4	2.7	1.1	2.1	3.1	2.1	17.3
1500		.2		1.1	2.6	1.7	2.1	2.9	2.2	17.2
1800			.1	.9	2.1	2.0	2.2	3.9	1.9	16.9
2100			.1	1.3	2.1	2.2	2.5	4.2	1.6	16.0
Av.	.0	.1	.1	1.2	2.2	1.6	2.8	3.9	1.8	16.3
					May					
0300	.1	.9	.8	1.8	1.7	1.8	2.8	5.3	1.4	14.4
0900		.1	.7	2.8	1.7	1.8	2.4	3.9	1.2	16.4
1200		.2	.3	2.1	1.7	1.3	1.8	4.6	1.9	17.1
1500			.3	1.1	2.5	1.0	1.4	4.4	2.4	17.9
1800		.2	.2	.8	1.8	1.4	2.1	4.0	2.3	18.2
2100		.6	.1	1.1	1.8	1.2	2.0	4.6	1.6	18.0
Av.	.0	.3	.4	1.6	1.9	1.4	2.1	4.5	1.8	17.0
					June					
0300		.8	1.1	2.1	1.6	1.0	2.9	5.3	2.2	13.0
0900		.2	1.6	1.9	2.6	1.4	3.1	4.3	2.4	12.5
1200		.3	.4	2.0	1.8	1.6	2.7	3.7	2.9	14.6
1500		.4	.8	1.1	1.0	1.1	2.2	3.3	4.0	16.1
1800		.7	.7	.8	.2	1.4	3.0	4.2	3.8	15.2
2100		.8	.8	1.3	.8	.7	2.2	6.6	2.4	14.4
Av.		.5	.9	1.5	1.3	1.2	2.7	4.6	3.0	14.3
					July					
0300	.1	.7	1.0	2.9	2.3	1.6	4.1	4.4	4.0	9.9
0900		1.1	.7	3.9	3.7	2.1	2.6	5.0	2.4	9.5
1200		.6	.7	2.4	3.4	2.2	3.1	3.8	3.2	11.6
1500		.3	.8	2.1	1.6	2.1	3.1	4.3	4.1	12.6
1800		.2	.7	1.7	1.1	1.9	3.8	6.0	3.3	12.3
2100		.2	.7	1.7	2.1	1.9	3.3	6.0	3.3	11.8
Av.	.0	.5	.8	2.4	2.4	2.0	3.3	4.9	3.4	11.3
					August					
0300		.3	.7	3.4	4.2	3.9	5.2	5.4	1.6	6.3
0900		.1	.2	5.0	4.9	2.9	3.9	6.2	2.0	5.8
1200			.1	4.0	5.2	3.0	3.6	4.7	2.8	7.6
1500		.1	.1	2.3	4.3	3.9	3.9	5.7	2.7	8.0
1800		.2	.2	2.6	2.9	3.1	5.0	5.3	3.3	8.4
2100		.1	.1	3.1	1.9	4.0	5.7	6.9	2.0	7.2
Av.		.1	.2	3.4	3.9	3.5	4.6	5.7	2.4	7.2

LAKE MINCHUMINA

Time of day	0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
					Ceiling in hundreds of feet					
					April					
0300		0.1		0.2	0.6	1.2	2.7	6.4	[illegible]	[illegible]
0900				.2	.7	1.7	1.7	4.8	[illegible]	[illegible]
1200				.1	.7	1.3	3.1	[illegible]	[illegible]	[illegible]
1500				.1	.1	1.4	[illegible]	[illegible]	[illegible]	16.7
1800				.1	.1	1.2	4.1	5.8	[illegible]	15.9
2100					.2	1.2	3.7	4.8	[illegible]	17.4
Av.		.0		.1	.4	1.3	3.3	5.0	[illegible]	[illegible]
					May					
0300	0.1			.2	.7	.9	3.4	8.7	[illegible]	14.3
0900				.4	.7	1.0	3.0	6.8	[illegible]	16.4
1200					1.1	1.0	5.4	7.9	[illegible]	12.3
1500				.1	.6	.9	7.1	7.2	[illegible]	11.8
1800				.2	.2	.6	4.8	[illegible]	[illegible]	12.9
2100				.4	.4	.6	3.1	[illegible]	[illegible]	13.9
Av.	.0			.2	.6	.8	4.5	8.4	[illegible]	[illegible]
					June					
0300				.3	.4	.7	4.4	8.8	[illegible]	[illegible]
0900				.4	1.4	1.1	4.1	[illegible]	[illegible]	[illegible]
1200				.1	1.0	1.0	[illegible]	7.9	[illegible]	[illegible]
1500				.1	.3	.7	[illegible]	9.9	[illegible]	10.4
1800				.1	.1	.8	5.8	[illegible]	[illegible]	9.4
2100					.2	.4	3.9	11.6	[illegible]	[illegible]
Av.				.2	.6	.8	4.9	9.3	[illegible]	[illegible]
					July					
0300	.2	.2	0.1	1.3	1.2	1.4	5.4	[illegible]	[illegible]	11.7
0900				1.1	1.9	3.0	4.1	6.6	[illegible]	[illegible]
1200				.3	2.1	3.1	5.6	[illegible]	1.7	[illegible]
1500				.2	1.9	1.7	6.8	[illegible]	1.6	[illegible]
1800				.2	1.3	1.3	6.2	7.9	2.0	[illegible]
2100				.2	1.6	1.4	5.5	8.2	2.7	11.4
Av.	.0	.0	.0	.6	1.7	2.0	[illegible]	7.4	2.0	11.7
					August					
0300	.1		.1	1.0	1.8	2.0	5.1	[illegible]	[illegible]	9.4
0900			.1	1.9	3.0	2.1	4.3	7.7	[illegible]	9.1
1200				.8	2.7	[illegible]	[illegible]	7.1	[illegible]	8.7
1500				.3	2.2	2.6	[illegible]	[illegible]	[illegible]	[illegible]
1800				.4	1.0	2.2	[illegible]	[illegible]	[illegible]	8.5
2100			.1	.2	1.2	2.3	[illegible]	[illegible]	[illegible]	8.7
Av.	.0		.1	.7	2.0	2.2	[illegible]	[illegible]	.4	9.9

Table [illegible].--Height of ceiling by hour of day, and number of days per month in each height class--Continued

(Av. 1950-58)

McGRATH

Time of day	0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
					April					
0300		.1		0.4	1.1	2.7	3.3	5.3	2.2	14.9
0900				.2	1.3	1.9	2.2	5.0	2.2	17.2
1200				.1	1.4	2.0	2.9	3.2	1.9	18.5
1500				.1	1.4	.9	4.0	3.6	2.2	17.8
1800				.1	1.0	1.3	2.8	5.2	2.0	17.6
2100				.3	1.0	2.0	2.9	5.0	1.7	17.1
Av.		.0		.2	1.2	1.8	3.0	4.6	2.0	17.2
					May					
0300			0.1	.6	1.2	1.4	3.3	8.2	3.7	12.5
0900				.4	1.7	2.0	2.3	7.2	2.8	14.6
1200				.1	1.0	1.6	4.3	9.0	2.9	12.1
1500					.8	.9	4.4	11.3	3.1	10.5
1800					.4	1.0	4.0	10.8	2.7	12.1
2100			.1		.6	.9	3.9	8.2	3.4	13.9
Av.			.0	.2	1.0	1.3	3.7	9.1	3.1	12.6
					June					
0300				.2	1.2	.4	2.2	10.8	4.4	10.8
0900				.1	1.6	2.4	3.6	7.2	3.7	11.4
1200					.6	1.3	6.1	9.4	2.0	10.6
1500					.2	1.0	5.0	11.2	2.8	9.8
1800					.2	.3	3.0	11.6	4.0	10.9
2100				.1	.4	.8	2.8	10.2	3.8	11.9
Av.				.1	.7	1.0	3.8	10.1	3.4	10.9
					July					
0300	0.1	.2	.1	.7	2.6	1.9	3.7	10.4	2.4	8.9
0900				.4	4.4	2.3	3.3	7.0	2.1	11.5
1200					3.2	3.4	4.4	7.6	2.1	10.3
1500					1.7	2.8	6.0	8.3	2.6	9.6
1800				.1	1.3	1.2	4.3	11.4	3.3	9.4
2100				.1	.9	1.6	4.4	11.1	2.2	10.7
Av.	.0	.0	.0	.2	2.4	2.2	4.4	9.3	2.4	10.1
					August					
0300		.1	.1	.9	3.9	2.7	5.3	8.2	2.9	6.9
0900		.1	[illegible]	1.7	5.1	2.7	5.2	6.8	2.1	7.1
1200			.1	.4	3.6	3.7	7.8	6.3	1.9	7.2
1500			.1	.1	2.3	2.2	8.7	9.2	2.0	6.4
1800					2.7	1.6	5.7	10.3	2.8	7.9
2100				.6	2.2	2.1	5.8	10.5	2.1	7.7
Av.		.0	.1	.6	3.3	2.5	6.4	8.6	2.3	7.2

NAKNEK

Time of day	0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
					April					
0300	0.1	0.6	0.4	0.9	3.2	1.3	5.1	3.6	1.7	13.1
0900			.3	2.4	3.0	2.8	4.1	3.8	1.6	12.0
1200				1.8	4.8	3.6	3.1	3.3	2.0	11.4
1500				1.8	3.2	3.8	4.7	3.4	1.3	11.8
1800			.2	1.0	3.6	2.4	4.0	4.6	1.6	12.6
2100		.1	.1	1.3	3.4	2.3	3.4	3.8	1.3	14.3
Av.	.0	.1	.2	1.5	3.5	2.7	4.1	3.8	1.6	12.5
					May					
0300	.2	.8	.7	2.2	2.1	3.2	5.3	5.7	1.8	9.0
0900			.2	1.7	5.0	3.0	4.0	5.6	2.9	8.6
1200				.7	4.1	4.7	7.0	5.2	2.4	6.9
1500				.4	2.8	5.1	9.1	5.3	1.4	6.9
1800				.6	2.2	3.7	7.7	4.9	2.3	9.6
2100		.1	.1	1.0	1.6	3.4	5.8	5.8	2.4	10.8
Av.	.0	.2	.2	1.1	3.0	3.8	6.5	5.4	2.2	8.6
					June					
0300	.1	1.3	2.3	2.9	2.3	2.8	4.9	5.4	1.7	6.3
0900			.1	3.8	4.8	3.1	5.2	4.2	1.9	6.9
1200				.4	4.6	5.7	7.8	3.4	1.2	6.9
1500				.4	2.6	4.4	10.0	3.6	1.2	7.8
1800			.1	.9	2.6	3.6	7.2	4.8	1.2	9.6
2100			.1	2.6	1.7	2.9	5.8	6.7	1.7	8.5
Av.	.0	.2	.4	1.8	3.1	3.8	6.8	4.7	1.5	7.7
					July					
0300	.6	1.9	2.6	3.6	2.3	2.3	6.0	4.9	1.2	5.6
0900		.1	1.0	5.3	4.9	2.3	4.7	4.4	1.6	6.7
1200			.1	3.1	5.0	5.3	6.3	3.3	1.3	6.6
1500				1.2	4.4	5.1	7.3	4.1	1.0	7.9
1800				1.6	4.0	2.7	7.0	5.6	1.1	9.0
2100		.1	.6	2.9	2.9	2.0	5.4	5.3	3.0	8.8
Av.	.1	.4	.7	3.0	3.9	3.3	6.1	4.6	1.5	7.4
					August					
0300	.8	1.6	1.3	3.3	2.8	2.8	5.6	5.2	.9	5.7
0900		.1	.8	5.9	5.3	2.8	4.6	5.8	1.4	4.3
1200			.2	3.2	4.8	5.7	7.1	4.3	.9	4.8
1500			.1	2.8	4.3	4.3	8.5	4.7	1.4	4.9
1800				2.8	3.0	3.4	7.0	6.4	2.1	6.3
2100		.2	1.0	2.9	2.4	3.8	6.1	6.9	1.6	6.1
Av.	.1	.3	.6	3.5	3.8	3.8	6.5	5.6	1.4	5.4

NORTHWAY

Time of day	0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
					April					
0300		0.1		0.4	0.9	1.0	3.3	6.9	3.2	14.2
0900			0.1	.6	1.2	.8	2.3	3.8	3.6	17.6
1200				.6	.6	.4	2.8	4.8	3.4	17.4
1500			.1	.3	.7	.4	3.2	5.0	3.1	17.2
1800				.8	.3	.4	2.2	6.6	4.2	15.5
2100				.6	.6	1.0	2.4	7.1	2.8	15.5
Av.		.0	.0	.6	.7	.7	2.7	5.7	3.4	16.2
					May					
0300		.1		.9	.4	.6	3.3	10.8	3.3	11.6
0900				1.1	.7	1.0	4.8	6.3	3.7	13.4
1200				.8	.6	.8	6.7	9.3	3.3	9.5
1500				.2	.3	1.1	4.4	12.6	2.9	9.5
1800				.1	.2	.7	3.3	12.4	3.1	11.2
2100					.6	1.2	2.6	12.2	3.4	11.0
Av.		.0		.5	.5	.9	4.2	10.6	3.3	11.0
					June					
0300		.1		.4	.4	.6	2.4	11.2	4.1	10.8
0900				.2	.7	1.1	3.4	7.3	3.6	13.7
1200				.1	.6	.8	5.5	9.8	3.0	10.2
1500					.6	.4	3.9	12.7	3.6	7.8
1800					.4	.2	2.7	13.0	3.7	10.0
2100					.7	.2	2.9	14.1	4.0	9.1
Av.				.1	.6	.6	3.5	11.2	3.7	10.3
					July					
0300			.1	.4	.8	.8	2.7	13.0	4.[illegible]	9.1
0900			.1	.4	1.6	2.0	3.5	7.1	3.3	13.0
1200				.2	1.1	1.6	4.6	6.9	4.0	12.6
1500				.2	.6	1.0	3.3	10.0	3.1	12.8
1800				.1	.6	.3	2.1	11.4	3.9	12.6
2100			.1	.1	.4	.7	2.2	12.2	3.1	12.0
Av.			.0	.2	.8	1.1	3.1	10.1	3.6	12.0
					August					
0300			[illegible]	[illegible]	.6	.8	4.0	11.3	3.5	10.0
0900		[illegible]		.7	1.5	1.[illegible]	2.9	[illegible]	2.5	12.9
1200			[illegible]		1.0	2.5	5.[illegible]	8.9	[illegible].5	1[illegible].6
1500				.1	.4	1.2	4.8	8.1	4.[illegible]	1[illegible].2
1800				.1	.5	.4	3.5	1[illegible].7	3.5	11.[illegible]
2100				[illegible]	.6	.4	3.2	12.1	[illegible].5	11.1
Av.			[illegible]	[illegible]	.8	1.0	3.9	9.9	[illegible].6	11.4

SUMMIT

Time of day	0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
					April					
0300			0.2	.7	1.7	1.3	3.6	5.0	1.7	15.8
0900				.1	2.1	1.7	3.6	4.0	2.8	15.7
1200				.2	1.6	1.4	4.2	4.8	2.8	15.0
1500		0.1		.5	1.6	1.2	3.7	5.8	3.1	14.0
1800				.4	2.0	.9	4.4	5.4	2.2	14.7
2100				.7	1.8	1.3	4.1	4.1	1.9	16.1
Av.		.0	.0	.4	2.0	1.3	3.9	4.8	2.4	15.2
					May					
0300		.3	.9	2.4	2.8	1.3	3.1	6.1	2.2	11.9
0900				1.4	2.9	2.9	2.9	6.6	2.2	12.1
1200		.1		.9	2.3	1.7	4.9	7.3	2.2	11.6
1500				.6	1.9	1.4	5.7	7.9	2.3	11.2
1800				.9	1.4	1.3	3.9	7.6	2.2	13.7
2100			.3	1.1	2.0	1.3	3.4	6.5	1.9	14.5
Av.		.1	.2	1.2	2.2	1.6	4.0	7.0	2.2	12.5
					June					
0300		.3	.9	2.4	3.2	2.3	4.1	6.2	1.6	9.0
0900			.1	1.4	3.1	3.0	5.8	5.4	2.[illegible]	9.0
1200			.1	.1	2.2	2.5	6.6	8.6	2.1	7.8
1500				.2	1.4	2.7	5.6	9.8	2.2	8.1
1800				.2	1.7	2.0	5.8	9.3	1.7	9.3
2100				.8	2.4	1.5	4.4	6.7	3.6	10.6
Av.		.1	.2	.8	2.3	2.3	5.4	7.7	2.2	9.0
					July					
0300	0.2	.9	1.7	3.1	4.1	[illegible].0	4.2	4.9	1.0	8.9
0900			.2	2.0	4.0	4.0	6.1	3.7	1.8	8.6
1200				1.2	2.8	3.4	6.9	5.7	1.3	9.7
1500				.9	2.1	1.4	8.0	7.8	1.8	9.0
1800		.1		.9	2.3	1.3	6.7	8.9	2.0	8.8
2100	.1	.1	.3	1.5	2.3	.9	5.7	7.7	1.7	9.7
Av.	.1	.2	.4	1.6	3.0	2.3	6.3	6.4	1.6	9.1
					August					
0300	.1	.3	[illegible]	3.6	4.4	2.7	4.8	5.9	1.4	7.5
0900			.1	2.7	5.0	3.4	6.4	5.3	1.2	6.9
1200			.2	.8	3.9	3.7	9.1	5.1	1.3	6.9
1500				.8	2.4	3.1	8.3	8.3	.9	7.2
1800		.1		.9	2.0	1.9	8.0	8.7	2.0	7.4
2100		.1	.4	1.7	2.9	2.3	6.4	6.7	1.8	8.7
Av.	.0	.1	.2	1.8	3.4	2.8	7.2	6.7	1.4	7.4

Table 31.--Height of ceiling by hour of day, and number of days per month in each height class--continued

(Av. 1950-58)

NANA

me y	0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
					April					
00				0.1	0.3	1.3	2.9	5.2	2.2	18.0
00				.3	.8	1.2	1.6	4.4	4.6	17.1
00				.1	.8	1.0	2.2	4.3	2.9	18.7
00				.1	.8	.1	2.7	5.1	4.3	16.9
00				.2		.8	2.0	5.7	3.2	18.1
00					.4	1.3	3.2	4.5	2.5	18.0
.				.1	.5	1.0	2.4	4.9	3.3	17.8
					May					
00	0.1		0.1	.1	.6	1.0	2.0	8.9	2.4	15.8
00				.1	1.1	1.4	2.0	7.1	3.0	16.3
00					.8	.9	4.8	7.1	3.4	14.0
00					.6	.8	5.0	8.9	3.4	12.3
00				.1	.3	.6	4.8	8.4	2.9	13.9
00				.2	.7	.2	3.4	8.6	1.8	16.1
.	.0		.0	.1	.7	.8	3.7	8.2	2.8	14.7
					June					
00				.3	1.3	.9	2.6	7.9	3.1	13.9
00				.3	1.3	.9	3.0	7.0	3.3	14.2
00				.3	.4	1.1	4.2	9.2	3.4	11.4
00				.1	.3	1.0	3.9	9.6	3.4	11.7
00				.1	.4	.6	3.8	9.1	3.0	13.0
00				.1	.2	.3	2.9	8.9	3.4	14.2
r.				.2	.6	.8	3.4	8.6	3.3	13.1
					July					
300		0.1		1.4	1.9	2.2	2.9	6.8	1.6	14.1
900				1.2	3.0	1.7	4.4	6.6	1.4	12.7
200				1.0	2.1	2.6	5.8	6.2	2.0	11.3
500				.4	2.1	2.4	5.4	6.4	3.6	10.7
800				.7	1.0	1.8	5.2	7.2	3.4	11.7
100				.4	1.7	1.7	3.1	8.2	2.7	13.2
r.		.0		.8	2.0	2.1	4.5	6.9	2.4	12.3
					August					
300		.3	.2	.7	2.1	2.1	5.7	9.4	1.6	8.9
900		.1	.2	1.0	3.6	3.4	3.1	8.4	2.2	9.0
200			.3	.4	2.4	3.6	6.3	6.3	2.9	8.8
500				.6	1.8	2.9	7.2	7.6	2.6	8.3
800				.1	1.1	2.2	5.7	9.7	2.1	10.1
100					1.6	2.7	5.2	9.1	2.4	10.0
v.		.1	.1	.5	2.1	2.8	5.5	8.4	2.3	9.2

UNALAKLEET,

Time of day	0	1-2	3-4	5-9	10-19	20-29	30-49	50-95	96-199	Unlim.
					April					
0300	0.1	0.2	0.6	0.4	2.4	2.6	4.3	4.8	1.2	13.4
0900		.1	.4	1.1	2.2	1.6	4.0	5.7	.8	14.1
1200		.1	.2	.3	1.9	1.6	4.4	5.3	1.3	14.9
1500			.1	1.1	1.6	1.8	3.2	5.3	1.9	15.0
1800	.1		.1	.8	2.6	1.6	3.1	4.2	2.1	15.4
2100			.3	1.0	2.1	1.8	2.7	4.4	1.8	15.9
Av.	.0	.1	.3	.8	2.1	1.8	3.6	5.0	1.5	14.8
					May					
0300	.1	.1	.8	1.7	2.0	.9	3.9	7.1	1.6	12.8
0900			.1	2.3	1.8	1.1	4.0	6.2	1.4	14.1
1200			.1	1.6	1.8	1.2	4.1	6.7	1.3	14.2
1500		.1	.4	1.1	1.4	1.9	3.8	7.2	1.6	13.5
1800		.4	.4	.7	1.2	1.6	3.2	8.3	2.8	12.4
2100	.2	.2	.8	.9	1.0	1.3	2.5	8.1	1.8	14.2
Av.	.1	.1	.4	1.4	1.5	1.3	3.6	7.3	1.8	13.5
					June					
0300	.1	.4	.4	1.1	2.9	2.4	3.1	8.0	1.6	10.0
0900		.2	.3	1.2	3.0	2.7	4.6	6.0	1.1	10.9
1200		.3	.2	1.4	2.4	2.3	5.4	5.1	1.8	11.1
1500		.3	.2	1.3	2.6	1.9	4.9	6.6	1.2	11.0
1800		.3	.3	1.2	2.1	1.4	4.3	7.1	1.5	11.8
2100	.1	.6	.3	1.1	2.0	1.7	4.4	6.9	1.3	11.6
Av.	.0	.4	.3	1.2	2.5	2.1	4.4	6.6	1.4	11.1
					July					
0300			.2	1.4	5.2	4.0	4.9	5.8	1.3	8.2
0900				2.3	4.7	3.7	5.0	5.0	1.6	8.7
1200				2.2	4.3	3.8	4.6	5.9	1.6	8.6
1500			.4	.8	4.6	2.3	6.6	5.2	1.4	9.7
1800			.1	.9	4.3	3.3	5.6	6.7	1.8	8.3
2100		.1	.2	.9	5.1	3.8	4.8	6.3	1.1	8.7
Av.		.0	.2	1.4	4.7	3.5	5.2	5.8	1.5	8.7
					August					
0300		.1	.2	1.6	5.1	4.7	6.7	6.2	1.0	5.4
0900				2.0	4.7	4.3	6.0	5.7	2.0	6.3
1200		.1		1.6	3.9	6.4	6.2	4.6	2.2	6.0
1500		.2		.8	4.8	3.9	7.1	6.9	1.7	5.6
1800		.1		1.1	3.8	4.1	6.7	7.9	1.8	5.5
2100			.3	1.8	4.0	3.3	5.8	7.0	1.7	7.1
Av.		.1	.1	1.5	4.4	4.4	6.4	6.4	1.7	6.0

Source: United States Weather Bureau coded data.

Table 3[illegible].--Type of weather by time of day, and number of days per month in each weather class

(Av. 1950-58)

ANCHORAGE

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
April–August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

BETHEL

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
				April			
[illegible]	1.2	5.1		2.6			
9[illegible]	0.9	5.3		2.1			
12[illegible]	1.7	4.7		0.8			
15[illegible]0	[illegible].2	4.1		.9			
[illegible]	1.[illegible]	4.3		1.[illegible]			
21[illegible]	[illegible]	3.8		1.3			
Av.	1.3	4.6		1.4			
				May			
[illegible]	2.7	2.3		1.4			
0900	3.0	2.6		[illegible].7	0.1		
12[illegible]	3.7	1.3		[illegible].1			
15[illegible]	4.7	[illegible].9		[illegible].2			
1[illegible]	5.0	0.6	0.1	0.2			
21[illegible]	2.7	0.6					
Av.	[illegible]	1.4	.0	.4	.0		
				June			
[illegible]	4.9	[illegible]		2.9		0.2	
0900	6.1	[illegible]		1.4		0.[illegible]	
[illegible]00	5.[illegible]	.1		0.7		0.1	
[illegible]	4.[illegible]			[illegible].3		0.2	
[illegible]	4.7			[illegible]		0.2	
[illegible]	5.[illegible]			.3		0.1	
Av	5.1	.[illegible]		1[illegible]		.2	
				July			
[illegible]	[illegible]			4.4	0.1	0.[illegible]	
[illegible]	4.[illegible]			3.3		0.3	
[illegible]	5.[illegible]			.7		0.3	
[illegible]	5[illegible]			1.[illegible]		0.3	
[illegible]	[illegible]			0.9		.4	
[illegible]	4[illegible]			1.2		0.2	
A[illegible]	[illegible]4			2.1	.[illegible]	.3	
				August			
[illegible]	[illegible]			[illegible]	[illegible]		
[illegible]	[illegible]			[illegible]9	[illegible]		
[illegible]	[illegible]			[illegible]	[illegible]	0.1	
[illegible]	[illegible]			[illegible]		[illegible]	0.1
[illegible]	[illegible]			6	[illegible]	[illegible].1	
[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]			[illegible].9	.1	.1	0

BETTLES

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
				April			
0300	0.1	4.6		0.8			
0900	0.1	3.6		1.7			
1200	0.1	3.3		1.1			
1500	0.3	2.9		0.9			
1800	0.3	2.4		1.2			
2100	0.3	3.0		1.0			
Av.	.2	3.3		1.1			
				May			
0300	1.4	1.4		1.1			
0900	1.4	1.7		1.0			
1200	1.3	0.8		0.6			
1500	1.4	0.3		0.4			0.1
1800	1.9	0.6		0.3			
2100	1.4	0.8		0.2			
Av.	1.5	.9		.6			.0
				June			
0300	2.8	0.1		0.6		0.7	0.1
0900	2.4			0.4		0.4	
1200	3.6			0.3		0.4	0.1
1500	3.2	0.1		0.4		0.3	0.1
1800	1.7			0.1		0.3	
2100	1.8			0.2		0.4	
Av.	2.6	.0		.3		.4	.0
				July			
0300	2.1			1.3	0.1	1.8	
0900	3.6			1.2		1.8	0.1
1200	3.9			1.1		1.8	
1500	3.1			0.4	0.1	1.9	
1800	2.9			0.7		2.0	0.1
2100	2.8			1.0		2.0	0.1
Av.	3.1			1.0	.0	1.9	.0
				August			
0300	5.2			3.4	0.1	0.8	
0900	5.9			2.8	0.1	0.9	
1200	5.7			1.6		0.6	0.1
1500	5.9			1.4		0.7	
1800	4.4			1.2		0.9	
2100	5.7			1.9	0.1	0.6	
Av.	5.5			2.0	.0	.8	.0

[illegible]

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
April–August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
				April			
[illegible]	[illegible]	[illegible]		[illegible]			
				May			
[illegible]	[illegible].9			[illegible].1			0.1
Av.	[illegible]			[illegible]			.0
				June			
[illegible]	[illegible].7			[illegible]		0.4	
[illegible]	[illegible]			[illegible]		0.3	
[illegible]	[illegible]			[illegible]		0.2	0.3
[illegible]	[illegible].9					[illegible]	0.1
[illegible]	[illegible].7			[illegible]		0.4	0.2
[illegible]	[illegible]			[illegible]		0.9	0.2
Av.	[illegible]9			[illegible]		.4	.1
				July			
[illegible]	4.[illegible]			[illegible].3	[illegible].3	[illegible].2	
0900	4.[illegible]			[illegible]	0.1	1.9	
[illegible]	3.7			[illegible]		1.4	0.1
[illegible]	3.[illegible]			[illegible]		1.9	0.6
[illegible]	2.9			[illegible]		.6	0.1
[illegible]	[illegible].1			[illegible]		1.6	
A[illegible]	[illegible].7			[illegible]	[illegible]	1.6	.1
				August			
[illegible]	4.9			2.8	[illegible]	0.8	
[illegible]	3.[illegible]			1.3	[illegible]	1.7	
[illegible]	3.3			[illegible].6		1.4	
[illegible]	3.7			[illegible]		0.8	
[illegible]	4.[illegible]			[illegible]		[illegible].9	
[illegible]	4.[illegible]			[illegible]		0.6	
Av.	4.[illegible]			[illegible]	[illegible]	[illegible]	

FT. YUKON

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
				April			
0300	[illegible].2	1.9		0.2			
0900	[illegible].1	2.[illegible]		[illegible].1			
1200	[illegible].1	2.7		0.2			
1500	[illegible]	1.1		0.3			
1800		1.3		0.2			
2100		1.8		0.4			
Av.	.1	1.8		.2			
				May			
[illegible]	1.[illegible]	[illegible].4		[illegible].2			
90[illegible]	1.7	0.4		.1			
1200	1.4	0.2		0.1			
1500	1.[illegible]	0.3		0.1			
[illegible]	1.[illegible]	[illegible].2		0.1			
21[illegible]	1.2	0.6		0.1			
Av.	1.3	.4		.1			
				June			
0300	1.7				0.7		
090[illegible]	[illegible]				[illegible].8		
1200	1.7				0.7		
1500	1.6				0.8		
1800	[illegible].9				0.6		
2100	1.9				0.6		
Av.	1.8				.7		
				July			
0300	2.0				0.2	2.1	
0900	3.0					2.9	
1200	2.3			0.1		2.6	
1500	2.9			0.1		2.9	
1800	3.3					1.4	
2100	2.8					2.2	
Av.	2.7			.0	.0	2.4	
				August			
0300	2.4			0.3		1.6	
0900	3.1			0.2		2.3	
1200	2.8					1.4	
1500	3.1			0.1		1.3	
1800	3.9			0.1		0.3	
2100	3.8					1.2	
Av.	3.2			.1		1.4	

Table 32.--Type of weather by time of day, and number of days per month in each weather class--Continued

(Av. 1950-58)

GALENA

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
April							
0300	0.4	4.1		0.1			
0900	0.6	3.3		0.7			
1200	0.4	2.9		0.2			
1500	0.6	2.4		0.1			
1800	0.7	1.7		0.2			
2100	0.8	1.9		0.3			
Av.	.6	2.7		.3			
May							
0300	1.7	0.8		0.2			
0900	2.3	0.8		0.1			
1200	2.2	0.3					
1500	2.8	0.3					
1800	2.6	0.6					
2100	1.6	0.6					
Av.	2.2	.6		.0			
June							
0300	3.1					1.0	0.1
0900	2.2			0.2		1.3	
1200	3.0					1.0	0.1
1500	2.1			0.1		1.0	
1800	2.6		0.1	0.1		1.3	0.1
2100	1.8					1.0	0.1
Av.	2.5		.0	.1		1.1	.1
July							
0300	3.9			0.9		2.1	
0900	3.4			0.8	0.2	1.9	
1200	3.2			0.2	0.2	1.2	0.1
1500	3.2			0.6	0.1	1.8	0.1
1800	4.9			0.2		2.1	0.2
2100	3.2			0.4		1.9	0.1
Av.	3.6			.5	.1	1.8	.1
August							
0300	6.5			1.2		0.1	
0900	6.4			1.0		0.5	
1200	5.9			0.5		0.4	
1500	6.1			0.2		0.4	
1800	6.0			0.2		0.2	0.1
2100	5.2			0.4		0.2	
Av.	6.0			.6		.3	.0

GULKANA

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
April							
0300		1.3		0.2			
0900		1.1					
1200	0.1	1.1					
1500	0.4	1.0					
1800	0.3	0.8					
2100	0.4	0.9					
Av.	.2	1.0		.0			
May							
0300	1.2	0.3		0.3			
0900	1.0	0.2		0.3			
1200	1.1	0.2		0.2			
1500	1.8	0.3		0.1			
1800	1.8	0.1					
2100	0.9	0.2					0.1
Av.	1.3	.2		.2			.0
June							
0300	2.0			0.6			
0900	2.2			0.1			
1200	1.9						0.3
1500	2.6						0.3
1800	2.9						0.4
2100	1.9						0.1
Av.	2.2			.1			.2
July							
0300	4.4	0.1		0.8	0.1	0.2	
0900	3.6			0.4		0.1	
1200	2.8			0.1		0.2	0.1
1500	3.0			0.1		0.3	0.4
1800	3.2					0.3	0.7
2100	3.8			0.2		0.3	0.1
Av.	3.5	.0		.3	.0	.2	.2
August							
0300	4.1	0.1		1.2			
0900	3.8			0.4			
1200	4.2			0.1			
1500	4.7			0.1			
1800	4.4						
2100	4.8			0.2			
Av.	4.3	.0		.3			

HOMER

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
April							
0300	2.4	2.2		1.0			
0900	2.6	2.1		0.9			
1200	2.9	1.8		0.3			
1500	3.3	2.3		0.4			
1800	2.6	1.9		0.6			
2100	2.6	1.8		1.0			
Av.	2.7	2.0		.7			
May							
0300	3.2			0.7			
0900	2.8			0.2			
1200	2.8	0.2		0.1			
1500	4.6			0.1			
1800	3.3			0.1			
2100	3.1			0.1			
Av.	3.3	.0		.2			
June							
0300	3.6			1.2			
0900	3.1			0.3			
1200	2.9			0.3			
1500	3.9						
1800	2.6			0.2			
2100	3.4			0.4			
Av.	3.3			.4			
July							
0300	4.4			1.9	0.2	0.1	
0900	2.9			0.4		0.2	
1200	3.4			0.1		0.1	
1500	3.6			0.4		0.1	
1800	3.7			0.4		0.1	
2100	3.4			0.7		0.1	
Av.	3.6			.6	.0	.1	
August							
0300	3.6			2.3			
0900	4.3			0.8		0.1	
1200	5.4			0.6			
1500	5.0			0.7			
1800	4.8			0.7			
2100	5.4			1.2			
Av.	4.8			1.0		.0	

ILIAMNA

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
April							
0300	1.2	4.3		0.8			
0900	1.0	3.6		1.1			
1200	1.4	3.0		0.7			
1500	0.9	2.8		1.0			
1800	1.2	3.2		1.2			
2100	1.1	3.4		1.6			
Av.	1.1	3.4		1.1			
May							
0300	4.6	0.8		1.3			
0900	2.8	0.7		0.7			
1200	2.7	0.4		0.3			
1500	3.6	0.3		0.3			
1800	3.3	0.3		0.2			
2100	4.7	0.2		0.7			
Av.	3.6	.5		.6			
June							
0300	4.0			1.6		0.1	
0900	3.8			1.1			
1200	3.7			0.4			
1500	3.9			0.1			0.1
1800	2.9			0.1			
2100	3.3			0.3		0.1	
Av.	3.6			.6		.0	.0
July							
0300	3.0			4.6	0.3		
0900	3.8			2.9	0.2	0.3	
1200	3.9			0.9	0.1	0.4	
1500	4.0			1.2	0.1	0.6	
1800	4.6			0.8		0.3	0.1
2100	4.0			0.9		0.3	
Av.	3.9			1.9	.1	.3	.0
August							
0300	6.6			4.3		0.1	
0900	5.8			2.7			
1200	5.8			1.6		0.1	
1500	5.6			2.0			
1800	5.9			2.2			
2100	5.8			2.7		0.1	
Av.	5.9			2.6		.0	

KOTZEBUE

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
April							
0300	0.8	5.8		2.3			
0900	0.3	4.7		2.7	0.2		
1200	0.3	5.1		2.3	0.2		
1500	0.6	4.9		2.1	0.1		
1800	0.8	4.8		1.7	0.1		
2100	0.8	5.2		1.9	0.1		
Av.	.6	5.1		2.2	.1		
May							
0300	1.9	2.1		2.9			
0900	1.9	2.1		2.8			
1200	1.8	1.3		1.9			
1500	1.3	0.9		0.9			
1800	1.2	0.8		1.1			
2100	2.0	1.1		1.7			
Av.	1.7	1.4		1.9			
June							
0300	3.2			2.9			
0900	2.0	0.1		2.6			
1200	2.3			2.3			
1500	1.3			1.9			
1800	1.6			1.9			
2100	3.0			2.4			
Av.	2.2	.0		2.3			
July							
0300	4.1			2.8		0.4	
0900	2.9			2.2		0.4	
1200	2.8			1.4		0.3	
1500	3.7			0.9		0.3	
1800	3.8			1.0		0.4	0.1
2100	3.4			1.3		0.4	0.1
Av.	3.4			1.6		.4	.0
August							
0300	7.0			2.3	0.1	0.1	0.1
0900	5.3			2.2		0.1	
1200	6.3			1.8		0.2	
1500	5.9			1.2		0.2	
1800	5.3			1.4		0.2	
2100	5.3			1.3	0.1	0.2	
Av.	5.8			1.7	.0	.2	.0

LAKE MINCHUMINA

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
April							
0300	0.1	2.3		0.4			
0900	0.3	2.1					
1200	0.3	1.9		0.1			
1500	0.4	1.7					
1800	0.2	1.7		0.1			
2100	0.1	1.6		0.2			
Av.	.2	1.9		.1			
May							
0300	1.6	0.8		0.8			
0900	1.2	0.4		0.3			
1200	1.1	0.3		0.1			0.1
1500	2.0	0.4		0.3			
1800	1.3	0.4		0.1			
2100	1.7	0.8		0.1			
Av.	1.5	.5		.3			.0
June							
0300	4.0			0.2		0.6	
0900	3.4					0.6	
1200	2.3					0.3	
1500	2.4					0.4	0.2
1800	3.2					0.2	0.4
2100	2.1					0.4	0.1
Av.	2.9			.0		.4	.1
July							
0300	4.4			1.1		1.4	
0900	2.9			0.1		1.8	
1200	4.1					1.1	0.1
1500	4.2					0.7	0.3
1800	3.4			0.1		0.9	0.1
2100	4.3					0.9	0.3
Av.	3.9			.2		1.1	.1
August							
0300	5.0			0.9		0.3	0.1
0900	4.7			0.3		0.2	
1200	4.3			0.4		0.2	0.1
1500	3.4					0.2	0.2
1800	5.1			0.1		0.2	
2100	5.2					0.2	
Av.	4.6			.3		.2	.1

Table 32.--Type of weather by time of day, and number of days per month in each weather class--Continued

(Av. 1950-58)

McGRATH

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
				April			
0300	0.8	3.6		0.1			
0900	0.6	3.4		0.4			
1200	0.9	2.9		0.3			
1500	0.7	2.0		0.4			
1800	0.9	1.9		0.2			
2100	0.7	2.4		0.3			
Av.	.8	2.7		.3			
				May			
0300	2.9	0.2		0.3			
0900	2.9	0.9		0.1			
1200	2.3	0.4		0.2			0.1
1500	2.3	0.2					0.1
1800	2.7	0.2					
2100	2.7	0.2		0.1			
Av.	2.6	.4		.1			.0
				June			
0300	3.8			0.7		0.4	
0900	3.9			0.1		0.7	
1200	2.8		0.1	0.1		0.6	
1500	3.3					0.3	0.1
1800	3.1			0.1		0.4	0.4
2100	3.6					0.4	
Av.	3.4		.0	.2		.5	.1
				July			
0300	4.6			1.2		1.4	
0900	4.7			0.6		1.3	
1200	4.[illegible]			0.7		1.2	
1500	5.1			0.8		0.8	0.1
1800	5.4			0.7		0.8	
2100	5.1			0.4		1.0	0.3
Av.	4.9			.7		1.1	.1
				August			
0300	7.2			2.2	0.2		
0900	5.6			2.3	0.1	0.[illegible]	
1200	5.6			0.6		0.2	
1500	6.7			0.6		0.2	
1800	7.7			1.0		0.2	0.1
2100	6.4			1.1		0.1	0.1
Av.	6.5			1.3	.0	.1	.0

NAKNEK

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
				April			
0300	2.2	3.6		2.4			
0900	1.7	3.4		2.0			
1200	2.1	3.3		1.2			
1500	2.3	2.7		1.6			
1800	2.1	2.8		1.0			
2100	2.1	3.1		1.3			
Av.	2.1	3.2		1.6			
				May			
0300	4.7	0.9		3.4			
0900	3.9	0.4		0.9			
1200	4.7	0.3		0.4			
1500	7.0	0.1		0.2			
1800	6.3	0.1		0.3			
2100	4.3	0.1		1.1			
Av.	5.2	.3		1.0			
				June			
0300	5.9	0.1		6.4			
0900	3.8			1.4			
1200	4.7	0.1	0.1	0.3			
1500	4.4			0.3			
1800	4.9			0.4			
2100	4.9			1.0			0.1
Av.	4.8	.0	.0	1.6			.0
				July			
0300	4.8			9.3	0.1		0.1
0900	4.1			3.2		0.1	
1200	3.2			1.7		0.1	
1500	3.8			1.1		0.1	0.1
1800	4.8			1.7		0.1	0.1
2100	4.4			2.6		0.1	0.1
Av.	4.2			3.3	.0	.1	.1
				August			
0300	5.9			9.3			
0900	5.0			4.3			
1200	4.4			2.1		0.1	
1500	5.4			2.2		0.1	
1800	4.9			2.8			
2100	4.9			3.3		0.1	
Av.	5.1			4.0		.0	

NORTHWAY

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder storm
				April			
0300		2.3		0.6			
0900	0.2	2.2		0.2			
1200	0.3	2.0		0.1			
1500	0.3	1.6					
1800	0.3	1.1					
2100	0.1	2.3					
Av.	.2	1.9		.2			
				May			
0300	2.4	0.4		1.1			
0900	2.4	0.2		0.2			
1200	2.3	0.6					0.2
1500	2.9	0.2		0.1			0.3
1800	2.3	0.2					
2100	3.0	0.2					
Av.	2.6	.3		.2			.1
				June			
0300	3.3			0.7		0.2	
0900	3.7			0.1		0.2	
1200	3.3		0.1	0.2			1.3
1500	3.2			0.2		0.3	1.4
1800	3.7			0.1		0.3	0.7
2100	3.7					0.2	0.3
Av.	3.5		.0	.2		.2	.6
				July			
0300	3.8			0.8		0.5	
0900	4.2			0.4		0.8	0.2
1200	3.2			0.1		0.6	0.9
1500	4.3			0.2		0.6	0.9
1800	4.3					0.4	1.2
2100	4.7			0.1		0.7	0.4
Av.	4.1			.3		.6	.6
				August			
0300	5.0			1.8			
0900	4.2			0.4		0.2	
1200	2.4			0.2		0.4	0.1
1500	4.1			0.1		0.1	0.2
1800	3.9			0.1		0.1	0.4
2100	4.5			0.1		0.2	
Av.	4.0			.4		.2	.1

SUMMIT

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
				April			
0300		6.4		.6			
0900		4.7		.3			
1200	.1	3.4		.4			
1500		3.6		.8			
1800	.1	4.1		0.7			
2100	.1	5.7		0.3			
Av.	0	4.6		.5			
				May			
0300	1.4	3.2		1.8			
0900	0.7	3.1		1.2			
1200	1.8	2.2		0.4			
1500	1.8	1.6		0.6			
1800	1.9	1.9		0.6			
2100	1.6	1.9		0.6			
Av.	1.5	2.3		.9			
				June			
0300	3.8	0.3		1.1			
0900	3.2	0.2		0.1			
1200	3.3	0.1	0.1	0.1			0.1
1500	4.0	0.2		0.2			0.4
1800	4.1	0.1				0.1	0.1
2100	3.8	0.1		0.2		0.1	
Av.	3.7	.2	.0	.3		.0	.1
				July			
0300	6.2			4.6		0.2	
0900	4.9			0.6		0.3	
1200	4.7			0.3		0.3	0.1
1500	5.4			0.2		0.2	0.1
1800	5.2			0.7		0.4	0.1
2100	5.9			1.3		0.4	
Av.	5.4			1.3		.3	.0
				August			
0300	8.2	0.2		3.3			
0900	6.6	0.1		0.9			
1200	5.9	0.1		0.9			
1500	6.6			0.8			
1800	6.0	0.1		1.0			0.1
2100	7.3	0.2		1.8		0.1	
Av.	6.8	.1		1.4		.0	.0

TANANA

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
				April			
0300	0.2	2.3		0.3			
0900	[illegible]	2.9		.4			
1200	.4	2.1		0.4			
1500	0.4	1.7		0.3			
1800	0.4	0.9		.1			
2100	0.2	1.6					
Av.	.4	1.9		.2			
				May			
0300	1.3	0.8		0.8			
0900	1.3	1.1		0.4			
1200	1.7	0.4		0.4			
1500	2.2	0.3		0.3			
1800	1.8	0.3		0.3			
2100	2.1	0.6		0.2			
Av.	1.7	.6		.4			
				June			
0300	3.2			0.4	0.1	0.9	
0900	2.1			0.2		1.4	
1200	2.1					1.1	0.1
1500	1.7					1.0	0.1
1800	2.3			0.1	0.1	0.7	
2100	2.3			0.1		0.8	0.1
Av.	2.3			.1	.0	1.0	.0
				July			
0300	2.6			0.9	0.3	1.3	
0900	3.0			0.9	0.1	2.1	
1200	3.7			0.4	0.1	1.8	0.3
1500	2.9			0.3	0.1	1.2	0.2
1800	2.7			0.4		1.7	0.3
2100	3.2			0.3		1.7	0.1
Av.	3.0			.5	.1	1.6	[illegible]
				August			
0300	4.2			1.9	0.1	0.6	
0900	4.2	0.1		2.1	0.1	0.6	
1200	3.9			1.0		0.5	0.2
1500	4.3			0.6		0.3	0.2
1800	4.1			0.2		0.1	
2100	3.9			0.8		0.3	0.1
Av.	4.1	.0		1.1	.0	.4	.1

UNALAKLEET

Time of day	Rain	Snow sleet	Hail	Fog	Fog w/ smoke	Smoke haze	Thunder-storm
				April			
0300	0.3	4.0		1.9			
0900	0.4	3.6		2.2	0.3		
1200	0.3	2.8		1.2	0.2		
1500	0.4	3.1	0.1	1.1			
1800	0.3	3.4		1.2			
2100	0.6	3.8		1.4			
Av.	.4	3.4	.0	1.5	.1		
				May			
0300	2.7	1.2		2.4			
0900	2.2	1.7		2.3			
1200	2.0	0.9		1.0			
1500	2.3	1.1		1.1			
1800	2.1	0.6		1.3			
2100	1.9	0.6		1.6			
Av.	2.2	1.0		1.6			
				June			
0300	2.8	0.1		2.3		0.3	
0900	3.3			1.4		0.1	
1200	3.7	0.1		1.7			
1500	3.7			1.4			
1800	2.0			1.3			
2100	2.3			1.4		0.1	
Av.	3.0	.0		1.6		.1	
				July			
0300	4.8			0.9		0.3	
0900	4.0			1.4		0.8	
1200	4.6			1.1		0.3	0.1
1500	4.9			1.2	0.1	0.2	
1800	4.6			0.9	0.1	0.3	0.1
2100	4.8			0.6		0.6	
Av.	4.6			1.0	.0	.4	.0
				August			
0300	7.1			2.3		0.2	
0900	7.6			2.1		0.2	
1200	7.1			0.8		0.1	
1500	8.0			1.1		0.1	
1800	6.3			1.8	0.1	0.1	
2100	7.1	0.1		2.2	0.1	0.1	0.1
Av.	7.2	.0		1.7	.0	.1	.0

Source: United States Weather Bureau coded data.

Table 33.--Time of season by which ground is thawed to various depths

(Av. 1950-58)

Date		Ft. Yukon	Northway	Anchorage	Bettles	Big Delta	Summit	Fairbanks	Tanana	Kotzebue	Unalakleet	Gulkana	Galena	McGrath
							6" Depth							
April	1		1/											
	11			x										
	21			x										
May	1			x		x		x	x		x	x		
	11			x	x	x	x	x	x		x	x	x	x
	21	x		x	x	x	x	x	x	x	x	x	x	x
June	1	x		x	x	x	x	x	x	x	x	x	x	x
	11	x		x	x	x	x	x	x	x	x	x	x	x
	21	x		x	x	x	x	x	x	x	x	x	x	x
							12" Depth							
April	1													
	11													
	21			x										
May	1			x		x		x						
	11			x		x	x	x	x		x			
	21	x		x	x	x	x	x	x		x	x	x	x
June	1	x	x	x	x	x	x	x	x		x	x	x	x
	11	x	x	x	x	x	x	x	x	x	x	x	x	x
	21	x	x	x	x	x	x	x	x	x	x	x	x	x
							24" Depth							
April	1													
	11													
	21													
May	1			x										
	11			x										
	21			x	x	x	x	x	x		x		x	x
June	1			x	x	x	x	x	x		x	x	x	x
	11	x		x	x	x	x	x	x		x	x	x	x
	21	x	x	x	x	x	x	x	x	x	x	x	x	x

1/ No data for 6-inch depth.

Source: United States Weather Bureau compilation.

Table 34.--Forest fire statistics for the United States, 1950-58

Year	Place	Area protected	Fires		Area burned		Cause				Size					
							Lightning		Other		Under ¼ acre		¼-10 acres		Over 10 acres	
		M acres	Number	Number per MM acres	Acres	Acres per fire	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
	Alaska BLM [1/]	225,000	224	1.0	2,057,817	9,186.7	27	12	197	88	94	42	46	20	84	38
1950	Other states BLM	138,121	472	3.4	78,827	167.0	152	32	320	68	84	18	121	26	267	56
	Other states all agencies [2/]	573,186	104,996	183.2	3,798,464	36.2	6,491	6	98,505	94	16,215	15	50,281	48	38,500	37
	Alaska BLM	225,000	271	1.2	219,694	810.7	27	10	244	90	119	44	72	27	80	29
1951	Other states BLM	140,111	635	4.6	124,848	196.6	203	32	432	68	103	16	182	29	350	55
	Other states all agencies	575,916	105,868	183.8	3,526,373	33.3	7,029	7	98,839	93	15,682	15	51,630	49	38,556	36
	Alaska BLM	225,000	136	.6	73,801	542.6	11	8	125	92	76	56	32	24	28	20
1952	Other states BLM	140,625	637	4.6	97,223	152.6	207	32	430	68	110	17	171	27	356	56
	Other states all agencies	581,210	127,997	220.2	6,628,093	51.8	8,012	6	119,985	94	19,109	15	63,277	49	45,611	36
	Alaska BLM	225,000	285	1.3	466,748	1,637.7	75	26	210	74	126	44	64	22	95	33
1953	Other states BLM	138,680	601	4.4	107,252	178.4	176	29	425	71	111	18	194	32	296	49
	Other states all agencies	586,220	104,595	249.0	2,851,455	27.3	8,529	8	96,067	92	19,867	19	54,883	52	29,845	29
	Alaska BLM	225,000	262	1.2	1,389,920	5,305.0	63	24	199	76	125	48	53	20	84	32
1954	Other states BLM	138,446	567	4.1	117,347	207.0	164	29	403	71	94	17	171	30	302	53
	Other states all agencies	600,237	127,273	212.0	2,962,671	23.3	7,780	6	119,493	94	19,988	16	79,257	55	37,028	29
	Alaska BLM	225,000	190	.8	37,232	196.0	26	14	164	86	105	55	42	22	43	23
1955	Other states BLM	134,419	380	2.8	51,835	136.4	116	30	264	70	91	24	122	32	163	44
	Other states all agencies	603,884	87,604	145.1	2,812,208	32.1	6,261	7	81,343	93	17,981	21	48,177	55	21,446	24
	Alaska BLM	225,000	225	1.0	476,542	2,118.0	63	28	162	72	88	39	59	26	78	35
1956	Other states BLM	138,468	571	4.1	37,451	65.6	254	44	317	56	180	32	187	32	204	36
	Other states all agencies	607,032	94,338	155.4	1,985,084	21.0	11,459	12	82,879	88	21,298	23	52,067	55	20,972	22
	Alaska BLM	225,000	403	1.8	5,034,554	12,492.7	164	41	239	59	124	31	93	23	186	46
1957	Other states BLM	138,799	827	6.0	309,212	373.9	272	33	555	67	140	17	262	32	425	51
	Other states all agencies	613,382	65,702	107.1	1,286,458	19.6	5,659	9	60,043	91	15,523	24	37,768	57	12,411	19
	Alaska BLM	225,000	284	1.3	315,860	1,112.2	90	32	194	68	98	34	80	28	106	37
1958	Other states BLM	137,487	1,075	7.8	617,936	574.8	449	42	626	58	181	17	319	30	575	53
	Other states all agencies	614,134	80,308	130.8	1,461,367	18.2	10,828	13	69,480	87	20,816	26	44,184	55	15,308	19
	Alaska BLM	225,000	253	1.1	1,119,130	4,417.6	61	24	192	76	106	42	60	24	87	34
Av.	Other states BLM	138,351	641	4.6	171,326	267.3	221	34	419	65	122	19	192	30	327	51
	Other states all agencies	595,022	99,848	167.8	3,034,686	30.4	8,005	8	91,848	92	18,498	18	52,503	53	28,853	29

Source: 1/ Annual Reports of the Director, BLM (Statistical Appendix).
2/ Forest Fire Statistics. Prepared annually by the Division of Cooperative Forest Protection, Forest Service, U.S.D.A.

Table 35.--Number of fires by cause on lands protected by Bureau of Land Management, 1950-58

Year	Place	Cause 1/								Total
		LI	CF	S	DB	I	LU	RR	MI	
1950	Alaska	27	58	43	54	9	0	7	26	224
	Other states	152	20	115	75	40	2	31	37	472
1951	Alaska	27	77	47	71	12	2	2	33	271
	Other states	203	20	181	76	56	1	37	61	635
1952	Alaska	11	38	16	46	6	0	4	15	136
	Other states	207	21	188	73	52	1	23	72	637
1953	Alaska	75	82	35	51	1	0	0	41	285
	Other states	176	37	154	96	30	2	38	68	601
1954	Alaska	63	68	49	51	8	0	0	23	262
	Other states	164	22	127	95	46	1	16	96	567
1955	Alaska	26	75	30	25	3	0	1	30	190
	Other states	116	26	79	61	34	1	18	45	380
1956	Alaska	63	64	28	40	5	0	1	24	225
	Other states	254	31	49	78	46	1	28	84	571
1957	Alaska	164	85	30	78	11	2	2	31	403
	Other states	272	20	140	97	36	2	74	186	827
1958	Alaska	90	73	27	54	9	0	0	31	284
	Other states	449	37	185	121	83	2	43	155	1,075
		Average number of fires by cause								
1950-1958	Alaska	61	70	34	52	7	0.4	0.2	28	253
	Other states	221	26	136	86	47	2	34	89	641
		Percentage of fires by cause								
1950-1958	Alaska	24	27	13	21	3	0≠	1	11	100
	Other states	35	4	21	14	7	0≠	5	14	100

1/ LI - Lightning; CF - Campfires; S - Smokers; DB - Debris burning; I - Incendiary; LU - Lumbering; RR - Railroad; MI - Misc.

Source: Annual Reports of the Director, BLM (Statistical Appendix).

Table 36.--Number of fires by size class on lands protected by Bureau of Land Management, 1950-58

Year	Place	Size Class A	B	C	D	E	Total
1950	Alaska	94	46	25	7	52	224
	Other states	84	121	141	55	71	472
1951	Alaska	119	72	35	14	31	271
	Other states	103	182	155	76	119	635
1952	Alaska	76	32	16	3	9	136
	Other states	110	171	184	69	103	637
1953	Alaska	126	64	39	15	41	285
	Other states	111	194	153	52	91	601
1954	Alaska	125	53	31	16	37	262
	Other states	94	171	142	59	101	567
1955	Alaska	105	42	21	10	12	190
	Other states	91	122	79	31	57	380
1956	Alaska	88	59	40	14	24	225
	Other states	180	187	116	42	46	571
1957	Alaska	124	93	64	20	102	403
	Other states	140	262	176	79	170	827
1958	Alaska	98	80	45	16	45	284
	Other states	181	319	241	123	211	1,075
1950-	Alaska	955	541	316	115	353	2,280
1958	Other states	1,094	1,729	1,387	586	969	5,765
	Total	2,049	2,270	1,703	701	1,322	8,045
		Average number of fires by size class					
1950-	Alaska	106	60	35	13	39	253
1958	Other states	122	192	154	65	108	641
		Percent of fires by size class					
1950-	Alaska	42	24	14	5	15	100
1958	Other states	19	30	24	10	17	100
		Number of fires per million acres protected by size class					
1950-	Alaska	0.47	0.27	0.15	0.06	0.17	1.12
1958	Other states	0.88	1.39	1.11	0.47	0.78	4.63

Source: Annual Reports of the Director, BLM (Statistical Appendix).

Table 37.--Fires according to size class by number, percent of total, and number per million acres[1], 1950-58

Year	Size class A			Size class B			Size class C			Size class D			Size class E			Total	
	Number	Percent of total	Number MM acres	Number	Percent of total	Number MM acres	Number	Percent of total	Number MM acres	Number	Percent of total	Number MM acres	Number	Percent of total	Number MM acres	Number	Number MM acres
1950	94	42.0	.42	46	20.5	.20	25	11.2	.11	7	3.1	.03	52	23.2	.23	224	.99
1951	119	43.9	.53	72	26.6	.32	35	12.9	.16	14	5.2	.06	31	11.4	.14	271	1.20
1952	76	55.9	.34	32	23.5	.14	16	11.8	.07	3	2.2	.01	9	6.6	.04	136	.60
1953	126	44.2	.56	64	22.4	.28	39	13.7	.17	15	5.3	.07	41	14.4	.18	285	1.27
1954	125	47.7	.56	53	20.2	.24	31	11.8	.14	16	6.1	.07	37	14.1	.16	262	1.16
1955	105	55.3	.47	42	22.1	.19	21	11.1	.09	10	5.3	.04	12	6.3	.05	190	.84
1956	88	39.1	.39	59	26.2	.26	40	17.8	.18	14	6.2	.06	24	10.7	.11	225	1.00
1957	124	30.4	.55	93	22.8	.41	64	15.7	.28	20	4.9	.09	102	26.2	.48	403	1.81
1958	98	34.5	.44	80	28.2	.36	45	15.8	.20	16	5.6	.07	45	15.8	.20	284	1.26
Av.	106	41.9	.47	60	23.7	.27	36	13.8	.15	13	5.0	.06	39	15.5	.17	253	1.12

1/ Based on 225 million acres protected.

Source: Annual Reports of the Director, Bureau of Land Management (Statistical Appendix).

Table 38.--Acreage burned by fuel types on lands protected by Bureau of Land Management, 1950-58

Year	Place	Vegetative cover type				Total
		Forest	Brush	Grass	Other	
1950	Alaska	568,123	1,353,693	47,268	88,733	2,057,817
	Other states	16,353	35,552	26,921	1	78,827
1951	Alaska	92,791	88,589	1,312	37,002	219,694
	Other states	17,157	58,185	49,506	--	124,848
1952	Alaska	14,599	8,166	4,776	45,260	73,801
	Other states	8,561	56,562	32,068	32	97,223
1953	Alaska	284,575	113,916	5,415	62,842	466,748
	Other states	17,031	46,363	33,858	--	107,252
1954	Alaska	354,817	333,890	84,588	616,625	1,389,920
	Other states	12,966	75,380	29,001	--	117,347
1955	Alaska	12,066	11,353	4,102	9,711	37,232
	Other states	2,702	25,489	23,610	34	51,835
1956	Alaska	86,075	6,011	9,942	374,514	476,542
	Other states	9,707	19,876	7,813	55	37,451
1957	Alaska	2,461,472	487,621	9,826	2,075,635	5,034,554
	Other states	9,185	170,287	129,740	--	309,212
1958	Alaska	204,454	28,973	11,874	70,559	315,860
	Other states	18,849	238,527	281,183	79,377	617,936
		Average acreage burned by fuel type				
1950-1958	Alaska	453,219	270,246	20,011	375,654	1,119,130
	Other states	12,501	81,802	68,189	8,833	171,325
	Total Average	465,720	352,048	88,200	384,487	1,290,455
		Percent of acreage burned by fuel type				
1950-1958	Alaska	40	24	2	34	100
	Other states	7	48	40	5	100

Source: Annual Reports of the Director, Bureau of Land Management, (Statistical Appendix).

Table 39.--Fires by general cause according to number, acreage, and percentage, 1940-58

Year	Lightning				Man-caused				Total	
	Number 1/	Percent	Acres 2/	Percent	Number 1/	Percent	Acres 2/	Percent	Number	Acres 3/
1940	0	0			130	100			130	4,500,000
1941	0	0			116	100			116	3,645,774
1942	0	0	Not		78	100	Not		78	452,510
1943	40	20.6	available		154	79.4	available		194	666,773
1944	18	24.6			55	75.4			73	110,604
1945	30	42.2			41	57.8			71	117,313
1946	52	40.0			78	60.0			130	1,436,597
1947	32	20.1			127	79.9			159	1,429,896
1948	21	15.7			113	84.3			134	33,676
1949	7	13.2			46	86.8			53	17,933
Total	200	17.6			938	82.4			1,138	12,411,076
Av.	20				94				114	1 241,108
1950	27	12.0	445,595	21.6	197	88.0	1,612,222	78.4	224	2,057,817
1951	27	10.0	17,484	8.0	244	90.0	202,210	92.0	271	219,694
1952	11	8.1	14,556	19.7	125	91.9	59,245	80.3	136	73,801
1953	75	26.3	381,143	81.6	210	73.7	85,605	18.4	285	466,748
1954	63	24.0	1,347,990	97.0	199	76.0	41,930	3.0	262	1,389,920
1955	26	13.7	10,467	28.1	164	86.3	26,765	71.9	190	37,232
1956	63	28.0	446,531	93.7	162	72.0	30,011	6.3	225	476,542
1957	164	40.7	4,773,323	94.8	239	59.3	261,231	5.2	403	5,034,554
1958	90	31.7	228,637	72.4	194	68.3	87,223	27.6	284	315,860
Total	546	23.9	7,665,726	76.1	1,734	76.1	2,406,442	23.9	2,280	10,072,168
Av.	61		851,748		192		267,382		253	1,119,130

Source: 1/ 1940-1945 Data from files at BLM office, Anchorage.
1946-1958 Annual reports of the Director, BLM (Statistical Appendix).
2/ Computed from annual fire reports on file at BLM office, Anchorage and from individual fire reports.
3/ 1940-1945 Forestry Program for Alaska.
1946-1958 Annual reports of the Director, BLM (Statistical Appendix).

Table 40.--Percent of all fires on which no action was taken, 1950-58

Year	Lightning			Man-caused		
	Total 1/	No action 2/		Total 1/	No action 2/	
	Number	Number	Percent	Number	Number	Percent
1950	27	18	67	197	39	20
1951	27	13	48	244	21	9
1952	11	1	9	125	28	22
1953	75	33	44	210	12	6
1954	63	25	40	199	5	3
1955	26	11	42	164	6	4
1956	63	31	49	162	15	9
1957	64	30	18	239	15	6
1958	90	21	23	194	9	5
Av.	61	20	33	193	17	9

1/ Annual Reports of the Director, Bureau of Land Management (Statistical Appendix).

2/ Coded IBM runs from individual fire reports.

Table 41.--Area burned according to cause and whether or not suppression action was taken, 1950-58

Year	Lightning				Man-caused				Total
	Action		No-action		Action		No-action		
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres
1950		0	679,080	33	82,313	4	1,296,424	63	2,057,817
1951		4	6,591	3	149,391	68	54,924	25	219,694
1952		20	40	0	47,945	65	11,064	15	73,801
1953	209,138	45	121,354	26	130,256	28	6,000	1/	466,748
1954	389,078	28	972,674	70	27,798	2	370	0/	1,389,920
1955	6,329	17	10,053	27	10,053	27	10,797	29	37,232
1956	323,708	68	133,282	28	19,062	4	490	0/	476,542
1957	3,826,261	76	755,183	15	201,382	4	251,728	5	5,034,554
1958	168,106	53	50,671	16	95,258	30	1,825	1-	315,860
Av.	549,574	49	303,214	27	84,828	8	181,514	16	1,119,130

Source: Percentages from coded IBM runs from individual fire reports.
Total acreages from Annual Reports of the Director, Bureau of Land Management (Statistical Appendix).
Other acreages computed from above sources.

Table 42.--Frequency of all fires for each month of the fire season by size class

(Av. 1950-58)

Size class	April Number	April Percent	May Number	May Percent	June Number	June Percent	July Number	July Percent	August Number	August Percent	September Number	September Percent	October Number	October Percent	November Number	November Percent	Total Number	Total Percent
Lightning fires																		
A			2	14	19	8	20	10	3	8	2	50					46	9
B			1	7	39	15	38	19	9	23	1	25					88	23
C			4	29	59	23	50	24	6	15							119	17
D			2	14	27	11	16	8	2	5	1	25					47	9
E			5	36	110	43	79	39	19	49							214	42
Total			14	100	254	100	203	100	39	100	4	100					514	100
percent per month				3		49		39		8		1						
Man-caused																		
A	29	52	153	34	199	27	161	55	109	69	64	56	2	22	1	14	718	49
B	11	20	159	36	108	50	72	25	21	13	27	24	2	22	2	29	402	27
C	7	12	80	18	48	12	22	8	15	10	11	10	2	22	1	14	186	13
D	1	2	21	5	14	4	13	5	2	1	1	1	1	11			53	3
E	8	14	32	7	28	7	24	7	11	7	10	9	2	22	3	43	118	8
Total	56	100	445	100	397	100	292	100	158	100	113	100	9	100-	7	100	1,477	100
percent per month		4		30		27		19		11		8		1		0+		
Total fires																		
A	29	52	155	34	218	33	181	37	112	57	66	56	2	22	1	14	764	38
B	11	20	160	35	147	23	110	22	30	15	28	24	2	22	2	29	490	25
C	7	12	84	18	107	17	72	14	21	11	11	9	2	22	1	14	305	15
D	1	2	23	5	41	6	29	6	4	2	2	2	1	11			100	5
E	8	14	37	8	138	21	103	21	30	15	10	9	2	22	3	43	332	17
Total	56	100	459	100	651	100	495	100	197	100	117	100	9	100-	7	100	1,991	100
percent per month		3		23		33		25		10		6		0+		0+		

Source: Actual tally of all available individual fire reports (289 less than official count).

Table 43 --Acreage burned by months and causes, 1950-58

Year	April	May	June	July	August	September	October	November	Total
				Lightning					
1950		303,775	29,651	12,607	22,080				368,113
1951			4,107	30,116	151				34,374
1952			14,289	1,020	4				15,313
1953		381	245,178	124,243	4,945				374,747
1954		4,203	1,249,376	79,573	22,956	3			1,356,111
1955			14,374	6,154	3,382				23,910
1956			450,823	6,222					457,045
1957		4,753	3,420,608	1,341,450	61,513	910			4,829,234
1958		140	196,341	45,832	479				242,792
Av. acres burned		34,806	624,972	183,024	12,834	101			855,737
Percent of lightning fires		4.1	73.0	21.4	1.5				100.0
Percent of all fires		3.1	55.8	16.4	1.1				76.4
				Man-caused					
1950	82	1,471,808	45,888	86,474	34,942	35,758	123	14,629	1,689,704
1951	146	97,033	4,671	55,214	26,238	2,018			185,320
1952		270	57,251	63	127	3	774		58,488
1953	2,257	22,028	20,229	43,526	367		3,594		92,001
1954	30	17,082	1,014	750	14,932	1			33,809
1955	10	1,765	2,729	8,721	51	46			13,322
1956		343	9,047	10,106		1			19,497
1957		4,646	3,723	193,267	110	3,574			205,320
1958	6,754	34,361	11,289	20,406	137	121			73,068
Av. acres burned	1,031	183,260	17,316	46,503	8,545	4,614	499	1,625	263,393
Percent of man-caused fires	0.4	69.6	6.6	17.7	3.2	1.7	0.2	0.6	100.0
Percent of all fires	0.1	16.4	1.5	4.2	0.8	0.4	.0	0.2	23.6
				All fires					
Av. acres burned	1,031	218,065	642,287	229,527	21,379	4,715	499	1,625	1,119,130
Percent of all fires	0.1	19.5	57.5	20.5	1.9	0.4	.0	0.1	100.0

Source: Coded IBM runs from individual fire reports, adjusted to the official totals.
(1957 from summary sheets of Area 4).
Totals from Annual Reports of the Director, BLM (Statistical Appendix).

Table 44.--Estimated damage from forest fires on lands protected by Bureau of Land Management, 1950-58

Year	Place	Tangible damage			Intangible damage			Total
		Timber	Brush	Grass		Other		
1950	Alaska	$3,289,979	$1,488,183	$976,367		$2,000,000		$7,754,529
	Other states	52,507	115,470	66,924		1,882		236,783
1951	Alaska	425,420	160,000	192,747		10,000		788,167
	Other states	429,210	214,161	154,371		3,384		801,126
1952	Alaska	73,472	14,538	6,728		35,256		129,994
	Other states	212,017	272,158	128,218		-		612,393
1953	Alaska	876,571	150,955	7,424		82,902		1,117,852
	Other states	835,889	214,284	191,705		1,972		1,243,850
		Timber	Reproduction	Forage	Watershed	Wildlife	Recreation	
1954	Alaska	990,534	-	500	$ 536,418	1,331,965	$ 1,503	2,860,920
	Other states	90,881	12,601	439,467	146,820	8,384	-	698,153
1955	Alaska	6,430	169	36	29,038	30,587	15,899	82,159
	Other states	6,962	6,399	105,861	408,878	4,865	1,102	534,067
1956	Alaska	112,797	10	2,216	328,770	285,838	847	730,478
	Other states	55,418	21,772	18,681	241,487	11,925	1,251	350,534
1957	Alaska	2,508,724	3,781	274,808	2,311,253	2,506,080	121,406	7,726,052
	Other states	96,178	10,133	162,600	3,045,114	13,191	515	3,327,731
1958	Alaska	403,892	2,452	58,846	355,304	312,645	307,997	1,441,136
	Other states	57,266	6,430	328,137	3,635,495	71,977	4,695	3,104,000

Source: Annual Reports of the Director, Bureau of Land Management (Statistical Appendix).

Table 45.--Summary of damage in dollars

(Av. 1950-58)

Place	Tangible		Intangible		Total	Average
	Dollars	$/Mil A	Dollars	$/Mil A	Dollars	$/Mil A
Alaska	$12,027,579	$53,456	$10,603,708	$47,128	$22,631,287	$100,584
Other states	4,305,700	31,201	7,602,937	55,094	11,908,637	86,294
Total	$16,333,279		$18,206,645		$34,539,924	
Average		$44,995		$50,156		$ 95,151

Source: Annual reports of the Director, BLM (Statistical Appendix).

Table 46. - Number of fires in each cost class by month and year

(1950-58)

Year	$0-[illegible]	$[illegible]-$300	$301-$1,000	$1,001-$5,000	$5,001-$10,000	$10,001-$20,000	$20,001-$40,000	$40,001-$60,000	$60,001-$80,000	$80,000+
April										
[illegible]										
August										
1950		2	1							
1951	14	[illegible]	3	2			1			
1952	9	[illegible]		1		1				
1953	11	4	5	[illegible]		1				
1954	14	[illegible]	2	4	1		1			
1955	13	[illegible]	2	2						
1956	6									
1957	[illegible]	[illegible]	9	4	1	2				1
1958	[illegible]	[illegible]	4	3	1	1				
Total	[illegible]	[illegible]	26	19	[illegible]	5	2			[illegible]
Percent	[illegible]	[illegible]	2.9	2.1	[illegible]	[illegible]	[illegible]			.2
September										
1950	[illegible]	[illegible]	2	3						
1951	[illegible]		1							
1952										
1953	[illegible]	[illegible]								
1954			1							
1955	[illegible]									
1956	4									
1957	5		[illegible]		2					2
1958	4			2						
Total	41	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]
Percent	4.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					

Summary by cost class and year

[illegible]

Summary by cost class and month

[illegible]

Source: Coded IBM runs from individual fire reports, based on 1,808 fires.

Table 47 Number of fires according to time from origin to [illegible]

Fire class	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	[illegible]
[illegible]									
A	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B	[illegible]	2	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	[illegible]	[illegible]	[illegible]	1	1	[illegible]	[illegible]	[illegible]	[illegible]
D	[illegible]	[illegible]	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	7	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]									
A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	47	19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]									
A	[illegible]	9	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]									
A	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	1	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	2	1	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]
Total	[illegible]	9	[illegible]	1	[illegible]	[illegible]	11	[illegible]	[illegible]
[illegible]									
A	[illegible]	[illegible]	[illegible]	[illegible]	27	[illegible]	[illegible]	[illegible]	[illegible]
B	75	47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	[illegible]	[illegible]	[illegible]	7	7	[illegible]	[illegible]	[illegible]	[illegible]
D	12	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	[illegible]	[illegible]	11	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	79	[illegible]	[illegible]

1/ 'Spruce' type consists of Spruce, spruce-hardwood.
'Other': Broadleaf, reproduction, brush, grass, tundra, muskeg.

Source: Coded IBM runs from individual fire reports based on 1,149 fires.

Table 48.--Percent of fires according to time from origin to discovery within each size class and fuel type

(Av. 1950-58)

Final size class	Time in hours																			
	0 - 1		1 - 2		2 - 3		3 - 6		6 - 12		12 - 24		24 - 48		48 - 72		72+		Total	
	Fuel type 1/																			
	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other
	May																			
A	40.7	53.1	13.5	8.2	5.1	10.2	8.5	10.2	5.1	4.1	11.8	6.1	3.4	2.0	3.4	0	8.5	6.1	100.0	100.0
B	44.7	58.3	13.8	6.3	9.2	6.3	15.4	8.3	7.7	2.1	3.1	4.2	3.1	6.2	1.5	0	1.5	8.3		
C	35.7	37.0	21.4	3.7	0	7.4	10.7	14.9	10.7	11.1	0	0	7.1	14.8	7.2	3.7	7.2	7.4		
D	33.3	16.7	11.1	16.7	11.1	0	0	16.7	0	0	11.1	16.7	22.2	16.6	11.2	0	0	16.6		
E	15.4	18.2	30.8	36.4	0	0	15.4	9.1	7.7	18.1	15.4	9.1	7.7	0	0	0	7.6	9.1		
	June																			
A	38.5	42.1	6.4	7.0	6.4	12.2	6.5	14.0	6.4	5.3	19.2	12.3	7.7	1.8	5.1	1.8	3.8	3.5		
B	36.2	23.5	14.5	14.7	7.3	11.8	8.7	11.8	7.3	11.8	4.3	8.8	13.0	8.8	2.9	0	5.8	8.8		
C	38.3	16.7	4.3	12.5	10.7	4.2	8.6	20.8	10.6	8.3	10.6	20.8	4.2	12.5	2.1	0	10.6	4.2		
D	38.9	31.2	11.1	0	5.6	0	0	12.5	5.5	6.2	27.8	12.5	0	25.1	11.1	0	0	12.5		
E	50.0	35.3	0	5.9	0	5.9	0	17.6	0	0	50.0	11.8	0	17.6	0	5.9	0	0		
	July																			
A	34.7	32.2	8.7	25.0	3.8	7.1	10.6	14.3	4.8	3.6	16.3	0	9.6	7.1	4.8	7.1	6.7	3.6		
B	32.0	35.8	16.0	10.7	2.0	10.7	10.0	7.1	6.0	10.7	10.0	7.1	14.0	14.3	0	0	10.0	3.6		
C	19.4	24.0	9.8	12.0	6.4	12.0	29.0	12.0	3.2	8.0	3.2	8.0	9.7	20.0	6.4	4.0	12.9	0		
D	0	50.0	16.7	0	0	16.7	16.7	33.3	0	0	0	0	33.3	0	0	0	33.3	0		
E	13.5	21.4	16.2	14.3	10.8	14.3	18.9	14.3	0	0	24.3	14.3	5.4	14.3	5.4	0	5.5	7.1		
	August																			
A	20.4	27.8	7.9	5.6	7.8	11.1	10.9	11.1	7.8	11.1	23.4	5.5	7.8	11.1	6.2	5.6	7.8	11.1		
B	26.3	11.1	5.3	0	5.3	11.1	5.3	22.3	10.5	11.1	10.5	0	21.0	33.3	5.3	0	10.5	11.1		
C	12.5	25.0	12.5	0	0	0	25.0	25.0	0	12.5	0	12.5	25.0	12.5	0	0	25.0	12.5		
D	66.7	0	0	0	0	0	0	0	0	0	0	0	33.3	0	0	0	0	0		
E	25.0	25.0	12.5	0	0	0	12.5	0	0	0	0	25.0	0	0	12.5	25.0	37.5	25.0		
	Summary																			
A	33.8	42.1	8.8	10.5	5.6	10.5	9.2	12.5	5.9	5.3	17.7	7.2	7.5	3.9	4.9	2.6	6.6	5.4	100.0	100.0
B	36.9	39.5	13.8	9.2	6.4	9.2	10.8	10.1	6.5	7.6	5.9	5.9	10.8	10.9	3.0	0	5.9	7.6		
C	30.7	26 2	10.5	8.3	6.1	7.1	15.8	16.7	7.9	9.5	5.3	9.5	7.9	15.5	4.4	2.4	11.4	4.8		
D	33.3	30.0	11.1	3.3	5.6	3.3	2.8	16.7	2.8	3.3	16.6	16.7	13.9	16.7	8.3	0	5.6	10.0		
E	16.7	26.1	18.3	15.2	6.7	6.6	16.6	13.0	1.7	4.3	20.0	13.0	5.0	10.9	5.0	4.3	10.0	6.6		

1/ 'Spruce' type consists of Spruce, spruce-hardwood.
'Other': Broadleaf, reproduction, brush, grass, tundra, muskeg.

Source: Coded IBM runs from indifidual fire reports based on 1,149 fires.

Table 49.--Percent of fires according to time from origin to discovery within each time class and fuel type

(Av. 1950-58)

Final size class	0 - 1		1 - 2		2 - 3		3 - 6		6 - 12		12 - 24		24 - 48		48 - 72		72+	
	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other
May																		
A	35.3	38.8	28.6	30.8	30.0	50.0	25.0	33.3	25.0	25.0	58.3	42.8	22.2	11.1	33.3	0	55.6	27.3
B	42.7	41.8	32.1	23.0	60.0	30.0	50.0	26.6	41.7	12.5	16.7	28.6	22.2	33.4	16.7	0	11.1	36.4
C	14.7	14.9	21.4	7.7	0	20.0	15.0	26.7	25.0	37.5	0	0	22.2	44.4	33.3	100	22.2	18.1
D	4.4	1.5	3.6	7.7	10.0	0	0	6.7	0	0	8.3	14.3	22.2	11.1	16.7	0	0	9.1
E	2.9	3.0	14.3	30.8	0	0	10.0	6.7	8.3	25.0	16.7	14.3	11.2	0	0	0	11.1	9.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
June																		
A	37.1	51.1	26.4	30.8	31.3	53.8	33.3	36.4	31.2	30.0	51.7	36.8	35.3	7.1	44.4	50.0	25.0	25.0
B	30.9	17.0	52.6	38.5	31.3	30.8	40.0	18.2	31.2	40.0	10.3	15.8	52.9	21.4	22.2	0	33.3	37.5
C	22.2	8.5	10.5	23.0	31.2	7.7	26.7	22.7	31.2	20.0	17.3	26.4	11.8	21.4	11.2	0	41.7	12.5
D	8.6	10.6	10.5	0	6.2	0	0	9.1	6.4	10.0	17.3	10.5	0	28.7	22.2	0	0	25.0
E	1.2	12.8	0	7.7	0	7.7	0	13.6	0	0	3.4	10.5	0	21.4	0	50.0	0	0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
July																		
A	57.2	29.0	33.3	46.7	36.4	18.2	33.3	30.8	55.6	16.7	53.1	0	41.7	15.4	55.6	66.7	35.0	33.4
B	25.4	32.2	29.7	20.0	9.1	27.3	15.2	15.4	33.3	50.0	15.6	33.4	29.2	30.8	0	0	25.0	33.3
C	9.5	19.4	11.1	20.0	18.1	27.2	27.3	23.0	11.1	33.3	3.2	33.3	12.5	38.4	22.2	33.3	20.0	0
D	0	9.7	3.7	0	0	9.1	3.0	15.4	0	0	0	0	8.3	0	0	0	10.0	0
E	7.9	9.7	22.2	13.3	36.4	18.2	21.2	15.4	0	0	28.1	33.3	8.3	15.4	22.2	0	10.0	33.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
August																		
A	56.5	55.6	62.5	100	83.3	66.7	63.6	33.4	71.4	50.0	88.2	33.4	41.7	33.3	66.7	50.0	41.6	40.0
B	21.7	11.1	12.5	0	16.7	33.3	9.1	33.3	28.6	25.0	11.8	0	33.3	50.0	16.6	0	16.7	20.0
C	4.4	22.2	12.5	0	0	0	18.2	33.3	0	25.0	0	33.3	16.7	16.7	0	0	16.7	20.0
D	8.7	0	0	0	0	0	0	0	0	0	0	0	8.3	0	0	0	0	0
E	8.7	11.1	12.5	0	0	0	9.1	0	0	0	0	33.3	0	0	16.7	50.0	25.0	20.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Summary																		
A	43.8	41.6	32.9	38.0	39.5	43.2	35.4	33.9	42.8	28.6	60.0	29.7	37.1	14.2	46.9	50.0	37.7	29.6
B	31.9	30.5	34.2	26.2	30.2	29.7	27.8	21.5	31.0	32.1	13.3	18.9	35.5	31.0	18.8	0	22.6	33.3
C	14.9	14.3	14.6	16.7	16.4	16.3	22.8	25.0	21.4	28.6	6.7	21.7	14.5	31.0	15.6	25.0	24.6	14.9
D	5.2	5.8	4.9	2.4	4.6	2.7	1.4	8.9	2.4	3.6	6.7	13.5	8.1	11.9	9.3	0	3.8	11.1
E	4.2	7.8	13.4	16.7	9.3	8.1	12.6	10.7	2.4	7.1	13.3	16.2	4.8	11.9	9.4	25.0	11.3	11.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Time in hours; Fuel type 1/

1/ 'Spruce' type consists of Spruce, spruce-hardwood.
'Other': Broadleaf, reproduction, brush, grass, tundra, muskeg.

Source: Coded IBM runs from individual fire reports, based on 1,149 fires.

Table 50.--Distance to fires from headquarters at Anchorage or Fairbanks[1]

(Av. 1950-58)

Lightning

Size class	Miles 0-100	Miles 101-200	Miles 201-300	Miles 301+
A	2.9	2.6	0.6	0.1
B	3.4	4.8	1.7	1.4
C	3.6	5.2	2.8	1.9
D	.9	1.9	.9	1.7
E[2]	2.7	6.7	3.8	1.3
E+[3]	.8	2.4	1.1	.8
Total	14.3	23.6	10.9	7.2
Percent	26	42	19	13

Other

Size class	Miles 0-100	Miles 101-200	Miles 201-300	Miles 300+
A	64.0	24.7	6.4	0
B	33.2	12.7	2.2	1.3
C	12.0	6.1	2.2	.4
D	3.9	1.6	.9	.7
E	4.9	2.1	1.4	1.1
E+	.9	1.6	.9	.2
Total	118.9	48.8	14.0	3.7
Percent	64	26	8	2

Action

Size class	Miles 0-100	Miles 101-200	Miles 201-300	Miles 301+
A	66.1	25.6	6.2	0
B	34.3	14.8	3.4	1.7
C	14.2	8.1	3.8	.9
D	4.2	2.7	1.1	1.0
E	6.5	5.8	2.4	1.3
E+	1.2	1.9	.9	.6
Total	126.5	58.9	17.8	5.5
Percent	60	28	9	3

No-action

Size class	Miles 0-100	Miles 101-200	Miles 201-300	Miles 300+
A	0.9	1.7	0.8	0.1
B	2.2	2.7	.4	1.1
C	1.3	3.2	1.2	1.5
D	.6	.8	.7	1.3
E	1.1	3.0	2.8	1.1
E+	.4	2.1	1.1	.4
Total	6.5	13.5	7.0	5.5
Percent	20	41	22	17

All fires

Size class	Miles 0-100	Miles 101-200	Miles 201-300	Miles 301+
A	66.9	27.2	7.0	0.1
B	36.7	17.6	3.9	2.8
C	15.5	11.3	5.0	2.3
D	4.8	3.4	1.8	2.3
E	7.6	8.8	5.2	2.4
E+	1.7	4.0	2.0	1.0
Total	133.2	72.3	24.9	10.9
Percent	55	30	10	5

Fires per million acres

Size class	Miles 0-100	Miles 101-200	Miles 201-300	Miles 300+
A	2.03	0.42	0.12	0.01
B	1.11	.26	.07	.04
C	.47	.17	.09	.03
D	.14	.05	.03	.03
E	.23	.13	.09	.04
E+	.05	.06	.03	.01
Total	4.03	1.09	.43	.16
Percent	70	19	8	3

1/ According to Operations Area in which the fire occurred.
2/ 301-10,000 acres
3/ Over 10,000 acres

Source: Occurrence maps from 2,171 individual fire reports, (109 less than official count)

Table 51.--Number of fires according to time from attack to control

(Av. 1950-58)

Final size class	Time in hours: 0 - 1		1 - 2		2 - 3		3 - 6		6 - 12		12 - 24		24 - 48		48 - 72		72+		Total	
	Fuel type 1/: Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other
May																				
A	16	21	4	2	1	1	1	3											[illegible]	27
B	22	24	12	10	[illegible]	6	13	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]	[illegible]
C	5	4	3	4	[illegible]	5	13	1	[illegible]	[illegible]	[illegible]		1	[illegible]			[illegible]		[illegible]	[illegible]
D			1		4	2	5		4		1	1	[illegible]				1		[illegible]	[illegible]
E	1					1	1	1	1	1	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Total	44	49	20	16	[illegible]	15	33	19	19	9	[illegible]	[illegible]	9	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
June																				
A	35	19	4	3	2	1	1	3	1										[illegible]	[illegible]
B	20	17	12	2	11	5	[illegible]	7	9	1	[illegible]		[illegible]	[illegible]			[illegible]		[illegible]	[illegible]
C	4	5	2	5	4	2	[illegible]	3	12	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
D		1		3	1			[illegible]	7	[illegible]	[illegible]		[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]
E	1			1		[illegible]		1	4	[illegible]	[illegible]	1	[illegible]	[illegible]		[illegible]	[illegible]	9	[illegible]	[illegible]
Total	60	42	18	14	15	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9	[illegible]	7	[illegible]	[illegible]	[illegible]	18	[illegible]	[illegible]
July																				
A	34	17	8	3	2	1	5				1			1		1			[illegible]	[illegible]
B	13	9	11	4	[illegible]	5	[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]	4			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	1	2		1		4	[illegible]	4	[illegible]	4	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D					1						[illegible]	1	[illegible]						[illegible]	[illegible]
E				1		1	[illegible]	1	1	1	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	[illegible]
Total	48	[illegible]	19	9	11	11	25	[illegible]	[illegible]	7	17	7	[illegible]	7	[illegible]	[illegible]	24	[illegible]	[illegible]	[illegible]
August																				
A	22	4	4		1	[illegible]	[illegible]			1									[illegible]	7
B	1	1	6	2	2		[illegible]	1	[illegible]		5	[illegible]			[illegible]				[illegible]	7
C	1		1	1		1					[illegible]		[illegible]		[illegible]	[illegible]	1		[illegible]	[illegible]
D	1								1		1				[illegible]				[illegible]	[illegible]
E									2	1			1		1		[illegible]	[illegible]	7	[illegible]
Total	25	5	11	3	3	3	[illegible]	1	6	2	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	4	[illegible]	[illegible]	[illegible]
Summary																				
A	107	61	20	[illegible]	6	5	12		[illegible]	1	1			1		[illegible]			[illegible]	[illegible]
B	56	51	41	18	29	16	[illegible]	[illegible]	21	[illegible]	[illegible]	[illegible]	9	[illegible]	1	1	[illegible]	[illegible]	[illegible]	[illegible]
C	11	11	6	11	7	[illegible]	[illegible]	17	[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	7	[illegible]	[illegible]
D	1	1	1	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	7		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
E	2			2		3	4	[illegible]		7	7		[illegible]	[illegible]	1	[illegible]	[illegible]	17	[illegible]	[illegible]
Total	177	124	[illegible]	42	48	40	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1/ 'Spruce' type consists of Spruce, spruce-hardwood.
'Other': Broadleaf, reproduction brush, grass, tundra, muskeg

Source: IBM runs from individual fire reports, based on 986 fires

Table 52.—Percent of fires according to time from attack to control within each size class and fuel type

(Av. 1950-58)

Final size class	Time in hours: 0 - 1		1 - 2		2 - 3		3 - 6		6 - 12		12 - 24		24 - 48		48 - 72		72+		Total	
	Fuel type 1/																			
	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other
May																				
A	72.7	77.8	18.2	7.4	4.5	3.7	4.6	11.1											100.0	100.0
B	33.8	48.0	18.5	20.0	12.3	12.0	20.0	10.0	9.2	6.0	3.1	2.0	3.1	2.0						
C	12.8	13.3	7.7	13.3	7.7	16.7	33.3	33.3	20.5	16.7	12.8		2.6	6.7			2.6			
D			5.6		22.1	66.7	27.8		22.2		5.6	33.3	11.1				5.6			
E	8.3					10.0	8.4	10.0	8.3	10.0	16.7	40.0	33.3	10.0	16.7	20.0	8.3			
June																				
A	81.4	73.1	9.3	11.5	4.6	3.8	2.3	11.6	2.4											
B	28.2	51.5	16.9	6.1	15.5	15.2	11.3	21.2	12.7	3.0	7.0		4.2	3.0			4.2			
C	8.5	20.8	4.3	20.8	8.5	8.3	23.5	12.6	25.5	12.5	10.6	8.3	12.8	4.2	4.2		2.1	12.5		
D		4.8		14.3	5.0	9.5	5.0	9.5	35.0	23.8	15.0	14.3	5.0	9.5	15.0		20.0	14.3		
E	2.8			3.7		3.7		3.7	11.4	14.8	8.6	14.8	14.3	11.1	14.3	14.8	48.6	33.4		
July																				
A	64.2	73.9	15.0	13.0	3.8	4.3	15.1				1.9			4.4		4.4				
B	23.2	25.7	19.6	11.4	14.3	14.3	14.3	14.3	5.4	5.7	10.7	14.3	7.1	8.6		2.9	5.4	2.8		
C	4.0	17.5		5.2		21.1	24.0	21.0	24.0	21.1	24.0	5.3	12.0			10.5	12.0	5.3		
D					16.7						33.3	20.0	50.0	40.0				40.0		
E				9.1		9.1	9.4	9.1	3.1	9.1	6.2		18.8	9.1	6.3		56.2	54.5		
August																				
A	[illegible]	57.1	[illegible]		3.4	28.6	6.9			14.3										
B	4.2	14.3	[illegible]	[illegible]	8.3		25.0	14.3	12.5		20.8	42.8			4.2					
C	11.1		11.1	12.5		12.5					44.4	12.5	11.1	12.5	11.1	12.5	11.2	37.5		
D	[illegible]								25.0		25.0				25.0					
E									28.2	33.3			14.3		14.3		42.8	66.7		
Summary																				
A	[illegible]	[illegible]	[illegible]	9.6	4.1	[illegible]	5.2	7.2	.7	1.2	.7			1.2		1.2			100.0	100.0
B	[illegible]	[illegible]	[illegible]	14.4	13.4	12.8	16.2	14.4	9.7	4.8	8.3	7.2	4.2	4.0	.5	.8	2.8	.8		
C	[illegible]	[illegible]	[illegible]	[illegible]	5.7	14.8	25.0	21.0	21.7	14.8	16.7	4.9	9.2	4.9	2.5	3.7	5.0	8.6		
D	[illegible]	3.4	2.1	[illegible]	12.5	13.9	12.5	6.9	25.0	17.3	14.6	17.2	12.5	13.8	8.3		10.4	17.2		
E	[illegible]			[illegible]		5.9	4.6	5.9	9.3	13.7	8.1	15.7	18.7	9.8	11.6	11.8	45.4	33.3		

1/ 'Spruce' type consists of Spruce, spruce-hardwood.
'Other': Broadleaf, reproduction, brush, grass, tundra, muskeg.

Source: Coded IBM runs from individual fire reports, based on 986 fires.

Table 53.--Percent of fires according to time from attack to control within each time class and fuel type

Final size class	0 - 1		1 - 2		2 - 3		3 - 6		6 - 12		12 - 24		24 - 48		48 - 72		72+	
	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other	Spruce	Other
May																		
A	36.4	42.8	20.0	12.5	6.2	6.7	3.0	15.8										
B	50.0	49.0	60.0	62.5	50.[illegible]	40.0	39.4	26.3	31.6	33.3	20.0	16.6	22.3	25.0				
C	11.4	8.2	15.0	25.0	18.8	33.3	39.4	52.6	42.1	55.6	50.0		11.1	50.			33.4	
D			5.0		25.0	13.3	15.2		21.0		10.0	16.7	22.2				33.3	
E	2.2					6.7	3.0	5.3	5.3	11.1	20.0	60.7	44.4	25.0	100	100	33.3	
June																		
A	58.3	45.2	22.2	21.4	11.1	9.1	4.8	18.8	3.0									
B	33.3	40.5	66.7	14.3	61.1	45.4	38.1	43.8	27.3	7.7	31.2		20.0	14.3			12.0	
C	6.7	11.9	11.1	35.8	22.2	18.2	52.4	18.7	36.4	23.1	3[illegible]	22.3	40.0	14.3	20.0		4.0	[illegible]
D		2.4		21.4	5.6	18.2	4.7	12.5	21.2	38.5	1[illegible].9	33.3	6.7	23.6	20.[illegible]		16.0	[illegible]
E	1.7			7.1		9.1		6.2	12.1	30.7	18.8	44.4	[illegible].3	42.8	5[illegible]	100	68.0	[illegible]
July																		
A	70.8	60.8	42.1	33.3	18.2	9.1	32.0				5.9			14.3		[illegible]		
B	27.1	32.1	57.9	44.5	72.7	45.4	32.0	50.0	50.0	2[illegible].6	35.2	71.4	[illegible]5.[illegible]	42.[illegible]		[illegible]	12.5	[illegible]
C	2.1	7.1		11.1		36.4	24.0	40.0	60.0	57.1	35.3	14.3	18.8			50.0	12.5	[illegible]
D					9.1						11.8	14.[illegible]	18.8	28.[illegible]				20.0
E				11.1		9.1	12.0	10.0	10.0	14.3	11.8		[illegible]7.4	14.3	100		75.0	[illegible]
August																		
A	88.0	80.0	36.4		33.3	66.7	25.0			50.0								
B	4.0	20.0	54.5	66.7	66.7		75.0	100	50.0		50.0	75.[illegible]			25.5			
C	4.0		9.1	33.3		33.3					40.0	25.[illegible]	5[illegible]	100	25.5	100	25.[illegible]	[illegible]
D	4.0								16.7		10.0				25.5			
E									33.3	50.0			50.0		[illegible]5.5		75.0	4[illegible]
Summary																		
A	60.5	49.2	29.4	19.0	12.5	12.5	13.8	13.0	1.5	3.2	1.9			5.4		9.[illegible]		
B	31.6	41.1	60.3	42.8	60.4	40.0	40.2	39.2	30.9	19.4	34.0	34.6	2[illegible].4	26.3	5.5	9.1	[illegible]0.8	3.[illegible]
C	6.2	8.9	8.8	26.3	14.6	30.0	34.5	37.0	38.2	38.7	37.7	15.4	26.2	21.0	16.7	[illegible]7.3	10.7	2[illegible]
D	.6	.8	1.5	7.1	12.5	10.0	6.9	4.3	17.[illegible]	16.1	13.2	19.2	14.3	21.0	22.2		8.9	16.7
E	1.1			4.8		7.5	4.6	6.5	11.8	22.6	13.2	30.8	38.1	26.3	55.6	54.5	39.[illegible]	56.7
	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Time in hours; Fuel Types 1/

1/ 'Spruce' type consists of Spruce, spruce-hardwood.
'Other': Broadleaf, reproduction, brush, grass, tundra, muskeg.

Source: Coded IBM runs from individual fire reports, based on 986 fires.

Table 54.--Forward behavior of fire at time of arrival by percent within each characteristic class and between size classes

(Av. 1950-58)

Final size class	Smoldering		Creeping		Running		Spotting	Crowning
	Fuel type[1/]							
	Spruce	Other	Spruce	Other	Spruce	Other	Spruce[2/]	Spruce[2/]
				May (159 fires)				
A	56.0	41.7	21.6	35.0	4.0	31.9	0	0
B	36.0	33.3	37.9	35.0	52.0	40.9	66.7	66.7
C	4.0	25.0	29.7	20.0	24.0	9.1	33.3	0
D	4.0	0	8.1	0	4.0	4.5	0	4
E	0	0	2.7	10.0	16.0	13.6	0	33.3
				June (266 fires)				
A	60.6	60.5	24.4	24.0	17.1	8.0	25.0	3.1
B	23.0	18.2	43.9	32.0	29.2	8.0	12.5	18.8
C	8.2	6.1	19.5	20.0	19.5	24.0	25.0	18.8
D	3.3	9.1	4.9	12.0	9.8	16.0	12.5	12.5
E	4.9	6.1	7.3	12.0	24.4	44.0	25.0	46.8
				July (232 fires)				
A	80.0	40.8	35.7	20.0	10.3	15.8	50.0	14.3
B	9.2	25.9	38.1	44.0	48.3	21.0	0	4.8
C	7.7	22.2	7.1	20.0	20.7	31.6	0	14.3
D	0	7.4	4.8	0	0	5.3	25.0	9.5
E	3.1	3.7	14.3	16.0	20.7	26.3	25.0	57.1
				August (87 fires)				
A	76.5	66.7	56.3	20.0	14.3	0	0	0
B	20.6	25.0	31.2	40.0	42.9	20.0	100	33.3
C	2.9	8.3	12.5	40.0	42.8	60.0	0	66.7
D	0	0	0	0	0	20.0	0	0
E	0	0	0	0	0	0	0	0
				Summary all months (744 fires)				
A	69.8	51.1	30.9	25.3	11.8	16.9	25.0	6.8
B	19.4	25.0	39.0	27.4	41.2	22.5	25.0	16.9
C	6.5	15.6	17.6	21.3	22.5	23.9	18.7	18.7
D	1.6	5.2	5.1	4.0	4.9	9.9	12.5	10.2
E	2.7	3.1	7.4	12.0	19.6	26.8	18.8	47.4

1/ 'Spruce' type consists of Spruce, spruce-hardwood.
'Other': Broadleaf, reproduction, brush, grass, tundra, muskeg.

2/ Only scattered occurrences of spotting and crowning occur in the fuel type 'Other' since it is composed mostly of grass, tundra, and brush.

Source: Coded IBM runs from individual fire reports.

Table 55.--Cost of protection by Bureau of Land Management, 1950-58 1/

Year	Cost of protection in dollars			Cost/acre (fraction of cent)	
	Pre-suppression	Suppression	Total	Alaska	Other states
1950	143,529	6,422	149,951	0.07	0.34
1951	194,023	89,139	283,162	.12	.15
1952	198,316	157,946	356,262	.16	.21
1953	210,003	180,588	390,591	.17	.18
1954	230,695	275,718	506,413	.22	.19
1955	247,324	239,941	487,265	.22	.21
1956	287,813	152,653	440,466	.20	.33
1957	294,911	584,000	878,911	.39	.30
1958	395,551	1,875,643	2,271,194	1.01	.80
Av.	244,685	395,783	640,491		

Percent of acreage protected and total protection costs

(Av. 1950-58)

Place	Pre-suppression	Suppression	Total Cost	Acreage
Alaska	66	60	62	62
Other states	34	40	38	38

1/ Fiscal Year Data. Based on 225 million acres protected. Does not include contract protection costs.

Source: Annual Reports of the Director, BLM (Statistical Appendix).

FOR YOUR CARD FILE

Hardy, Charles E., and Franks, James W.
1963. Forest fires in Alaska. U.S. Forest Serv., Intermountain Forest and Range Expt. Sta., Ogden, Utah. 163 pp., illus. (U.S. Forest Serv. Res. Paper INT-5)

The natural resources of Interior Alaska deserve a higher level of protection than is now feasible. This publication is written for both the person requiring specific data to do a better research or protection job and the person who wishes to become more thoroughly acquainted with the overall protection problems. The relation of geography and climate to fire control is described; weather, fire behavior, and fire statistics for the period 1950-1958 are summarized in order to help resource managers to shape the type and size of fire detection and control organization necessary to obtain adequate protection. Research programs based on these findings will delve deeper into the basic relationships between Interior Alaska's geography, climate, weather, fuels, and fire behavior.

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CAMPGROUNDS
FOR MANY TASTES

Intermountain Forest and Range Experiment Station
Forest Service
U. S. Department of Agriculture
Ogden, Utah
Joseph F. Pechanec, Director

U. S. FOREST SERVICE RESEARCH PAPER INT-6

JUNE 1963

THE AUTHOR

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Cover photo: Seeley Lake Campground. (Lolo National Forest, Montana)

U. S. Forest Service
Research Paper INT-6
June 1963

CAMPGROUNDS FOR MANY TASTES

J. Alan Wagar

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
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CONTENTS

This publication is a product of a cooperative outdoor recreation research program by Utah State University, Logan, Utah, and the Intermountain Forest and Range Experiment Station, Ogden, Utah.

INTRODUCTION

This paper departs widely from the usual pattern of research reports. The reader will find here no tabulated data, no statistics or equations, no bibliography of authoritative publications on the subject. Rather, he will find results of an exploration of the boundaries and content of a general but concrete concept of the kinds of campground facilities that might and should be available on public and private lands to enable American citizenry to enjoy their outdoor heritage.

For many people camping is an essential ingredient of outdoor recreation — either as a worthwhile experience in itself or as a means of reaching and remaining near other recreational opportunities. But all campers do not seek the same types of experiences and do not want to use the same kinds of camping areas or facilities.

Like other people, campers come in many varieties. Some prefer to be surrounded by all the conveniences of home and by the sociability and security of other people. By contrast, a few campers pack their equipment across miles of rugged country in search of solitude and truly wild surroundings. Others want as much wilderness as they can reach by automobile. Camping tastes of all shades lie between these extremes of complete convenience and wilderness surroundings.

Campers who find facilities matched to their individual interests are delighted. But when someone seeking solitude arrives at a large and elaborate camp, he may be just as unhappy as the gregarious, comfort-seeking camper who stops at a tiny campground that has only minimum facilities. Fortunately there are lands suitable for every part of the broad spectrum of camping needs. But, without planning, these lands will not contribute their full measure of benefits either to recreationists or to other land users.

If campgrounds are to provide maximum benefits and enjoyment, land managers must recognize that campers have an extremely wide variety of needs and that the camping facilities suited to these needs will vary accordingly. To serve this whole range of needs will probably require the efforts of several agencies, plus private enterprise. The purpose of this paper, therefore, is to emphasize the range of campground needs and to suggest a classification that may help recreation planners meet the full spectrum of campers' needs. This paper does not discuss needs for camps to be used by organizations or large groups.

The suggested classification is given below and is illustrated in figure 1:

1. Central camps
2. Forest camps
3. Peakload camps
4. Long-term camps
5. Travelers' camps
6. Large back-country camps
7. Small back-country camps

Of course, it is recognized that other campground classifications are possible. The important point is that a variety of campgrounds is needed.

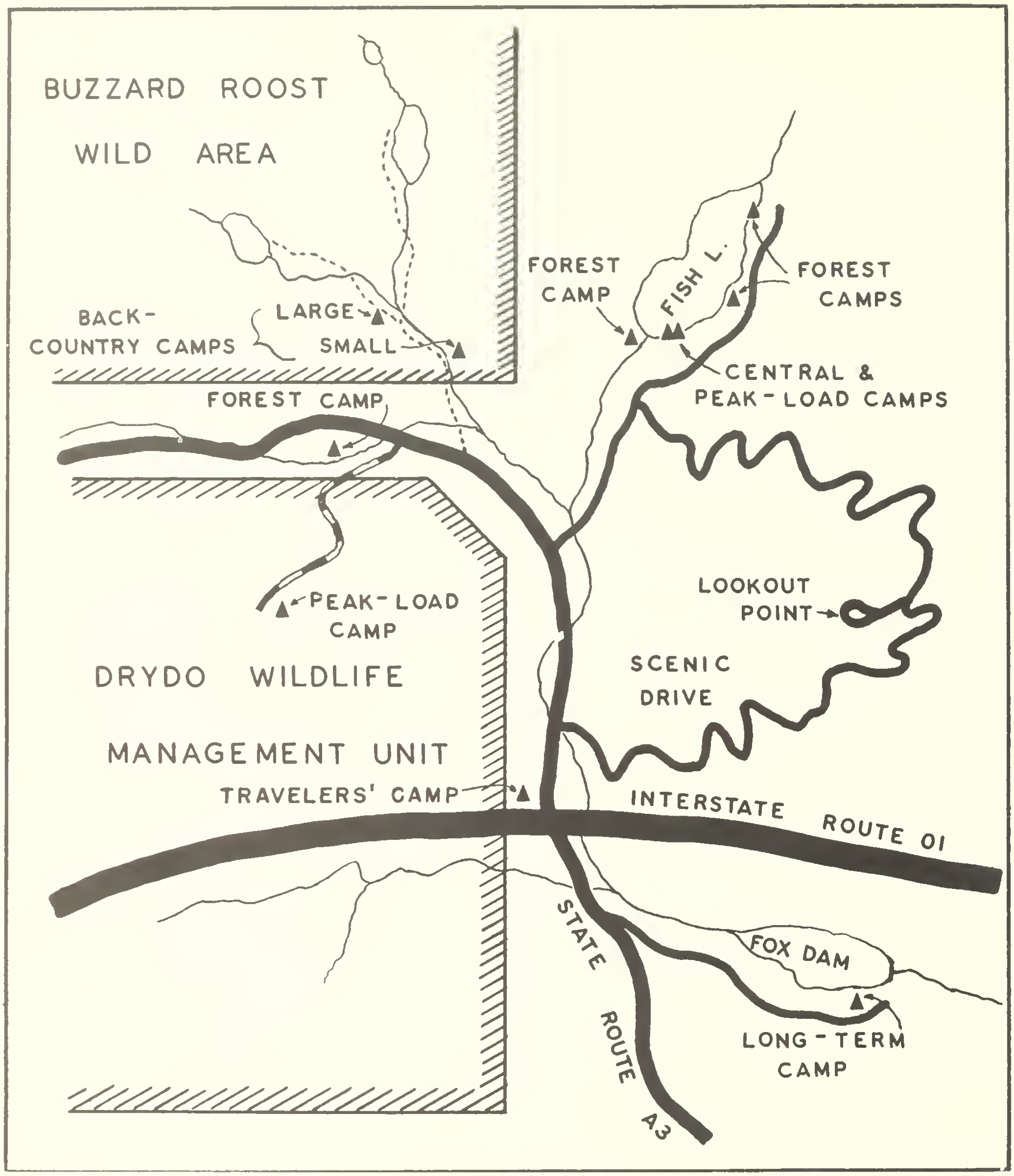

Figure 1.—Campgrounds for many tastes in a recreation region. The **central camp** on Fish Lake provides a comfortable headquarters with complete facilities. **Forest camps** have minimum facilities and wide spacing to preserve the forest environment. The **peakload camps** provide an overflow area for the central camp and a base for seasonal use of the wildlife management unit. The privately owned **long-term camp** at Fox Dam rents spaces by the month or season. On Route 01 the concession-operated **travelers' camp** rents overnight camping facilities. Along the trail into the wild areas, **large** and **small back-country camps** provide for large and small trail groups. Beyond the trail junction, rates of use have not yet required the establishment of permanent campsites.

CAMPGROUNDS ACCESSIBLE BY AUTOMOBILE

CENTRAL CAMPS

Many of today's campers lack the experience, equipment, and state of mind needed to be comfortable amid truly primitive surroundings. Yet these same people seek the outdoors and apparently have much to gain from outdoor experiences. Their needs might best be met by **central camps** that provide maximum facilities and a comfortable headquarters from which visitors can see or venture into the outdoors (fig. 2).

The experience offered by central camps would be only one step more primitive than staying in a cabin — with the scenery provided more by the surrounding countryside than by the camp itself. For example, a worthwhile camping trip might depend far more on a pleasant view from camp than on whether there is pavement or pine litter underfoot. Also, for many persons the presence of numerous other campers and elaborate facilities seems to enhance rather than detract from an enjoyable stay. So, recreation planners probably should not design all camping areas to an arbitrary standard of naturalness.

The usual procedure for maintaining attractive campgrounds has been to space campsites widely to assure light use per total area — placing sole reliance on the area's natural capacity for self-repair. But in central camps, attractiveness could also be maintained by such mangement procedures as irrigation, planting, thinning, fertilizing, paving, frequent policing, and increased use of barriers — augmenting the natural capacity for self-repair. This might permit intensities of use that would justify such comforts as flush toilets, showers, laundry facilities, and other services for the many campers who want them. Trailer hookups for water, sewage, and electricity might also be perfectly acceptable for this class of campgrounds.

Design should be flexible enough to provide for trailers, coaches on pickups, station wagons, and a variety of tent designs. Now, for example, campers who have tents attached to cars are often forced to stay in parking areas because so many campsites are designed to separate the parking from the tent area.

Wherever possible, central camps should be located several miles from main highways in regions rich in recreation opportunities. Although these camps should be in pleasant surroundings, they should not encroach upon sites for specific recreational activities. Instead, these central camps should provide a headquarters from which campers could reach a variety of attractions such as scenic drives, nature trails, fishing waters, and areas where wildlife is likely to be seen. Distances to these attractions might range from a short walk to several hours of hiking or driving.

The size of central camps might range from about 30 to several hundred campsites—depending on demand, durability of the surrounding resource, and the capacity of neighboring campgrounds.

FOREST CAMPS

The desires of campers who want a good measure of naturalness mixed with their camping might be met by **forest camps** (fig. 3). Here some management and artificiality might be essential to prevent campgrounds from deteriorating with use. But the accent would be on maintaining a largely natural environment —requiring minimum facilities and perhaps no more than 8 or 10 widely spaced campsites per campground.

In certain situations it might be desirable to space forest camps around a central camp —some within walking distance, others within a short drive. Campers from the neighboring camps could then walk or ride to the central camp for showers and other services. These services to forest camp users might justify having complete facilities at central camps without the latter being too large or overcrowded. Since people would have access to convenience as well as isolation and naturalness, they could choose whatever mixture best suited their individual tastes. Giving scattered campers the use of central camp facilities might also reduce demands for elaborate facilities at forest camps; these could remain small, simple, and fairly natural. However, not all forest camps would need to be associated with central camps.

Photo: U. S. Forest Service

Figure 2.—The central camp would provide a comfortable headquarters from which visitors could see or venture into the outdoors. (Nicolet National Forest, Wisconsin.)

Photo: U. S. Forest Service

Figure 3.—The forest camp would have a few widely spaced campsites, minimum facilities, and a rather natural environment. (Sawtooth National Forest, Idaho.)

Figure 4.—Peakload camps would handle temporary crowds. These Fourth-of-July campers could find no unoccupied sites in the regular campground. (Nicolet National Forest, Wisconsin.)

Photo: U. S. Forest Service

Forest camps probably should be some distance from main highways and near specific recreational opportunities such as outstanding scenery, hiking trails, or particularly pleasant surroundings. Great care would have to be taken that the number and spacing of campsites did not exceed the capacity of the recreational opportunity. For example, 10 campsites should not be placed where the main attraction is a fishing stream that can withstand only 20 man-days of fishing per year. Nor should campsites be crowded so closely that campers lose the solitude and naturalness that many visitors to this type of area would be seeking.

PEAKLOAD CAMPS

In many areas peak numbers of campers occur for only a short time (fig. 4). Examples are holiday crowds, users of hunting camps, and groups on field trips. Portable facilities, especially water tanks and toilets, might be moved about to meet temporary needs. Where use will recur each year, as in overflow camping areas and hunting camps, **peakload camps** could be established by marking campsites and installing fireplaces. Concrete anchors might also be installed so that lightweight tables could be fastened securely in place while in use.

LONG-TERM CAMPS

In some parts of the country, families like to camp for long periods — perhaps a month or more — without moving (fig. 5). Thus, **long-term camps** may be desirable where demand for this type of camping is great and where they would not deny camping opportunities to visitors who have less time to spend. These camps could be large or small, simple or elaborate. The primary considerations would be to provide enjoyable camping, to protect the site, and to collect sufficient fees to be self-supporting. On public lands, these campgrounds should not be located where they would monopolize areas needed by other campers. If pressures for short-time camping increased, long-term camping privileges might be stopped after one or more years of warning. Depending on their location and design, these areas would then become central camps or forest camps.

Where camping fees are charged, the longer a camper stays, the more predictable the income he provides. For this reason, long-term camps might offer a reasonable business venture for owners of private lands or for concessionaires on public lands. Because these campgrounds would give exclusive use to very few people, they probably should, as already mentioned, be self-supporting.

TRAVELERS' CAMPS

As Hutchison[1] pointed out, "Camps for travelers looking only for a place to stop overnight may not be a public responsibility." However, there is a real demand for campgrounds that are little more than places to park tired bodies for the night. Unless some campgrounds are designed specifically for overnight travelers, they will continue to crowd into areas designed for more deliberate camping. Whether left to private owners, run by concessionaires or public agencies, **travelers' camps** probably should be considered as part of any overall system of campgrounds (fig. 6).

These camps would be designed for travelers who are in a hurry and who wish inexpensive accommodations. Such visitors probably would not worry much about lack of natural surroundings but would be most interested in low cost and in conveniences that save time. Travelers' camps therefore may need to be of such size and design that they provide the lowest per unit construction and maintenance costs while still providing adequate privacy and conveniences. All the management techniques used for city landscapes may be needed to retain pleasant surroundings, and permanent accommodations such as tents with floors might be desirable.

Travelers' camps would be located close to major highways; they might have showers, flush toilets, and laundry facilities, but would not need to offer any particular recreational activities. Locations should be about a day's drive from other places where cross-country travelers are likely to stay overnight. Since entrance fees to recover all costs would be highly desirable, travelers' camps might best be operated by private owners or concessionaires under special-use permits.

[1]Hutchison, S. Blair. Recreation opportunities and problems in the National Forests of the Northern and Intermountain Regions, U. S. Forest Serv. Intermountain Forest and Range Expt. Sta. Res. Paper 66. 1962. Ogden, Utah.

Photo: U. S. Forest Service

Figure 5.—Long-term camps would provide for people who want to camp a month or more. (Concession-operated Twin Lakes Campground, Allegheny National Forest, Pennsylvania.)

Figure 6.—Travelers' camps would provide overnight accommodations for travelers who are in a hurry but want economy and convenience. Tent-cabins, such as those designed by the Grand Teton Lodge Company, would meet this need and might also be desirable at central camps. (Coulter Bay Tent Village, Grand Teton National Park, Wyoming.)

Photo: Grand Teton Lodge Company

BACK-COUNTRY CAMPING AREAS

Wherever possible, it will be desirable to allow unrestricted choice of campsites in the back country. Such freedom of choice is one of the reasons people leave the roads and seek out these areas. However, some back-country areas are already being used so heavily that they are rapidly deteriorating.[2] [3] This is especially true where groups use large numbers of pack and saddle horses. Where back-country areas are in danger of overuse, it may be necessary to protect them by establishing campsites and encouraging their use. Careful location of trails may disperse visitors and prevent concentrated use in the near future. But in problem areas, the size and itinerary of each back-country party might eventually have to be controlled.

LARGE BACK-COUNTRY CAMPS

Where uncontrolled use by large groups would damage off-highway areas, campsites to provide safe water, toilets, and permanent fire spots would need to be established. In horse country, corrals would also be needed to keep pack and saddle stock in designated areas.

Where deterioration is becoming a problem, all groups of more than about 15 people or 5 horses might be required to use these **large back-country camps**. The size of these camps and the number of parties allowed to use them would depend on allowable harvests of forage and firewood and on the durability of the campsites themselves. For some areas it might be necessary to limit the number of horses used by one party.[4]

SMALL BACK-COUNTRY CAMPS

Small groups also use some back-country areas heavily enough to cause deterioration. Where these problems occur, campsites might be established with the minimum facilities needed to provide safe water, adequate sanitation, and to prevent each party from choosing and using a new fire spot (fig. 7). Where several campsites are needed, they could be widely spaced to maintain solitude and to put minimum stress on the area itself. Provision might be made for one or two horses used by a small group. But groups with more than a few people or with more than a few animals should not use these small camps.

[2]Snyder, A. P. Wilderness Area management—an administrative study of a portion of the High Sierra Wilderness Area. U. S. Dept. Agr., Forest Serv., Region 5, San Francisco Calif. 1960.

[3]Hutchison. *Op. cit.*

[4]J. V. K. Wagar in a personal communication to the author has observed that some outfitters use lighter equipment than others. Light equipment requires fewer pack horses, thus fewer wranglers, and therefore fewer horses to carry wranglers, their food, and their equipment. Lists of especially suitable food and equipment might be developed to help outfitters reduce the number of horses needed for a given number of riders. However, it would not be desirable to standardize so completely that the traditions and methods of local outfitters would be lost.

Photo: U. S. Forest Service

Figure 7.—Small back-country camps would prevent the spread of damage at sites used frequently by small groups. Canoeists in the Boundary Waters Canoe Area, Superior National Forest, Minnesota.

A CAMPGROUND SYSTEM

All of the campground types suggested here are already in existence. But there is still need to incorporate these types within a system that will allocate the broad range of available camping opportunities among the great variety of camping needs. Once different kinds of campgrounds are labeled and listed in directories, campers can seek out the kinds suited to their tastes. Future planning and construction can then be guided by demonstrated needs. However, location of campgrounds will have to depend on many factors.

Too often, recreation has been viewed primarily in terms of access and unrestricted use — about the way people thought of timber a century ago. But there is increasingly a need to guide types and levels of use to conform to the capabilities of the resource. Placement of campgrounds can be a management tool to flow recreationists away from overused areas into equally suitable areas that are underused. This would be preferable to developing unsuitable areas because camping pressure had already gained the upper hand. Selection of each campground location would have to include considerations of demand, recreation resources, accessibility, present and rotation ages of timber, other forest uses, availability of safe drinking water, fire and health hazards, and durability of the site itself.

If the various categories of campgrounds are to provide specific types of experiences, thoughtful administration will be needed in addition to careful location. Intensity of use and means of access may need particular attention. For example, the quality of experience offered by a forest camp would change drastically if the area were used at twice its designed capacity. As for access, the experience of a hiking camper at a small back-country camp might be spoiled by others using horses. And the experiences of both hikers and horseback riders might be marred by the presence of trail scooters or jeeps. Thus, some controls may be needed to protect the full range of camping experiences.

By establishing and managing different types of campgrounds within an overall plan, those who provide campgrounds might more fully meet the full spectrum of camping needs. At the same time, this planning could reduce the impact of camping on the many other land uses needed by society.

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EFFECTS OF BROOM RUSTS ON SPRUCE AND FIR

by

ROGER S. PETERSON

DIVISION OF FOREST DISEASE AND
TIMBER MANAGEMENT RESEARCH

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
FOREST SERVICE
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OGDEN, UTAH

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EFFECTS OF BROOM RUSTS ON SPRUCE AND FIR

Roger S. Peterson [1]

"How significant is broom rust damage?" is a common question among western foresters who work with spruce and fir. This paper reviews the evidence and reports new data.

Broom rusts attack most species of spruce and fir throughout North America, but are particularly abundant in the West. Their most conspicuous symptoms are branch proliferations called witches'-brooms, which produce annual crops of yellow needles. Other symptoms are branch and trunk swellings and cankers. Broom rust of spruce is caused by *Chrysomyxa arctostaphyli*, a fungus that completes its life cycle on bearberry and other *Arctostaphylos* species. *Melampsorella caryophyllacearum* causes the similar disease of true firs; it alternates in its life cycle to chickweeds and their relatives in *Cerastium* and *Stellaria*.

REVIEW

Spruce Broom Rust

Spruce broom rust occurs only in North America. The most concentrated outbreaks are in northern Arizona and southern Colorado on Engelmann and blue spruce and in Alaska on black and white spruce, with local epidemics scattered over the 2,000 miles between these areas. The rust is missing where *Arctostaphylos* does not grow, for instance in southeastern Idaho.

Spruce brooms are associated with bole deformation, loss of increment, spike-tops, and mortality (Bourchier 1953; Foster and Ziller 1952; Kimmey and Stevenson 1957; Thomas 1953). Brooms also serve as infection courts for decay fungi such as *Fomes pini* and *Lentinus lepideus*, and thereby increase cull (Hedgcock 1912; Mielke and Davidson 1947). A survey in Colorado determined that heart rot was associated with 68 percent of dead rust brooms on trunks of sampled Engelmann spruce (U.S. Forest Service 1959). Wind breakage at rust trunk infections has been reported by Alexander (1957) and Pady (1942). No comprehensive study of economic effects of spruce broom rust has been made, and there has been no large-scale control work.

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[1] Plant pathologist. Data from Colorado were obtained while the writer was with the Rocky Mountain Forest and Range Experiment Station at Fort Collins, Colorado. Work was completed at headquarters in Logan, Utah, maintained in cooperation with Utah State University.

Fir Broom Rust

Melampsorella occurs in most of the world's fir forests. Only European foresters, however, have undertaken large-scale investigation and practical control of this "most important" parasite of fir (Neger 1924). In Germany Melampsorella usually infects from 2 to 15 percent and occasionally 20 to 30 percent of silver fir trunks before control work (Heck 1894; Flury 1932). Percentage of trees infected may be much higher, particularly in wet sites, if branch brooms are counted (Koch 1891; Neger 1924). Other site factors and stand composition appear not to affect the amount of rust on fir in Europe (Fröhlich 1931; Schwerdtfeger 1957).

Mortality due to snow and wind breakage at rust trunk cankers is thought to be important in Eurasia (Hartig 1900; Vanin 1955). But cull due to bole deformation and to decay centered at rust cankers is regarded as by far the most serious form of broom rust damage (Koch 1891; Schwerdtfeger 1957). Rust-caused swellings and resin accumulations make infected trunks undesirable for pulpwood. Cankers provide infection courts for decay fungi, chiefly Fomes hartigii and Pholiota adiposa (Fröhlich 1931; Gäumann 1950; Hartig 1900). In Siberia a large part of fir heart rot is associated with broom rust (Kravtsev 1933). Effects of rust brooms on tree growth rate are not thought to be important in Eurasia, and Guinier (1922) claims that even the branch on which a broom is located continues normal diameter growth.

Because fir stands in Europe are managed intensively, it has proved possible to eliminate rust cankers economically during regular thinnings (Heck 1927). Controversy regarding the pruning of branch brooms has continued for decades, but even the "broom-control" group believes that pruning prevents trunk infection and subsequent cull, not that brooms themselves cause loss (Guinier 1922; Schwerdtfeger 1957).

Fir broom rust is widespread in North America. Pomerleau (1956) reported a large outbreak in the East in balsam fir, but most concentrations of the rust are in the West. It is locally common in California on red fir, and was found on 3 percent of 917 trees of this species examined in statewide randomized plots (California Forest Pest Control Action Council 1963). Serious outbreaks on white fir occur near Albuquerque, New Mexico.[2] But the rust reaches its greatest known abundance on subalpine fir in the Sawtooth, Cache, Caribou, and Bridger National Forests of southern Idaho, northern Utah, and western Wyoming (Mielke 1957). Informal tree counts by Forest Service investigators on Idaho's Cassia Plateau indicated that 70 percent, 80 to 90 percent, and 90 to 95 percent of the subalpine fir were infected in three different localities.

Fir broom rust in North America reduces growth and eventually causes death, particularly in seedlings and saplings (Mielke 1957). Freeman (1905) and Faull (1932) also reported stunting of trees by this rust. However, Boyce (1961) stated that lightly infected firs seem to grow as rapidly as sound ones, and Meinecke (1916) thought that branch brooms in no way affect trunks. Alexander (1958) recognized the importance of trunk cankers in subalpine fir. But it appears that the ratio of trunk infections to branch infections of Melampsorella is lower in America than in Europe (Boyce 1961).

[2] Rocky Mountain Forest and Range Experiment Station, unpublished observations.

In America, unlike Europe, no large-scale projects to control fir broom rust have been undertaken--possibly because we manage fir stands less intensively and are uncertain that broom rust causes significant damage here.

CURRENT STUDIES

Spruce Broom Rust: Damage Tallies in Outbreaks

Survey strips were run through broom rust outbreaks in six National Forests in Colorado to identify any easily recognized effects that the rust might have on Engelmann spruce. Ten transects were examined in the San Juan, Rio Grande, Grand Mesa-Uncompahgre, Gunnison, White River, and San Isabel National Forests. Sampled stands were mature or overmature, and either uncut or lightly cut over. Transects were 0.5 chain wide, varied in length, and included a total of 1,249 spruce. Because surveys were deliberately placed in rust outbreak areas, the infection levels recorded are not representative for these forests. The transects began at arbitrary starting points chosen before they were reached, therefore no trees in them had been seen before tallying began. This resulted in two transects' being mostly in healthy stands. Percentages of spruce infected varied from 5 to 25 in the 10 strips; the average was 17 percent.

Rust infection appeared to be causally related to tree death in these samples. Much higher percentages of dead trees than live trees were broomed in the eight transects that included dead trees (table 1). Furthermore, the dead trees that had been infected bore an average of 2.3 brooms (or clusters of brooms) per tree, compared to 1.5 in infected live trees. Because the mortality rate was 7 percent for rust-free trees, but 23 percent for broomed trees, rust infection appeared to increase the probability of a tree's death by a factor of more than 3. It could be argued that rust "picks on" weak or dying trees and that the correlation, therefore, is not significant. But this would be contrary to facts known about infection by rust fungi, namely that the more vigorous members of a plant population are the most likely to be infected by these obligate parasites (Arthur 1929).

Table 1.--Comparison of rust broom on live and dead spruce in eight transects in Colorado

Tree size	Live trees		Dead trees		All trees	
	Total	Broomed	Total	Broomed	Total	Broomed
	Number	Percent	Number	Percent	Number	Percent
Less than 6" d.b.h.	180	5	15	13	195	6
More than 6" d.b.h.	818	18	93	48	911	21
All trees	998	16	108	44	1,106	18

Spike-topped and broken spruce were recorded separately in the 10 transects (table 2). All dead tops in small spruce apparently resulted from suppression, but in larger trees 8 of 14 spike-tops originated at rust infections. Broken trunks were not significantly correlated with rust in the samples, but trees broken at rust brooms are commonly seen in Colorado (fig. 1).

Table 2.--Occurrence of rust brooms in spike-topped and broken spruce in 10 transects in Colorado

Tree size	All live		Spike-topped		Broken	
	Total	Broomed	Total	Broomed	Total	Broomed
	Number	Percent	Number	Percent	Number	Percent
Less than 6" d.b.h.	241	5	7	0	3	33
More than 6" d.b.h.	900	17	14	57	10	20
All trees	1,141	15	21	38	13	23

Figure 1.--Engelmann spruce in San Juan National Forest. Rust infections in trunks provide starting points for decay that makes trees susceptible to wind breakage.

Spruce Broom Rust: Study of Effects on Growth

In 1962 a small study was made to determine whether broom rust causes growth loss in Engelmann spruce. Three variable-size plots were chosen, one each in the Deerlodge (Montana), Teton (Wyoming), and Wasatch (Utah) National Forests. In each plot we marked 10 to 12 broomed spruce with an aggregate diameter of 80 inches. The trees selected were those nearest an arbitrary point in each plot. Trees that were forked or otherwise deformed, that were less than 3 inches d.b.h., or that had only one or two small brooms far out on the branches were excluded from the sample. After marking the diseased trees, which had an average of three rust brooms (or clusters of brooms) each, the rust-free tree nearest each marked tree and having a d.b.h. within 10 percent of the latter's diameter was identified. Average distance between members of diseased-nondiseased pairs was 14 yards. The paired trees were then cut and dissected to compare ages, diameter growth by decades (measured on a 6-inch stump), heights, height growth in the last 10 years, and extent of decay. Assuming that infection occurs on current-year shoots, we determined the approximate year of first infection from the age of the stem section bearing the oldest broom. Diameter growth rates before and after the decade in which first infection occurred were compared for infected and healthy trees. In almost all trees, rusted or not, annual increments increased with tree age, because the trees had been partly suppressed in their early years.

Table 3 summarizes data from the three plots. The difference in recent height growth correlated with rust infection is real, by "t" test, unless a 1-in-100 mischance has occurred in sampling. Measured diameter growth differences also reflect actual effects of rust unless a 1-in-17 mischance occurred in sample selection. Current height and diameter growth were greater in healthy trees than in broomed trees in all three plots, but the percentage differences averaged twice as large in the Teton plot as in either of the others. In the Teton plot infections averaged only 1.4 per broomed tree, compared with 3.3 and 3.6 in the other plots; but the average time since infection was 61 years, compared with 20 and 30 in the others. Time since infection thus appears more important than number of infections in evaluating damage.

Table 3.--Average measurements of 32 pairs of healthy and rust-broomed Engelmann spruce

Item	Healthy trees	Broomed trees	Percentage difference
Diameter at breast height	8.66 in.	8.63 in.	-0.3
Total age	126 yrs.	127 yrs.	+1
Total height	49.5 ft.	49.2 ft.	-1
Height growth, last decade	6.0 ft.	4.5 ft.	-25
Diameter growth before decade of first rust	1.6 mm./yr.	1.9 mm./yr.	+19
Diameter growth after decade of first rust	2.9 mm./yr.	2.3 mm./yr.	-21

The broomed trees, on the whole, had more potential for growth than did the healthy trees, as is shown by their faster growth before infection by rust. Therefore their final diameter increments would have averaged more than the 2.9 mm. per year given for healthy trees in table 3, if they had not been infected. We can assume that the increase in growth rate of the broomed trees would at least have equaled the 1.3 mm. per year of the healthy trees; this increase would give the broomed trees an expected rate of 3.2 mm. per year (1.9+1.3 = 3.2) in the broomed trees. Or we can assume that the growth increase would be proportional to initial growth rates, for an expected rate of 3.4 mm. per year in the broomed trees (1.6/1.9 = 2.9/3.4). On the basis of these assumptions the apparent reduction in diameter growth caused by rust is 28 percent or 32 percent, respectively, rather than the 21 percent given in table 3.

Decay associated with rust brooms in the sample was of minor importance. There were 25 trunk infections by the rust, only 2 of which appeared to be the centers of decay. The decay columns were small.

Fir Broom Rust: Study of Effects on Growth

To measure effects of *Melampsorella* on fir, we made comparisons of growth of paired healthy and infected trees by the methods described above for spruce broom rust. Plots were in the Sawtooth (Idaho), Cache (Idaho), and Wasatch (Utah) National Forests. Average distance between members of pairs was 39 yards. The 33 broomed trees of the sample bore an average of 9 rust brooms each.

From the data of the three plots summarized in table 4, no statistically significant differences in growth between healthy and diseased trees are evident. This absence of growth effects may result from the relative recency of infection. Of the 300 fir brooms examined, fewer than 10 were more than 30 years old; average age was 19 years. Perhaps the apparent difference in recent height growth between healthy and rusted trees (table 4) represents the first damaging effect of rust.

Table 4.--Average measurements of 33 pairs of healthy and rust-broomed subalpine fir

Item	Healthy trees	Broomed trees	Percentage difference
Diameter at breast height	7.61 in.	7.58 in.	-0.4
Age	100 yrs.	100 yrs.	0
Height	43.6 ft.	41.4 ft.	-5
Height growth, last decade	6.5 ft.	5.8 ft.	-11
Diameter growth before decade of first rust	1.8 mm./yr.	1.8 mm./yr.	0
Diameter growth after decade of first rust	2.6 mm./yr.	2.6 mm./yr.	0

Figure 2.--Dead subalpine fir in Sawtooth National Forest. The death of such a tree, bearing more than 100 rust brooms but showing no other apparent symptoms, suggests that broom rust infection can kill directly.

Figure 3.--Subalpine fir, Sawtooth National Forest. Trees dead above rust trunk infections are common.

Although this study did not demonstrate that branch brooms cause measurable effects, one cannot argue from this that Melampsorella causes no damage in the Rocky Mountains. The study specifically excluded the broomed firs most affected by the parasite--the dead, spike-topped, and small deformed trees (figs. 2 and 3). Their frequency and significance have not been evaluated.

In the fir sample, as in the spruce, decay associated with rust was of minor importance. Of 300 infections in the sample, 29 appeared to extend into trunks, and only 1 of these appeared to be a center of decay.

SUGGESTED STUDIES

These pilot studies suggest both additional questions and some changes in technique. It appeared that time since infection bears importantly on damage, but that random samples of infected trees do not give a comprehensive sample of ages of infection. To evaluate future effects of broom rust on fir growth in the Intermountain Region we should find examples of outbreaks 50 to 100 years old. This will require a radical departure from random sampling; as yet no outbreaks of fir broom rust more than 26 years old have been encountered in the Region. It will also be possible, in a larger sample, to determine the relation between intensity of brooming (percentage of crown broomed) and growth decline.

Another unknown to be studied is how broom rusts kill trees. Among the possible explanations are (1) food loss to the parasite and to the hyperactive brooms, (2) interference with conduction, and (3) increase in secondary pests following rust infection. Whether bark beetles single out rusted trees for attack, as several foresters have suggested, is a particularly important problem.

The work reported in this paper does not completely answer its starting question, "How significant is broom rust damage?" Our studies show damaging effects of rust on spruce, and suggest that similar effects might be expected in fir outbreaks older than those sampled. Further work will be required to evaluate breakage and mortality due to rust and to measure damage to young trees.

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MECHANISMS OF FIRE SPREAD RESEARCH PROGRESS REPORT NO. 1

by

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DIVISION OF FOREST FIRE RESEARCH

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
FOREST SERVICE
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MECHANISMS OF FIRE SPREAD
RESEARCH PROGRESS REPORT NO. I

By

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MECHANISMS OF FIRE SPREAD

RESEARCH PROGRESS REPORT NO. I

Hal E. Anderson [1]

INTRODUCTION

An understanding of fire spread is important to the development of improved methods and systems for the control of free burning fires. Gaining knowledge about fire spread in forest fuels is complex because many variables are involved and because we still lack full understanding of the interaction of these variables. The research reported here involves studies of fire spread in natural forest fuels in which the characteristics of the fuel and the weather environment were controlled.

Several investigators have studied the spread of fires in forest fuels where burning was not started until the desired ambient conditions were obtained (Curry and Fons 1940; Fons 1946; Fahnestock 1960). Direct control of wind, air temperature, humidity, and fuel moisture content could not be accomplished although these items were measured during the studies and cross correlations were accomplished. Some uncertainties enter the relationships if the environmental conditions cannot be controlled, and the full importance of a given factor cannot be determined until control can be achieved. Other investigations have dealt with solid or liquid fuels in which fire environmental characteristics are of lesser importance. By conducting our research in a laboratory where ambient conditions could be controlled, the masking tendency of certain ambient conditions could be kept at a minimum.

The present research project on Mechanisms of Fire Spread involves experiments performed as follows:

1. Natural forest fuels were used in fuel beds artificially packed in a random manner.

2. Fuel beds were controlled with respect to type and species of material, moisture content, and compactness of fuel particles. Compactness was controlled to the degree constant loading was achieved.

3. Fires were burned in these fuel beds under controlled conditions of air temperature, relative humidity, and wind velocity.

4. Investigations were aimed at providing information about the influence of both fuel and environment parameters on the mechanisms of fire spread along a segment of the flame front.

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All experiments were performed in a specially equipped forest fire laboratory. The experimental facilities include: a 66-foot-high combustion laboratory where air temperature, relative humidity, and atmospheric pressure can be varied and controlled; a fuels laboratory for preparation of fuel materials; and conditioning cabinets for bringing fuels to required moisture content. Future experiments will include use of two wind tunnels. Results of laboratory experiments are checked by field experiments.

This progress report deals only with experiments measuring rate of fire spread in two forest fuels in the combustion laboratory.

SUMMARY OF RESEARCH RESULTS

To date, 32 experimental fires have been studied in two types of natural, light forest fuels to determine the effects of moisture content on the rate of fire spread and other fire characteristics. The two fuels are beds of ponderosa pine (*Pinus ponderosa* Laws.) and western white pine (*P. monticola* Dougl.) needles. The environmental conditions include: fuel moisture 3 to 16 percent; air temperature 90° to 95° F., and relative humidity 5 to 75 percent.

These 32 experimental fires were preceded by 21 preliminary test fires that were burned to determine the effects of fuel bed width and depth, use of fuel bed side strips, an exhaust system, and to test instrumentation and other experimental techniques.

Results of these experiments show that:

1. Reproducible fuel beds of forest fuels can be made.

2. Forest fuels can be employed in steady-state fire experiments using principles similar to those developed by Project Fire Model as reported in Publication 786, NAS-NRC (Fons et al. 1959).

3. Fire environmental factors can be varied and controlled to permit studies of the effect of moisture content on fire spread.

4. Rate of fire spread in ponderosa pine and white pine needles is a linear function of moisture content within the range of 5- to 15-percent fuel moisture.

5. Residence flame time and flame depth appear to reach a maximum when fuel moisture is between 8 and 10 percent.

6. The rates of fire spread in ponderosa pine and white pine needles are nearly identical for the specific loading and compactness, but ponderosa pine burns more intensely.

BACKGROUND

Forest fire researchers in the United States have developed empirical methods for evaluating and estimating fire spread. Analysis of nearly 3,000 wildfires has shown the importance of fuel, topography, and weather parameters on fire spread (Barrows 1951a, 1951b). More recently Project Fire Model has shown the finite importance of wood fuel characteristics to fire spread (Fons et al. 1962). Experiments to measure fire spread in logging slash have emphasized the importance of fuel species characteristics, fuel amount, and some aspects of weather environment on fire spread and intensity (Fahnestock 1960).

The Committee on Fire Research of the National Academy of Science-National Research Council has emphasized the importance of understanding fire spread in forest fuels. In outlining a proposed fire research program, the committee specifically detailed the following type of studies:

"D. Determination of the Model Laws for Fire Development and Spread

1. Measurements to be made include such items as:

   a. Fuel-system properties and air properties (including temperature, wind velocity, humidity, lapse rate)."

(The Committee on Fire Research 1958)

These backgrounds of research experience and recommendations for a national program of fire research led to the present project on Mechanisms of Fire Spread. The project became feasible with the creation of needed research facilities at the Northern Forest Fire Laboratory (Anonymous 1960).

In 1961 a coordinated research program was started by Washington State University and the Northern Forest Fire Laboratory with the assistance of National Science Foundation grants. Under NSF Grant No. G-16275, Washington State University is performing studies directed toward mathematical and physical modeling of single fuel elements. The Northern Forest Fire Laboratory with the assistance of NSF Grant No. G-16303 is studying the mechanisms of fire spread along a segment of the flame front in natural forest fuels. Both these interrelated studies are aimed at mathematical and physical descriptions of fire spread that can be the basis for future modeling and analysis of the several variables involved in free burning fires.

The initial approach at the Northern Forest Fire Laboratory is based upon a fuel bed model which can be subjected to rather strict environmental control. In this type of model two basic measurements can describe the rate of spread in a simplified equation where rate of spread equals the flame depth over the residence time or $R_s = D/T_r$. Measurement of these parameters will allow investigation of the independent variables and determination of the interrelations. This requires accurate control and/or measurement of such items as moisture content, air temperature and humidity, fuel loading, air velocity, convection column properties, flame temperature and shape, and radiant energy.

The studies are being conducted by Hal E. Anderson, physicist; Richard C. Rothermel, research aeronautical engineer; Erwin H. Breuer and Merlin L. Brown, electronic technicians; and Robert D. Schuette, physical science aid. Charles H. Kaehn, mechanical engineer, participated until October 1962.

RESEARCH AREAS

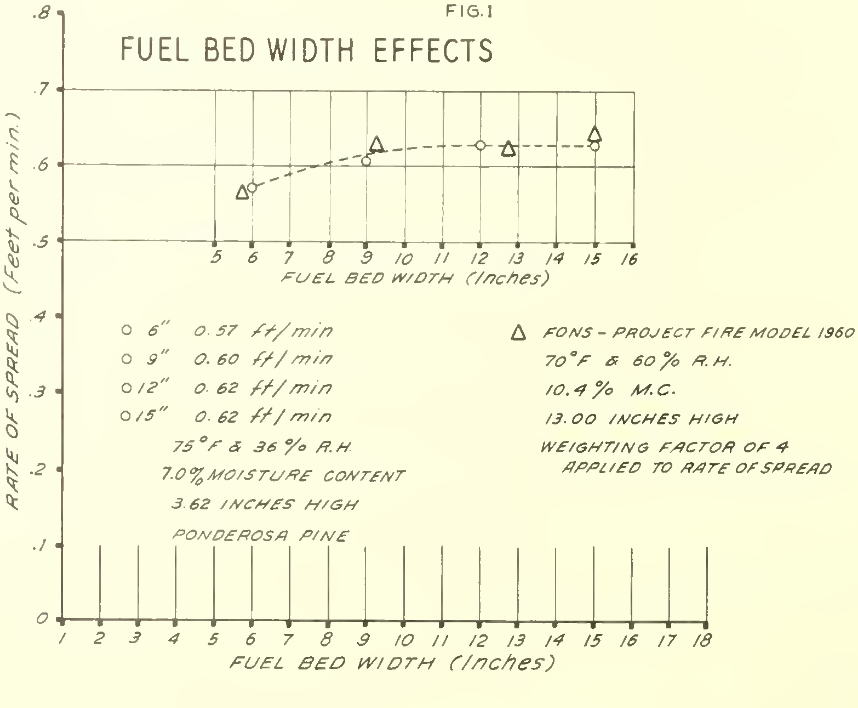
FUEL BED CHARACTERISTICS

Initial studies were directed toward determining the most suitable fuel bed depth, width, and loading for building a fuel bed that would be reproducible. These investigations led to the conclusion that a fuel bed wider than 12 inches and 3 or more inches deep would provide a model in which width and depth do not materially affect characteristics of the rate of spread. The same dimensions have been used for ponderosa and white pine mat-type fuel beds; ponderosa pine beds were used as the test standard, since all preliminary investigations have been made using this fuel. Figure 1 shows the effects of varying fuel bed widths and compares the results of these investigations with ponderosa pine to those conducted by Project Fire Model. The rate of spread for the Fire Model studies was a factor of 4 less and the points shown weighted by this factor.

Figure 2 shows the effects of fuel bed depth upon rate of spread. It indicates that fuel depths greater than 3.0 inches do not influence rate of spread. A comparison with Project Fire Model shows the same characteristic. Fire spread studies show an essentially constant rate of spread for fuel bed depths greater than 3.0 inches. The differences are probably due to fuel size and shape, compactness, and the geometry of the fuel loading.

Fuel loading and distribution presented a problem since we had to maintain constant loading and compactness to have correlation between one set of fires and the next. Loading was maintained at 0.50 pound per square foot wet weight and compactness at 8.33 square inches/cubic inch for ponderosa pine and 9.95 square inches/cubic inch for white pine. Our first loading techniques resulted in an uneven distribution of residue. The method used was to load on

FIG. 1



an equal unit volume loading by filling each 6- by 12-inch area with the proportioned weight to the proper fuel depth. Our present method applies a proportioned amount of fuel to one-third the fuel depth for the fuel bed length and making three layers of fuel. This improved the distribution of residue after burning and provided a more consistent measure of rate of spread.

FUEL CONDITIONING

All of the fires used for studies of rate of spread under the influence of varying moisture content have been burned at a stabilized moisture content. To provide fuel at the proper conditions, preconditioning cabinets were fabricated. Temperature is controlled by use of steam coils and/or refrigerant coils, and humidity is controlled by use of saturated salt solutions. Suitable salts provide relative humidities from 8 to 75 percent. Table 1 shows the various relative humidities and moisture contents that can be achieved at 90° to 95° F. Only freshly cast needles are collected for use in the fuel bed; these are cleaned to remove as much foreign material as possible.

The decided difference between moisture contents of ponderosa pine and white pine is shown in figure 3. Plotted with these data is the equilibrium moisture content curve for wood shown in the U.S. Department of Agriculture's "Wood Handbook." The moisture content curve for ponderosa pine needles is similar to that of wood, but white pine needles show a higher moisture content and a different response curve. This suggests that the light natural fuels have responses to relative humidity that can be quite different from that of wood. The fuels used for these studies were ovendried at 130° F. for 2 hours before being exposed to the test humidities, and were in the preconditioning cabinets for 2 weeks or longer before they were used in a test-fire fuel bed. Moisture contents were determined by the xylene distillation method (Buck and Hughes 1939).

FIG. 2

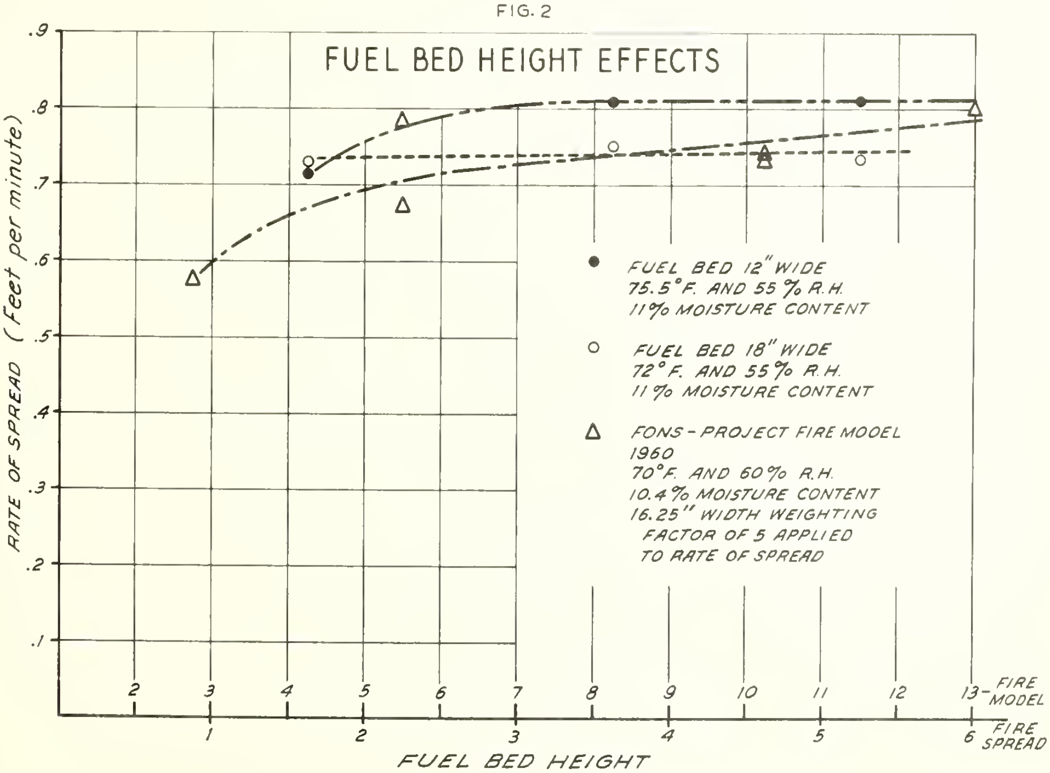


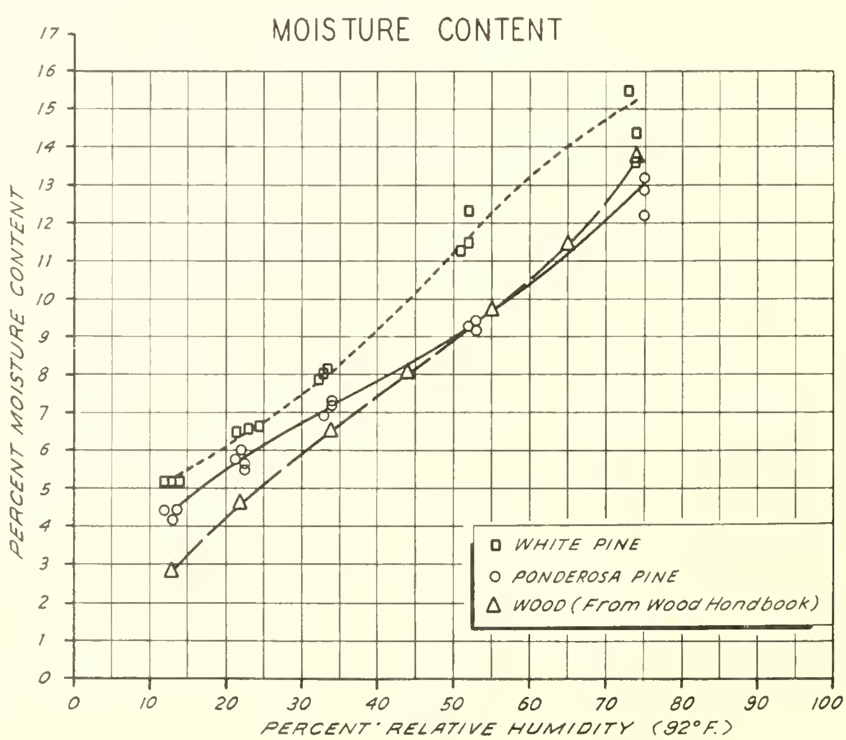
Table 1.--Saturated salt solutions for stabilized moisture contents

Chemical name	Formula	Relative humidity	Moisture content ponderosa pine	Moisture content white pine
		- - - - - - - - - Percent	- - - - - - - - - - - - -	
Potassium hydroxide	KOH	8	3.8 estimated	5.2 estimated
Lithium chloride	LiCl	12.5	4.3 measured	5.6 measured
Potassium acetate	KA_c	22	5.7 "	6.6 "
Magnesium chloride	$MgCl_2 \cdot 6H_2O$	32	7.0 "	7.9 "
Magnesium nitrate	$Mg(NO_3)_2 \cdot 6H_2O$	52	9.4 "	11.7 "
Sodium chloride	NaCl	75	13.4 "	15.2 "

RATE OF SPREAD

The primary objective of this study is to determine the relations existing between rate of spread and moisture content, air velocity, and slope. The influence of moisture content was selected as the initial study so that techniques of measurement and analysis could be developed under conditions exhibiting slower rates of spread and a stable flame, and because of moisture's role in allowing a fire to grow.

FIG. 3



Measurements are made by visual methods and by thermocouples located in the fuel bed with their junctions just at the surface of the fuel. Six chromel-alumel thermocouples of 30-gage material are located on 9-inch centers in the center portion of the 8-foot fuel bed. The signals from these thermocouples drive light-beam galvanometers in continuous recording oscillographs. From the traces thus generated, the rate of spread can be calculated, and by further analysis the residence time[2] can be determined. These thermocouples also indicate the rate of temperature buildup in the fuel before the fire reaches it. The rate of spread values obtained are compared to the visual measurements. Three fires are burned in each fuel at each moisture content condition and checked for repeatability of rate of spread. The percent variation between the visual and thermocouple rate of spread is -4.2 to +3.6 percent for ponderosa pine and -11.5 to +5.5 percent for white pine. Rate of spread plotted against moisture content yields a linear curve (fig. 4).

The rate of spread in the two fuel types is not greatly different; however, other measurements and observations show considerable difference in their combustion characteristics. Figure 4 shows the results of field tests in ponderosa pine (Curry and Fons 1938). Their work shows a probable slower rate of spread over the entire moisture range but a greater change in rate of spread per unit change in moisture content. The plotted points indicate only the probable rate of spread--not measured values. The differences in results of the two studies may be caused by dissimilar loading, in-draft effects of center-firing used by Curry and Fons, and moisture content gradients within the fuel. Fire spread studies will be continued until a minimum moisture content is achieved to determine whether the curve remains linear or becomes nonlinear at low humidities.

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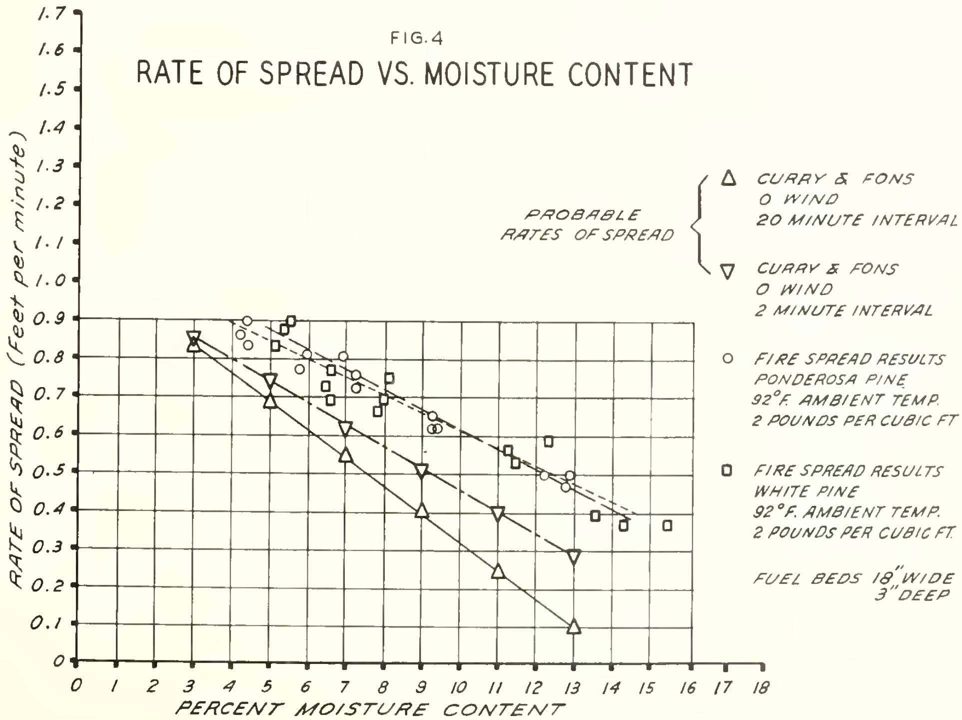
[2] The duration of time a fuel particle or thermocouple is in the flaming zone.



By further analysis of the signals generated by the thermocouples at the surface of the fuel, residence time can be estimated. Analysis included time displacement of each thermocouple's signal when the flame front reached the thermocouples and copying the signal traces. From these grouped traces for each fire, the temperature profile of the base of the combustion zone could be analyzed. Figure 5 shows residence time plotted against moisture content. At moisture content levels between 8 and 10 percent, both fuels show a maximum residence time. By using the data obtained from the thermocouples, which provide both rate of spread and residence time, the flame width can be calculated from the equation $R_s = D/T_r$. Figures 6 and 7 show these values plotted against moisture content and show the visual measured values of flame width for ponderosa pine and white pine, respectively.

FIG 5

RESIDENCE TIME VS. MOISTURE CONTENT

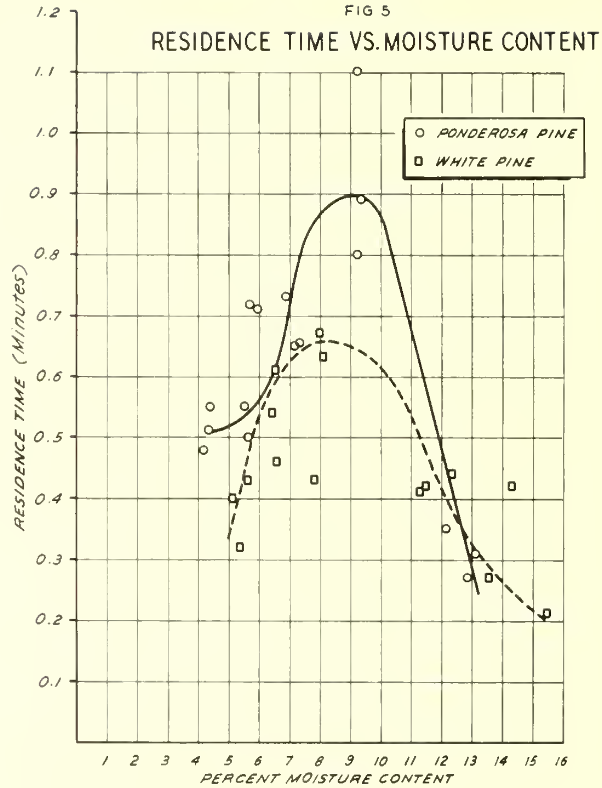
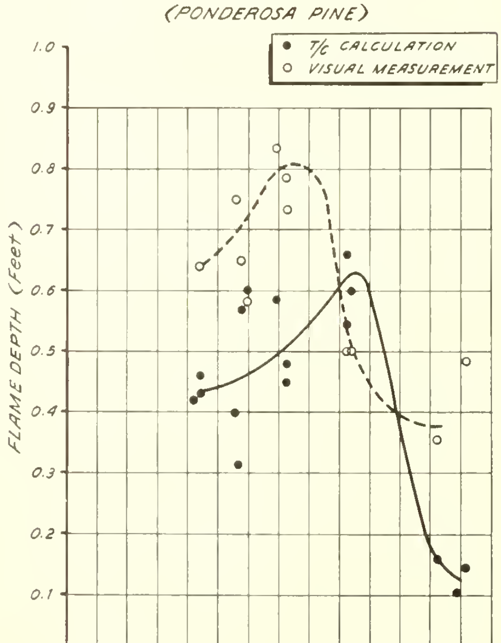


FIG 6

FLAME DEPTH VS. MOISTURE CONTENT

(PONDEROSA PINE)



Flame width was measured by thermocouples and visual methods to compare the two techniques and determine whether measurements could be made in fires where visual assessment was not possible.

Since flame depth is calculated by multiplying rate of spread by residence time, it is expected that flame depth will have a relation to moisture content similar to that of residence time. This is shown by the above curves and verified by the visual measurements also plotted. It is apparent that the human eye sees a wider reaction zone than the thermocouples (fig. 6) since the visual curve encloses greater flame depths. The offset in the peak of the curve may be caused by error in selection of the point where active combustion is considered complete.

RADIANT HEAT

A Gier and Dunkle directional radiometer is used to measure the radiant heat flux at a point in front of the fire. It is placed 18 feet from the fire and vertically positioned to see all of the flame. Shape factor, flame emissivity, and other factors influencing the complete description of the emitted radiant heat were not included in the analysis since only a general indication was desired during these studies. The radiant flux was plotted (fig. 8) against moisture content after correction for ambient conditions. Measurements of radiant flux on both fuel types show a break at 11-percent moisture content, but white pine shows an increasing rate below 8 percent. The radiant flux measurement shows the difference in the amount of energy released by each fuel type, although the rates of spread are nearly the same.

FIG. 7

FLAME DEPTH VS. MOISTURE CONTENT (WHITE PINE)

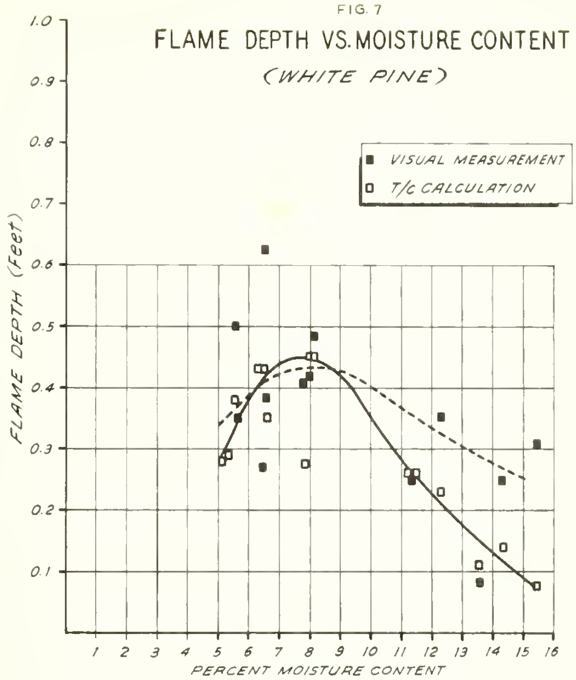
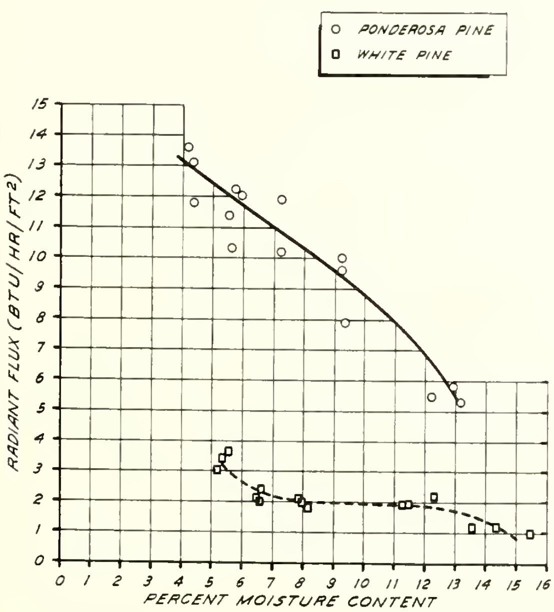


FIG 8

RADIANT FLUX AT 18 FEET VS. MOISTURE CONTENT



Use of the resident thermocouples made possible an initial study of the effective preheating distance for each type of fire. The continuous traces provided an indication of when the first sensible heating occurred; then, by using the average rate of spread, the distance in front of the flame for effective heating could be calculated. These values were calculated and a ratio of preheating distance to average flame height was determined. Figure 9 shows this ratio plotted against moisture content of the fuel. The distribution of points indicates that the most effective conditions for preheating may not be the driest moisture conditions. This may be due to the types of emitting constituents of the combustion products, absorbing elements between the flame and fuel, and variation of flame depth. The instrumentation used for this initial study was not designed for this purpose, and other means of measuring the radiation preheating effects are being investigated.

FLAME AND CONVECTION TEMPERATURES

Five levels of thermocouple networks were used to measure the vertical temperature gradients in the flame and convection column. The residence time thermocouples measured temperatures at the initial fuel surface height. An array of six thermocouples at $1\frac{1}{4}$ inches above the fuel indicated the temperature and profile of the flame at this height. At the 1- and 3-foot levels, three thermocouples on 3-inch centers provided temperature information. Five thermocouples in parallel at 12 feet above the fuel measured the average temperature at this point. Figure 10 shows the temperature profile of both fuels tested. Even though the rates of spread were approximately the same in the two fuel types, the temperature distribution was considerably different. The reason for this difference is shown by the combustion utilization of available fuel.

FIG. 9

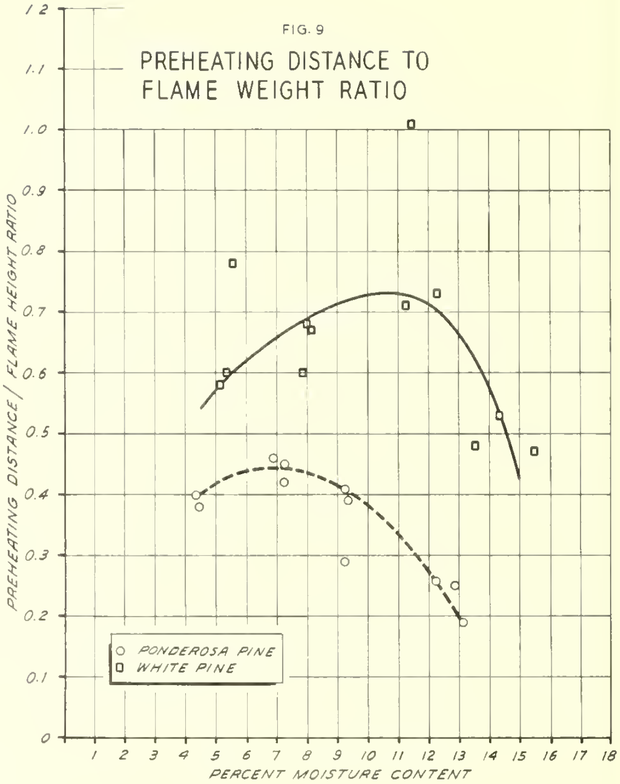
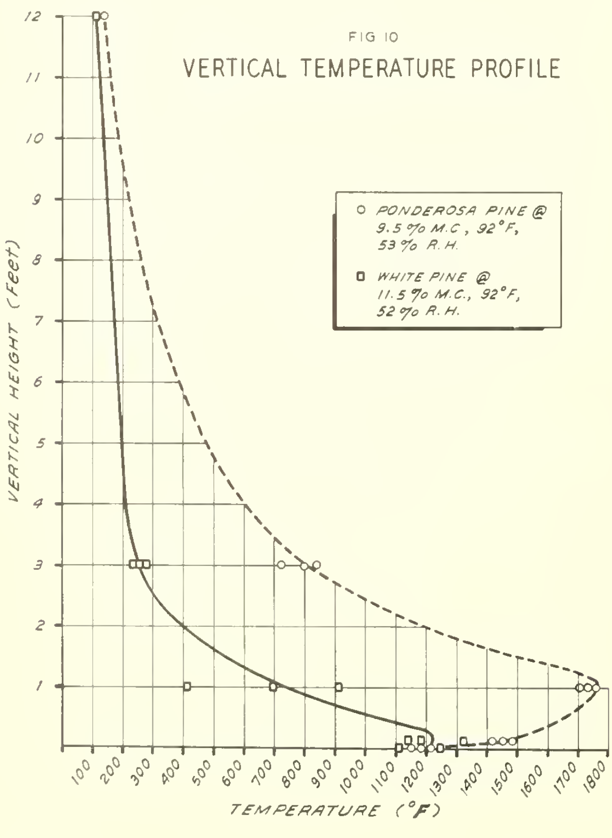


FIG 10



The amount of residue remaining after a ponderosa pine fire ranges from 5 to about 20 percent, but the white pine fires left a residue ranging from 60 to 90 percent of the total fuel load. The physical character of each fuel undoubtedly plays a major role through the volume/area ratio, needle length and thickness, needle warp, and compactness of the fuel. Chemical composition may also be important.

Measurements were taken at the $1\frac{1}{4}$-inch height above the fuel bed in an attempt to measure the flame depth. The results of these measurements to date (fig. 11) are compared to the flame depths calculated from the residence thermocouples. These curves show a considerable difference takes place within the first inch of height above the fuel bed. This behavior may influence visual and photographic techniques of determining flame depth.

OTHER MEASUREMENTS

Convective column velocities have been measured by a Kiel probe and an ionization pressure transducer that can measure 0.0002 inch of water. These measurements are only preliminary, and not enough data have been collected and analyzed to be useful.

The temperature profile of the combustion process could be depicted from the traces of the residence thermocouples. Distinctive flame charactertistics are displayed by each type of fuel. Three zones of combustion are displayed: the flame front; the transitive combustion zone; and the residual burning zone. The flame front, as it encompasses the residence thermocouple, generally is the zone of highest temperature. In a fuel bed of ponderosa pine, the more volatile fuel, the flame front is followed by a zone of lower temperature (transitive combustion zone) that shows little variation. This zone, in turn, is followed by the residual burning zone, characterized by an increase in temperature and perturbation that builds to a maximum and then declines as the heat generation diminishes within the fuel bed.

FIG. 11

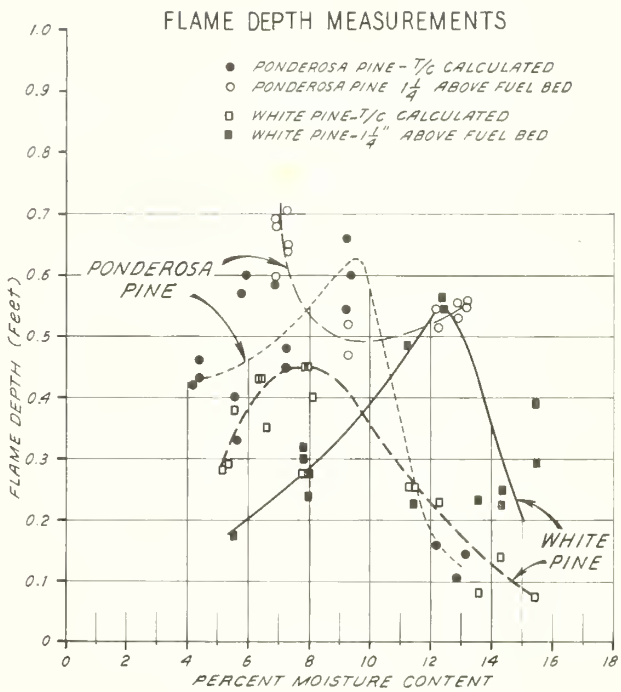
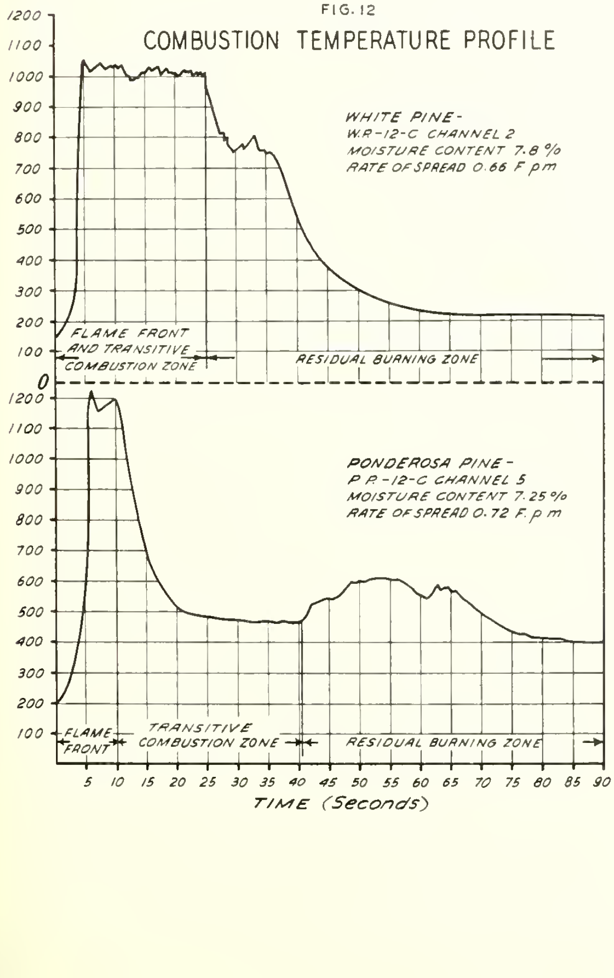


FIG. 12



The white pine fires exhibit a different profile. The rise in temperature induced by the advancing flame front is sustained but rather erratic; then comes a sharp drop in temperature, followed by slowly diminishing temperatures. In these burnings of white pine needles, the flame front and transitive combustion zone have merged, and the sharp drop in temperature represents passing from the transitive combustion zone to the residual burning zone. The residence time in these studies has been the duration of time the thermocouple was in the flame front and transitive combustion zone. Figure 12 shows the general profile displayed by each type of fuel. Temperatures in the gas evolution zone may vary from 450° to 750° F. in the ponderosa pine fires.

Continued study of the characteristics exhibited by the fuels already tested and of additional fuels, plus study of the influence of wind and slope, should provide information leading to better understanding of characteristics of free burning fire and to more accurate evaluation of fire-danger potentials.

CONCLUSIONS

1. Steady rates of spread are obtained in mat-type beds of light forest fuels.

2. Rate of spread may be nearly identical for different types of forest fuels, but the fire intensity may differ greatly.

3. Rate of spread is a linear function of moisture content between 5- and 15-percent equilibrium moisture content.

4. Residence time and flame depth are not linear functions of moisture content but appear to be complex variables.

5. Stabilized moisture contents for various natural light forest fuels may deviate several percent from the equilibrium moisture content curve for wood at the same conditions.

6. Radiant flux at a point forward of the fire front is nearly linear with moisture content, but a slight rolloff occurs at about 11-percent moisture content.

7. Preheating of the fuel can be observed. Further refinement of instrumentation will make possible a description of this process.

8. Chemical properties and physical characteristics of fuel affect the intensity of the fire but appear to have little effect upon rate of spread.

9. Rate of spread is sensitive to the loading and compactness of the fuel; but by proper procedures, reproducible fuel beds can be made.

10. Application of techniques developed by Project Fire Model studies allows the investigation of fire spread in natural fuels as well as wood cribs.

11. Vertical temperature gradients indicate fire intensity and also indicate the flame boundary temperature to be approximately 700° F.

12. Proper use of thermocouples may enable a detailed analysis of combustion zone characteristics.

PROJECTED STUDIES

The studies of moisture content relations will be continued to a minimum moisture content, expected to be 3 percent. Remaining points to be checked include a rerun at 14-percent relative humidity, 8-percent relative humidity, and 5-percent relative humidity or less. No salt has been found for less than 5-percent relative humidity, but silica gel as a dry desiccant will be used. A method of weighing the fuel bed during the fire is being developed to provide a measure of the combustion rate. This is considered essential to basic understanding of the processes involved.

After we complete the moisture content study, we expect to incorporate wind variations into the tests using the low-speed wind tunnel. Tests will be run at three or more windspeeds between 1 and 5 miles per hour with at least three different moisture content levels.

Experiments with variation of slope will be started after completion of studies of moisture and wind. We shall first run a series under no-wind conditions; later we shall add changes in moisture content and then changes in wind condition.

As these studies progress and we develop an understanding of the phenomena involved, we expect to formulate equations that describe the reactions and interrelations that link fire characteristics to fire propagation.

Table 2.--Summary of test data

Fire identification: Fire No.	Run No.	Fuel information: Fuel wt.	M.C. %	Dry wt.	Heat content per lb.	Total B.t.u. content	Laboratory conditions: T_D °F	% R.H.	Radiant flux B.t.u./hr./ft.^{2}: Max.	Ave.	Flame and convection column temperatures °F: Fuel level	1½"	4"	1'	2'	3'	4'	8'	12'	Flame height: Visual[4] ft.	Flame depth F_D (ft.): Visual	$F_D=(R_s)(t_r)$ T/C	Residence time t_r (min.): Visual	T/C	Rate of spread (ft./min.): Fuel T/C	Obs.
pp-1-C[1]	1	6.00	4.20	5.75	8869	51,000	93	13	15.4	13.6	1162	1645	675	122	1600	495	123	156	144	3.2	0.7[5]	0.42	0.01[5]	0.50	0.845	0.857
pp-2-C	1	6.00	4.41	5.73	8869	50,800	92.5	13.5	15.6	11.8	860	----	1046	567	1016	646	327	208	143	3.2	0.7[5]	0.43	0.01[5]	0.50	0.860	0.830
pp-3-C	2	6.00	4.38	5.74	8869	50,900	92	12	15.6	13.1	1057	1394	1587	434	249	761	123	208	143	3.8	0.64	0.46	0.77	0.51	0.900	0.893
wp-1-C[2]	1	6.00	5.16	5.69	8476	48,300	93	14	5.8	3.0	1048	----	1050	122	156	264	101	125	116	0.9	0.4[5]	0.57	0.66	0.34	0.855	0.830
wp-2-C	2	6.00	5.55	5.67	8476	48,000	92	13	4.2	3.6	1064	1503	1371	122	106	317	95	126	115	1.1	0.50	0.58	0.62	0.40	0.942	0.893
wp-3-C	2	6.00	5.37	5.68	8476	48,100	93	12	3.7	3.4	721	1420	868	151	156	250	93	112	112	1.0	0.35	0.55	0.64	0.34	0.865	0.876
pp-4-C	3	6.625	13.15	5.75	8869	51,000	92	75	6.1	5.3	1020/697[3]	1417/1217		1801/1350		722/682			133/127	3.2	0.48	0.15	0.93	0.31	0.470	0.461
pp-5-C	4	6.625	12.21	5.82	8869	51,600	91	75	6.6	5.5	911/729	1520/1233		1612/1209		599/543			124/118	3.2	0.36	0.16	0.63	0.32	0.495	0.494
pp-6-C	6	6.625	12.88	5.77	8869	51,200	92	75	7.8	5.8	1025/779	1468/1300		1619/1333		614/553			135/122	3.3	0.06[5]	0.11	0.35	0.21	0.495	0.493
wp-4-C	4	6.625	14.33	5.73	8476	48,500	91	74	2.4	1.2	968/683	1372/1002		437/405		252/202			106/97	0.75	0.25	0.14	0.77	0.36	0.386	0.365
wp-5-C	5	2.208	17.62	1.82	8476	15,400	92	74	1.1	0.8	553/399	1046/		298/246		160/132			102/100	0.50	0.12					0.421
wp-6-C	5	6.625	13.59	5.72	8476	48,500	92	74	1.9	1.2	985/686	1256/1031		526/424		179/177			105/102	0.79	0.08[5]	0.11	0.28	0.28	0.405	0.388
wp-7-C	6	6.625	15.47	5.60	8476	47,400	93	73	1.8	1.0	965/671	1336/1070		630/511		260/226			108/105	0.88	0.32	0.07	0.85	0.21	0.344	0.362
pp-7-C	7	6.375	9.26	5.76	8869	51,100	91	52	10.2	9.6	1180/930	1452/1329		1714/1253		798/690			141/128	4.0	0.50	0.66	0.81[6]	1.1	0.60	0.616
pp-8-C	8	6.375	9.39	5.78	8869	51,300	92	53	9.8	7.9	1150/1034	1419/1331		1733/1380		724/661			141/128	4.0	0.50	0.60	0.81[6]	0.95	0.63	0.616
pp-9-C	9	6.375	9.26	5.76	8869	51,100	92	53	11.7	10.0	1215/919	1481/1333		1755/1372		839/715			141/132	4.0	0.50	0.55	0.93	0.87	0.625	0.648
wp-8-C	7	6.375	11.48	5.64	8476	47,800	92	52	2.4	1.9	1111/954	1144/782		412/362		239/234			111/103	0.86	0.08[5]	0.26	0.15[6]	0.48	0.55	0.525
wp-9-C	8	6.375	11.28	5.66	8476	47,950	92	51	2.6	1.9	1155/1042	1189/815		701/618		259/243			118/105	1.20	0.25	0.26	0.43[6]	0.48	0.54	0.569
wp-10-C	9	6.375	12.32	5.59	8476	47,300	92	52	2.5	2.2	1250/923	1324/1102		911/655		285/261			114/108	1.17	0.35	0.23	0.85	0.43	0.55	0.584
pp-10-C	10	6.187	6.92	5.76	8869	51,100	92	33	---	---	1042/848	1399/1299		1721/1480		717/501			142/129	3.4	0.83	0.65	0.90	0.73	0.804	0.803
pp-11-C	11	6.187	7.28	5.74	8869	50,900	92	34	13.2	11.9	1259/890	1371/1269		1636/1311		780/660			144/133	4.0	0.73	0.64	1.00	0.58	0.735	0.756
pp-12-C	12	6.187	7.25	5.74	8869	50,900	91	34	12.3	10.2	1221/993	1496/1291		1680/1406		893/708			147/134	3.8	0.78	0.70	1.07	0.65	0.690	0.720
wp-11-C	10	6.187	8.13	5.68	8476	48,100	92	33.5	2.5	1.8	1151/862	1356/1101		764/656		284/227			123/109	1.3	0.48	0.40	0.67	0.60	0.758	0.746
wp-12-C	11	6.187	7.84	5.70	8476	48,500	92	32.5	2.4	2.1	1209/900	1151/939		561/468		528/329			114/106	1.1	0.41	0.31	0.63	0.43	0.585	0.661
wp-13-C	12	6.187	8.00	5.69	8476	48,300	92.5	33	2.7	2.0	999/729	1173/923		814/543		244/192			115/109	1.1	0.42	0.25	0.58	0.64	0.684	0.691
pp-13-C	13	6.00	5.96	5.64	8869	50,000	91	22	14.18	12.04	1189/894	1445/1306		1497/1222		712/456			147/128	3.58	0.579	0.60	0.824	0.720	0.830	0.809
pp-14-C	14	6.00	5.54	5.67	8869	50,300	91.2	22.5	13.08	11.40	1078/901	1603/1339		1515/1146		818/657			140/127	3.17	0.750	0.40	0.803	0.550	0.719	0.723
pp-15-C	15	6.00	5.64	5.66	8869	50,200	92	22.5	11.18	10.32	1135/829	1348/1253		1578/1144		821/605			141/127	3.16	0.750	0.33	0.898	0.500	0.669	0.673
wp-14-C	13	6.00	6.46	5.61	8476	47,510	91.5	21.5	2.62	2.10	1115/988	1259/1072		551/454		241/190			112/107	0.745	0.270	0.43	0.570	0.540	0.804	0.724
wp-15-C	14	6.00	6.53	5.61	8476	47,510	91.5	23.0	2.50	2.00	1142/979	1352/1130		500/478		253/199			115/106	0.980	0.625	0.43	0.470	0.610	0.714	0.687
wp-16-C	15	6.00	6.61	5.60	8476	47,450	92.0	24.5	3.10	2.40	1236/865	1339/1138		771/543		408/357			114/108	0.892	0.383	0.35	0.556	0.460	0.753	0.767
pp-16-C	16	6.00	5.76	5.65	8869	50,110	92	21.5	13.72	12.20	1268/1045	1367/1183		1553/1364		824/597			150/130	3.44	0.650	0.57	0.846	0.730	0.781	0.769

[1] pp = ponderosa pine
[2] wp = white pine
[3] Peak temperature/average maximum: used for all positions above fuel bed.
[4] Visual measurements made by observer at time of fire. Time lapse movies also made but not included at present.
[5] Observations made of narrow flame front preceding transitive combustion zone.
[6] Calculated from observed rate of spread and flame depth.

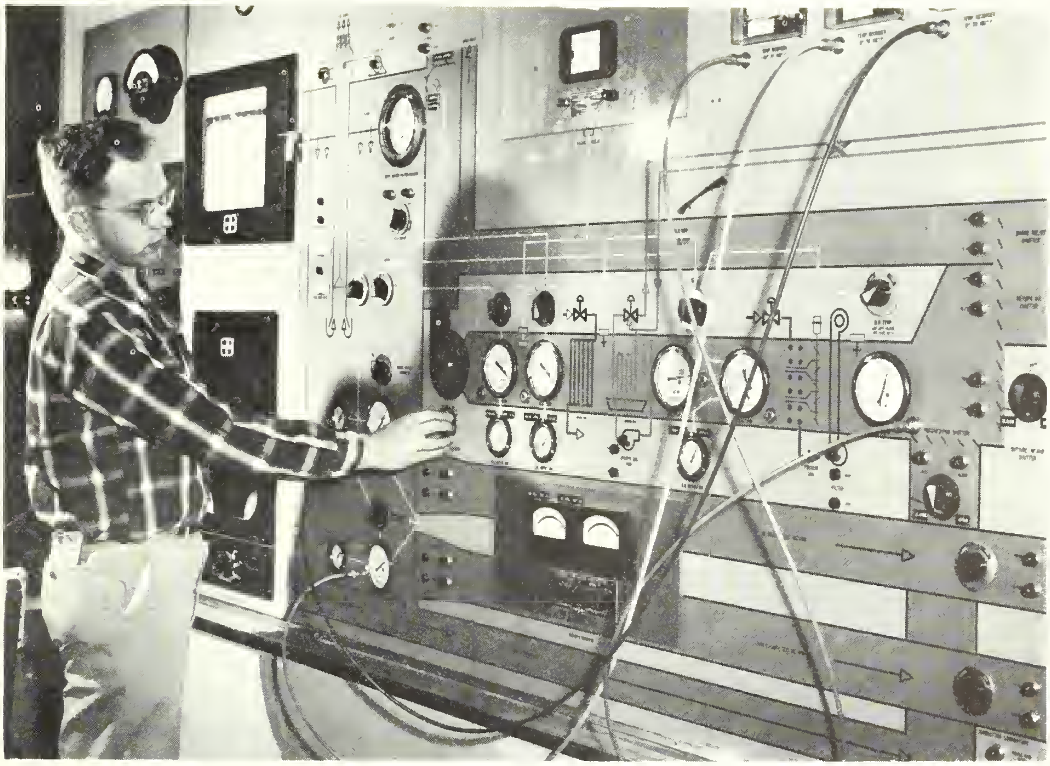


Figure 13.--Control panel for maintaining test conditions in the combustion laboratory and wind tunnels.

Figure 14.--Recorders used in measuring temperature, air velocity, radiation, and humidity.

Figure 15.--Environmental chambers used to precondition fuels prior to a test series.

Figure 16.--Prototype fuel bed similar to those used during these studies.

Figure 17.--General view of combustion laboratory during an experimental fire.

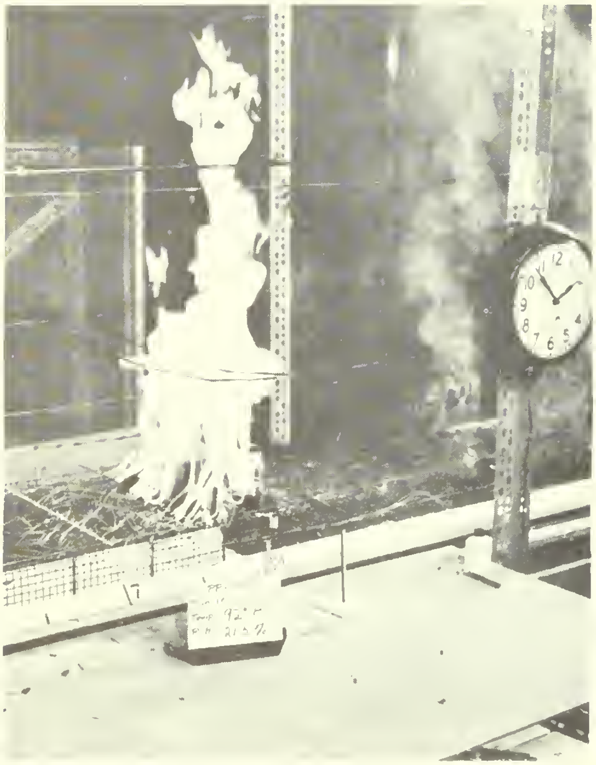


Figure 18.--Rear view of fire front showing dark zone directly behind flame front of ponderosa pine fire.

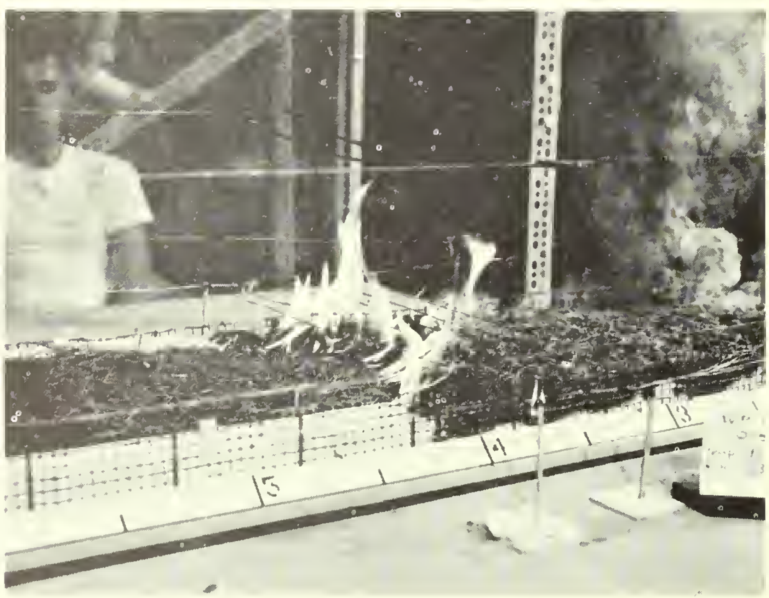
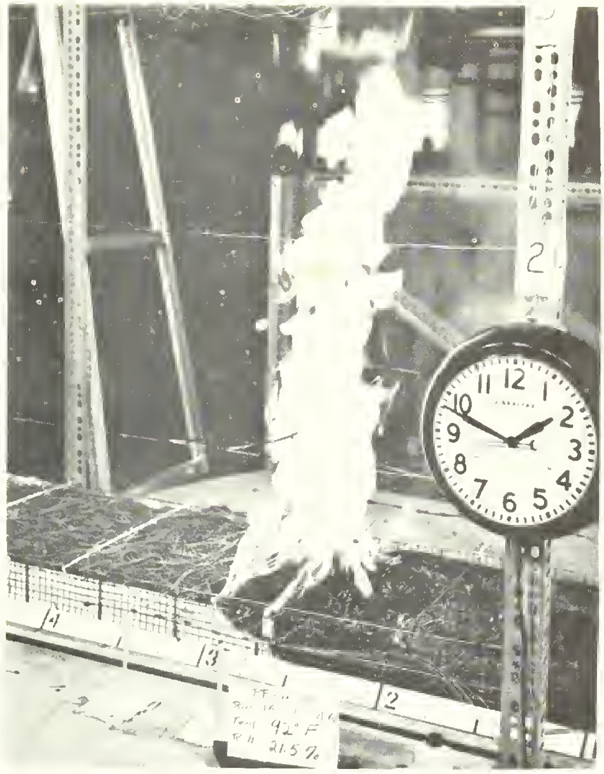


Figure 19.--Rear view of fire front in white pine needles. Comparison with figure 18 shows differences between ponderosa pine and white pine fires.

Figure 20.--Front view of ponderosa pine flame front.



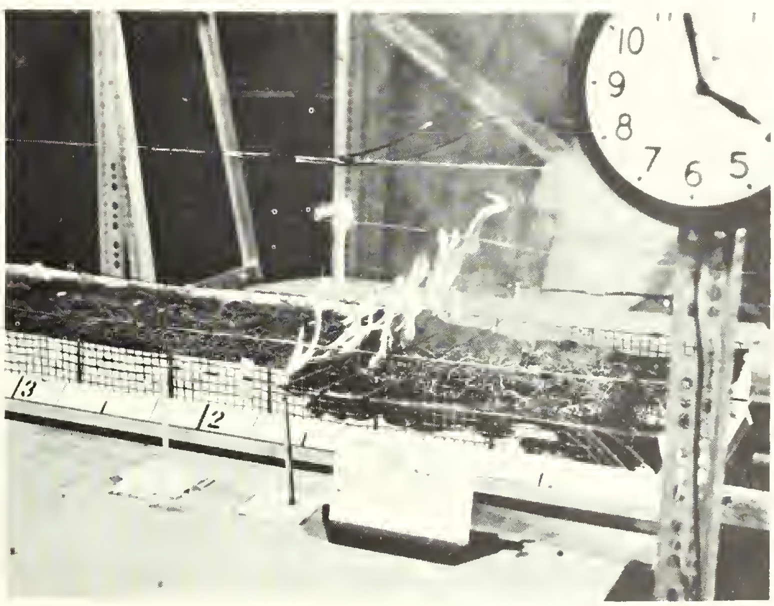


Figure 21.--Front view of white pine flame front.

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ROOTS OF A PONDEROSA PINE

by

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ROOTS OF A PONDEROSA PINE

James D. Curtis [1]

At best a silviculturist has difficulty in deciding whether a tree should be cut or left in a stand. Actually he can see only half the tree--the half that is above ground. He knows neither the extent nor the condition of the half beneath ground even though it may, to some extent, be revealed by the crown. He uses various criteria to make his decision depending on the species, age, density, composition of the stand, the condition of the tree, and the market for forest products. And yet, the condition of the aerial part of the tree depends on the condition and arrangement of the subterranean parts. For mature and overmature stems this disadvantage is not very important, but familiarity with and knowledge of tree root systems in weedings, improvement cuttings, and thinnings enable the silviculturist to gain proficiency in marking and thus leave his stand in a better condition than he would otherwise leave it.

An obvious deficiency in silvical information about many tree species is a lack of knowledge of the development, arrangement, and functioning of root systems, particularly in the 25th to the 75th year age group. This deficiency may be due to the work involved in exposing all the roots of a sizable tree without undue damage. Again, it is virtually impossible to find a "typical" tree. Our knowledge of root systems of middle-aged North American conifers in natural stands is confined, with several notable exceptions (Berndt and Gibbons 1958; Bishop 1962; Cheyney 1932; Heyward 1933; Horton 1958; McQuilkin 1935; Woolsey 1911; Yeager 1935), to windthrown individuals and others whose root systems have been exposed by soil disturbance caused by land clearing, roadbuilding, and massive or limited sloughing. Windthrown trees are a precarious basis for judging the nature of a species' root habit, but they may provide a clue (Büsgen and Münch 1929).

The causes of tree root variation are the depth and nature of soil and the height of the water table which, in turn, determine (1) the availability of oxygen and moisture, and (2) the frequency and nature of obstructions through which roots cannot pass (Büsgen and Münch 1929; Kramer 1949). Several investigators point out that although a species usually has a typical root system, this trait is by no means consistent (Berndt and Gibbons 1958; Büsgen and Münch 1929; Horton 1958; Jeffrey 1959; Yeatman 1955). The difficulty arises in knowing when this variation occurs because obviously it can modify silvicultural practice. To guide his choice, the tree marker can observe only surface configurations, soil characteristics, and condition and appearance of the tree. Nevertheless, if he can keep in his mind's eye the general nature of the root system of the species with which he is dealing, he will do a better job of marking.

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[1] Research forester, Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, stationed at Boise, Idaho.

What *is* the arrangement of a ponderosa pine root system?

This question and the limited study of root systems of this species (Woolsey 1911; Yeager 1935) prompted the writer in 1950 to investigate the root system of a 16.9-inch d.b.h., 60-year-old ponderosa pine 67 feet high.[2] The tree was a vigorous dominant specimen growing in a stand supporting a basal area of 95 square feet per acre in Boise Basin Experimental Forest, Idaho City, Idaho. The exposure was easterly and had about a 15-percent slope. Availability of a good water supply and sufficient equipment enabled most of the excavating to be done by washing. The coarse granitic loam soil contained many large aggregates; as excavating proceeded, it became apparent that the tree was beside a diorite formation. Hence, it became necessary to alternate the washing with hand-picking tools and to vary the pressure of the water stream to avoid injury to the small roots. The excavating started in mid-July and continued intermittently until September 6.

Besides the diorite, the soil included sandy loam and gravelly loam. Most of the lateral root system was growing in the sandy loam. The diorite formation was near the surface at the downhill base of the tree, but also extended up the slope above it. On the uphill side the coarse gravelly loam covered a gravel bed to a depth of a little more than 2 feet.

The direction of main lateral root growth appeared to be closely related to the soil type in which the roots grew. In the loose gravelly soil, which had small stones throughout, the roots grew in a generally straight-line direction. Where the soil was compacted and contained larger stones, the root direction changed often. Main root growth in the diorite formation followed fissures and cleavage planes. The ends of several main laterals were dead up to 43 percent of their length and therefore were not mapped.

All the main lateral roots were excavated, their directions determined, and their diameters and depths measured. Wherever a main lateral forked, only the larger fork was followed and mapped. The taproot and sinker roots were traced as far as hardness of the substratum permitted--never more than 50 inches. Secondary laterals were tallied by diameter by 5-foot lengths along the main laterals. Sections of several main laterals near the trunk were cut and removed after measurement to facilitate excavation of roots close to or beneath them. Because of the recording and plotting system followed, the delineation of the root system and the tally of the roots present a conservative picture.

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[2] The author gratefully acknowledges assistance of Richard H. LeDosquet, Bureau of Land Management, Fairbanks, Alaska, in the excavating.

The appearance of the root system in plan and in west elevation and a projection of the live tree crown perimeter are shown in figure 1. Several interesting facts are readily apparent:

1. The arrangement and extent of main laterals are uneven.

2. The root system extends horizontally further than the radial spread of the tree's crown.

3. Most lateral roots and their rootlets are located within 18 inches of the ground surface; only the main taproot and the sinker roots penetrate to greater depths.

4. Some of these lateral roots extend considerable distances from the trunk (53 feet straight line) and can be within an inch or two of the mineral soil surface.

5. The horizontal area designated by joining the adjacent live ends of lateral roots is larger (5.4 times) than the projection of green crown.

6. More of the root system is on the downhill side than on the uphill side, an observation recorded by others (Berndt and Gibbons 1958; Büsgen and Münch 1929; McMinn 1955[3]).

7. Most of the sinker roots lie close to the stem.

8. The taproot forks at a depth of about 25 inches.

Figure 1 could not show that the proximity of other trees apparently did not affect the direction of the main laterals of the study tree.

Table 1 records the numbers of rootlets by their diameter and their distance from the main trunk. From this table and from root measurements the following facts can be noted:

1. More than 73 percent of primary and secondary laterals were located in 18 inches (between 6 and 24 inches beneath the ground surface) of soil.

2. More than 92 percent of primary and secondary laterals were found in the first 24 inches of mineral soil.

3. Nearly 85 percent of the secondary roots were in the 0.10- to 0.25-inch diameter class, and 98 percent were 1 inch or smaller in diameter.

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[3] McMinn, R. G. Studies on the root systems of healthy and pole blight affected white pine (Pinus monticola Dougl.). Canada Dept. Agr. Sci. Serv. Interim (unpub.) Rpt., 31 pp., illus. 1955.

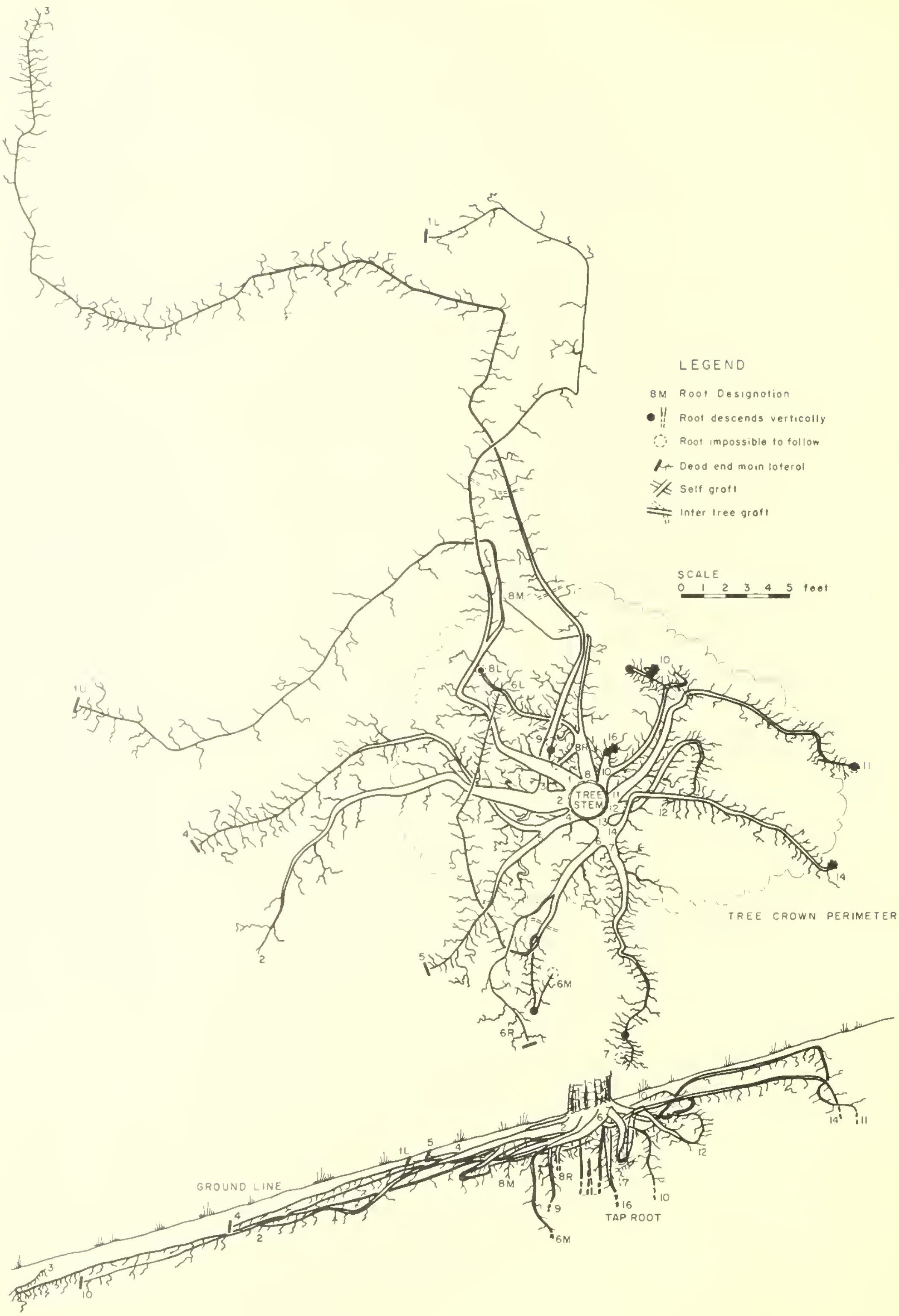

Figure 1.--Root system of a 60-year-old ponderosa pine in plan (above) and in elevation (below).

Table 1.--Numbers of rootlets on main laterals by diameter and distance from main trunk

Root diameter (inches)	Distance from main trunk (feet)														Total	Distribution
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70		
	Number															Percent
0.10-0.25	249	311	198	113	29	29	68	63	37	17	23	14	13	43	1,207	84.6
.26- .50	43	38	14	11	6	5	7	5				2			131	9.2
.51-1.00	26	11	8	4	1	4	1	2	1						58	4.1
1.10-1.50	15	3	1												19	1.3
1.60-2.00	8														8	.6
2.10-2.50	1														1	.2
2.60-3.00	2														2	
Total	344	363	221	128	36	38	76	70	38	17	23	16	13	43	1,426	
Percent	24.1	25.5	15.5	9.0	2.5	2.6	5.3	4.9	2.6	1.2	1.6	1.1	.9	3.0		100.0

4. Close to 50 percent of secondary laterals were within 10 feet of the tree stem, 65 percent within 15 feet, and 75 percent within 20 feet. Similar relations have been recorded for Scots pine (Kalela 1954). Moisture measurements made at the end of the growing season in a 16-year-old loblolly pine plantation suggest that this species has a similar pattern of rootlet density. Available soil moisture was greatest at points furthest from the stems and lowest a few inches from them (Douglass 1960).

5. Lengths of main laterals varied from 45 to 797 inches; three exceeded 700 inches, and eight exceeded 200 inches.

6. The total of live main lateral root lengths was 4,801 inches.

7. Most of the sinker roots were within 3 feet of the stem (see fig. 1).

8. In addition to the main laterals (fig. 1), 19 other roots emanated from the main root collar. All of these were less than 3 inches in diameter; 14 were less than one-half inch in diameter, and none were of significant length. They may well have been adventitious roots.

The taproot of Pinus ponderosa is believed to have four xylem strands and the lateral roots may have two, three, or four.[4] Because secondary laterals usually originate opposite these xylem strands, and because in this instance the roots are assumed to be triarch, figure 1 in plan shows only two-thirds of the total root tally and in elevation only one-third.

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[4] According to Dr. K. Esau, Department of Botany, University of California, Davis, California, through courtesy of Dr. N. T. Mirov, formerly with the Pacific Southwest Forest and Range Experiment Station, Berkeley, California.

During the excavation, several general observations were made. In spite of the large number of rootlets measured, very few growing tips were found, a condition common on plants in soils having little surface moisture (Kramer 1949). The sinker roots, together with some laterals, disappeared into crevices in the diorite or hardpan and could not be traced to their ends. Most, but not all, main laterals developed independently and avoided their neighbors (fig. 1). Eight instances of what appeared to be true intraspecific grafting and one interspecific (with aspen) were noted as well as several instances of self-grafting--phenomena that have been recorded for other species (Bormann and Graham 1959). The taproot was excavated to a depth of 35 inches; the diorite prevented further digging. Sinker roots sometimes grow deeper than taproots (Büsgen and Münch 1929), but no comparisons could be made in this study.

A light surface fire had burned through the stand 5 years previous to the excavation, and apparently had killed some of the root ends. However, the dying of roots and their parts from various causes is apparently a common occurrence (Büsgen and Münch 1929).

A striking feature of the exposure of the main laterals was the competition provided by the dense network of herbaceous and woody ground cover in the top 18 inches of soil (fig. 2). In fact, this competition, judged by the number of rootlets tallied, and

Figure 2.--A main lateral 45 feet from the main trunk and 10 inches beneath the soil surface lies just below this root mass. This root has few secondary laterals and little taper, giving the "ropelike" appearance described by other investigators.

the number observed on the laterals of neighboring trees, was much greater than that of other tree roots. A similar situation was recorded in the Lake States where, out of a total of 33,829 inches of rootlets in a square yard, more than half, or 18,879, were other than tree roots (Cheyney 1929). Elimination of this competition might have a pronounced effect on growth of the stand. A correlation between the amount of this ground cover and diameter growth of the stand above it was found in preliminary studies in Oregon.[5]

The tenacity for life of trees is well known (Kramer 1949), but it is illustrated quite forcefully by this tree. The root system described here was exposed and partly eliminated in 1950; only the forked taproot and some sinker roots remained. In the 10 years since excavation, radial growth has been only 0.15 inch compared to 1.0 inch during the 10 years prior to excavation. Although the crown had an unhealthy appearance for several years, the crown color and annual height growth now appear to be normal.

Inasmuch as ponderosa pine is considered a species whose root habits are fixed by heritability (Kramer 1949), some silvicultural guides can be noted for consideration.

1. Many main laterals are close to the surface and can be injured, even severed, by surface fires and logging activity.

2. The root system extends over an area several times the size of the projected crown. For 18 eastern hardwood trees (17 to 104 years old) this ratio was 4.5 to 1 (Stout 1956). For this ponderosa pine it was 5.4 to 1. Competition may therefore be greater beneath ground than above it because root systems have more overlapping than crowns. Thinning could decrease this competition.

3. Because the greatest concentration of secondary laterals is within a radius of 10 feet of the bole, and because all the sinker roots are close to the stem (on this tree, about 3 feet from it), thinning near selected crop trees should produce the greatest benefit. This effect of release in terms of diameter growth has been demonstrated for central Idaho (Curtis 1952).

4. Root grafting can be lessened by thinning, but this would be entirely on a chance basis. Any benefit to uncut trees would depend on the respective sizes of the trees cut and left.

5. Ponderosa pine is recognized as an inherently taprooted species, but it can also have sinker roots close to the trunk.

---

[5] Correspondence with E. L. Mowat, formerly with the Pacific Northwest Forest and Range Experiment Station, Bend, Oregon.

6. There appeared to be more competition for the rootlets of the tree's main laterals from roots of lesser vegetation than from the roots of other trees. Judicious early thinning and application of selected herbicides might reduce this competition from the undergrowth.

7. The area contained within the perimeter of the primary lateral root ends is not fully utilized by the tree. Because roots develop in soil where there are moisture and nutrients (Kramer 1949), roots of neighboring trees can encroach into zones presently unoccupied.

SUMMARY

The root system of a 60-year-old, 67-foot-high ponderosa pine was excavated for examination in central Idaho. Soil removal was achieved by washing and careful picking. All main lateral roots were exposed, mapped, and measured. The taproot and sinker roots were traced as far as hardness of the substratum permitted--never more than 50 inches. Secondary laterals were tallied by 5-foot lengths along the main laterals. More than 3 percent of the primary and secondary laterals were located between 6 and 24 inches beneath the ground surface. Ninety-eight percent of secondary roots were 1 inch or smaller in diameter. Lengths of laterals varied from 45 to 797 inches. The root system extended over an area 5.4 times the size of the projected tree crown. More of the root system grew on the downhill side than on the uphill side.

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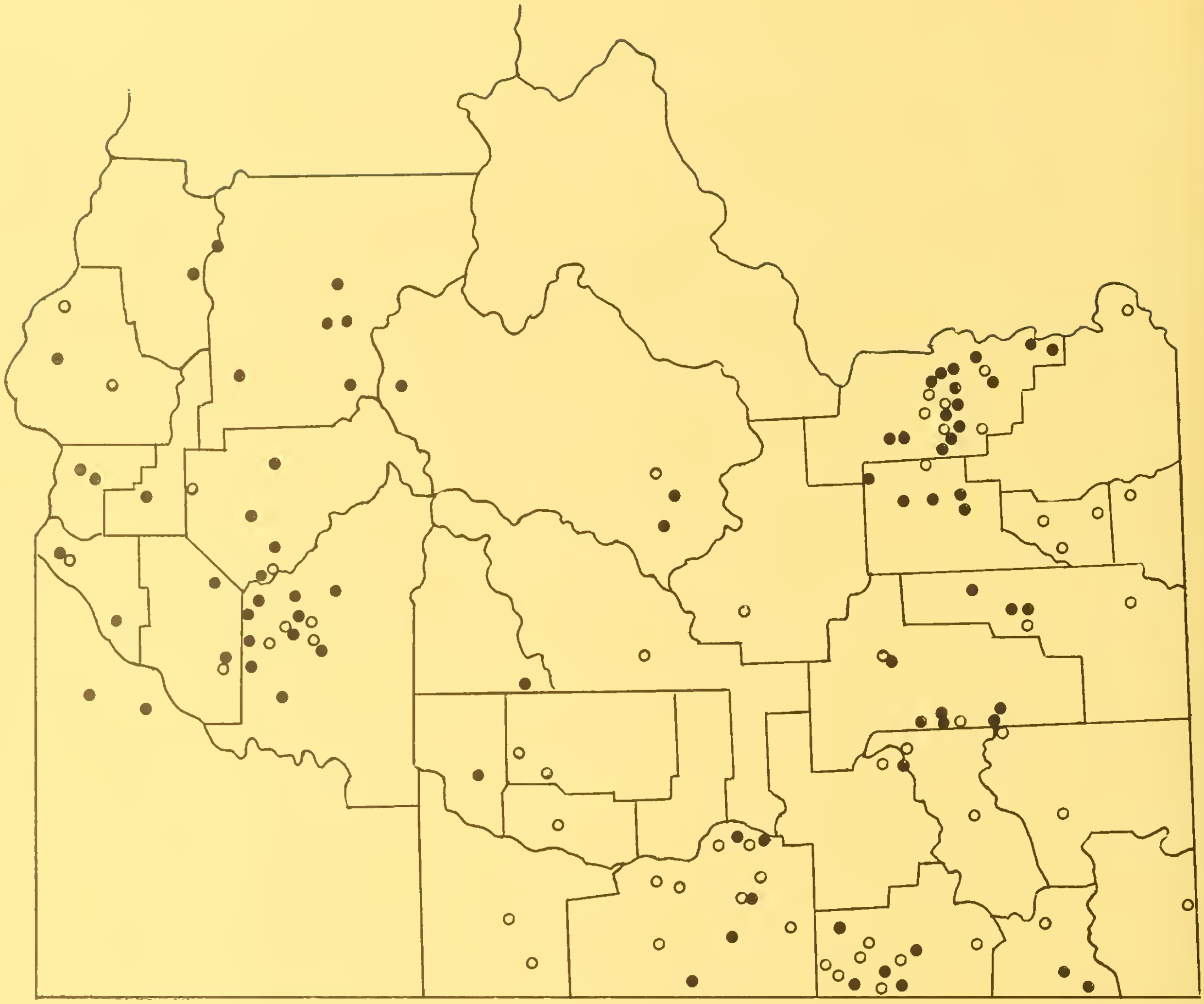

Sites of experimental (•) and large-scale (o) seedings in southern Idaho on which this paper is based.

COVER PHOTO

Cattle on seeded crested wheatgrass range near Willow Creek, Boise National Forest, Elmore County, Idaho

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SEEDING SOUTHERN IDAHO RANGELANDS

by

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PREFACE

This publication summarizes available information and experience to serve as a guide to range seeding. Recommendations are based primarily on results of experimental seedings made since 1936 in southern Idaho. More than 230 species have been planted in more than 13,000 plots at 79 locations. Many large-scale seedings have been observed to check the soundness of recommendations for species, methods, and management practices. Locations of the experimental and large-scale seedings are shown on the map inside the front cover. Results of some of the research have been published previously. This publication reviews published information and presents additional information previously unpublished.

The studies were planned to determine adapted species and to develop effective methods of seeding southern Idaho rangelands. Many of the seedings were grazed. They show the relative palatability and grazing tolerance of individual species. The studies and large seedings have shown that seeding can be a profitable investment.

Much of the work reported here was cooperative with ranchers. Cooperating agencies included the Agricultural Research Service, Soil Conservation Service, and Forest Service, U.S. Department of Agriculture; the Bureau of Indian Affairs, and Bureau of Land Management, U.S. Department of the Interior; and the University of Idaho.

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SEEDING SOUTHERN IDAHO RANGELANDS

INTRODUCTION

Seeding is the key to quick restoration of an estimated 6 million acres of deteriorated southern Idaho rangeland. Seeding can increase forage and produce more feed for livestock and game animals than would be available naturally. Also, increased herbage usually helps protect the soil from forces that cause erosion, and it promotes more effective infiltration of moisture into the ground. Seeding depleted lands also indirectly benefits adjacent ranges since use of the additional forage obtained by seeding can lighten grazing pressure on these areas and facilitate their natural improvement.

Some seeded species are suitable for grazing earlier in the season than are the plants now occupying lands that need seeding (figs. 1 and 2). Grazing can be extended later into the season by seeding late-maturing species. Yearly production by perennial species that are adapted to a site varies less than that of annuals. Hence, perennials furnish a more dependable source of forage than annuals (Stewart and Hull 1949)[1] (fig. 3) and this forage has better quality. This is especially true where the annuals are undesirable or poisonous species such as medusahead[2] and halogeton (fig. 4). Seeding key areas with grass will replace annual weeds that are hosts of the beet leafhopper and will thus reduce losses of beets, beans, and tomatoes caused by the curly-top virus (Piemeisel and Chamberlin 1936).

Figure 1. -- Fairway wheatgrass plant at left had green leaves 8 inches long in mid-March 1957. Cheatgrass at right and in foreground is only $1\frac{1}{2}$ inches tall. Elmore County.

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[1] See References, pp. 27-28.
[2] A list of common and scientific names of all species mentioned appears on pp. 25-26.

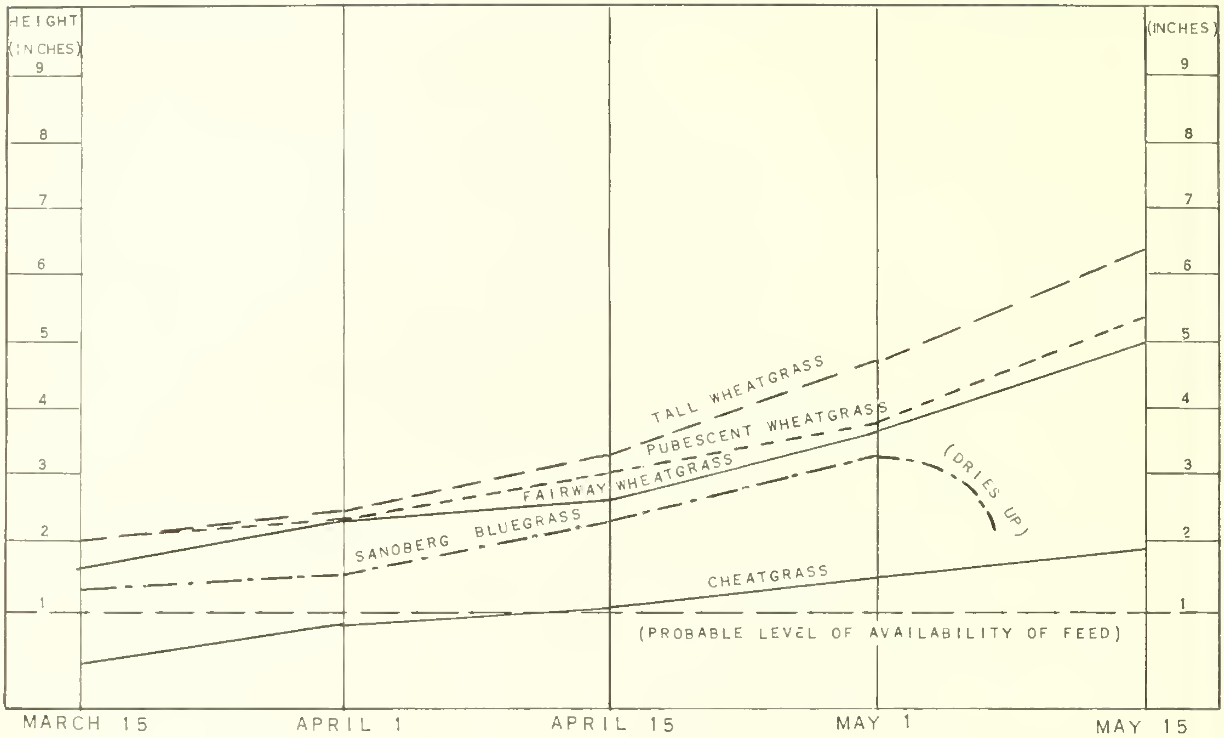


Figure 2.--Heights of plants of five grass species at five dates. Heights shown are averages of measurements in 1947, 1948, 1949, and 1950. Elmore County.

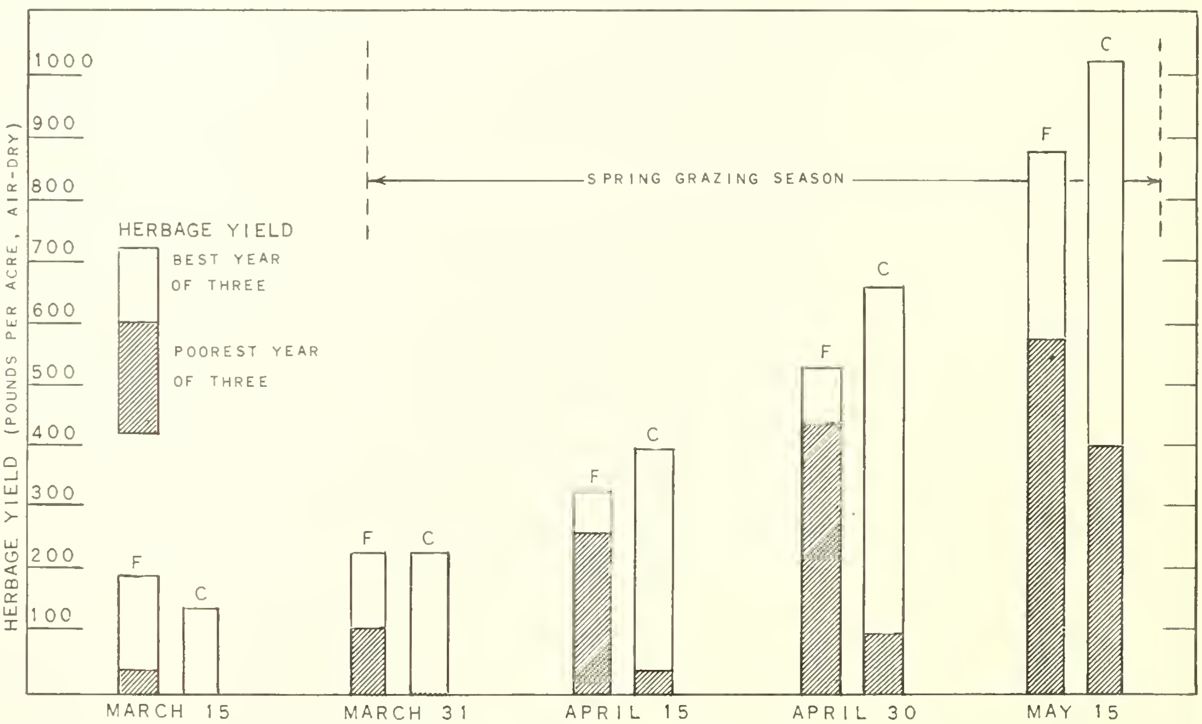
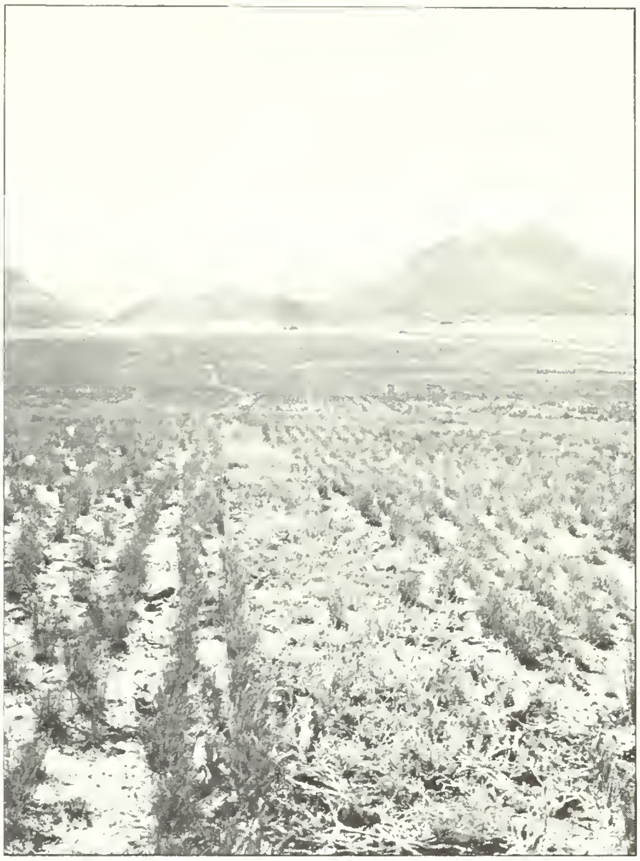


Figure 3.--Herbage yield of fairway wheatgrass (F) and cheatgrass (C) on five dates in spring, showing highest and lowest yields for each date in 1948, 1949, 1950. Elmore County.

Figure 4.--A good stand of crested wheatgrass suppresses and replaces halogeton except in the drill "skip." Cassia County.



CONSIDERATIONS PRELIMINARY TO SEEDING

To be a sound investment, seeding should be done only where the anticipated returns would justify the expense. Usually, returns are measured in forage quantity or quality, or in livestock products. Sometimes the benefit may be control of poisonous or otherwise undesirable plants, improvement of watershed or of wildlife habitat, or a reduction of fire hazard. The decision to seed a range should be made only after considering the questions that follow:

1. Is seeding needed for improvement?--The major consideration in deciding whether to seed is current production in comparison to the estimated potential of the range. On poor-condition ranges where some desirable perennials remain, reducing the grazing pressure or changing the season of use may permit native plants to increase and revegetate the range at only a fraction of the cost of seeding. Burning, spraying with herbicides, or mechanically destroying sagebrush, juniper, wyethia, or other undesirable plants may release desirable plants from competition and increase range productivity without seeding (Mueggler and Blaisdell 1951; Pechanec, Stewart, and Blaisdell 1954; Pechanec et al. 1964).

2. Can the site be worked?--Steep slopes and presence of rocks increase costs and limit the effectiveness of machinery used in seedbed preparation and planting. Unstable soils, broken up for seeding, may blow or wash; this could result in a seeding failure and create an erosion problem. Sands, rocks, or steep slopes may entirely preclude artificial revegetation.

3. Can success be expected?--Best returns come from depleted range areas with moderately level topography and deep fertile soils. Potential productivity of such sites is often indicated by the vigorous growth of undesirable plants. It is good business to seed the best sites first, and then proceed to less productive or harsher sites that are steep, rocky, dry, or saline.

Moisture is the major factor in success of seeding. Season of precipitation and the moisture-holding capacity of the soil both influence the effectiveness of rainfall; but, in general, wherever the average annual precipitation in Idaho is 11 inches or more, seeding has been successful. Where the annual precipitation averages from 9 to 11 inches, success can reasonably be expected, but an especially good job of seedbed preparation and planting is required. Several seedings have been successful in the 7- to 9-inch precipitation belt, but the percentage of successes is much lower than in wetter areas.

4. Can the area be managed?--Good range management is as important on seeded as on native range. Seeding can be a sound and durable investment only if the number of livestock and the season of grazing can be controlled. Fencing is usually an integral part of a seeding project.

5. Will returns justify costs?--Current seeding costs range from \$5 to \$25 per acre. Where the yearly production of usable forage can be changed from about 50 pounds or less per acre to 400 pounds or more, or the per-acre gain of livestock increased from 4 to 40 pounds or more, seeding is a profitable investment. With such increases, a range seeding costing \$10 per acre would pay for itself during the third season of grazing, or about the fifth or sixth year after seeding. Many seedings have equaled or excelled this and are still productive after 20 to 30 years of grazing. Methods of calculating seeding costs and returns can be found in bulletins by Caton and Beringer (1960) and Lloyd and Cook (1960).

6. Will wildlife values be damaged?--Browse is the primary sustenance of big game animals in winter, and shrubs provide the cover essential to good habitat of game animals and birds. Before converting a brushy site to grass by seeding, the range owner or manager should consider what effect such a change would have upon wildlife.

7. Can sound practices be applied?--Most of the past failures in range seeding could have been prevented if certain procedures necessary to success had been followed. Experience and research have demonstrated four principles to be fundamental to seeding success:

a. Vegetation that competes with seeded species for moisture must be eliminated.

b. Planting must be at the time, depth, and rate that are best for emergence and survival of seedlings.

c. Only species suited to the site should be seeded.

d. The resulting stand must be managed to assure sustained maximum productivity.

REMOVAL OF COMPETING VEGETATION

Stands of undesirable plants use the soil moisture needed for establishment and survival of seeded species; this has been demonstrated in cheatgrass, big sagebrush, mountain meadows, and other types in the Intermountain region (Blaisdell 1949; Hull and Stewart 1948; Mueggler and Blaisdell 1951). The more the competing vegetation is reduced, the better the stand of seeded plants will be.

The competitive effect of sagebrush on grass was shown by results of an experiment near Malta, in Cassia County, where an area was subjected to treatments that removed different amounts of sagebrush before seeding. Before treatment, the area had 20 sagebrush plants per 100 square feet and was producing 50 pounds of native grass per acre. Railing twice killed 53 percent of the brush. Three years after treatment, the yield of native grass had increased to 210 pounds per acre and the seeded grass yielded 530 pounds for a total of 740 pounds of grass per acre. Railing once and burning killed 92 percent of the sagebrush. After this reduction, the native grass yield increased to 335 pounds per acre and the seeded grass yielded 1,785 pounds for a total of 2,120 pounds of grass.

At eight locations in southern Idaho, crested wheatgrass or intermediate wheatgrass or both were drilled in the fall of 1954 in standing sagebrush and on adjacent areas where sagebrush had been plowed. Seeded plants emerged equally well on plowed and unplowed areas, but by the third growing season there were 20 times more well-established grass plants in the plowed area--an average of 1.6 plants per square foot. The average height of the grass in the sagebrush was only one-fifth of that where sagebrush had been eradicated.

Southeast of Boise, perennial grasses were drilled for 4 years where burning at different seasons had reduced the cheatgrass by varying amounts. Seeded species emerged equally well in all cheatgrass densities, but as cheatgrass was reduced from an average of 1,325 plants per square foot to 21 plants, survival of the seeded grass after 5 years was improved from almost none to 1.7 plants per square foot (Hull and Stewart 1948).

SEEDING PROCEDURES

METHOD

The seeding method to be used will be governed by the topography, soil, and the treatment used to remove competing vegetation. The best method will distribute seed uniformly and at the most favorable depth for successful seedling emergence and survival.

Drilling is the best method for attaining both of these goals; and wherever a drill can be used, it should be. Double disk drills are satisfactory for well-prepared, trash-free seedbeds. For most range seedings, however, the single-disk drill has a wider range of adaptability. Where the seedbed is loose, a depth-regulating band can be attached to the furrow-opening disks of single-disk drills to prevent seeding too deep (fig. 5).

Deep-furrow disk or shovel-type drills place the seed at the bottom of furrows, where moisture conditions favor germination and growth of seedlings. They also suppress small weeds on either side of the furrow by covering them with soil. Deep furrows are not desirable on sites where they would be flooded or would be filled with soil by blowing, washing, or sloughing. On sloping lands, furrows should be on the contour.

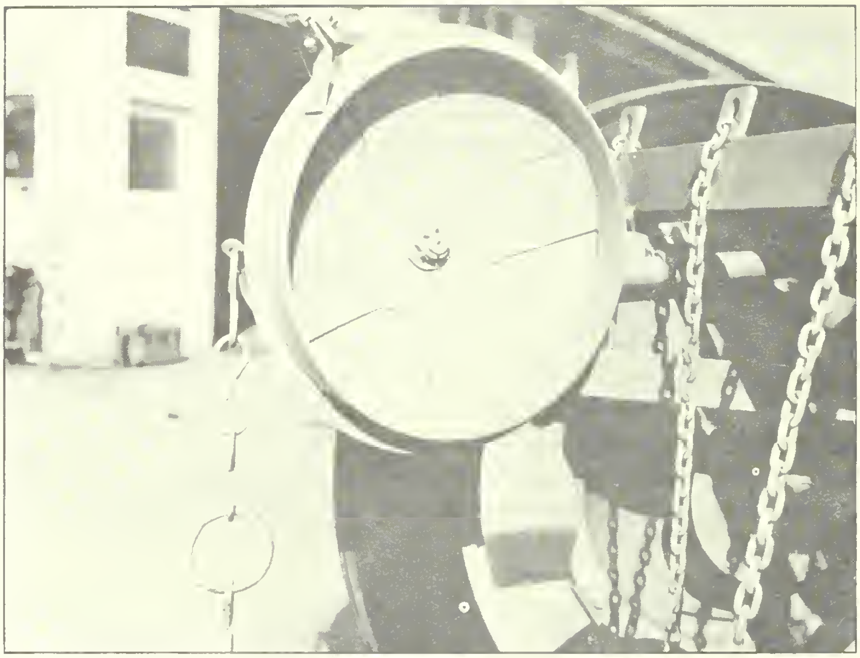


Figure 5.--The Rangeland drill recently developed by Federal agencies for seeding rough, rocky ranges. The circular metal flange prevents penetration of the furrow-opening disk beyond optimum depth of seed placement. Furrow openers have flexibility of movement that permits the drill to roll over large obstacles without breakage.

Seeds of most grasses can be fed from the grain hopper of the drill with cups on the "wheat" setting. Small seeds such as clover, alfalfa, and timothy, can be seeded from the small "grass seed" hopper attached to most grain drills (Plummer et al. 1955).

Broadcasting usually wastes seed because it distributes it poorly. Also, broadcast seed may be covered unevenly or not at all. However, broadcasting may have to be used where drilling cannot be done because of steepness, rockiness, or trees. Broadcast seed should be covered. Some covering can be accomplished by a harrow, chain, brush drag, or hand rake. Under a few conditions broadcast seed is covered by natural means. On all but sandy soils, seed broadcast immediately on newly turned ground is covered as the fresh clods break up and the soil settles. On timber and brush burns, a deep layer of fresh ashes covers seed if broadcasting is done before the ashes are packed down by rains. Sagebrush ashes are seldom deep enough to cover broadcast seed.

The disadvantage of broadcasting is shown by comparing it with drilling on freshly plowed seedbeds at eight locations in southern Idaho in 1954. When these seedings were 2 years old, crested wheatgrass plants averaged 1.4 plants per square foot and produced 487 pounds of herbage, air-dry, per acre on drilled plots; on broadcast-seeded plots, with the same amount of seed per acre (Hull 1959), the averages were 0.5 plant per square foot and 182 pounds of herbage per acre.

Broadcasting seed in pellets of compressed earth or coated seed pellets has attracted much attention. The compressed earth pelleting operation damages the seed, and poor stands have resulted on all areas seeded by these pellets (Tisdale and Platt 1951; Moomaw et al. 1954).

Coated pellets have given results comparable to those for broadcast naked seed; but without soil covering, poor stands or failures result for both (Hull 1959). A survey of all range seedings with pellets showed that none was successful and that pellet seeding of rangelands could not be recommended (Hull et al. 1963).

DEPTH

For best emergence and survival, seed should be placed at a depth related to seed size. As depth increases beyond optimum, fewer seedlings can emerge. At shallower depths, germination decreases and seedling mortality increases. The sustaining secondary root system of grasses arises from the shoot above the level of the seed. When the seed is too shallow, the secondary root system either fails completely or develops very slowly. With no secondary root system the plant also is inadequately anchored and may be blown over or broken off. Recommended depths for different species are shown in table 3 (pp. 12-14).

SEASON

Planting should be timed so that seedlings will start to germinate and emerge at the beginning of the longest period of favorable soil moisture and temperature. A review of results in southern Idaho shows that fall seedings have produced consistently better stands than spring seedings.

October seedings are usually somewhat more successful than September seedings (Hull 1948). At high elevations, of course, seeding must be early enough to be completed before winter starts.

Spring seedings have been successful, but they have several limitations. Spring rains interrupt work, areas dry unevenly, and the favorable season for seeding is usually short. In western Idaho, there may be no spring or summer rain after the ground becomes dry enough for cultivation.

RATE

The amount of seed to use varies with species and seeding method. If planting techniques could provide even distribution and insure the development of a mature plant from every seed, then less than a pound of seed per acre would be sufficient to establish a seeded stand. But some seeds never germinate; some germinate and the shoots do not emerge; and some plants die after emergence. Seeding rates must compensate for these losses. Beyond what is required for establishing a full stand, however, increase in rate wastes seed. Each site can support only a limited maximum number of mature plants; if more than that emerge, the excess will die.

In Elmore County, for example, yields from plots seeded at rates of 1 and 40 pounds of fairway wheatgrass seed per acre were essentially the same when the seedings were 10 years old (table 1). Similar results were obtained in Clark and Bonneville Counties (Mueggler and Blaisdell 1955).

Table 1.--Fairway wheatgrass plants per square foot and herbage yields from seeding at rates of 1 to 40 pounds per acre, Elmore County

Seeding rate	First year seedlings	Fourth year plants [1]	Mortality	Tenth year yields
Lbs./acre	- - - - - -	Number - - - - - -	Percent	Lbs./acre
1	0.7	0.7	0	690
2	1.9	1.0	47	685
4	3.5	1.0	71	705
6	5.0	1.3	74	770
8	7.5	1.4	81	800
10	9.5	1.5	84	715
20	19.0	1.9	90	520
40	37.5	2.0	95	700

[1] It was difficult to count plants older than 4 years.

Although plant numbers equalize over several years' time, low seeding rates have three inherent disadvantages:

1. Stands require longer time to reach full productivity.

2. A thin stand is more subject to invasion by undesirable species than a thick stand.

3. Where original seedling density is low, plant distribution is irregular, robust and relatively unpalatable plants tend to develop, and subsequent grazing is uneven.

Recommended seeding rates for drilling (table 3) should be increased to compensate for the nonviable and impure seed and for deficiencies in seeding techniques. A common practice is to increase the rates shown by 50 percent for broadcast seeding.

ROW SPACING

Spacing of seeded rows normally ranges from 6 to 24 inches. Tests in Oneida, Clark, and Elmore Counties showed no difference in ultimate herbage yield of stands seeded at any row spacing up to 2 feet. As the rows are spaced farther apart, less seed is required, but more years are required to attain full production. Close spacing helps to inhibit invasion by undesirable plants during the early years after seeding. The wider the space between rows, the coarser the plants, and with some species, the less palatable.

The most suitable distance between drill rows on the drier Idaho rangelands is 10 to 12 inches. On moister sites, drill rows should be 6 to 8 inches apart.

SELECTION OF SPECIES TO SEED

CHARACTERISTICS OF SPECIES

Many features contribute to or detract from a species' value for seeding. Ability to survive and grow on the site to be seeded is of first importance; this has been well established for all species and types of sites discussed herein. Additional considerations that influence a choice of species for a particular site and purpose include competitive ability, longevity, palatability and grazing tolerance, and distinctive growth habits such as those mentioned in table 3.

Competitive Ability

A species should be able to prevent or inhibit invasion by undesirable plants. Grass species vary markedly in this ability. Following are two examples of such differences from Cassia and Oneida Counties. At Meadow Creek, Cassia County, crested wheatgrass and intermediate wheatgrass were seeded on adjacent parts of a favorable sagebrush site in 1948. Vegetation was mainly big sagebrush with some serviceberry and snowberry. Good stands of both grasses started, and many seedlings of sagebrush came up among the grass seedlings. Some sagebrush seedlings died, but 14 sagebrush seedlings per 100 square feet became established in the crested wheatgrass and 19 in the intermediate wheatgrass. In the crested wheatgrass area, subsequent establishment of sagebrush plants increased their number to 15 in 1955 and to 17 in 1962. But in the intermediate wheatgrass, sagebrush plants increased to 46 in 1955 and 96 in 1962. Crested wheatgrass suppressed the growth rate of sagebrush that became established the same year as the grass and subsequently allowed establishment of only a few additional plants. On the other hand, intermediate wheatgrass inhibited neither the continued establishment of sagebrush nor its vigorous growth. The production of intermediate wheatgrass was much less in 1962 than in 1955, while crested wheatgrass yielded the same amount of herbage both years.

Near Holbrook, Oneida County, crested wheatgrass and bluebunch wheatgrass were seeded on adjacent areas on abandoned farmland in the fall of 1939. Both grasses established a good seedling stand. For 25 years, crested wheatgrass has maintained a good stand under moderate to heavy grazing, and has allowed only negligible sagebrush reinvasion. Bluebunch wheatgrass, on the other hand, gradually disappeared and has been completely replaced by a mixed stand of crested wheatgrass and big sagebrush. Obviously, the more competitive grass, which inhibits establishment or growth of brush, allows a greater interval of time until the seeding requires brush control.

Longevity

Another important consideration in selecting species to seed is longevity of plants. Ideally, range seeding is a one-time operation that will last indefinitely with good management.

Longevity of seeded stands is often questioned. Although yields vary with year-to-year climatic deviations, production generally increases for 2 to 5 years after planting. Later, production characteristically declines to what seems to be the level of sustained productivity for the site. Crested and fairway wheatgrasses, smooth brome, and bulbous bluegrass have produced for more than 25 years on sites to which they are adapted. The oldest known seedings of crested wheatgrass in Idaho that have been grazed regularly were made in 1932 and 1933. At the end of 30 years these stands were still productive and yielded far more palatable herbage than adjacent unseeded ranges. The highest recorded yield was produced in the 30th growing season for a 1933 seeding near Dubois, Clark County, and during the 20th season for a 1943 seeding near Sublette, Cassia County (table 2). These high yields in 1963 followed favorable precipitation in 1962.

Table 2.--Yields of crested wheatgrass in air-dry herbage from seedings near Dubois (1933) and Sublette (1943)

Year	Dubois	Sublette	Year	Dubois	Sublette
	Lbs./acre			Lbs./acre	
1941	729	[1] --	1953	--	--
1942	665	--	1954	--	--
1943	--	--	1955	1,005	700
1944	--	--	1956	856	860
1945	--	1,274	1957	--	1,160
1946	--	1,785	1958	--	1,280
1947	785	1,267	1959	--	820
1948	685	840	1960	--	700
1949	800	820	1961	--	640
1950	675	700	1962	1,316	1,790
1951	555	990	1963	2,016	2,173
1952	560	941	1964	1,268	1,746

[1] Dash (--) indicates no observation.

Palatability and Tolerance to Grazing

Palatability is important where there are two or more species in the same grazing area. Unless they are similar in palatability, the more palatable will suffer from heavy use (fig. 6). If stock are forced to eat only a moderate amount of the less palatable, the more palatable species is weakened.

Some species are better adapted to survive heavy grazing than others, but productivity of any species is reduced by continued heavy use.

SPECIES FOR SOUTHERN IDAHO RANGES

From more than 250 species and strains tested on a variety of sites in southern Idaho, enough have been found to fit almost all kinds of sites needing revegetation from the low-rainfall areas to the high mountains. Recommended species are listed in table 3. A complete list of species tested in southern Idaho is in the Appendix. Further information about species characteristics is given by Hafenrichter et al. 1949; Plummer et al. 1955; Stark et al. 1950; and Weintraub 1953.

A

B

Figure 6.--Differences in palatability create problems of grazing management: A, Two grass species growing in alternate drill rows. Sheep utilized about 70 percent of the intermediate wheatgrass but scarcely any of the beardless wheatgrass. Elmore County. B, Cattle grazed crested wheatgrass close to the ground in spring but took very little of the native beardless wheatgrass. Lincoln County.

Table 3.--Species recommended for seeding rangelands in southern Idaho; characteristics, suggested planting depths and seeding rates[1] for drilled seedings, and sites recommended

Species, planting depth, and rate	Description	Recommended sites
Alfalfa		
1/4 inch; 1 to 2 pounds per acre, in mixture with grass.	Productive and palatable introduced legume. Vulnerable to pocket gophers because of taproot. Creeping varieties are less susceptible to damage by rodents. Not persistent when grazed on rangelands. Seed should be inoculated with nitrogen-fixing bacteria. Should be seeded in spring. Not shade tolerant.	Intermediate[2] and favorable sagebrush, mountain brush, and ponderosa pine sites. Poor at higher elevations in west-central Idaho.
Bluegrass, big		
1/4 to 1/2 inch; 4 to 5 pounds per acre.	Long-lived native bunchgrass. Yields much palatable foliage early in spring, but becomes unpalatable earlier than most grasses. Seedlings relatively low in vigor. Requires 4 to 8 years to reach full productivity. Because young plants are easily pulled up, grazing should be deferred until roots are well anchored. Somewhat shade tolerant.	Intermediate and favorabl sagebrush sites. Sunny places on mountain-brush and ponderosa pine range: Meadows at lower elevations.
Bluegrass, bulbous		
Surface to 1/2 inch; 5 to 10 pounds per acre, the higher rate for broadcast seeding.	Small introduced bunchgrass, very palatable in spring. Grows rapidly in early spring and dries up before summer. Resumes growth in fall. Not highly productive. Because it can become established when broadcast without other treatment, it is useful on sites that cannot be tilled. Shade tolerant.	Sagebrush sites (except the driest), mountain-brush, and ponderosa pine Especially the basaltic soils between Payette and Weiser Rivers. Not recommended for southeastern Idaho.
Brome, meadow		
1/2 to 1 inch; 6 to 10 pounds per acre.	Long-lived bunchgrass. Reaches full productivity in 2 or 3 years. Moderately palatable. Shade tolerant.	Favorable sagebrush sites and higher ranges. Meadows.
Brome, mountain		
3/4 to 1 inch; 8 to 10 pounds per acre.	Short-lived vigorous native bunchgrass. Reaches full productivity in 1 to 3 years. Volunteers well in some situations. Moderately palatable. Valuable for quick cover. Will be replaced by long-lived species in mixtures. Susceptible to smut.	Weedy openings at high altitudes and on timber burns.
Brome, smooth		
1/2 to 1 inch; 8 to 12 pounds per acre.	Long-lived introduced sod-forming grass. Very palatable and productive. Seedlings not vigorous, but once established, plants spread vegetatively to provide full stands. Notable ability to suppress reinvasion of undesirable vegetation. Shade tolerant.	Southern strains best for mountain-brush and favorable sites in the sagebrush zone. Northern strains have been best on higher elevation mountain rangelands. Meadows.

[1] Rates should be adjusted for other seeding methods (see pages 5 ff.) and for mixtures (see page 15).
[2] The adjectives "intermediate" and "favorable" describing sagebrush sites are defined in the text, pages 17 and 18.

Table 3.--(con.)

Species, planting depth, and rate	Description	Recommended sites
Fescue, Chewings		
1/4 to 3/4 inch; 3 to 5 pounds per acre.	Fine-leaved introduced bunchgrass. Low forage production. Remains green throughout the summer. Numerous roots make it a valuable soil stabilizer. Palatable early and late in the growing season. Shade tolerant.	Mountain-brush and higher ranges. Best results on dry meadows and timber burns at high altitudes.
Foxtail, meadow		
1/4 to 1/2 inch; 2 to 4 pounds per acre.	Introduced bunchgrass. Moderately palatable. Begins growth early in spring; leaves remain green until after hard frosts in late fall. Volunteers readily on sites where adapted.	Wet and dry meadows, and most high-elevation ranges.
Oatgrass, tall		
1/4 to 1 inch; 4 to 6 pounds per acre.	Short-lived introduced bunchgrass. Reaches full production very early. Moderately palatable. In some locations can maintain stand many years by volunteer seeding. Shade tolerant.	Mountainous areas, especially aspen, timber burns, ponderosa pine, and mountain-brush.
Orchardgrass		
1/4 to 3/4 inch; 3 to 5 pounds per acre.	Long-lived introduced bunchgrass. Very palatable, especially in early part of season. High yields. Very shade tolerant.	Favorable mountain-brush and mountain lands except dry south exposures. Especially valuable for aspen and other shady sites.
Timothy		
1/4 to 1/2 inch; 2 to 3 pounds per acre.	Short-lived introduced bunchgrass. Forms quick cover. Volunteers readily. Moderately palatable. High yields. Can be broadcast successfully. Shade tolerant.	Mountain sites. Ponderosa pine zone and above. Meadows.
Wheatgrasses, beardless and bluebunch		
1/2 to 1 inch; 6 to 10 pounds per acre.	Long-lived, native bunchgrasses. Begin growth early in spring, and again in fall after rains. High producers. Require several years for stands to attain full productivity. Moderately palatable. Slightly shade tolerant.	Intermediate and favorable sagebrush sites, mountain-brush, ponderosa pine, and juniper-pinyon ranges.
Wheatgrass, crested		
1/2 to 1 inch; 5 to 8 pounds per acre.	Long-lived, drought-enduring, introduced bunchgrass. Begins growth very early in spring. Dormant in late summer. Greens up again in the fall. Vigorous seedlings. Palatable in spring and late fall; rather unpalatable after seed formation. Withstands heavy grazing. Slightly shade tolerant.	Sagebrush, ponderosa pine, mountain-brush, and juniper-pinyon ranges. Low vigor and poor stands at elevations above 5,500 feet in western Idaho or 6,500 feet in eastern Idaho.

Table 3.--(con.)

Species, planting depth, and rate	Description	Recommended sites
Wheatgrass, fairway		
1/2 to 3/4 inch; 5 to 7 pounds per acre.	Similar to crested wheatgrass, but its finer stems and leaves are conducive to more uniform grazing. Shorter than crested. Matures a week or more earlier than crested wheatgrass. Slightly shade tolerant.	Same sites as above, but grows well at higher elevations than crested wheatgrass.
Wheatgrass, intermediate		
1/2 to 1 inch; 7 to 10 pounds per acre.	Long-lived introduced sod-forming grass. Vigorous, rapidly developing seedlings. Begins to grow very early in spring. Remains green and palatable into summer. High producer. Does not mature seed at high elevations, but spreads vegetatively. Moderately shade tolerant.	From intermediate sagebrush sites into the high mountains, and on dry meadows. Good for granitic soils in west-central Idaho.
Same.	Amur, a strain of intermediate wheatgrass, has vigorous seedlings.	Same.
Wheatgrass, pubescent		
1/2 to 1 inch; 7 to 10 pounds per acre.	Long-lived, introduced sod former. Similar to intermediate wheatgrass, but is somewhat more drought-resistant, and matures about a week earlier. Not shade tolerant.	From intermediate sagebrush sites into the high mountains, but not in meadows and shady areas.
Wheatgrass, slender		
1/2 to 1 inch; 6 to 8 pounds per acre.	Short-lived native bunchgrass. Vigorous seedlings. Volunteers aggressively. Forms a quick cover, but usually is replaced by other species. Moderately palatable. Many strains. Shade tolerant.	High-altitude ranges and more favorable sites on mountain-brush areas.
Wheatgrass, tall		
1/2 to 1 inch; 6 to 10 pounds per acre.	Long-lived robust introduced bunchgrass. Vigorous seedlings. Starts growth early in spring; matures in late summer. Useful for summer grazing on drylands at low elevations. Poor to fair palatability. Old coarse growth often makes current growth unavailable. Tolerant to salt, alkali, and water, but not to shade.	Salty areas such as greasewood and saltgrass sites, where the water table is from a few inches to several feet below ground surface. Also intermediate and favorable sagebrush, mountain-brush, and juniper sites.
Wildrye, Russian		
1/2 to 1 inch; 4 to 8 pounds per acre.	Long-lived introduced bunchgrass, producing abundance of basal leaves. Is palatable even when dry. Endures close grazing better than most grasses. Grows rapidly in spring, renews growth in fall. Erratic in establishment. Has low seedling vigor. Withstands drought, once it is established. Provides poor soil protection.	Sagebrush, mountain-brush, and juniper sites. Useful on soils too alkaline for fairway or crested wheatgrass, and too dry for tall wheatgrass. Because of poor establishment, not recommended for western Idaho.

MIXTURES

Most lowland ranges having fairly even terrain and uniform soil conditions are best seeded to single species. A single species is easier to seed, more uniformly palatable, and easier to manage than a mixture. Species that differ markedly in palatability, growth rate, and green growth periods, can be sown in different units so that grazing can be rotated among them.

In mountainous or other areas having a variety of soil and moisture conditions, mixtures are recommended (Plummer et al. 1955). Short-lived fast-developing species seeded in mixtures with species that are longer lived but slower developing are useful for preventing erosion and for controlling undesirable plants during the first year or two after seeding while the slower growing plants are still small.

The amount of seed of each species to be planted in the mixture should be less than that recommended in table 3. A safe rule to follow in order to have sufficient seed of the adapted species on local sites where other components of the mixture will not become established is to compute the proportional amount from the table, using the highest value shown. For example, if it is desired that crested wheatgrass compose about half of the total mixture, use 4 rather than $2\frac{1}{2}$ pounds of seed of that species per acre in the mixture.

MANAGEMENT OF SEEDED RANGES

Seedings need total protection until plants are well established. A safe rule is to withhold grazing until after the first seed crop has matured and then to permit only light grazing late that season. This usually means that a seeding will be grazed for the first time during its second or third growing season.

Grazing too early in the life of a stand or too heavily year after year reduces the number of plants, lessens their vigor and productivity, and encourages invasion by undesirable weeds and brush. With mature stands of crested or fairway wheatgrasses on relatively level lands, about 40 percent of the herbage volume should be left ungrazed if the grass is to maintain vigor and high production. This utilization is heavier than is advisable for most native grasses. On sloping lands, to provide litter for prevention of erosion and enhancement of percolation of moisture into the ground, more unused herbage must be left on the ground than is required on level lands. Few grazing trials have been made on other seeded species, but observations show that most of them should be more lightly grazed than crested wheatgrass.

Sagebrush often becomes reestablished on grass seedings, especially during the first year when seeded plants are small and unable to suppress the reinvasion. Small sagebrush plants have little importance (fig. 7), but as the shrubs grow and give the seeding a brushy aspect, they reduce herbage production and accessibility of feed.

Reinvading sagebrush can be controlled by beating, cutting, or burning, or by applying chemical herbicides. These treatments are described below under "Site Preparation and Seeding." Beating is feasible if the ground surface is relatively free of rocks and if the sagebrush has attained a rather robust size with few branches or small plants below 6 inches. Herbicides and fire can be used on sagebrush of all ages. Burning should be planned to prevent injury to the seeded species. This can be accomplished by allowing litter to accumulate by grazing lightly for a year or two and then burning late in the season--preferably while the soil is damp.

After sagebrush control, the forage plants should be grazed only lightly or late for at least one season.

Figure 7.--Young sagebrush in a seeding of crested wheatgrass. These small shrubs neither obstruct grazing animals nor compete seriously for moisture. In a few years they will dominate the seeding unless they are controlled.

RECOMMENDATIONS FOR SPECIFIC RANGE TYPES

The natural vegetation is usually a good indicator of whether the climate and other site factors are favorable; thus it helps in selecting species to be seeded. The type of vegetation to be removed, of course, chiefly determines the method of site preparation for seeding.

Seeding trials have been conducted in most depleted range types in southern Idaho. Desirable species and effective methods have been determined for most range types, except the salt-desert shrub ranges. The following sections describe where artificial revegetation is possible and recommend species and seeding procedures.

SAGEBRUSH LANDS

Sagebrush occupies the largest acreage of range suitable for seeding in Idaho. Big sagebrush dominates, but threetip sagebrush occupies large areas in southeastern Idaho. On shallow soils underlain by rock or other impervious strata, low sagebrush is locally dominant. Other shrubs often associated with sagebrush are rabbitbrushes, bitterbrush, and horsebrush.

Species to Seed

Sagebrush sites in Idaho can be divided into three classes for the selection of species to seed: (1) harsh, (2) intermediate, and (3) favorable.

Harsh sites, where rainfall is generally less than 9 inches, are usually identifiable by presence of low-stature big sagebrush and by Sandberg bluegrass, squirreltail, or Thurber needlegrass. Remnants of Great Basin wildrye are found in swales and mounds of deeper soil. Bluebunch wheatgrass is rarely found, and arrowleaf balsamroot is absent. On sandy areas needle-and-thread and Indian ricegrass sometimes occur. Nearby saline lands may support stands of shadscale, winterfat, or Gardner saltbush.

Low sagebrush, although usually found in southern Idaho where rainfall is greater than on sites just described, is indicative of shallow soils that limit moisture storage. For this reason, sites below 7,500 feet elevation that support low sagebrush usually should be classed as "harsh" regardless of how much moisture they receive. Conditions favoring seedling establishment on harsh sites are uncertain, especially in dry years. Even when the most careful planting procedure is used, failure can be expected in about 1 year out of 3.

Only crested and fairway wheatgrasses have consistently shown themselves to be adapted. Siberian wheatgrass has the same adaptability as crested wheatgrass and can be used wherever crested wheatgrass is recommended. In eastern Idaho, Russian wildrye has yielded well, but its establishment is less dependable than that of the wheatgrasses.

Intermediate sites in the sagebrush zone have 9 to 14 inches of rainfall and are identifiable by presence of vigorous big or threetip sagebrush. In the upper levels of this zone, dryfarming has been successful. Where undisturbed, arrowleaf balsamroot is often an important component of the vegetation. Bitterbrush and prairie junegrass are usually present, and Idaho fescue often grows on north exposures.

Crested, Siberian, and fairway wheatgrasses are useful on these intermediate sites. Russian wildrye produces well but is difficult to establish. Two sod formers, intermediate and pubescent wheatgrasses, produce more on some of these sites than do crested or fairway wheatgrass. The Amur strain of intermediate wheatgrass has had only limited testing, but shows promise. Big bluegrass, tall wheatgrass, and bluebunch (including beardless) wheatgrass have produced well on some areas. Bulbous bluegrass is useful where broadcasting is the only possible method of seeding. Alfalfa can be included in mixture with grasses when seeding is done in the spring.

Yields of some seeded grasses on these intermediate sagebrush sites are shown in table 4.

Table 4.--Yield per acre in pounds of air-dry herbage of six species on "intermediate" sagebrush sites in southern Idaho in 1955, 1962, and 1963

Location	Crested wheatgrass			Fairway wheatgrass			Intermediate wheatgrass			Pubescent wheatgrass			Russian wildrye		
	1955	1962	1963	1955	1962	1963	1955	1962	1963	1955	1962	1963	1955	1962	1963
Eastern Idaho															
U.S. Sheep Expt. Station, Clark County	1,056	1,299	1,738	942	1,060	2,238	898	1,198	2,037	869	1,287	2,238	705	668	1,794
Michaud, Power County	660	796	1,920	--	--	--	990	1,484	2,020	960	1,425	2,170	667	566	440
Southern Idaho															
Almo, Cassia County	580	1,043	2,013	460	1,147	1,513	--	--	--	--	--	--	494	1,178	1,728
Southwestern Idaho															
Regina, Elmore County	800	424	1,181	562	390	835	699	250	567	786	407	729	424	403	324

Favorable sites are in the cooler, higher vegetational zones, where annual precipitation is usually greater than 14 inches. Most species recommended for the intermediate sagebrush sites are also adapted for the favorable areas; however, above 5,500 feet in western Idaho and 6,500 feet in eastern Idaho, crested wheatgrass has not been productive. Smooth brome and meadow brome become useful about where crested wheatgrass begins to fail. The best producers on these favorable sagebrush sites are smooth brome, and intermediate, pubescent, fairway, and tall wheatgrasses. Where silver sagebrush is common, the species and methods recommended are the same as for mountain meadows (see pages 22-23).

Site Preparation and Seeding

For successful establishment of seeded species, practically all of the sagebrush and other brush species associated with it must be eradicated. Big sagebrush is easily eradicated. When defoliated or burned, it dies and does not sprout from the base. Sagebrush seed ripens in the fall; therefore, areas should be treated before fall to lessen the likelihood of reestablishment of sagebrush.

Methods of controlling sagebrush are discussed in U.S. Department of Agriculture Agriculture Handbook 277, "Sagebrush control on rangelands," by Pechanec et al. 1964. Only a brief summary of eradication methods is given here.

The three general methods of sagebrush eradication use chemicals, fire, and mechanical equipment.

Chemical control is useful for releasing a good stand of seeded or native grasses from suppression by sagebrush. It is not entirely satisfactory, though, because it leaves some standing brush, which hinders planting grass. Inferior plants that are not destroyed by chemicals remain and compete with seeded plants for moisture.

Burning is an effective, economical method of controlling sagebrush. Carefully handled, fire can be a good tool; but improperly used it can damage soil and vegetation. Burning leaves a clean, firm seedbed that requires no further treatment before drilling the seed. U.S. Department of Agriculture Farmer's Bulletin 1948, "Sagebrush burning--good and bad" (Pechanec et al. 1954) describes burning techniques and necessary precautions.

Fire completely kills big sagebrush, but threetip sagebrush often resprouts. Low sagebrush can be killed by burning but it is often too sparse to carry a fire. Rabbitbrush and horsebrush sprout freely from the base and roots; so the number of plants often increases after a fire. Mechanical eradication should be used where any appreciable amount of these species is in the cover.

Almost every year wildfires occur in the sagebrush zone in southern Idaho. Many of these accidental burns leave seedbeds that provide excellent opportunities for seeding. They should be planted the year the burn occurs. Otherwise, undesirable plants will occupy the site and reduce the likelihood of successful establishment of seeded plants.

Mechanical eradication by plowing is recommended for sagebrush sites where burning is not feasible. The most common implements are disk-type plows such as the one-way single-axle disk (wheatland type) plow, the heavy offset disk, and the brushland plow. The brushland plow was designed for use on rough and rocky rangelands and is the only machine that can be used on such lands without undue breakage. Depth of plowing ordinarily should be from 2 to 4 inches, which is enough to destroy big sagebrush and most herbaceous species. A plowing depth of 4 to 6 inches is required to kill base- or root-sprouting species such as spineless horsebrush and rabbitbrush.

If cheatgrass is part of the understory, plowing should be done in the spring before it sets seed; otherwise, plowing merely plants the cheatgrass.

Other mechanical methods of eradication have been used successfully under certain conditions. Root cutters or root plows work well on rock-free sites to kill sagebrush and such root-sprouting plants as rabbitbrush. Railing and chaining are useful in tearing out old brittle brush, but they are ineffective on flexible young shrubs. Going over the same swath a second time in the opposite direction greatly increases the brush kill. Brush piled by railing and chaining can be burned to facilitate drilling.

The self-clearing pipe harrow is excellent for eliminating small brittle sagebrush in areas too rough or rocky to be plowed and for covering broadcast seed.

Rotary cutters and brush beaters effectively kill taller brush but leave young or low-lying shrubs and herbaceous plants undamaged. Cutters are most valuable to kill brush and thus to release desirable understory forage plants from competition for moisture and light.

WEEDY TYPES IN THE SAGEBRUSH ZONE

Cheatgrass, medusahead, Russian-thistle, halogeton, mustards, and other annual weeds occupy millions of acres of southern Idaho rangelands, mainly as a result of plowing and abandonment, burning, overgrazing, or other treatments that have killed part or all of the sagebrush and other native vegetation. These aggressive annual plants must be removed to obtain a clean seedbed before perennial grasses are planted.

Species to Seed

Species to seed on these weedy sites can be selected from those recommended above for similar sites on sagebrush lands.

Site Preparation and Seeding

Cheatgrass, a winter annual, is eliminated by treatments that prevent seed formation. Spring tillage, before seeds ripen, gives good control for one growing season. This is usually long enough to allow perennial grasses to become established. In years having enough fall moisture to assure good germination of cheatgrass, planting sites can be disked after fall germination. These sites can be plowed thoroughly with a moldboard plow whenever soil moisture conditions permit, since practically all the seed will be buried several inches deep.

Burning in early summer, before seed dispersal, has controlled cheatgrass the following year sufficiently to permit good establishment of perennials. For complete control, cheatgrass must be burned early, while still red--just before the tan color becomes prominent. Considerable litter from the previous year's growth is needed to help carry the fire this early in the season. If winter or spring germination is not complete, holdover seed is not damaged by an early fire.

Accidental summer burns destroy newly fallen seed if the fires are very hot; such clean, complete burns assure well-prepared seedbeds. Burns should not be planned for summer because they vary greatly in results and needlessly expose the soil to danger of erosion. Early burns, on the other hand, leave a thin turflike stubble as a protective ground cover.

Sandberg bluegrass competes strongly with planted seedlings and is little harmed by early fires; so considerable bluegrass in the cheatgrass cover indicates the need for some kind of tillage before seeding.

Medusahead, a range pest that has replaced cheatgrass in some parts of western Idaho, is a grass similar to cheatgrass in growth habit and life history. Preliminary experiments with medusahead have shown its response to several eradication treatments to be similar to that of cheatgrass; but too few tests have been made of eradication of medusahead for us to make more than a tentative recommendation that it be treated like cheatgrass.

Russian-thistle, a summer annual, demands most soil moisture after perennial grasses are dormant. It offers little direct competition to seedlings of recommended seeded species. Grass seed usually can be successfully drilled among these weeds without any ground preparation.

Halogeton has growth requirements similar to those of Russian-thistle and can be treated the same way (Plummer et al. 1955). Seedings of perennial grasses in areas occupied by halogeton have not been successful where soils were heavy or saline and had not supported good sagebrush.

Mustards and other winter annuals grow early in the spring and compete more directly with planted seedlings than Russian-thistle does. Drilling in mustard stands without preparatory ground treatment has seldom resulted in successful seedling establishment. For best results, mustard stands should be plowed or disked in the spring before mustard produces seed.

Abandoned farmlands offer economical seeding opportunities. They require no seedbed preparation if seeding is to be done the first fall or early spring following the last harvested crop. If seeding is delayed, the treatment should be that recommended for the vegetation that invades the field.

JUNIPER LANDS

The juniper type is relatively minor in Idaho, but its potential for improvement is great. Species recommended for juniper and pinyon sites are those mentioned above for intermediate sagebrush sites.

Juniper sites with openings dominated by weeds or sagebrush should be treated as recommended for those types. Thick stands of old juniper and pinyon can be cabled or chained. Juniper with enough understory to carry a fire can be burned and the burns seeded in the same manner as suggested for sagebrush. Individual junipers can be burned with a flame thrower or pushed over and piled by a bulldozer.

MOUNTAIN BRUSHLANDS

Large areas of foothill and mountain country in southeastern Idaho support a "mountain brush" type, which includes bigtooth maple, bitterbrush, chokecherry, curlleaf mountain-mahogany, rubber rabbitbrush, serviceberry, snowberry, and snowbrush. Sagebrush is an important associate. Good-condition ranges have an understory of perennial grasses and palatable broad-leaved herbs. On depleted ranges the understory vegetation is mostly low-quality weeds and grasses. Where topography permits, such depleted mountain-brush ranges can be greatly improved by seeding.

Because browse in this zone is a valuable forage, especially for fall use by livestock and fall and winter use by big game, it may not always be desirable to destroy brush stands for seeding grass.

Species to Seed

This brush type varies considerably, but the species usually recommended for the intermediate and favorable sagebrush sites are adapted to this zone. Tall oatgrass has been successful on most mountain-brush seedings. Slender wheatgrass and Chewings fescue can be planted on many sites, and orchardgrass is successful in shady areas. Alfalfa grows well but is sometimes badly damaged by livestock grazing and by gophers. The most useful species are intermediate, pubescent, and fairway wheatgrasses--the latter two on the drier sites.

Site Preparation and Seeding

Mountain-brush sites, if dominated by weeds or low shrubs, especially sagebrush, should be treated like sagebrush lands. Plowing is necessary to kill sprouting shrubs such as snowberry.

The larger treelike mountain-brush species, such as maple and chokecherry, may be burned; seed may then be broadcast in the loose ashes. Resprouting trees and shrubs may eventually suppress the seeded species. If understory openings between the treelike plants are almost bare, seed can be broadcast in early fall and will be covered by falling leaves. Establishment under such conditions is slow, but fair to excellent seeded stands have been attained by this method (fig. 8).

PONDEROSA PINE FORESTS

The ponderosa pine forests of western Idaho are important primarily for their watersheds and for timber production, but they provide considerable grazing for livestock and big game. The common perennial understory forage plants are bitterbrush, bluebunch wheatgrass, Idaho fescue, and balsamroot. Fires and heavy use by livestock and big game have reduced the understory to cheatgrass in many places. Wherever these forests can be seeded, forage production is greatly increased in the timber openings (fig. 9). Seeding also reduces erosion hazards following logging and accidental fires in this zone and in the higher forests as well.

Species to Seed

Species recommended above for the mountain-brush sites are also useful on the ponderosa pine sites. Tall oatgrass, slender wheatgrass, and timothy produce quick cover, while smooth and meadow bromes and fairway, crested, intermediate, and pubescent wheatgrasses are long-lived for permanent forage. Orchardgrass is useful in shady places. A mixture of timothy,

Figure 8.--This good grass cover was attained by broadcasting seed in a nearly bare opening in maple at time of leaf fall and by providing protection through two seasons. Franklin County.

orchardgrass, smooth brome, and intermediate and fairway wheatgrasses, with variations, has been successfully established on logged areas in western Idaho. Establishment has been consistently better on the lava sites west of the Payette River than on the granitic soils east of the river.

Site Preparation and Seeding

Timber openings supporting cheatgrass, sagebrush, and mountain brush should be treated by using the same methods and species as recommended for the type of vegetation that occupies them.

Timbered areas disturbed by logging or accidental burns should be seeded immediately after logging or burning. Broadcasting is the only feasible method for seeding skid trails, steep slopes, and most burns. If seed is broadcast before rains pack the surface, it can be covered by soil slough or deep ashes. Roads and landings can be drilled, or the seed could be broadcast and later covered by harrowing.

MOUNTAIN MEADOWS

High elevation meadows usually contain varied types of vegetation. Some meadows have deteriorated to silver sagebrush or to undesirable broad-leaved perennials, mainly wyethia. If good forage plants occupy the space between the undesirable plants, it is usually sufficient to treat meadows with some herbicide and then to protect them a year or more to allow the species thus released from competition to improve in vigor and productivity. Some dry flats and dry meadows have been brought to high productivity by irrigation.

Species to Seed

Meadow foxtail, timothy, and smooth and meadow bromes have shown the most promise of sustained high productivity on the wettest parts of the meadow. In somewhat drier parts of the true meadow, these four species plus intermediate wheatgrass and Chewings fescue have performed well. Redtop, orchardgrass, tall, red, and sulcata fescues, Kentucky bluegrass, reed canarygrass, tall oatgrass, slender and pubescent wheatgrasses, mountain brome, alsike clover, and birdsfoot trefoil have established good stands on some sites for varied periods of time; but as they have not done consistently well in all tests, we cannot recommend them.

Figure 9.--Seeded grass in the ponderosa pine zone. Washington County.

Site Preparation and Seeding

Plowing is the best method of eliminating undesirable meadow plants that are not susceptible to chemical control. Plowing should be done as early in the season as the meadow is workable. A plowing depth of 6 inches is necessary to kill wyethia (Mueggler and Blaisdell 1951). Tough sods are hard to break and difficult to turn with a moldboard plow (fig. 10). Many plowed meadows must be disked several times in order to prevent air pockets beneath the surface. Sometimes it has been found desirable to plow a meadow and let it lie fallow and settle for a year and then replow or disk. Good seedbed preparation is expensive, but seeding can be profitable because the potential of improved meadows is also high.

OTHER HIGH-ALTITUDE RANGES

Above the ponderosa pine and mountain-brush types in the higher mountains are forests of Douglas-fir, aspen, lodgepole pine, other species of fir, and spruce. The more open forests and parklike openings are the principal summer ranges for cattle and sheep in Idaho. Seeding opportunities are limited by steep topography, rockiness, presence of trees, or short growing season. However, grazing values of thousands of acres of burned timber, depleted aspen, and weedy openings could be greatly increased by seeding.

Timber Burns

Forest fires leave the ground exposed to elements that cause erosion. Seeding a herbaceous cover helps to control erosion and provides forage while the timber stand reestablishes itself (fig. 11).

Seed should be broadcast on the loose ashes before they settle and become packed by rains; otherwise, the seed will not have enough cover and anchorage.

Any mixture for seeding the varied sites on burns should include short-lived perennials for quick cover and slow-maturing, long-lived species. A good mixture includes timothy, tall oatgrass, meadow foxtail, smooth and mountain bromes, and Chewings fescue.

Figure 10.--The tough sod of a meadow is difficult to break. Sometimes the sod-ribbon slides off the moldboard into the adjacent furrow without turning. Valley County.

Aspen Forests

The highlands of southeastern Idaho contain large stands of aspen. In many of these, heavy grazing has caused valuable understory grasses and broad-leaved herbs to be replaced by a sparse cover of undesirable weeds. Presence of trees limits the seeding method to broadcasting with no preparatory seedbed treatment. In both Utah (Plummer and Stewart 1944) and southeastern Idaho, unproductive aspen ranges have been seeded successfully by broadcasting before or during the time of aspen leaf fall. The layer of leaves adequately covers the seed. Grass species that have performed best on aspen sites have been timothy, orchardgrass, tall oatgrass, meadow foxtail, intermediate wheatgrass, and smooth brome.

Weedy Openings

Much of the nonforested part of the higher country in southern Idaho is infested with tarweed and knotweed. These areas are often gullied and are the source of runoff from snowmelt and from summer storms.

On many of these sites, the temperature of surface soil fluctuates so greatly each day that seeding trials have not been successful. Except on some tarweed areas, further study is needed before we can make sound recommendations for seeding.

Tarweed often dominates high-altitude openings to the near-total exclusion of other species. In eastern Idaho, where summer rainfall is quite dependable, tarweed ranges have been improved by seeding; but no good seeded stands have been established in tarweed areas in western Idaho. Germination of tarweed seed is nearly complete each spring; hence it can be eliminated for 1 or more years by shallow cultivation or by spraying with 2,4-D in spring before seeds develop. Seeding should normally be done in early spring when tarweed is eliminated. Where spring seeding is not feasible, tarweed areas may be cultivated or sprayed with 2,4-D in the spring and seeded in the fall.

Smooth and mountain bromes, timothy, meadow foxtail, orchardgrass, intermediate, pubescent, and slender wheatgrass, and tall oatgrass are adapted for seeding on tarweed sites.

Figure 11.--Seeding this lodgepole pine burn has protected topsoil from erosion and provided feed for livestock and elk. Valley County.

LIST OF PLANTS

Common name	Scientific name
alfalfa	Medicago sativa L.
aspen	Populus tremuloides Michx.
balsamroot, arrowleaf	Balsamorhiza sagittata (Pursh) Nutt.
bitterbrush	Purshia tridentata (Pursh) DC.
bluegrass, big	Poa ampla Merr.
bluegrass, bulbous	P. bulbosa L.
bluegrass, Kentucky	P. pratensis L.
bluegrass, Sandberg	P. secundá Presl
brome, cheatgrass (See cheatgrass)	
brome, meadow	Bromus erectus Huds.
brome, mountain	B. carinatus Hook. & Arn.
brome, smooth	B. inermis Leyss.
canarygrass, reed	Phalaris arundinacea L.
cheatgrass	Bromus tectorum L.
chokecherry	Prunus virginiana L.
clover	Trifolium spp.
clover, alsike	T. hybridum L.
coneflower	Rudbeckia occidentalis Nutt.
Douglas-fir	Pseudotsuga menziesii (Mirb.) Franco
fescue, Chewings	Festuca rubra var. commutata Gaud.
fescue, Idaho	F. idahoensis Elmer
fescue, red	F. rubra L.
fescue, sulcata	F. ovina ssp. sulcata Hack.
fescue, tall	F. arundinacea Schreb.
fir	Abies spp.
foxtail, meadow	Alopecurus pratensis L.
halogeton	Halogeton glomeratus C. A. Mey.
horsebrush, spineless	Tetradymia canescens DC.
junegrass, prairie	Koeleria cristata (L.) Pers.
juniper	Juniperus spp.
knotweed	Polygonum spp.
maple, bigtooth	Acer grandidentatum Nutt.
medusahead	Elymus caput-medusae L.
mountain-mahogany, curlleaf	Cercocarpus ledifolius Nutt.
mustards	Sisymbrium spp. and Descurainia spp.
needle-and-thread	Stipa comata Trin. & Rupr.
needlegrass, Thurber	S. thurberiana Piper
oatgrass, tall	Arrhenatherum elatius (L.) Presl
orchardgrass	Dactylis glomerata L.
pine, lodgepole	Pinus contorta Dougl.
pine, singleleaf pinyon	P. monophylla Torr. & Frem.
pine, ponderosa	P. ponderosa Laws.
rabbitbrush	Chrysothamnus spp.
rabbitbrush, rubber	C. nauseosus (Pall.) Britton
redtop	Agrostis alba L.
ricegrass, Indian	Oryzopsis hymenoides (Roem. & Schult.) Ricker

Common name	Scientific name
Russian-thistle	*Salsola kali* var. *tenuifolia* Tausch
sagebrush, big	*Artemisia tridentata* Nutt.
sagebrush, low	*A. arbuscula* Nutt.
sagebrush, silver	*A. cana* Pursh
sagebrush, threetip	*A. tripartita* Rydb.
saltbush, shadscale (See shadscale)	
serviceberry	*Amelanchier alnifolia* Nutt.
shadscale	*Atriplex confertifolia* (Torr. & Frem.) Wats.
snowberry	*Symphoricarpos* spp.
snowbrush	*Ceanothus velutinus* Dougl. ex Hook.
spruce	*Picea* spp.
squirreltail	*Sitanion hystrix* (Nutt.) J. G. Smith
tarweed	*Madia glomerata* Hook.
timothy	*Phleum pratense* L.
trefoil, birdfoot	*Lotus corniculatus* L.
wheatgrass, beardless	*Agropyron inerme* (Scribn. & Smith) Rydb.
wheatgrass, bluebunch	*A. spicatum* (Pursh) Scribn. & Smith ex Link
wheatgrass, crested	*A. desertorum* (Fisch.) Schult.
wheatgrass, fairway	*A. cristatum* (L.) Gaertn.
wheatgrass, intermediate	*A. intermedium* (Host) Beauv.
wheatgrass, pubescent	*A. trichophorum* (Link) Richt.
wheatgrass, Siberian	*A. sibiricum* (Willd.) Beauv.
wheatgrass, slender	*A. trachycaulum* (Link) Malte
wheatgrass, streambank	*A. riparium* Scribn. & Smith
wheatgrass, tall	*A. elongatum* (Host) Beauv.
wildrye, Great Basin	*Elymus cinereus* Scribn. & Merr.
wildrye, medusahead (See medusahead)	
wildrye, Russian	*E. junceus* Fisch.
winterfat ("white sage")	*Eurotia lanata* (Pursh) Moq.
wyethia	*Wyethia* spp.

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APPENDIX

The following table lists 237 range forage species tested in experimental plots for usefulness in seeding rangelands in southern Idaho. Plantings were made at one or more locations each year during the period 1936 to 1955--by personnel of the Intermountain Forest and Range Experiment Station prior to 1954, and by the Agricultural Research Service subsequently.

Symbols in the table show a comparative rating of adaptability of these species for use on six classes of sites commonly found in this area. Ratings should be regarded as indicative rather than precise because of the variety of growing conditions within sites, the varied lengths of testing periods, and the different methods of seeding used throughout the 2 decades of the testing.

We have rated adaptation of individual species to environmental conditions on a scale of 1 to 3 as follows:

1 Adapted to the site and generally useful for range seeding in southern Idaho.

2 Either (a) adapted to the site and useful for special conditions, (b) adapted, but of little value for seeding southern Idaho rangelands, or (c) promising, but not yet adequately tested.

3 Failed to survive where tested, and presumed not to be adapted.

- Not tested for this site.

* Recommended in this publication for range seeding. (Some species carry this symbol in addition to either 1 or 2.)

Adaptability of grass species tested on varied types of sites in southern Idaho, 1936-1955

Species	Harsh sagebrush	Intermediate sagebrush	Favorable sagebrush	Mtn. brush & pond. pine	Mountain meadows	High altitude
Achillea lanulosa Nutt.	-	3	2	2	-	-
Aeluropus littoralis (Gouan) Parl.	-	3	-	-	-	-
Agastache urticifolia (Benth.) Kuntze	-	3	3	2	-	-
Agoseris glauca var. laciniata (D. C. Eat.) Smiley	-	3	3	3	-	-
Agropyron ciliare (Trin.) Franch.	-	3	3	3	-	-
A. cristatum (L.) Gaertn. (several strains)	1*	1*	1*	1*	3	2
A. dasystachyum (Hook.) Scribn.	3	2	2	2	3	-
A. desertorum (Fisch. ex Link) Schult.	1*	1*	2*	1*	3	3
A. elongatum (Host) Beauv.	3	2*	1*	2*	3	3
A. inerme (Scribn. & Smith) Rydb. (several strains)	2	1*	2*	1*	3	3
A. intermedium (Host) Beauv.	2	1*	1*	1*	1*	1*
A. popovii Drob.	-	3	-	2	-	-
A. repens (L.) Beauv.	-	3	-	2	2	-
A. riparium Scribn. & Smith	2	2	2	2	-	-
A. semicostatum (Steud.) Nees ex Boiss	3	3	3	3	-	-
A. sibiricum (Willd.) Beauv.	2*	2*	2*	2*	-	-
A. smithii Rydb.	3	2	2	2	2	3
A. spicatum (Pursh) Scribn. & Smith (several strains)	2	1*	2*	1*	3	3
A. subsecundum (Link) Hitchc.	3	3	3	2	2	2
A. trachycaulum (Link) Malte	3	3	3	2*	2	1*
A. trichophorum (Link) Richt.	2	1*	1*	1*	2	2*
Agrostis alba L.	-	3	3	3	2	2
Alopecurus pratensis L.	-	-	2	-	1*	2*
Amelanchier alnifolia Nutt.	-	-	-	2	-	-
Ammophila arenaria (L.) Link	3	3	3	-	-	-
Andropogon gerardi Vitman	-	3	-	3	-	-
A. ischaemum L.	-	3	-	-	-	-
A. scoparius Michx.	-	3	-		-	-
Aristida fendleriana Steud.	-	-	-	3	-	-
A. longiseta Steud.	-	3	-	3	-	-
Arrhenatherum elatius (L.) Presl (two strains)	3	3	3	1*	2	2*
Artemisia abrotanum L.	3	2	2	2	-	-
A. arbuscula Nutt.	-	-	-	2	-	-
A. bigelovii Gray	3	3	-	-	-	-
A. dracunculus L.	-	-	-	2	-	-
A. frigida Willd.	3	3	-	3	-	-
A. nova A. Nels.	2	2	-	3	-	-
A. tridentata Nutt.	2	2	-	2	-	-
A. tripartita Rydb.	2	2	-	-	-	-
A. spinescens D. C. Eat.	3	3	-	3	-	-
Aster adscendens Lindl.	3	3	-	3	-	-
Astragalus chinensis L.	3	3	-	3	-	-
A. cicer L.	-	-	2	-	3	3
A. diversifolius Gray	3	2	-	3	-	-
A. falcatus Lam.	3	2	2	2	3	2
A. mortoni Nutt.	3	3	-	3	-	-
A. rubyi Green & Morris	3	3	-	3	-	-
A. stenophyllus T. & G.	3	3	2	3	-	-
Atriplex canescens (Pursh) Nutt.	2	2	-	3	-	-
A. confertifolia (Torr. & Frem.) Wats.	-	3	-	3	-	-
A. gardneri (Moq.) Stendl.	3	3	-	-	-	-
Balsamorhiza sagittata (Pursh) Nutt.	3	2	2	2	-	-
Bassia hyssopifolia (Pall.) Kuntze	2	3	-	3	-	-
Blepharidachne kingii (S. Wats.) Hack.	-	3	-	3	-	-
Bouteloua curtipendula (Michx.) Torr.	-	3	-	3	-	-
B. eriopoda (Torr.) Torr.	-	3	-	3	-	-
B. gracilis (H.B.K.) Lag. ex Steud.	3	2	-	3	-	-
B. hirsuta Lag.	-	3	-	-	-	-
Bromus anomalus Rupr. ex Fourn.	-	3	-	3	-	-
B. carinatus Hook. & Arn. (several strains)	3	3	2	2	2	1*
B. erectus Huds.	-	2	2*	2*	2*	2
B. inermis Leyss. (several strains)	3	2	1*	1*	1*	1*
B. mollis L.	-	-	-	3	-	-
B. tomentellus Boiss.	-	-	-	2	-	2
Calamagrostis epigeios (L.) Roth	3	2	-	2	-	-
C. montanensis Scribn.	-	2	-	3	-	-
Calamovilfa gigantea (Nutt.) Scribn. & Merr.	-	3	-	-	-	-
C. longifolia (Hook.) Scribn.	3	3	-	3	-	-
Caragana arborescens Lam.	3	3	2	2	-	-
Ceanothus velutinus Dougl. ex Hook.	-	3	-	2	-	-
Cercis occidentalis Torr. ex Gray	-	3	-	3	-	-
Cercocarpus ledifolius Nutt.	-	3	-	2	-	-
C. montanus Raf.	-	3	-	3	-	-
Chrysothamnus lanceolatus Nutt.	-	-	-	3	-	-
C. nauseosus (Pall.) Britton	-	-	-	2	-	-
C. viscidiflorus (Hook.) Nutt.	-	-	-	3	-	-
C. viscidiflorus var. stenophyllus (Nutt.) Hall & Clem.	-	-	-	3	-	-
Clematis ligusticifolia Nutt. ex T. & G.	-	-	-	2	-	-
Cornus stolonifera Michx.	-	-	-	2	-	-
Cowania stansburiana Torr.	3	3	-	-	-	-
Crepis acuminata Nutt.	3	2	2	2	-	-
Cytisus scoparius (L.) Link	-	-	-	3	-	-
Dactylis glomerata L.	-	3	3	1*	2	1*
Distichlis stricta (Torr.) Rydb.	-	3	-	3	-	-
Drymocallis sp.	-	3	-	3	-	-
Elaeagnus angustifolia L.	3	3	-	2	-	-
Elymus canadensis L.	3	3	3	3	3	-
E. chinensis (Trin.) Keng	-	3	-	-	-	-
E. cinereus Scribn. & Merr.	3	3	2	2	-	2
E. dahuricus Griseb.	-	3	-	3	-	-
E. flavescens Scribn. & Smith	-	2	3	3	-	-
E. glaucus Buckl.	3	3	3	2	3	2
E. junceus Fisch.	2*	1*	2*	2*	3	2
E. pseudoagropyrum Trin. ex Turcz.	-	2	-	-	-	-
E. salina Jones	3	2	2	2	3	-
E. sibiricus L.	3	3	-	3	-	-
E. triticoides Buckl.	3	3	2	2	3	-
E. virginicus L.	-	3	-	3	-	-
Ephreda nevadensis Wats.	-	-	-	3	-	-
Eragrostis curvula (Schrad.) Nees	-	3	-	3	-	-
E. lehmanniana Nees	-	-	-	3	-	-
Erigeron ursinus D. C. Eat.	-	3	-	3	-	-
Eriogonum heracleoides Nutt.	-	2	2	2	-	-
E. umbellatum Torr.	-	3	-	2	-	-
Erodium cicutarium (L.) L'Her.	-	3	-	3	-	-
Eurotia lanata (Pursh) Moq.	2	2	-	3	-	-
Festuca arizonica Vasey	3	3	-	3	-	-
F. arundinacea Schreb.	-	-	-	3	2	3
F. elatior L.	-	3	3	3	2	3
F. idahoensis Elmer	3	2	2	2	3	-
F. ovina L.	3	3	2	2	2	-
F. ovina var. brachyphylla (Schult.) Piper	-	3	-	2	2	-
F. ovina var. duriuscula (L.) Koch	3	3	3	3	3	2
F. ovina ssp. sulcata Hack.	3	3	2	2	2	2
F. rubra L.	-	3	2	2	2	2

Adaptability of grass species tested on varied types of sites in southern Idaho, 1936-1955 (con.)

Species	Harsh sagebrush	Intermediate sagebrush	Favorable sagebrush	Mtn. brush & pond. pine	Mountain meadows	High altitude
F. rubra var. commutata Gaud.	-	-	-	2*	2*	1*
Geranium viscosissimum F. & M.	-	3	-	3	-	2
Gleditsia triacanthos L.	-	3	-	3	-	-
Glycyrrhiza lepidota Pursh	3	3	-	3	-	-
Grayia spinosa (Hook.) Moq.	-	3	-	3	-	-
Gutierrezia sarothrae (Pursh) Britt. & Rusby	-	-	-	3	-	-
Hedysarum boreale Nutt.	3	3	2	2	-	-
Helianthella uniflora (Nutt.) T. & G.	3	3	2	3	-	-
Heracleum lanatum Michx.	-	3	-	3	-	2
Hesperochloa kingii (S. Wats.) Rydb.	3	3	-	2	-	-
Heteropogon contortus (L.) Beauv.	-	-	-	3	-	-
Hilaria jamesii (Torr.) Benth.	-	3	-	3	-	-
H. mutica (Buckl.) Benth.	-	3	-	3	-	-
H. rigida (Thurb.) Benth. ex Scribn.	-	3	-	3	-	-
Holcus lanatus L.	-	3	-	3	-	-
Hordeum bulbosum L.	3	3	2	2	2	3
Juniperus osteosperma (Torr.) Little	-	-	-	3	-	-
J. scopulorum Sarg.	-	-	-	2	-	-
Kochia scoparia (L.) Schrad.	2	2	-	-	-	-
Koeleria cristata (L.) Pers.	3	3	-	2	-	-
Lespedeza stipulacea Maxim.	-	3	-	3	-	-
Ligusticum porteri C. & R.	-	3	-	3	-	-
Lolium multiflorum Lam.	-	3	-	3	-	-
L. perenne L.	-	3	3	3	-	-
L. remotum Schrank	-	-	-	3	-	-
Lomatium dissectum var. multifidum (Nutt.) Mathias & Const.	-	3	-	3	-	-
L. simplex (Nutt.) Macbr.	-	3	-	-	-	-
Lotus corniculatus L.	-	3	-	3	2	2
Lupinus alpestris A. Nels	-	3	-	3	2	2
L. caudatus Kell.	3	2	2	2	-	-
L. leucophyllus Dougl. ex Lindl.	3	2	2	2	-	-
L. sericeus Pursh	3	3	2	2	-	-
Lycium halimifolium Mill.	-	-	-	3	-	-
Medicago lupulina L.	-	-	-	3	-	-
M. sativa L. (several varieties)	3	2*	2*	2*	2	3
M. tribuloides Desr.	-	3	-	-	-	-
Melica bulbosa Geyer ex Port. & Coult.	-	3	-	3	-	-
Melilotus alba Desr. (two varieties)	3	3	-	3	3	3
M. officinalis (L.) Lam.	3	3	3	3	3	3
Muhlenbergia porteri Scribn.	-	3	-	3	-	-
Onobrychis viciaefolia Scop.	-	2	-	2	-	-
Oryzopsis bloomeri (Boland.) Ricker	-	3	-	-	-	-
O. hymenoides (Roem. & Schult.) Ricker	2	2	2	2	-	-
O. miliacea (L.) Benth. & Hook. ex Aschers. & Schweinf.	3	3	-	3	-	-
Penstemon cyananthus Hook.	3	3	-	-	-	-
P. palmeri Gray	3	3	-	2	-	-
P. rydbergii A. Nels.	-	3	-	3	-	-
P. speciosus Dougl. ex Lindl.	3	3	-	-	-	-
Pentzia incana (Thunb.) Kuntze	-	3	-	3	-	-
Phalaris arundinacea L.	-	3	3	3	2	2
P. tuberosa var. stenoptera (Hack.) Hitchc.	3	3	-	3	-	-
Phleum pratense L.	-	3	3	2*	1*	1*
Physocarpus malvaceus (Greene) Kuntze	-	-	-	3	-	-
Pinus edulis Engelm.	3	-	-	-	-	-
Poa ampla Merr.	3	2*	2*	2*	2	3
P. bulbosa L.	2	2*	2*	2*	3	3
P. canbyi (Scribn.) Piper	-	2	-	2	-	-
P. compressa L.	3	3	-	2	-	-
P. cusickii Vasey	3	2	-	3	-	-
P. fendleriana (Steud.) Vasey	3	3	-	2	-	-
P. juncifolia Scribn.	3	2	2	2	-	-
P. longiligula Scribn. & Williams	3	3	-	2	-	-
P. macrantha Vasey	3	3	-	3	-	-
P. nevadensis Vasey ex Scribn.	3	2	2	2	2	-
P. pratensis L.	-	3	-	2	2	-
P. secunda Presl	2	2	2	2	-	-
P. sterilis Bieb.	-	-	-	3	-	-
Polygonum phytolaccaefolium Meissn.	-	3	-	3	-	-
Prunus emarginata (Dougl.) Walp.	-	-	-	2	-	-
P. virginiana var. melanocarpa (A. Nels.) Sarg.	-	3	-	2	-	-
Psoralea stenostachys Rydb.	-	3	-	3	-	-
Puccinellia airoides (Nutt.) Wats. & Coult.	-	3	-	-	-	-
Purshia tridentata (Pursh) DC.	3	2	2	2	-	-
Quercus gambelii Nutt.	-	3	-	3	-	-
Rhus trilobata Nutt. ex T. & G.	-	3	-	3	-	-
Ribes aureum Pursh	-	3	-	3	-	-
Sambucus caerulea Raf.	-	3	-	2	-	-
S. melanocarpa Gray	-	3	-	2	-	-
S. microbotrys Rydb.	-	3	-	3	-	-
Sanguisorba minor Scop.	3	3	-	2	-	-
Secale cereale L.	3	3	3	3	3	-
S. montanum Guss.	3	2	3	3	-	3
Senecio serra Hook.	-	3	3	3	-	-
Shepherdia argentea Nutt.	-	-	-	3	-	-
Sitanion hystrix (Nutt.) J. G. Smith	2	2	2	2	-	-
Sorghastrum nutans (L.) Nash	-	3	-	-	-	-
Sorghum sudanense (Piper) Stapf	3	3	3	3	-	-
Sphaeralcea grossulariaefolia (H. & A.) Rydb.	-	3	-	3	-	-
S. munroana (Dougl.) Spach.	-	3	-	-	-	-
Sporobolus airoides (Torr.) Torr.	-	3	-	3	-	-
S. asper (Michx.) Kunth	-	-	-	3	-	-
S. cryptandrus (Torr.) A. Gray	3	3	-	3	-	-
Stipa arida Jones	3	3	-	3	-	-
S. columbiana Macoun	3	3	2	2	-	2
S. columbiana var. nelsoni (Scribn.) Hitchc.	3	3	-	2	-	-
S. comata Trin. & Rupr.	3	2	2	2	-	-
S. coronata var. depauperata (Jones) Hitchc.	-	3	-	-	-	-
S. lettermani Vasey	3	3	-	2	-	2
S. occidentalis Thurb.	-	2	-	2	-	-
S. pulchra Hitchc.	3	3	-	3	-	-
S. robusta (Vasey) Scribn.	3	3	-	3	-	-
S. speciosa Trin. & Rupr.	-	3	-	-	-	-
S. thurberiana Piper	3	2	-	-	-	-
S. viridula Trin.	3	2	2	-	-	-
Symphoricarpos oreophilus A. Gray	-	3	-	3	-	-
Thermopsis montana Nutt. ex T. & G.	-	3	-	3	-	-
Tragopogon porrifolius L.	-	3	-	3	-	-
Trifolium fragiferum L.	-	3	-	3	3	-
T. hybridum L.	-	-	-	3	2	2
T. lappaceum L.	-	3	-	-	-	-
T. lupinaster L.	-	3	-	-	-	-
T. macrocephalum (Pursh) Poir.	-	3	-	3	-	-
T. repens L. (two varieties)	-	3	3	3	3	-
T. subterraneum L.	-	3	-	-	-	-
T. wormskioldii Lehm	-	3	-	3	-	-
Tridens pilosus (Buckl.) Hitchc.	-	3	-	-	-	-
Vicia americana Muhl.	-	3	-	-	-	-
V. tenuifolia Roth	-	2	3	-	-	-
V. villosa Roth	3	3	-	3	-	2
Viguiera multiflora (Nutt.) Blake	3	3	3	2	-	-
Wyethia amplexicaulis Nutt.	3	3	-	2	-	-
Zoysia japonica Steud.	-	3	-	-	-	-

FOREST SERVICE CREED

The Forest Service of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives--as directed by Congress--to provide increasingly greater service to a growing Nation.

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Project headquarters are also at:

- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State College)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with Montana State University)
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FOREST SERVICE

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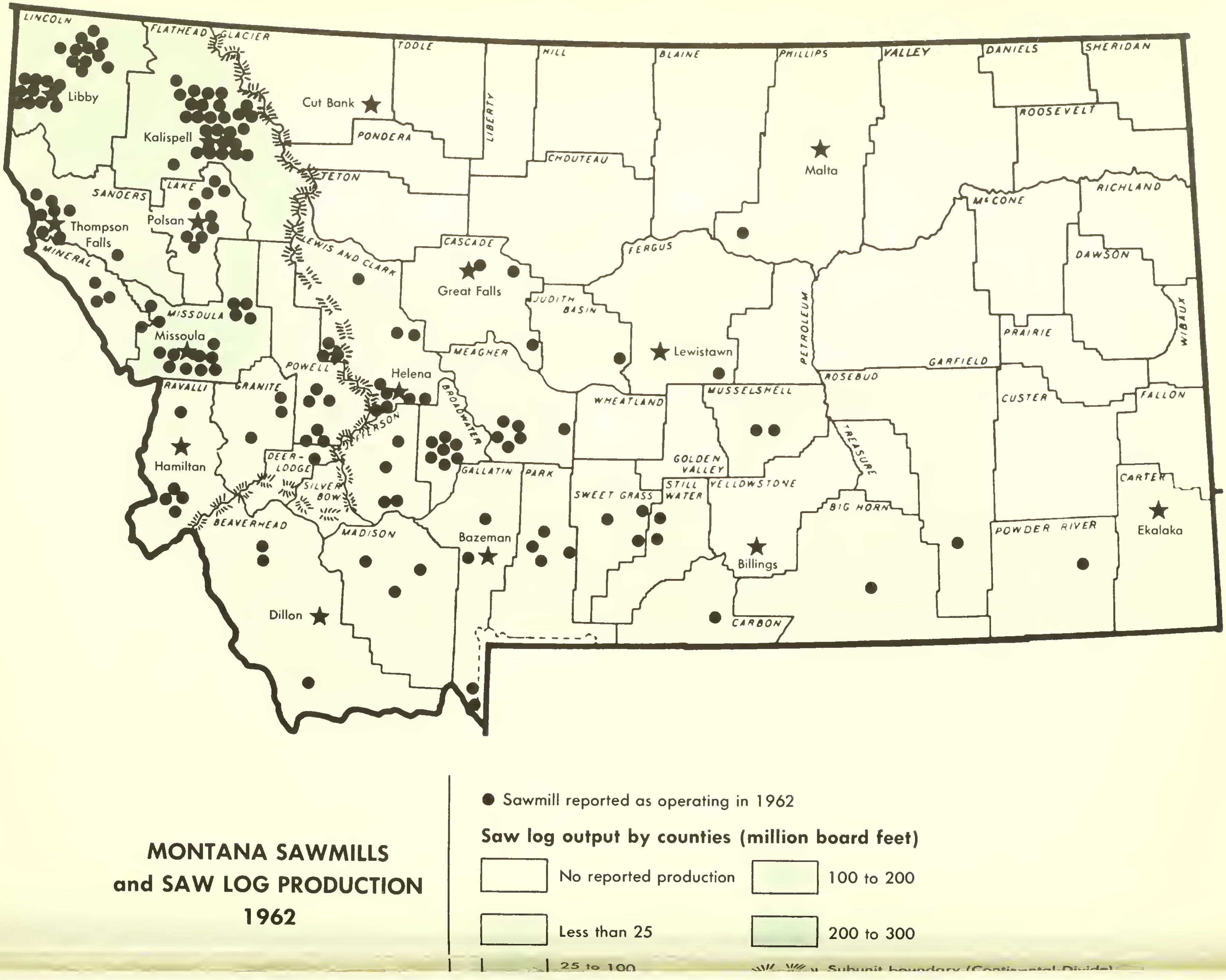
DEPARTMENT OF AGRICULTURE

OUTPUT OF TIMBER PRODUCTS IN MONTANA, 1962

Forest Service, U.S. Department of Agriculture
1964



MONTANA SAWMILLS
and SAW LOG PRODUCTION
1962

U.S. Forest Service
Research Paper INT-11
1964

OUTPUT OF TIMBER PRODUCTS IN MONTANA, 1962

By

Alvin K. Wilson
Division of Forest Economics and Recreation Research

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
U.S. Department of Agriculture
Ogden, Utah
Joseph F. Pechanec, Director

This report summarizes survey information collected in 1963 on the 1962 output of roundwood products from Montana's forests. The term "roundwood" designates products that were received at plants "in the round" (as logs or bolts) for the first steps in manufacture. Accordingly, the data presented here do not include pulpwood made from sawmill or veneer plant residues (slabs, edgings, trim ends, shavings, sawdust, lathe cores) nor do they include fuelwood or any other items (industrial or domestic) made from these residues. However, to evaluate the extent to which sawed materials compete with round timbers in mine use, data on sawed materials used in mines in 1962 are summarized in one table in this report, but are not included elsewhere.

Detailed results of this survey are presented in a series of tables. The highlights of 1962 production and major production trends between 1952 and 1962 are discussed. Data for saw log output are presented in more detail than data for other products because of the predominance of saw logs in the State's total production.

Forest products surveys in the Rocky Mountain States and western South Dakota are part of the Intermountain Forest and Range Experiment Station's program for periodic appraisals of the forest situation. In western South Dakota, eastern Wyoming, Colorado, New Mexico, and Arizona, products surveys and other phases of Forest Survey work are conducted cooperatively with the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

THE AUTHOR

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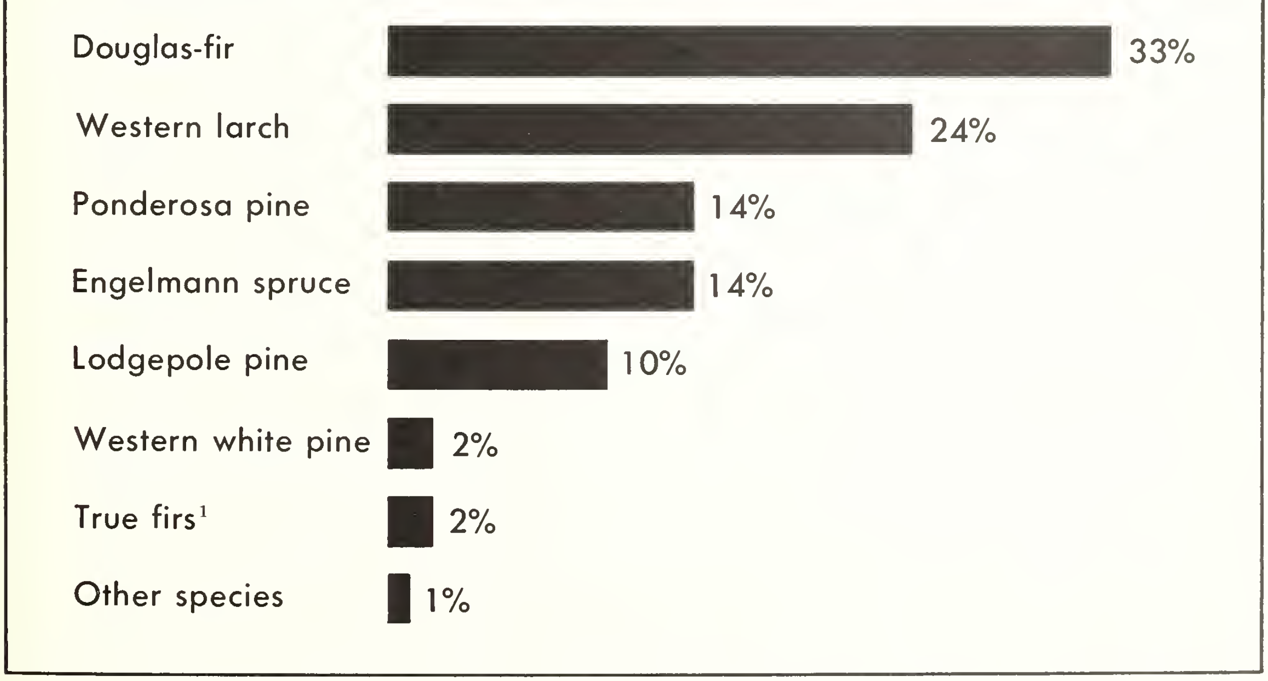
OUTPUT OF TIMBER PRODUCTS IN MONTANA, 1962

THE SITUATION IN 1962

The total output of roundwood products in Montana in 1962 was more than 207 million cubic feet--a gain of 44 percent since 1952. This total included production from live and dead trees, and from commercial[1] and noncommercial forest land. These products included saw logs (for lumber), veneer logs, pulpwood logs and bolts, utility poles, mine timbers, miscellaneous industrial wood (mainly converter poles and house logs), posts, fuelwood, and miscellaneous farm timbers. The total output from dead trees, cull trees,[2] and noncommercial forest land was estimated to have been 10 million cubic feet. Production from live, noncull trees on commercial forest lands was 197 million cubic feet.

The leading species were Douglas-fir and western larch.

Montana Timber Products Output By Species, 1962



[1]*Grand and subalpine firs.*

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[1] Forest land that is producing, or is capable of producing crops of industrial wood and not withdrawn from timber utilization.

[2] Live trees 5.0 inches or larger at breast height that are unmerchantable for saw logs now or prospectively because of defect, rot, or species.

National Forests supplied nearly 56 percent of the total and other public lands another 5 percent. Privately owned timberlands contributed 39 percent, of which more than half came from forest industry lands.[3]

Saw logs, by far the most important item produced from Montana forests in 1962, totaled nearly 1,276 million board feet[4] and accounted for 88 percent of the total volume output. Of this total, Montana sawmills received more than 1,246 million board feet and more than 29 million board feet were exported to mills in Idaho. The greatest concentration of sawmills--and the highest saw log output--was in western Montana (see inside front cover). In addition to the mills shown, there were an estimated 58 active small sawmills from which no saw log reports were received in the 1962 products survey. These mills received about 2.8 percent of the State's saw log output. Montana sawmills also received 32 million board feet of logs from Idaho. Almost half (49.6 percent) of the saw logs produced in Montana came from National Forests, and 4.3 percent came from other public lands. More than one-third of the total volume was Douglas-fir, 22 percent was western larch, and 16 percent was ponderosa pine.

Veneer log production in Montana has grown rapidly over the past few years so that, in cubic volume produced, veneer logs were the State's second most important primary forest product in 1962. Only one veneer plant was operating in Montana as recently as 1957. There were five veneer and plywood plants in 1962, which consumed nearly 111 million board feet of logs. Western larch supplied 49 percent of the total, and Douglas-fir about 37 percent.

Round pulpwood, totaling 46,936 standard cords, was shipped from Montana to mills in Idaho, Washington, and the Lake States in 1962. In volume, round pulpwood is the third most important timber product in the State. Although production has declined from the level maintained between 1952 and 1956, available data indicate little change since 1959; production in 1962 was practically the same as in 1959 when 46,749 cords were produced.[5]

Montana produced more than 122,000 commercial poles in 1962 from four species--western redcedar, lodgepole pine, western larch, and Douglas-fir. Of these, lodgepole pine, which furnished more than 105,000 poles, was clearly the predominant species. In volume, pole production accounted for slightly less than 1 million cubic feet of wood and ranked fourth in the State's roundwood products.

Other roundwood products--round mine timbers, miscellaneous industrial wood, posts, fuelwood, and miscellaneous farm timbers--collectively accounted for a total of more than 4.25 million cubic feet of wood in 1962. Miscellaneous farm timbers and posts were the major items and together accounted for about 80 percent of this total. Nearly all of the round mine timbers were used in eastern Montana, while most of the sawed timbers and lumber used in mines was consumed in western Montana.[6]

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[3] Lands owned by companies or individuals operating wood-using plants.

[4] The International $\frac{1}{4}$-inch log rule is used throughout this report.

[5] Intermountain Forest and Range Experiment Station file data compiled from a survey conducted in 1960.

[6] West of the Continental Divide.

TRENDS SINCE 1952

Montana's forest industrial facilities have grown a great deal since 1952, particularly those manufacturing lumber and plywood. Data for 1952, 1956, and 1962 (years for which information is available for all roundwood products) provide the following comparisons for percentage increases for all products, and indicate the general relationship with Census Bureau lumber figures:

Years	All roundwood products	Lumber
	(Percent increase)	
1952 to 1956	33	40
1956 to 1962	8	9
1952 to 1962	44	52

The comparison suggests that most of the 44 percent increase from 1952 to 1962 for all products had taken place by 1956. However, Census Bureau data for lumber production (used here for comparisons because they are available for each year and show a reasonably close relation to total output) indicate that production in 1956 was exceptionally high in relation to the general trend from 1952 through 1958. Census data also indicate that the average annual increase in production between 1952 and 1962 was about 5.1 percent.

Saw log production in 1962 was 85 percent greater than that of 1952 and 13 percent higher than in 1956 (again note that 1956 was an exceptional year). As a percentage of the total output, saw log production has also increased in importance, rising from 75 percent in 1952 to 88 percent of total output in 1962.

Although the number of active mills has decreased since 1956, the average mill produced more in 1962 than in 1956. Of the 333 mills operating in 1956, the average mill sawed nearly 3 million board feet of lumber, but the 209 mills that were active in 1962 averaged 5 million board feet. The following tabulation presents this information for sawmills in selected size-class groupings:

Number of mills by production class and their average lumber output in 1956 and 1962

Production class (bd. ft. per year)	Year	Active sawmills	Average annual production	Percent of total lumber production
		Number	Million bd.ft.	
10 million and more	1956	26	25.1	67
	1962	40	23.4	87
1 to 10 million	1956	78	3.4	27
	1962	40	2.7	11
Less than 1 million	1956	229	.3	6
	1962	129	.2	2

Several of the sawmills that were in the 1- to 10-million board-foot class in 1956 increased their production so that by 1962 they were in the largest production class. Although some of the mills that produced less than 1 million board feet in 1956 may have moved into the middle class by 1962, it is apparent that a large percentage of them had become inactive by 1962.

Patching veneer in a Montana plywood plant. Montana had only one plywood plant in 1957 but now has five.

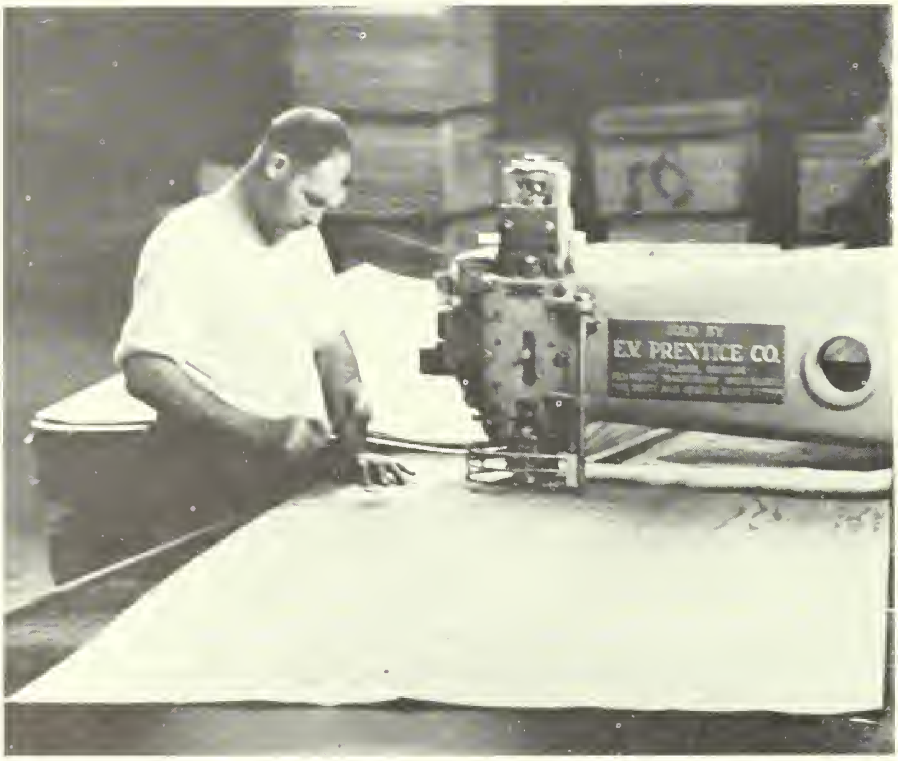

Photo by C. R. Lockard

Veneer and plywood production has grown rapidly in Montana in the last 5 years. From 1952 through 1957 there was only one active plywood plant in the State, and production of veneer logs was therefore a minor part of the total products output. In 1958, a second plant began operations, two more were in production by 1960, and in late 1962 a fifth plywood plant started operating. This expansion was so rapid that by 1962 the production of veneer logs was second only to that of saw logs.

Production of round pulpwood in Montana declined markedly in the last decade. All of Montana's round pulpwood has always been shipped to mills outside the State. These shipments were at a comparatively high level between 1952 and 1956, averaging about 110,000 standard cords per year. However, expansion in pulp production in northern Idaho, Washington, and the Lake States in the late 1950's was accompanied by increasing dependence on chipped sawmill residues for pulpwood. This shift in wood utilization was a principal cause of the decline in round pulpwood shipments to these areas that occurred between 1956 and 1959. Since 1959, production of round pulpwood appears to have leveled off at about 47,000 cords per year.

Montana's only pulpmill, which operates entirely on chipped sawmill residues, went into production in 1957 and by 1963 attained a daily pulp production capacity of 700 tons.[7]

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[7] Lockwood's Directory of the Paper and Allied Trades. 1963.

The estimate of 5,261,000 cubic feet for 1962 output of all other roundwood products is considerably lower than the 1956 estimate of 21,458,000 cubic feet. This difference is due to declines in output of commercial poles, round mine timbers, and fuelwood. Estimated outputs for 1962 for miscellaneous industrial wood, posts, and miscellaneous farm timbers were all higher than for 1956.

Annual surveys of commercial pole production in the northern Rocky Mountain area (northeastern Washington, Idaho, and Montana) have shown that pole production, which had been declining rapidly before 1955, declined less rapidly and tended to level off in the late 1950's. [8]

The use of round mine timbers has also shown a marked decline; increased use of sawed timbers and advances in mining methods were among the factors contributing to this decline.

The decline in fuelwood consumption follows the national trend[9] which reflects a shift to more easily handled fuels and to electricity.

SURVEY PROCEDURES

The survey of saw log receipts at sawmills was based on a late 1962 listing of mills that had been made as complete as possible by reviews by Forest Service personnel and the Montana State Forester's office. All listed mills were contacted by mail to obtain data on their saw log receipts for 1962. All mills outside the State that were considered as possible recipients of logs from within the State were also asked to report. Field sampling was used to provide data for estimating, within acceptable error limits, the receipts of sawmill operators who did not furnish mail reports (nonrespondents).

The standard error for that part of the total saw log receipts that was estimated by field sampling nonrespondents was 21,717,000 board feet, or 1.70 percent of the State's total saw log receipts. The odds, then, are 2 to 1 that the true State total, estimated at 1,275,688,000 board feet in this survey, was between 1,253,971,000 and 1,297,405,000 board feet.

Similar procedures were used in the survey of round mine timbers and sawed timbers and lumber received at Montana mines in 1962. Lists of mines were compiled from State sources[10] and a mining industry directory,[11] and nonrespondents were sampled by field contacts. For round timbers, the standard error of the estimated part of receipts from Montana timberlands was 4,711 cubic feet or 1.74 percent of the State total. At 2 to 1 odds the true State total for round mine timbers was therefore between 265,809 and 275,231 cubic feet. For sawed timbers and lumber receipts, the standard error was 0.18 percent of the State total so that, at 2 to 1 odds, the true State total was between 18,057,000 and 18,121,000 board feet, lumber tally.

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[8] Wilson, Alvin K. Commercial pole production in the northern Rocky Mountain area in 1962. Intermountain Forest and Range Expt. Sta. Res. Note INT-9, 6 pp., illus. 1963.

[9] U.S. Bureau of the Census. U.S. Census of Agriculture: 1959, vol. II, General Report Statistics by Subjects. U.S. Govt. Printing Office, Wash., D.C., 1,485 pp. 1962.

[10] Report and Statistical Tables of Department of Safety IN: Forty-Seventh Annual Report of the Montana Industrial Accident Board for July 1961 through June 1962.

[11] Miller Freeman Publications. Mining World Catalog Survey and Directory Number, 246 pp. 1962.

Reports were obtained by mail and field contacts with all plants that were known to receive veneer logs, round pulpwood, commercial poles, and miscellaneous industrial wood from Montana in 1962; estimates for these products are accordingly considered to be without sampling error.

Estimates for 1962 production of posts, fuelwood, and miscellaneous farm timbers were derived from reports furnished by the National Forests, the State Forester, Bureau of Land Management, and the Bureau of Indian Affairs, supplemented by trend estimates obtained from U.S. Bureau of the Census publications on farm use of these products. Since this procedure precluded the computation of a sampling error by the methods used with the preceding products, no error estimate has been assigned.

* * * * *

Table 1.--Output of timber products in Montana, by products and species groups, in standard units, 1962

Product		Quantity		
		Total	Softwoods	Hardwoods
Saw logs	M bd. ft.[1]	1,275,668	1,275,242	446
Veneer logs	M bd. ft.[1]	110,654	110,654	0
Mine timbers (round)	M cu. ft.	271	270	1
Miscellaneous industrial wood[2] . .	M cu. ft.	281	281	0
Miscellaneous farm timbers . . .	M cu. ft.	2,108	2,108	0
Pulpwood (round)	M std. cds.[3]	47	47	0
Fuelwood	M std. cds.	4	4	0
Poles	M pieces	122	122	0
Posts (round and split)	M pieces	1,047	1,047	0
All products converted to	M cu. ft.	207,289	207,224	65

[1] International ¼-inch log rule.
[2] Includes house logs and converter poles.
[3] Rough wood basis.

Table 2.--Saw log receipts of Montana sawmills by source areas, 1962

Source area	Volume	Percent
	M bd. ft.[1]	
Western Montana	1,108,865	86.7
Eastern Montana	137,523	10.8
Northern Idaho[2]	30,391	2.4
Southern Idaho	1,523	.1
Total	1,278,302	100.0

[1] International ¼-inch log rule. [2] North of the Salmon River.

Table 3.--Sawmill log receipts from Montana timberlands by species, subunits, and county of origin, 1962

Subunit and county	Log species: Ponderosa pine	White pines[1]	Lodgepole pine	Douglas-fir	True firs[2]	Engelmann spruce	Western larch	Other species[3]	All species: Volume	Percent
	Thousands of board feet, International $\frac{1}{4}$-inch rule[4]									
WESTERN										
Flathead	32,116	7,095	5,487	52,059	2,575	56,620	63,021	276	219,249	17.2
Granite	1,377	0	3,728	25,576	272	3,568	0	0	34,521	2.7
Lake	14,845	1,485	853	14,862	1,150	11,254	16,638	306	61,393	4.8
Lewis and Clark[5]	2,350	0	2,392	10,937	1,192	3,578	0	0	20,449	1.6
Lincoln	35,422	12,696	15,515	79,434	11,438	24,488	99,663	13,820	292,476	22.9
Mineral	20,367	3,050	200	15,960	1,225	3,182	12,658	636	57,278	4.5
Missoula	45,877	1,081	5,431	71,653	2,795	17,283	58,401	82	202,603	15.9
Powell, Silverbow[5]	6,123	0	4,390	29,401	163	1,324	6,203	0	47,604	3.7
Ravalli	14,359	0	224	40,966	1,763	42,137	80	0	99,529	7.8
Sanders	25,674	9,381	2,822	26,485	4,102	6,695	24,951	1,549	101,659	8.0
Total, Western	198,510	34,788	41,042	367,333	26,675	170,129	281,615	16,669	1,136,761	89.1
Percent of total	17.5	3.0	3.6	32.3	2.3	15.0	24.8	1.5	100.0	
EASTERN										
Broadwater	252	0	2,113	12,839	163	0	0	0	15,367	1.2
Gallatin	0	0	25,579	4,181	0	586	0	0	30,346	2.4
Madison	0	0	131	4,242	54	556	0	0	4,983	.4
Meagher	11	0	14,151	21,528	0	1,300	0	0	36,990	2.9
Park	0	0	5,600	14,478	0	182	0	0	20,260	1.6
Beaverhead, Jefferson	6	0	758	1,467	34	1,486	0	0	3,751	.3
Bighorn, Carter, Musselshell, Powder River, Rosebud	2,132	0	0	120	0	0	0	0	2,252	.2
Carbon, Stillwater, Sweet Grass	150	6	22	961	0	6	0	0	1,145	.1
Cascade, Judith Basin, Lewis and Clark[5]	1,895	0	17,941	3,042	97	363	0	0	23,338	1.8
Chouteau, Phillips, Fergus	403	0	75	17	0	0	0	0	495	([6])
Total, Eastern	4,849	6	66,370	62,875	348	4,479	0	0	138,927	10.9
Percent of total	3.5	0	47.8	45.3	.2	3.2	0	0	100.0	
STATE TOTAL	203,359	34,794	107,412	430,208	27,023	174,608	281,615	16,669	1,275,688	100.0
Percent of total	16.0	2.7	8.4	33.7	2.1	13.7	22.1	1.3	100.0	

[1] Practically all western white pine, but includes a small amount of whitebark and limber pines.
[2] Grand fir and subalpine fir.
[3] Western hemlock, western redcedar, aspen, and cottonwood.
[4] Scribner log rule volumes can be approximated by multiplying table volumes by 0.89.
[5] Lewis and Clark, and Silver Bow Counties overlap the Continental Divide. All saw log receipts from Silverbow County were from the western side of the Divide.
[6] Less than 0.05 percent.

Table 4.--Output of timber products in Montana by species, 1962

Product	Species									Total	Percent
	Ponderosa pine	White pines[1]	Lodgepole pine	Douglas-fir	True firs[2]	Engelmann spruce	Western larch	Western redcedar	Other species[3]		
	Thousand cubic feet										
Saw logs	29,080	4,976	15,360	61,520	3,864	24,968	40,271	1,742	642	182,423	88.0
Veneer logs	141	37	144	5,864	184	1,659	7,791	3	1	15,824	7.6
Pulpwood (round)	0	7	2,173	0	69	1,067	463	0	2	3,781	1.8
Poles	0	0	651	3	0	0	220	92	0	966	.5
Mine timbers (round)	29	0	214	22	5	0	0	0	1	271	.1
Miscellaneous industrial wood	78	0	97	106	0	0	0	0	0	281	.2
Posts, fuelwood, miscellaneous farm timbers	100	0	1,355	1,219	0	206	569	294	0	3,743	1.8
Total	29,428	5,020	19,994	68,734	4,122	27,900	49,314	2,131	646	207,289	
Percent of total	14.2	2.4	9.6	33.2	2.0	13.5	23.8	1.0	.3		100.0

[1]Practically all western white pine but includes a small amount of whitebark and limber pines.
[2]Grand, white, and subalpine firs.
[3]Western hemlock and cottonwood.

Table 5.--Output of timber products by land ownership classes, Montana, 1962

Product	Total volume	Land ownership classes				
		National Forest land	Other public lands	Forest industry lands[1]	Other private lands	All ownerships
	Thousand cu. ft.	Percent				
Saw logs	182,423	49.6	4.3	18.0	16.1	88.0
Veneer logs	15,824	3.6	.1	2.7	1.2	7.6
Pulpwood (round)	3,781	1.1	.5	.2	([2])	1.8
Poles	966	.2	([2])	.1	.1	.5
Mine timbers (round)	271	.1	0	([2])	([2])	.1
Miscellaneous industrial wood	281	.1	0	([2])	([2])	.2
Posts, fuelwood, miscellaneous farm timbers	3,743	1.0	.1	.4	.3	1.8
Total	207,289	55.7	5.1	21.4	17.8	100.0

[1]Lands owned by companies or individuals operating wood-using plants.
[2]Less than 0.05 percent.

Table 6.--Round and sawed timbers and lumber received at mines in eastern and western Montana, 1962

Subunit	Round timbers			Sawed timbers and lumber		
	All mines	Coal mines	Other mines	All mines	Coal mines	Other mines
	- - - Thousand cubic feet - - -			- - - Thousand board feet - - -		
Western Montana	18	0	18	15,732	0	15,732
Eastern Montana	253	21	232	2,357	970	1,387
Total	271	21	250	18,089	970	17,119

Table 7.--Lumber production and numbers of active sawmills by size classes in Montana, 1956 and 1962

Sawmill size class (M bd. ft. per year)	1956 [1]			1962		
	Lumber production		Active mills	Estimated lumber production [2]		Active mills [3]
	Million bd. ft. [4]	Percent	Number	Million bd. ft. [4]	Percent	Number
Less than 500	22	2	189	12	1	102
500 to 999	43	4	40	13	1	27
1,000 to 4,999	156	16	63	49	5	30
5,000 to 9,999	107	11	15	60	6	10
10,000 and over	653	67	26	935	87	40
Total	981	100	333	1,069	100	209

[1] Wilson, Alvin K. Montana lumber production, 1956. Intermountain Forest and Range Expt. Sta. Forest Survey Release 2, 7 pp., illus. 1958.

[2] Estimated from Census Bureau's lumber production total for Montana's 1962 production (1,069 million board feet, lumber tally) on the assumption that lumber production was distributed among sawmill size classes in proportion to their reported saw log receipts.

[3] Mill size class estimated from saw log receipts rather than from lumber production.

[4] Lumber tally.

Table 8.--Output of timber products in Montana, and percentages of totals for major products, 1952, 1956, and 1962

Product	1952[1]		1956[2]		1962	
	Output	Percent[3]	Output	Percent[3]	Output	Percent[3]
Saw logs . . . M bd. ft.[4]	691,001	75	1,128,614	84	1,275,688	88
Veneer logs . M bd. ft.[4]	([5])	([5])	([5])	([5])	110,654	8
Pulpwood . . . M std. cds.[6]	140	9	134	5	47	2
All other[7] . . M cu. ft.	23,642	16	21,458	11	5,261	2
Total converted to . . . . M cu. ft.	144,018	100	191,626	100	207,289	100

[1] U.S. Forest Service. Timber resources for America's future. U.S. Dept. Agr. Forest Resource Rpt. 14, 713 pp., illus. 1958. (Table 13, pp. 526-527.)

[2] (a) Wilson, Alvin K. Log production in Idaho and Montana, 1956. Intermountain Forest and Range Expt. Sta. Res. Note 54, 7 pp. 1958.

(b) Pissot, Henry J., and Harold E. Hanson. The forest resource of Western Montana. U.S. Forest Serv. Resource Bull. INT-1, 39 pp., illus. 1963.

(c) Intermountain Forest and Range Expt. Sta. file compilations for the 1956 products survey.

[3] Based on cubic-foot volume equivalents for products whose outputs are shown in other standard volume units.

[4] International $\frac{1}{4}$-inch log rule.

[5] To avoid disclosing the operations of the single veneer plant that was in operation in 1952 and 1956, veneer log volumes have been included with saw logs.

[6] Rough wood basis. Includes round pulpwood only; i.e., does not include pulpwood from sawmill and veneer plant residues.

[7] Includes commercial poles, round mine timbers, miscellaneous industrial wood, posts, fuelwood, and miscellaneous farm timbers.

Table 9.--Montana lumber production, 1952-1962

Year	Quantity
	Millions of board feet lumber tally
1952	702
1953	757
1954	738
1955	785
1956	981
1957	773
1958	924
1959	1,044
1960	985
1961	985
1962	1,069

Source: U.S. Bureau of the Census

DPSU/65/1496-1

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FOREST PRODUCTS OUTPUT IN UTAH AND NEVADA, 1962

Forest Service, U.S. Department of Agriculture
1964

This report summarizes survey information collected in 1963 concerning the output of roundwood products from the forests of Utah and Nevada in 1962. A separate discussion with set of tables for each State is followed by a statement on survey procedures and sampling accuracy.

Since the results of products surveys can be presented almost completely in tabular form, a series of tables is used here to present details. Discussion is confined to the highlights of 1962 production and to pointing out major production trends between 1952 and 1962. Data for saw log production are presented in more detail than data for other products because saw logs predominate in each State's total production.

The term "roundwood" is used to designate products that were received "in the round" (as logs or bolts) at plants for the primary steps in manufacture.

This report does not include estimates of output of any products (industrial or domestic) from sawmill residues (slabs, edgings, trim ends, or sawdust).

Forest products surveys in the Rocky Mountain States and western South Dakota are part of the Intermountain Forest and Range Experiment Station's program for periodic appraisals of the forest situation. In western South Dakota, eastern Wyoming, Colorado, New Mexico, and Arizona, products surveys and other phases of Forest Survey work are conducted cooperatively with the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

U.S. Forest Service
Research Paper INT-12
1964

FOREST PRODUCTS OUTPUT IN UTAH AND NEVADA, 1962

By

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FOREST PRODUCTS OUTPUT IN UTAH, 1962

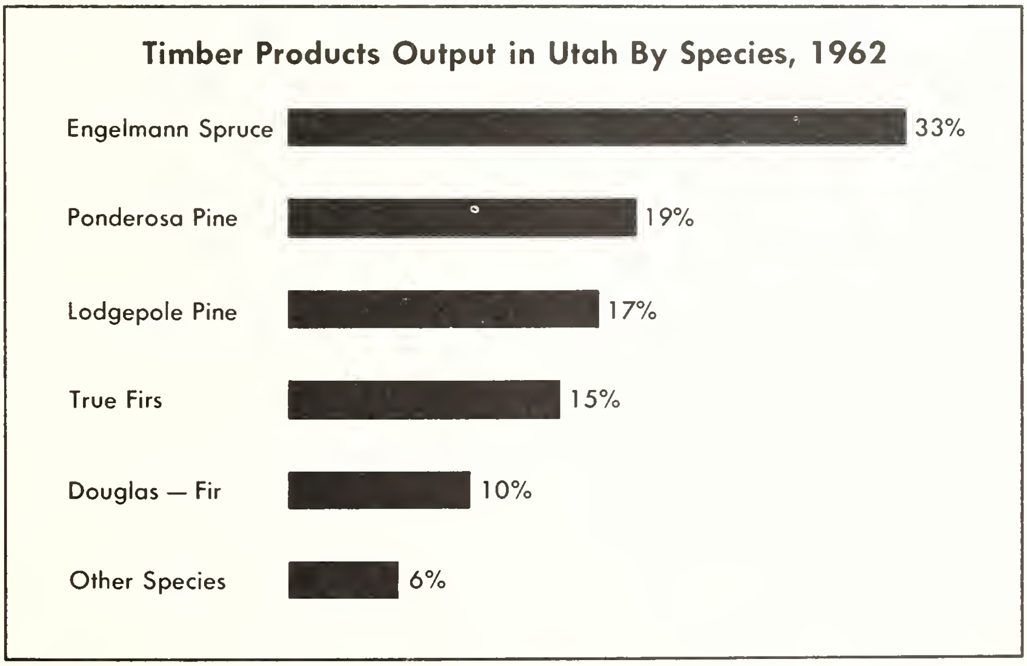
THE SITUATION IN 1962

The total output of roundwood products in Utah during 1962 was 12 million cubic feet, an increase of 36 percent from the 1952 output,[1] but a decline of 19 percent from the 1960 level.[2] This figure includes production from live and dead trees harvested from commercial[3] and noncommercial forest land.

Roundwood products harvested in Utah during 1962 included saw logs (for lumber), round mine timbers, commercial poles, converter poles, charcoal wood, excelsior bolts, fenceposts, miscellaneous farm timbers, and fuelwood.

Public lands--principally National Forests--supplied 88 percent of the total output in Utah in 1962.

Saw logs were the most important product harvested in Utah; they comprised 90 percent of the volume of all timber products. Nearly 65 million board feet[4] of saw logs was produced in 1962, and almost all of this volume went to sawmills within the State. A small amount--about



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[1] U.S. Forest Service. Timber resources for America's future. U.S. Dept. of Agr. Forest Resource Rpt. 14, 713 pp., illus. 1958.

[2] Wilson, Alvin K. Forest products output in Utah in 1960. U.S. Forest Serv., Intermountain Forest and Range Expt. Sta. Forest Survey Release 4, 6 pp. 1962.

[3] Forest land that is producing or is capable of producing crops of industrial wood and that has not been withdrawn from timber utilization.

[4] International $\frac{1}{4}$-inch log rule board-foot volumes are used throughout this report unless otherwise stated.

A large number of small sawmills in Utah, like the one shown here, had become inactive by 1962.

2 million board feet--was exported to Wyoming. Imports were small and consisted of about one-fourth million board feet from Idaho and Nevada. Engelmann spruce and ponderosa pine were the principal species harvested for saw logs; they represented 34 percent and 19 percent, respectively, of the total saw log volume.

Other roundwood products--mine timbers, miscellaneous industrial wood, posts, miscellaneous farm timbers, and fuelwood--accounted for 1,160,000 cubic feet, or 10 percent of the total 1962 timber products output in Utah. Miscellaneous industrial wood--charcoal wood, commercial poles, converter poles, and excelsior bolts--was the single most important product and represented nearly two-thirds of this volume.

TRENDS SINCE 1952

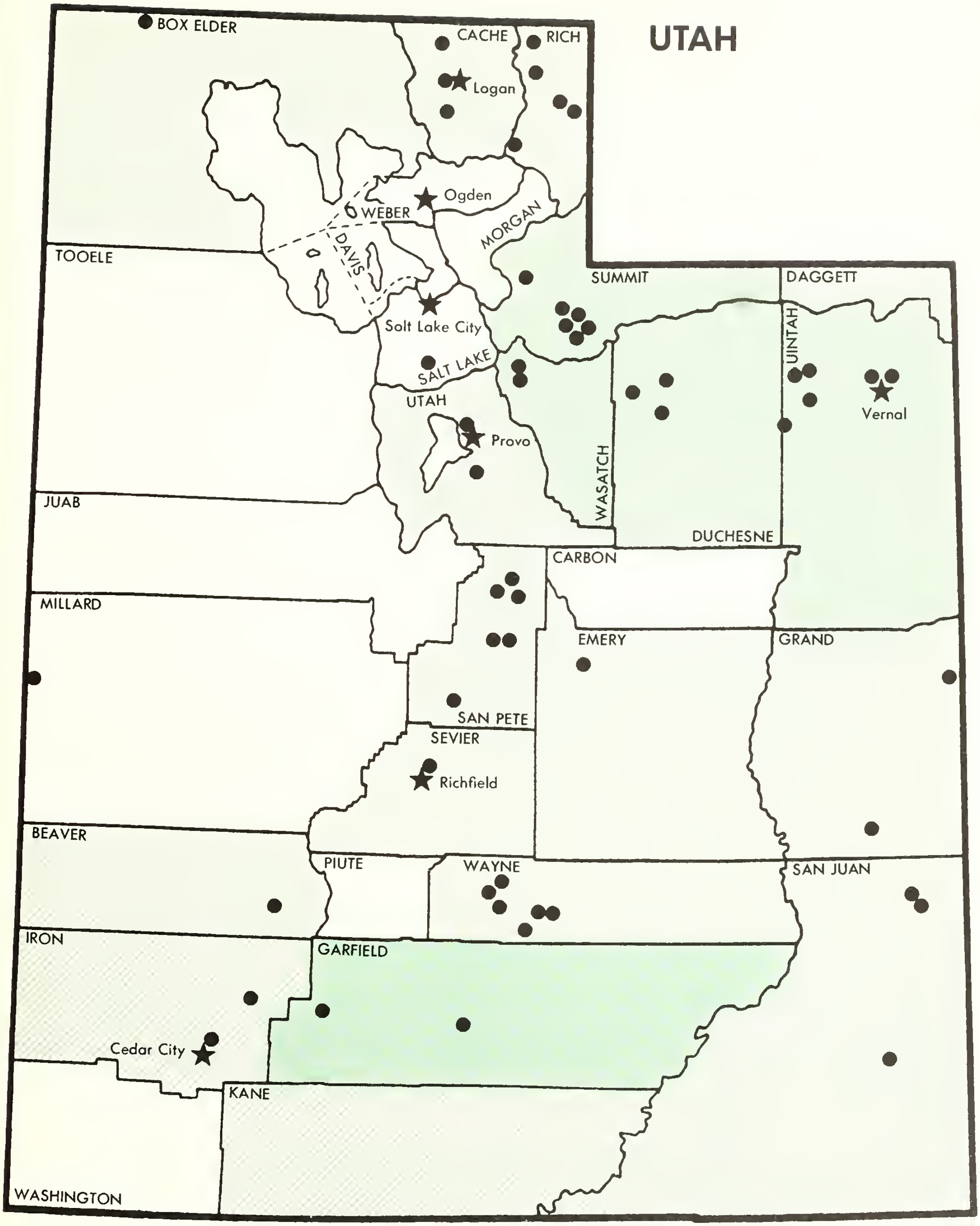
The period 1952 to 1962 was marked by a substantial increase in production of roundwood, particularly saw logs. Total output of products from roundwood increased 36 percent, but saw log production increased 86 percent. The relative importance of saw logs was further strengthened by a 66-percent decrease in the output of all other timber products during the decade.

Despite the increase in saw log output, the number of active sawmills in Utah dropped to 73 in 1962 from 99 in 1960, the only recent year for which there is a Forest Survey estimate of the number of active mills.

The following map shows the location of 54 mills that were operating in 1962 and also shows the relative volume of saw log output by counties. Besides the mills shown here, there were an estimated 19 producing mills, all small, which did not report saw log receipts for the 1962 products survey. These 19 mills apparently received about 5.1 percent of the State's saw log output that year.

Average production per mill in 1960 was 700,000 board feet (lumber tally), while in 1962 it was 900,000 board feet--an increase of 31 percent. The number of mills producing 1 million board feet or more was greater in 1962 than in 1960. Although some of the mills that produced less than 1 million board feet in 1960 may have moved up to a larger production class by 1962, it is obvious that many of them became inactive.

UTAH



UTAH SAWMILLS
nd SAW LOG PRODUCTION,
1962

● Sawmill reported as operating in 1962

Saw log output by counties (million board feet, Intl. ¼″ rule)

No reported production	5 to 10 MM bd. ft.
Less than 5 MM bd. ft.	More than 10 MM bd. ft.

Table 1.--Output of timber products by products and species groups in Utah, 1962

Product		Quantity: Total	Softwoods	Hardwoods
Saw logs	M bd. ft.[1]	64,938	62,916	2,022
Mine timbers (round)	M cu. ft.	245	245	0
Posts (round and split)	M pieces	16	16	0
Fuelwood	M std. cds.	1	1	0
Miscellaneous industrial wood[2]	M cu. ft.	703	306	397
Miscellaneous farm timbers	M cu. ft.	88	83	5
All products	M cu. ft.	12,005	11,264	741

[1] International $\frac{1}{4}$-inch log rule.
[2] Includes charcoal wood, commercial poles, converter poles, and excelsior bolts.

Table 2.--Saw log receipts of Utah sawmills by source areas, 1962

Source area	Volume	Percent
	M bd. ft.[1]	
Utah	62,636	99.6
Idaho and Nevada	251	.4
Total	62,887	100.0

[1] International $\frac{1}{4}$-inch log rule.

Table 3.--Sawmill log receipts from Utah timberlands by county of origin and by species, 1962

Counties	Species: Ponderosa pine	Lodgepole pine	Douglas-fir	True firs[1]	Spruce[2]	Other species[3]	All species: Volume	Percent
	Thousands of board feet, International $\frac{1}{4}$-inch log rule[4]							
Beaver, Garfield, Iron, Kane, Wayne	9,201	0	5,736	9,051	6,126	0	30,114	46.4
Box Elder, Cache, Rich	0	53	133	0	96	0	282	.4
Daggett, Summit	582	4,442	67	27	1,127	420	6,665	10.3
Duchesne, Uintah	996	5,543	149	74	5,892	194	12,848	19.8
Emery, Sanpete, Sevier	0	0	259	40	397	12	708	1.1
Grand, San Juan	1,871	0	0	65	2,752	0	4,688	7.2
Utah, Wasatch	0	1,676	355	387	5,819	1,396	9,633	14.8
State total	12,650	11,714	6,699	9,644	22,209	2,022	64,938	100.0
Percent of total	19.5	18.0	10.3	14.9	34.2	3.1	100.0	

[1] White and subalpine firs.
[2] Engelmann and blue spruce.
[3] Aspen and cottonwood.
[4] Scribner log rule volumes can be approximated by multiplying table volumes by 0.89.

Table 4.--Output of timber products in Utah by species, 1962

Product	Ponderosa pine	Lodgepole pine	Douglas-fir	True firs[1]	Engelmann spruce	Other species[2]	Total	Percent
	Thousand cubic feet							
Saw logs	2,113	1,956	1,119	1.610	3,709	338	10,845	90.3
Mine timbers	30	28	0	0	187	0	245	2.0
Miscellaneous industrial wood	100	55	51	50	50	397	703	5.9
Posts, fuelwood, miscellaneous farm timbers	63	27	4	79	18	21	212	1.8
Total	2,306	2,066	1,174	1,739	3,964	756	12,005	100.0
Percent of total	19.2	17.2	9.8	14.5	33.0	6.3	100.0	

[1] White and subalpine firs.
[2] Pinyon pine, juniper, aspen, cottonwood, and other minor hardwoods.

Table 5.--Output of timber products by land ownership classes, Utah, 1962

Product	Total volume	Land ownership class: National Forest lands	Other public lands	Private lands[1]	All ownerships
	M cu. ft.	Percent			
Saw logs	10,845	81.8	1.8	6.7	90.3
Mine timbers	245	1.9	.1	0	2.0
Miscellaneous industrial wood	703	.7	0	5.2	5.9
Posts, fuelwood, miscellaneous farm timbers	212	1.6	([2])	.2	1.8
Total	12,005	86.0	1.9	12.1	100.0

[1] Includes forest industry lands (lands owned by companies or individuals operating wood-using plants) and other private lands combined in order to avoid disclosure of information concerning operation of individual companies.
[2] Less than 0.05 percent.

Table 6.--Round and sawed timbers and lumber received at mines in Utah, 1962

Product		All mines	Coal mines	Other mines
Round timbers . .	M cu. ft.	245	193	52
Sawed timbers and lumber . .	M bd. ft.[1]	4,288	1,652	2,636

[1] Lumber tally.

Table 7.--Lumber production and numbers of active sawmills by sawmill size classes in Utah, 1960 and 1962

Sawmill size class (M bd. ft. per year)	1960[1] Lumber production		1960[1] Active mills	1962 Estimated lumber production[2]		1962 Active mills[3]
	M bd. ft.[4]	Percent	Number	M bd. ft.[4]	Percent	Number
Less than 50	582	0.8	25	536	0.8	19
50 to 499	13,958	20.2	49	5,293	7.9	33
500 to 999	7,974	11.5	13	3,417	5.1	4
1,000 and over	46,784	67.5	12	57,754	86.2	17
Total	69,298	100.0	99	67,000	100.0	73

[1] Wilson, Alvin K. Forest products output in Utah in 1960. Intermountain Forest and Range Expt. Sta. Forest Survey Release 4, 6 pp. 1962.

[2] Estimated from U.S. Census Bureau's lumber production total for Utah in 1962 (67 million board feet, lumber tally) on the assumption that lumber production was distributed among sawmill size classes in proportion to their reported saw log receipts.

[3] Mill size class estimated from saw log receipts rather than from lumber production.

[4] Lumber tally.

Table 8.--Output of timber products in Utah and percentages of total for major products, 1952, 1960, and 1962

Product	1952[1] Output	1952[1] Percent[3]	1960[2] Output	1960[2] Percent	1962 Output	1962 Percent
Saw logs . . M bd. ft.[4]	35,003	62	77,091	87	64,938	90
All other[5] . M cu. ft.	3,365	38	1,983	13	1,160	10
Total. M cu. ft.	8,825	100	14,831	100	12,005	100

[1] From table 13, U.S. Department of Agriculture, Forest Resource Rpt. 14. 1958.

[2] Wilson, Alvin K. Forest products output in Utah in 1960. Intermountain Forest and Range Expt. Sta. Forest Survey Release 4, 6 pp. 1962.

[3] Values shown in all "Percent" columns are based on cubic-foot volume equivalents for products whose outputs are shown in other standard volume units.

[4] International $\frac{1}{4}$-inch log rule.

[5] Includes round mine timbers, excelsior bolts, charcoal wood, commercial poles, posts, converter poles, fuelwood, and miscellaneous farm timbers.

Table 9.--Utah lumber production, 1954 and 1960-1962

Year	Production
	MM bd. ft. (lumber tally)
1954	51
1960	69
1961	66
1962	67

Source: U.S. Bureau of the Census

FOREST PRODUCTS OUTPUT IN NEVADA, 1962

THE SITUATION IN 1962

Nevada's output of roundwood products was 846,000 cubic feet in 1962. This figure--like the one for Utah's output--includes production from live and dead trees harvested from commercial and noncommercial forest land.

Roundwood products yielded by Nevada's timberlands in 1962 included saw logs (for lumber), converter poles, fenceposts, miscellaneous farm timbers, and fuelwood.

Forest industry lands[5] accounted for almost 80 percent of the 1962 output. Other private lands contributed 10 percent and National Forest lands only 8 percent.

Nevada's timberlands yielded nearly $2\frac{1}{2}$ million board feet of saw logs in 1962. Almost all of this volume, together with nearly 33 million board feet of saw logs imported from California, supplied the two sawmills active in the State in 1962. True firs (54 percent of the total) and ponderosa pine (42 percent) were the principal species harvested.

Other forest products harvested in Nevada during 1962--converter poles, posts, miscellaneous farm timbers, and fuelwood--amounted to 439,000 cubic feet or 52 percent of the total volume of forest products for that State.

TRENDS SINCE 1952

Nevada's output of forest products has fluctuated widely by years and, accordingly, it is difficult to establish a meaningful production trend. This is true largely because the industry remains small in Nevada--a State with only a minor proportion of commercial forest land. However, the total production from roundwood was 87 percent greater in 1962 than in 1952.

[5] Lands owned by companies or individuals operating wood-using plants.

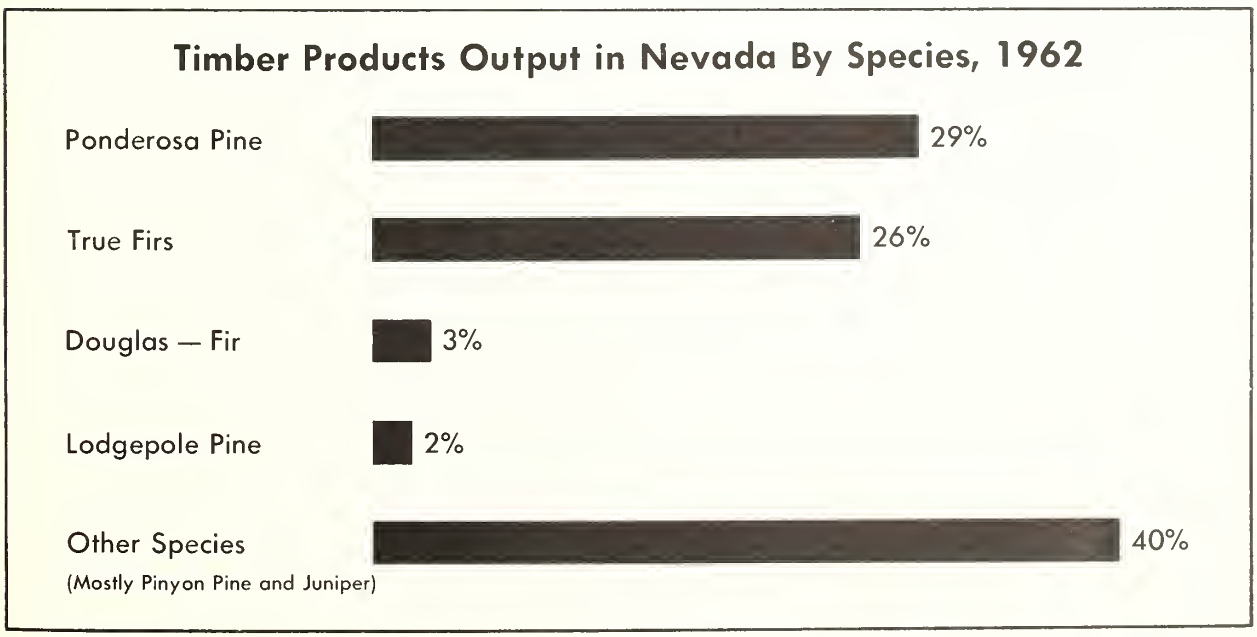


Table 10.--Output of timber products by products and by species groups in Nevada, 1962

Product		Quantity		
		Total	Softwoods	Hardwoods
Saw logs	M bd. ft.[1]	2,437	2,437	0
Posts (round and split)	M pieces	38	38	0
Fuelwood	M std. cds.	4	3	1
Miscellaneous industrial wood .	M cu. ft.	53	11	42
Miscellaneous farm timbers . .	M cu. ft.	2	1	1
All products	M cu. ft.	846	723	123

[1] International $\frac{1}{4}$-inch log rule.

Table 11.--Sawmill log receipts from Nevada timberlands by species, 1962

Species	Receipts	
	M bd. ft.[1]	Percent
True firs[2]	1,303	53.5
Ponderosa pine	1,037	42.5
Lodgepole pine	97	4.0
Total	2,437	100.0

[1] International $\frac{1}{4}$-inch log rule. Scribner log rule volumes can be approximated by multiplying by 0.89.
[2] Subalpine fir and California red fir.

Table 12.--Output of timber products in Nevada by species, 1962

Species	Saw logs	Miscellaneous industrial wood	Posts, fuelwood & miscellaneous farm timbers	Total	Percent
	Thousand cubic feet				
Ponderosa pine	173	0	73	246	29.1
Lodgepole pine	16	0	0	16	1.9
Douglas-fir	0	11	13	24	2.8
True firs[1]	218	0	0	218	25.8
Engelmann spruce	0	0	0	0	0
Other species[2]	0	42	300	342	40.4
Total	407	53	386	846	100.0
Percent	48.1	6.3	45.6	100.0	

[1] Primarily California red fir.
[2] Pinyon pine, juniper, aspen, cottonwood, and other minor hardwoods.

Table 13.--Output of timber products by land ownership classes, Nevada, 1962

Product	Total volume	Land ownership classes: National Forest lands	Other public lands	Forest industry lands[1]	Other private lands	All ownerships
	M cu. ft.	Percent				
Saw logs	407	3.3	0	39.9	4.9	48.1
Miscellaneous industrial wood	53	.5	0	5.2	.6	6.3
Posts, fuelwood, miscellaneous farm timbers	386	3.9	2.8	34.2	4.7	45.6
Total	846	7.7	2.8	79.3	10.2	100.0

[1]Lands owned by companies or individuals operating wood-using plants.

Table 14.--Output of timber products in Nevada and percentages of total for major products, 1952, 1960, and 1962

Product	1952[1]		1960[2]		1962	
	Output	Percent[3]	Output	Percent	Output	Percent
Saw logs . . M bd. ft.[4]	1,005	35	17,425	92	2,437	48
All other[5] . M cu. ft.	296	65	254	8	439	52
Total . M cu. ft.	453	100	3,158	100	846	100

[1] From table 13, U.S. Department of Agriculture, Forest Resource Rpt. 14, 1958.

[2] Wilson, Alvin K. Production of lumber and other forest products in Nevada, 1960.

[3] Values shown in all "Percent" columns are based on cubic-foot volume equivalents for products whose outputs are shown in other standard volume units.

[4] International $\frac{1}{4}$-inch log rule.

[5] Includes converter poles, posts, miscellaneous farm timbers, and fuelwood.

Table 15.--Nevada lumber production, 1960-1962

Year	Production
	MM bd. ft. (lumber tally)
1960	34
1961	31
1962	37

Source: U.S. Bureau of the Census

SURVEY PROCEDURES FOR BOTH STATES

The survey of saw log receipts at sawmills was based on a listing of mills made late in 1962. Reviews by National Forest personnel helped to make this listing as complete as possible. All listed mills were contacted by mail early in 1963 to obtain data on their saw log receipts for 1962. Also, all mills outside Utah and Nevada that were considered as possible recipients of logs from either State were asked to report. Field sampling was used to provide data for estimating, within acceptable error limits, the receipts of sawmill operators who did not furnish mail reports (nonrespondents).

The standard error for that part of the total saw log receipts for Utah that was estimated by field sampling of nonrespondents was 2,200,000 board feet, or 3.39 percent of the State's total saw log receipts. The odds, then, are 2 to 1 that the actual Utah total for saw log receipts in 1962 was in the interval 64,938,000 ± 2,200,000 board feet, International $\frac{1}{4}$-inch log rule.

Reports concerning saw log receipts in 1962 were obtained from both active sawmills in Nevada. Therefore, these estimates are considered to be without sampling error.

The estimate of mine timber production in Utah during 1962 was based on an adjustment of data from a 1960 intensive survey of mine timber use. A light sample (15 to 20 percent) of mines in 1962 provided a basis for adjustment. Because of the method of estimation used, no sampling error can be assigned.

Estimates for 1962 production of miscellaneous industrial wood, posts, fuelwood, and miscellaneous farm timbers in Utah and Nevada were obtained primarily from reports furnished by National Forests, State Foresters, the Bureau of Land Management, Bureau of Reclamation, and Bureau of Indian Affairs. These data were supplemented by trend estimates obtained from U.S. Bureau of the Census publications for farm use of these products. Since this procedure precluded the calculation of a sampling error, no error estimate has been assigned.

DPSU/65/1496-2

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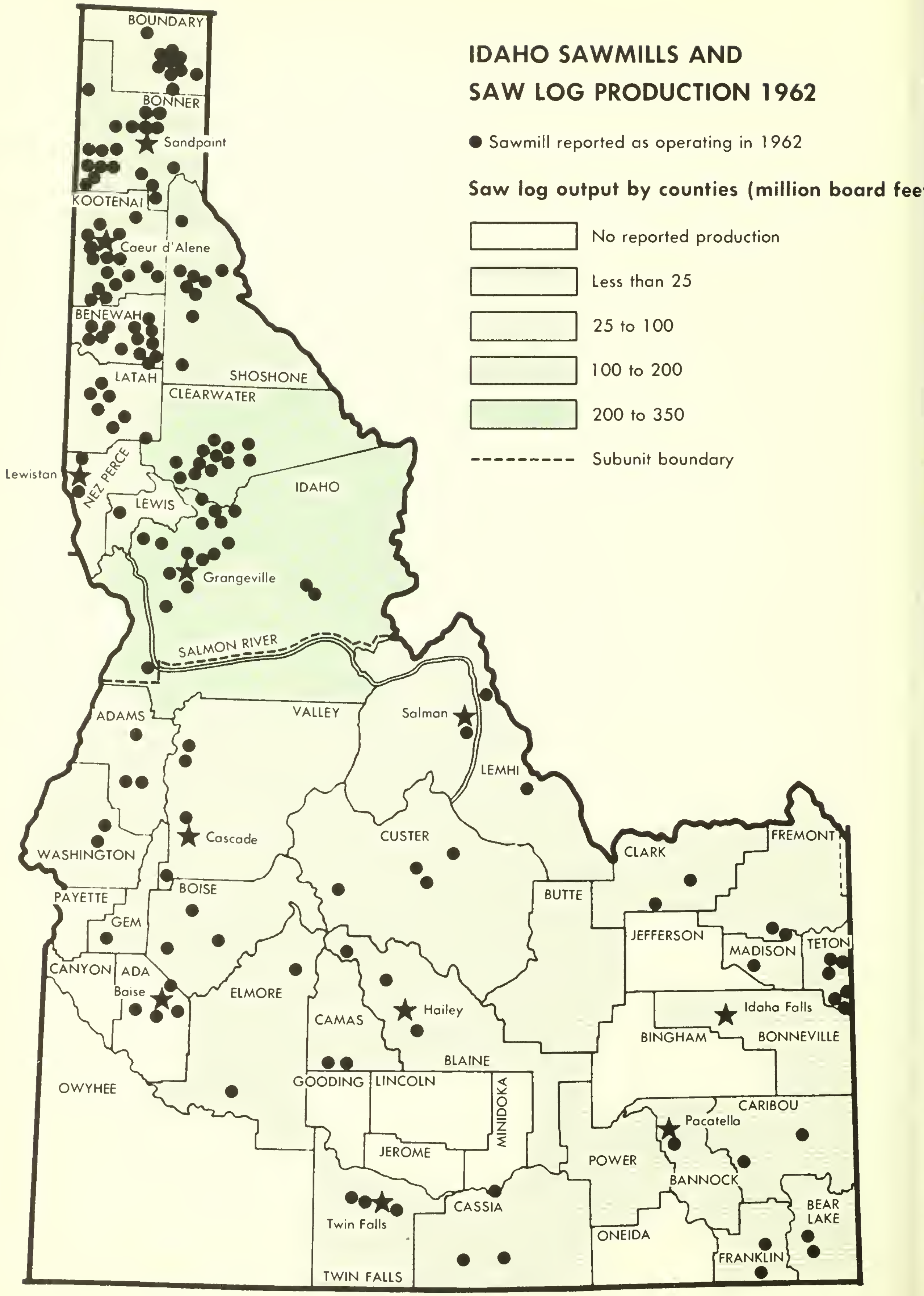
OUTPUT OF TIMBER PRODUCTS IN IDAHO, 1962

Forest Service, U.S. Department of Agriculture
1964

IDAHO SAWMILLS AND SAW LOG PRODUCTION 1962



U.S. Forest Service
Research Paper INT-13
1964

OUTPUT OF TIMBER PRODUCTS IN IDAHO, 1962

By

Alvin K. Wilson
Division of Forest Economics and Recreation Research

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
U.S. Department of Agriculture
Ogden, Utah
Joseph F. Pechanec, Director

This report summarizes survey information collected in 1963 about the output of roundwood products from Idaho's forests in 1962. The term "roundwood" designates products that were received at plants "in the round" (as logs or bolts) for the first steps in manufacture. Accordingly, the data presented here do not include pulpwood made from sawmill or veneer plant residues (slabs, edgings, trim ends, shavings, sawdust, lathe cores) nor do they include fuelwood or any other items (industrial or domestic) made from these residues. However, to evaluate the extent to which sawed materials compete with round timbers in mine use, data on sawed materials used in mines in 1962 are summarized in one table in this report, but are not included elsewhere.

The detailed results of this survey are presented in a series of tables. The highlights of 1962 production and major production trends between 1952 and 1962 are discussed. Data for saw log output are presented in more detail than for other products because of the predominance of saw logs in the State's total production.

Forest products surveys in the Rocky Mountain States and western South Dakota are part of the Intermountain Forest and Range Experiment Station's program for periodic appraisals of the forest situation. In western South Dakota, eastern Wyoming, Colorado, New Mexico, and Arizona, products surveys and other phases of Forest Survey work are conducted cooperatively with the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

THE AUTHOR

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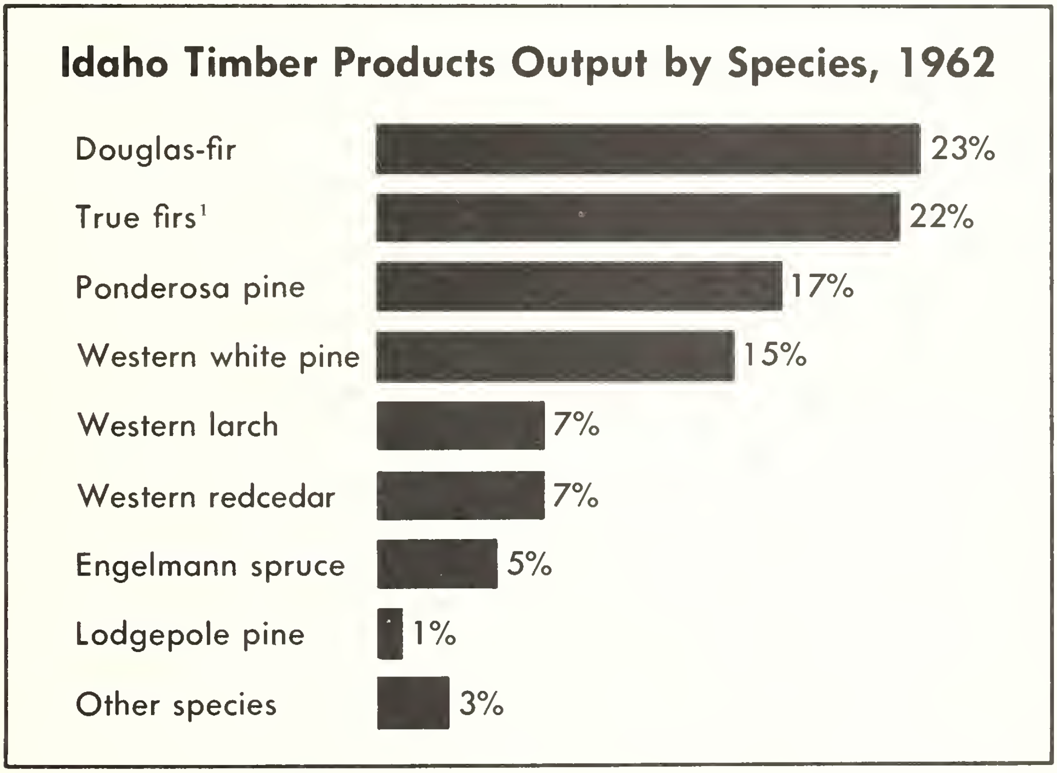
OUTPUT OF TIMBER PRODUCTS IN IDAHO, 1962

THE SITUATION IN 1962

The output of roundwood products originating in Idaho in 1962 totaled 249 million cubic feet. These products included saw logs (for lumber), veneer logs, pulpwood logs, commercial poles, mine timbers, miscellaneous industrial wood (principally house logs, shingle logs and bolts, and specialty logs), posts, fuelwood, and farm timbers.

Nearly two-thirds of the total output came from public lands; National Forests supplied 48 percent, and other public lands 14 percent of the total. Private lands contributed the remaining 38 percent, two-thirds of which came from forest industry lands.[1] The leading species were Douglas-fir, the true firs, ponderosa pine, and white pine.



[1]*Grand, white and subalpine firs.*

Saw logs accounted for 94 percent of the total roundwood cut and amounted to 1,547 million board feet.[2] Of this, 1,510 million board feet went to mills in Idaho. Geographically, the largest concentration of sawmills and the highest saw log output is in northern Idaho (see inside front cover). In addition to the mills shown there were an estimated 24 small active sawmills for which saw log reports were not received in the 1962 products survey. These mills received about 1.9 percent of the State's saw log output. The remaining 37 million board feet was shipped to mills in Washington, Montana, Utah, and Wyoming; however, some 49 million board feet of saw logs were imported from Washington, Montana, and Wyoming. Public lands provided more than 58 percent of all saw logs.

[1]Lands owned by companies or individuals operating wood-using plants.

[2]International $\frac{1}{4}$-inch log rule is used throughout this report.

Round pulpwood output in 1962, totaling 66,200 cords, was the lowest of the 1952-1962 period. Even so, in terms of volume, it was the State's second most important roundwood product.

Veneer log production in 1962, at 19 million board feet, was the highest on record for Idaho. Four veneer and plywood plants were in operation in 1962; as recently as 1960 only two were operating. Western white pine and western larch were the leading species used for veneer.

Commercial poles produced in 1962 totaled almost 150,000 and had a combined volume of nearly 2.7 million cubic feet. These were predominantly western redcedar but substantial numbers were made from lodgepole pine and western larch.

Other roundwood products (round mine timbers, miscellaneous industrial wood, posts, fuelwood, and miscellaneous farm timbers) totaled some 3.7 million cubic feet. Almost two-thirds of this volume was in miscellaneous farm timbers. More than three-fourths of the round mine timbers and 90 percent of the sawed mine materials used in the State were used in northern Idaho.

TRENDS SINCE 1952

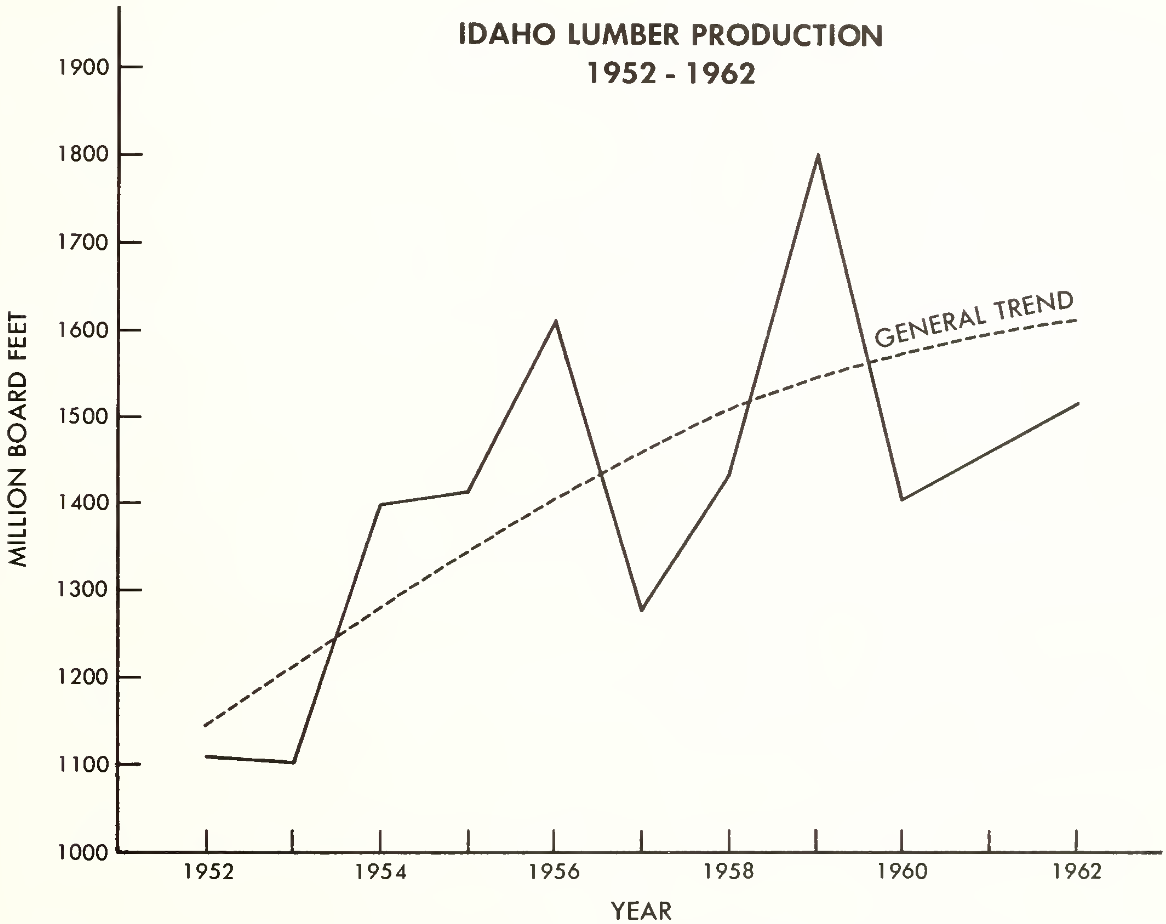
Production figures including the output of all roundwood products in Idaho are available for only 3 years--1952, 1956, and 1962. Roundwood output for these years was:

	Million cubic feet
1952	242
1956	328
1962	249

Potlatch Forests, Inc., Lewiston, utilizes several roundwood products in integrated operations--saw logs for lumber, pulp logs for pulp, and veneer logs for plywood.
Photo: Western Ways, Inc., Corvallis, Oregon

These figures show a net increase of only 3 percent in total roundwood output from 1952 to 1962. Because they do not provide year-to-year continuity, these data have only limited value in estimating the general production trend during the period 1952-1962.

There is, however, a means of estimating the production trend. Lumber production data are available from the Census Bureau for each year, and saw logs for lumber account for most of the roundwood output.[3] These data indicate that the general trend has been continuously, if unsteadily, upward since 1952. The average annual increase in lumber production between 1952 and 1962 was 4.4 percent.



Only about two-thirds as many sawmills were operating in 1962 as had been operating in 1956, but the production of the average mill was higher in 1962. The 311 sawmills that operated in 1956 produced an average of 5.2 million board feet of lumber per mill; the 193 mills that were active in 1962 averaged 7.9 million board feet. Despite the substantial decrease in the number of active mills, total production was only 6 percent less in 1962 than in 1956. Comparisons in more detail are made below:

---

[3] In 1952, saw logs for lumber comprised 74 percent of total output; this percentage rose to 84 by 1956, and was 94 in 1962.

Number of mills by production class and their average lumber output in 1956 and 1962

Production class (bd. ft. per year)	Year	Active sawmills	Average annual production	Percent of total lumber production
		Number	MM bd. ft.	
10 million and over	1956	37	31.5	73
	1962	42	28.2	78
1 to 10 million	1956	108	3.8	25
	1962	81	3.8	20
Less than 1 million	1956	166	.2	2
	1962	70	.4	2

Although a few mills increased their production so that by 1962 they had moved from the middle to the largest production class, it is apparent that many mills that were in the middle and lower production classes in 1956 had suspended operations by 1962.

Veneer log production, while still accounting for only a minor part of the State's roundwood output, more than doubled from 1952 to 1962. Production of round pulpwood, however, showed a different trend during the 10-year period. Output in 1952 totaled nearly 156,000 cords and increased to an estimated peak of about 230,000 cords around 1956, but by 1962 had declined to less than 70,000 cords. Although pulp production has increased in the northern Idaho-eastern Washington area, the increasing use of chipped sawmill residues for pulp manufacture has led to general reductions in demand for round pulpwood in the State.

The combined output of all other roundwood products declined 83 percent between 1956 and 1962 due largely to the reduced production of commercial poles, fuelwood, and round mine timbers. The decline in output of these products had a substantial effect on the total output for 1956 and 1962. Estimated outputs for posts and miscellaneous farm timbers were somewhat higher in 1962 than in 1956.

The decline in commercial pole production during recent years follows the general pattern observed throughout the northern Rocky Mountains.[4] Following the peak output of 1947, pole production dropped off rapidly during the early 1950's but has been more or less stable since 1957.

Changes in mining methods and increased use of sawed timbers were among the factors causing the decline in round mine timber production. The decline in fuelwood consumption conforms to the national trend as indicated in Census Bureau statistics.[5]

[4] Wilson, A. K. Commercial pole production in the Northern Rocky Mountain area in 1962. Intermountain Forest and Range Expt. Sta. Res. Note INT-9. 1963.

[5] U.S. Bureau of the Census. U.S. Census of Agriculture: 1959, vol. II, General Report Statistics by Subjects, 1485 pp. Wash., D.C.: U.S. Govt. Printing Office. 1962.

SURVEY PROCEDURES

The survey of saw log receipts was based on a listing of sawmills prepared late in 1962, made as complete as possible through reviews by Forest Service personnel and the Idaho State Forester's office. Operators of all listed mills were contacted by mail to obtain reports of their saw log receipts in 1962. Also, all sawmills outside the State that were considered to be possible recipients of logs from Idaho were asked to report. Field sampling provided data for estimating, within acceptable error limits, the receipts of sawmill operators who did not furnish mail reports (nonrespondents).

The standard error for that part of the total which was estimated by field sampling was 11,050,000 board feet, or 0.71 percent of the total saw log receipts from Idaho timberlands. The odds are 2 to 1 that the true total for 1962 saw log receipts from Idaho was between 1,536,284,000 and 1,558,384,000 board feet.

Procedures for the survey of round mine timbers and sawed timbers and lumber received at Idaho mines in 1962 were similar. Mail contacts were made from lists of mine operators compiled from State sources[6] and a mining industry directory.[7] Nonrespondents were sampled by field contacts. Since none of the nonrespondents contacted in the field reported any receipts of round timbers, the estimate of the total (223,000 cubic feet) is considered to be without sampling error. For sawed timbers and lumber receipts, the standard error was 15.8 percent of the State total so that, at 2 to 1 odds, the true State total was between 17,667,000 and 24,291,000 board feet, lumber tally.

Reports were obtained by mail and field contacts were made with all plants known to receive veneer logs, round pulpwood, commercial poles, and miscellaneous industrial wood from Idaho in 1962; estimates for these products are considered to be without sampling error.

Estimates for 1962 production of posts, fuelwood, and miscellaneous farm timbers were derived from reports furnished by the National Forests, the Idaho State Forester, Bureau of Land Management, and the Bureau of Indian Affairs, supplemented by trend estimates obtained from U.S. Bureau of the Census publications for farm use of these products. Since this procedure precluded the computation of a sampling error by the methods used with the preceding products, no error estimate has been assigned.

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[6] Idaho Bureau of Mines and Geology: 62nd Annual Report of the Mining Industry of Idaho for 1961, 147 pp.

[7] Miller Freeman Publications. Mining World Catalog Survey and Directory Number, 246 pp., 1962.

Table 1.--Output of timber products in Idaho by products and species groups in standard units, 1962

Product		Quantity		
		Total	Softwoods	Hardwoods
Saw logs	M bd. ft.[1]	1,547,334	1,546,858	476
Veneer logs	M bd. ft.[1]	19,030	18,750	280
Pulpwood (round)	M std. cds.[2]	66	66	0
Fuelwood	M std. cds.	5	5	([3])
Poles	M pieces	150	150	0
Posts (round and split)	M pieces	818	818	0
Mine timbers (round)	M cu. ft.	223	223	0
Miscellaneous industrial wood[4]	M cu. ft.	124	108	16
Miscellaneous farm timbers .	M cu. ft.	2,302	2,302	0
All products--converted to . .	M cu. ft.	249,231	249,092	139

[1] International $\frac{1}{4}$-inch log rule.
[2] Rough wood basis.
[3] Less than 0.5 M standard cords.
[4] Includes house logs, shingle logs and bolts, and specialty logs.

Table 2.--Total saw log receipts of Idaho sawmills by source areas, 1962

Source area	Volume	Percent
	M bd. ft.[1]	
Northern Idaho	1,125,624	72.2
Southern Idaho	384,302	24.6
Western Montana[2]	27,896	1.8
Eastern Montana	1,404	.1
Washington	18,387	1.2
Western Wyoming[2]	1,213	.1
Total	1,558,826	100.0

[1] International $\frac{1}{4}$-inch log rule.
[2] West of the Continental Divide.

Table 3.--Sawmill log receipts from Idaho timberlands by species, subunits, and county of origin, 1962

Subunit and county	Species: Ponderosa pine	White pines[1]	Lodgepole pine	Douglas-fir	True firs[2]	Engelmann spruce	Western larch	Other species[3]	All species: Volume	Percent
	Thousands of board feet, International $\frac{1}{4}$-inch log rule[4]									
NORTHERN										
Benewah	1,288	7,161	0	18,519	32,387	112	8,747	3,711	71,925	4.6
Bonner	5,825	21,771	224	24,390	15,793	5,142	16,682	20,290	110,117	7.1
Boundary	1,580	11,171	573	9,108	11,283	18,861	9,934	10,206	72,716	4.7
Clearwater	9,157	117,703	77	53,624	92,124	6,761	11,467	52,114	343,027	22.2
Idaho[5]	53,379	18,206	535	55,407	51,041	11,441	15,281	9,172	214,462	13.9
Kootenai	7,195	20,095	31	19,279	25,744	495	19,036	13,330	105,205	6.8
Latah	4,126	4,197	112	15,311	21,725	36	8,529	3,784	57,820	3.7
Lewis, Nez Perce	16,445	0	1,040	12,551	7,748	2,025	5,968	0	45,777	3.0
Shoshone	1,939	41,453	168	25,702	40,321	2,071	15,966	11,978	139,598	9.0
Total, Northern	100,934	241,757	2,760	233,891	298,166	46,944	111,610	124,585	1,160,647	75.0
Percent of total	8.7	20.8	0.2	20.2	25.7	4.1	9.6	10.7	100.0	
SOUTHERN										
Adams, Washington	41,964	0	513	28,504	19,178	4,411	1,277	0	95,847	6.2
Bannock, Bear Lake, Caribou, Franklin, Power	0	0	616	3,807	63	1,298	0	0	5,784	0.4
Blaine, Butte, Camas, Custer	40	0	150	8,189	121	184	0	349	9,033	0.6
Boise, Gem	82,413	0	770	39,599	18,134	4,508	1,914	0	147,338	9.5
Bonneville, Clark, Fremont, Madison, Teton	4,005	45	12,118	3,294	1,359	697	150	1	21,669	1.4
Cassia, Twin Falls	0	0	31	40	112	0	0	117	300	(6)
Elmore	26,611	0	158	17,043	3,211	881	375	0	48,279	3.1
Idaho,[5] Lemhi, Valley	15,738	0	16	23,318	6,287	12,399	679	0	58,437	3.8
Total, Southern	170,771	45	14,372	123,794	48,465	24,378	4,395	467	386,687	25.0
Percent of total	44.2	(6)	3.7	32.0	12.5	6.3	1.2	0.1	100.0	
STATE TOTAL	271,705	241,802	17,132	357,685	346,631	71,322	116,005	125,052	1,547,334	100.0
Percent of total	17.6	15.6	1.1	23.1	22.4	4.6	7.5	8.1	100.0	

[1] Practically all western white pine, but includes a small amount of limber pine.
[2] Grand, white, and subalpine firs.
[3] Includes western hemlock (33,765 M bd. ft.), western redcedar (90,811 M bd. ft.), and small amounts of cottonwood and other hardwoods.
[4] Scribner log rule volumes can be approximated by multiplying table volumes by 0.89.
[5] Idaho County is divided by the Salmon River and lies partly in each subunit.
[6] Less than 0.05 percent.

Table 4.--Output of timber products in Idaho by species, 1962

Product	Species									Total	Percent
	Ponderosa pine	White pines[1]	Lodgepole pine	Douglas-fir	True firs[2]	Engelmann spruce	Western larch	Western redcedar	Other species[3]		
	- - - Thousand cubic feet - - -										
Saw logs	43,356	35,547	2,806	55,056	51,923	10,972	17,141	13,349	5,042	235,192	94.4
Veneer logs	236	684	1	272	470	424	529	132	49	2,797	1.1
Pulpwood (round)	0	982	0	0	1,623	458	280	0	1,554	4,897	2.0
Poles	0	0	57	0	0	0	173	2,443	0	2,673	1.1
Mine timbers (round)	0	0	45	94	7	0	77	0	0	223	.1
Miscellaneous industrial wood	0	8	0	0	0	0	0	100	16	124	([4])
Posts, fuelwood, miscellaneous farm timbers	306	0	627	1,326	0	140	307	612	7	3,325	1.3
Total	43,898	37,221	3,536	56,748	54,023	11,994	18,507	16,636	6,668	249,231	100.0
Percent of total	17.6	14.9	1.4	22.8	21.7	4.8	7.4	6.7	2.7	100.0	

[1] Practically all western white pine, but includes a small amount of limber pine.
[2] Grand, white, and subalpine firs.
[3] Includes western hemlock, cottonwood, and other hardwoods.
[4] Less than 0.05 percent.

Table 5.--Output of timber products by land ownership classes, Idaho, 1962

Product	Total volume	Land ownership classes				
		National Forest lands	Other public lands	Forest industry lands[1]	Other private lands	All ownerships
	M cu. ft.	- - - Percent - - -				
Saw logs	235,192	45.8	12.7	23.7	12.2	94.4
Veneer logs	2,797	.5	.1	.5	([2])	1.1
Pulpwood (round)	4,897	.7	.3	.9	([2])	2.0
Poles	2,673	.5	.2	.3	.1	1.1
Mine timbers (round)	223	.1	([2])	0	([2])	.1
Miscellaneous industrial wood	124	([2])	([2])	([2])	([2])	([2])
Posts, fuelwood, miscellaneous farm timbers	3,325	.6	.2	.3	.2	1.3
Total	249,231	48.2	13.5	25.7	12.6	100.0

[1] Lands owned by companies or individuals operating wood-using plants.
[2] Less than 0.05 percent.

Table 6.--Round and sawed timbers and lumber received at mines in northern and southern Idaho, 1962

Subunit	Round timbers	Sawed timbers and lumber
	M cu. ft.	M bd. ft.
Northern Idaho	170	18,946
Southern Idaho	53	2,033
Total	223	20,979

Table 7.--Lumber production and numbers of active sawmills by sawmill size classes in Idaho, 1956 and 1962

Sawmill size class (M bd. ft. per year)	1956[1]			1962		
	Lumber production		Active mills	Estimated lumber production[2]		Active mills[3]
	MM bd. ft.[4]	Percent	Number	MM bd. ft.[4]	Percent	Number
Less than 500	16	1	139	9	1	54
500 to 999	17	1	27	17	1	16
1,000 to 4,999	210	13	80	111	7	53
5,000 to 9,999	200	12	28	195	13	28
10,000 and over	1,166	73	37	1,184	78	42
Total	1,609	100	311	1,516	100	193

[1] Wilson, Alvin K. Idaho lumber production, 1956. Intermountain Forest and Range Expt. Sta. Forest Survey Release 1, 8 pp., illus. 1958.

[2] Estimated from U.S. Census Bureau's lumber production total for Idaho's 1962 production (1,516 million board feet, lumber tally) on the assumption that lumber production was distributed among sawmill size classes in the same proportion as their reported saw log receipts.

[3] Mill size class estimated from saw log receipts rather than from lumber production.

[4] Lumber tally.

Table 8.--Output of timber products in Idaho, and percentages of totals for major products, 1952, 1956, and 1962

Product	1952[1]		1956[2]		1962	
	Output	Percent[3]	Output	Percent[3]	Output	Percent[3]
Saw logs . . . M bd. ft.[4]	1,155,998	74	1,873,700	84	1,547,334	94
Veneer logs . M bd. ft.[4]	8,525	1	([5])	([5])	19,030	1
Pulpwood . . . M std. cds.[6]	156	6	227	5	66	2
All other[7] . . M cu. ft.	46,043	19	37,790	11	6,345	3
Total converted to . . . M cu. ft.	241,677	100	327,907	100	249,231	100

[1] U.S. Forest Service. Timber resources for America's future. U.S. Dept. of Agr. Forest Resource Rpt. 14, 713 pp., illus. 1958. (Table 13, pp. 526-527.)

[2] Wilson, Alvin K. Timber resources of Idaho. Intermountain Forest and Range Expt. Sta. Forest Survey Release 3, 42 pp., illus. 1962. Also, Intermountain Station file data for 1956 products surveys.

[3] Based on cubic foot volume equivalents for products whose outputs are shown in other standard volume units.

[4] International $\frac{1}{4}$-inch log rule.

[5] Veneer logs data have been included with data for saw logs to avoid disclosing operations of the two veneer plants that were operating in 1956.

[6] Rough wood basis. Includes round pulpwood only; i.e., does not include pulpwood from sawmill and veneer plant residues.

[7] Includes commercial poles, round mine timbers, miscellaneous industrial wood, posts, fuelwood, and miscellaneous farm timbers.

Table 9.--Idaho lumber production, 1952-1962

Year	Quantity
	MM bd. ft. (lumber tally)
1952	1,106
1953	1,101
1954	1,399
1955	1,413
1956	1,608
1957	1,277
1958	1,437
1959	1,802
1960	1,405
1961	1,467
1962	1,516

Source: U.S. Bureau of the Census

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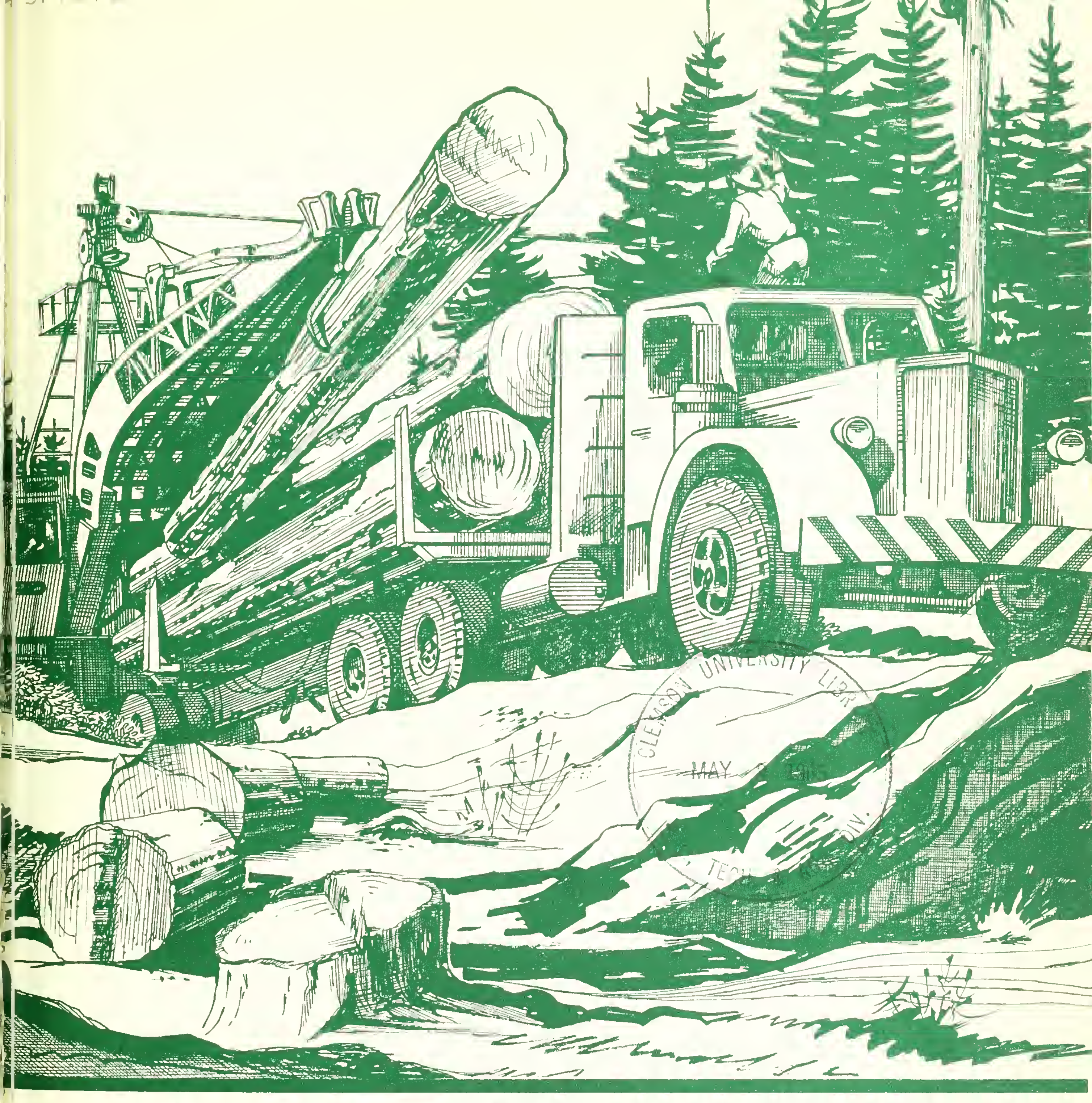

TIMBER PRODUCTS OUTPUT IN COLORADO, WYOMING, AND WESTERN SOUTH DAKOTA, 1962

Forest Service, U.S. Department of Agriculture
1964

This report summarizes survey information collected in 1963 on the 1962 output of roundwood products from the forests of Colorado, Wyoming, and western South Dakota. Production for each State is discussed separately, followed by a statement on survey procedures and sampling accuracy. The term "roundwood" is used to designate products that were received at plants "in the round" (as logs or bolts) for the primary steps in manufacture. This report does not include estimates of output for any product (industrial or domestic) from sawmill residues (slabs, edgings, trim ends, or sawdust).

However, to evaluate the extent to which sawed materials compete with round timbers in mine use, data on 1962 mine use of these materials were collected and summarized.

The detailed results of this survey are presented in a series of tables; the highlights of 1962 production and major production trends between 1952 and 1962 are discussed. Data for saw log production are presented in more detail than for other products because of the predominance of saw logs in each State's total production.

Forest products surveys in the Rocky Mountain States and western South Dakota are part of the Intermountain Forest and Range Experiment Station's program for periodic appraisals of the forest situation. In western South Dakota, eastern Wyoming, Colorado, New Mexico, and Arizona products surveys and other phases of Forest Survey work are conducted cooperatively with the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

U.S. Forest Service
Research Paper INT-14
1964

TIMBER PRODUCTS OUTPUT IN COLORADO, WYOMING, AND WESTERN SOUTH DAKOTA, 1962

by

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FOREST SERVICE — U.S. DEPARTMENT OF AGRICULTURE

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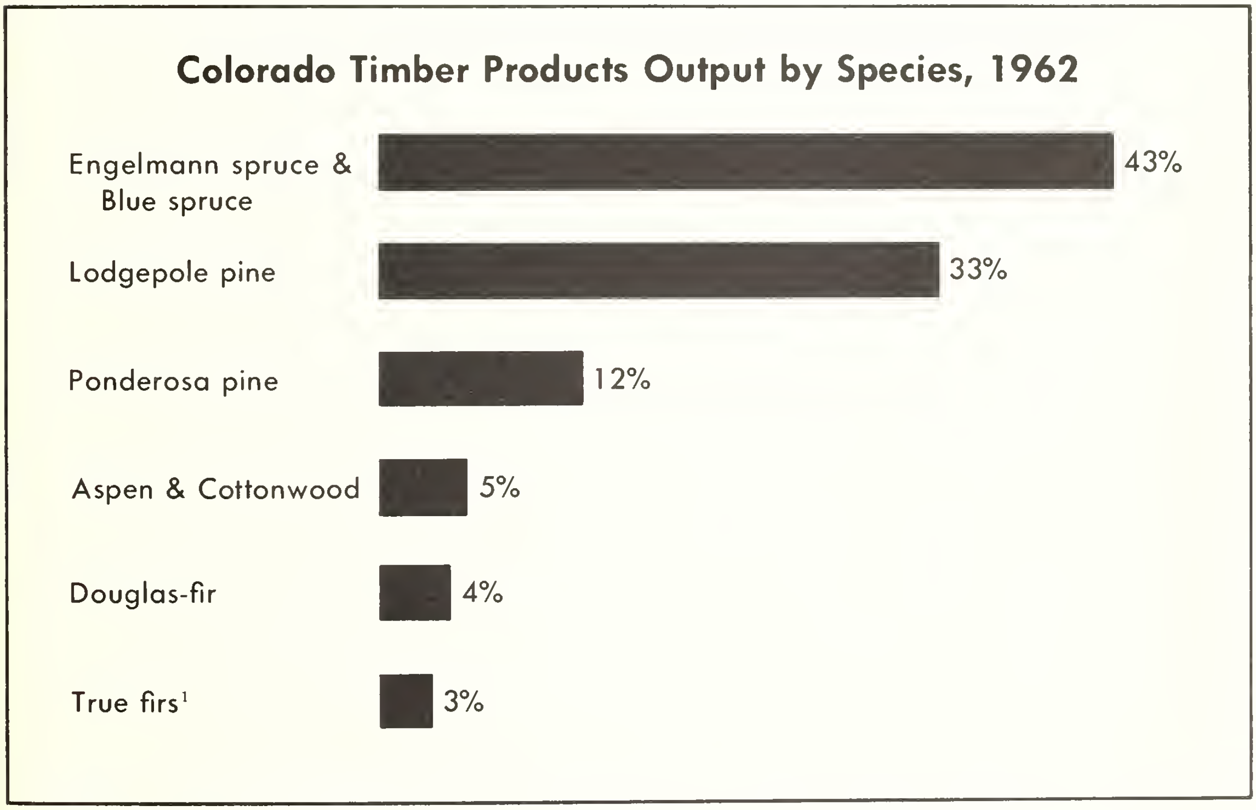
COLORADO

THE SITUATION IN 1962

The total output of roundwood forest products in Colorado during 1962 was about 36.4 million cubic feet--a decline of almost 16 percent since 1952.[1] That total included products from live and dead trees harvested on commercial[2] and noncommercial forest land.

Roundwood products harvested in Colorado in 1962 included saw logs (for lumber), pulpwood logs and bolts, commercial poles, mine timbers, miscellaneous industrial wood (mainly house logs, excelsior bolts, match splint logs, and converter poles), posts, fuelwood, and miscellaneous farm timbers. Engelmann spruce, blue spruce, and lodgepole pine collectively accounted for over 75 percent of the total output.



[1] *White, subalpine, and corkbark firs.*

Public lands, primarily National Forest lands, supplied 90 percent of Colorado's total output for 1962.

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[1] U.S. Forest Service. Timber resources for America's future. U.S. Dept. Agr., Forest Resource Rpt. 14, 713 pp., illus. 1958.

[2] Forest land which is producing or is capable of producing crops of industrial wood and is not withdrawn from timber utilization.

Saw logs were the most important product harvested in Colorado; nearly 185 million board feet[3] were produced in 1962, comprising 87 percent of the total cubic volume output. Almost all of the saw log volume went to sawmills within the State. The minor volume of saw logs exported went to Wyoming; imports were likewise small and came entirely from New Mexico. Spruce and lodgepole pine were the principal species harvested for saw logs, representing 48 percent and 34 percent, respectively, of the total saw log volume.

Other roundwood products--mine timbers, pulpwood, commercial poles, miscellaneous industrial wood, posts, fuelwood, and miscellaneous farm timbers--collectively accounted for almost 5 million cubic feet or 13 percent of the total 1962 output. Round mine timbers, the single most important product of this group, accounted for almost 30 percent of the volume in this category.

TRENDS SINCE 1952

Total roundwood output dropped 16 percent between 1952 and 1962. However, saw log production increased 9 percent during that same period. This indicates a shift in importance towards saw logs and away from other products. In 1962, as in 1952, Colorado pulpwood was obtained principally by salvaging dead spruce from extensive stands of insect-killed timber. The drop in pulpwood production from 33,000 cords in 1957 to only 3,000 cords in 1962 probably is due to increased use of chipped sawmill residues by pulpmills previously using round pulpwood from Colorado.

The number of active sawmills in Colorado dropped from 274 in 1957 to 170 in 1962,[4] the only recent years for which there were survey estimates of the number of mills. However, the average mill produced about 1.25 million board feet (lumber tally) during 1962, compared to an annual production of only about half that in 1957. These mills were fairly well distributed over the western two-thirds of the State (see map, following page). In addition to the mills shown, there were an estimated 44 active small mills, for which no saw log reports were received in the 1962 products survey. These mills received about 15.7 percent of the State's 1962 saw log output.

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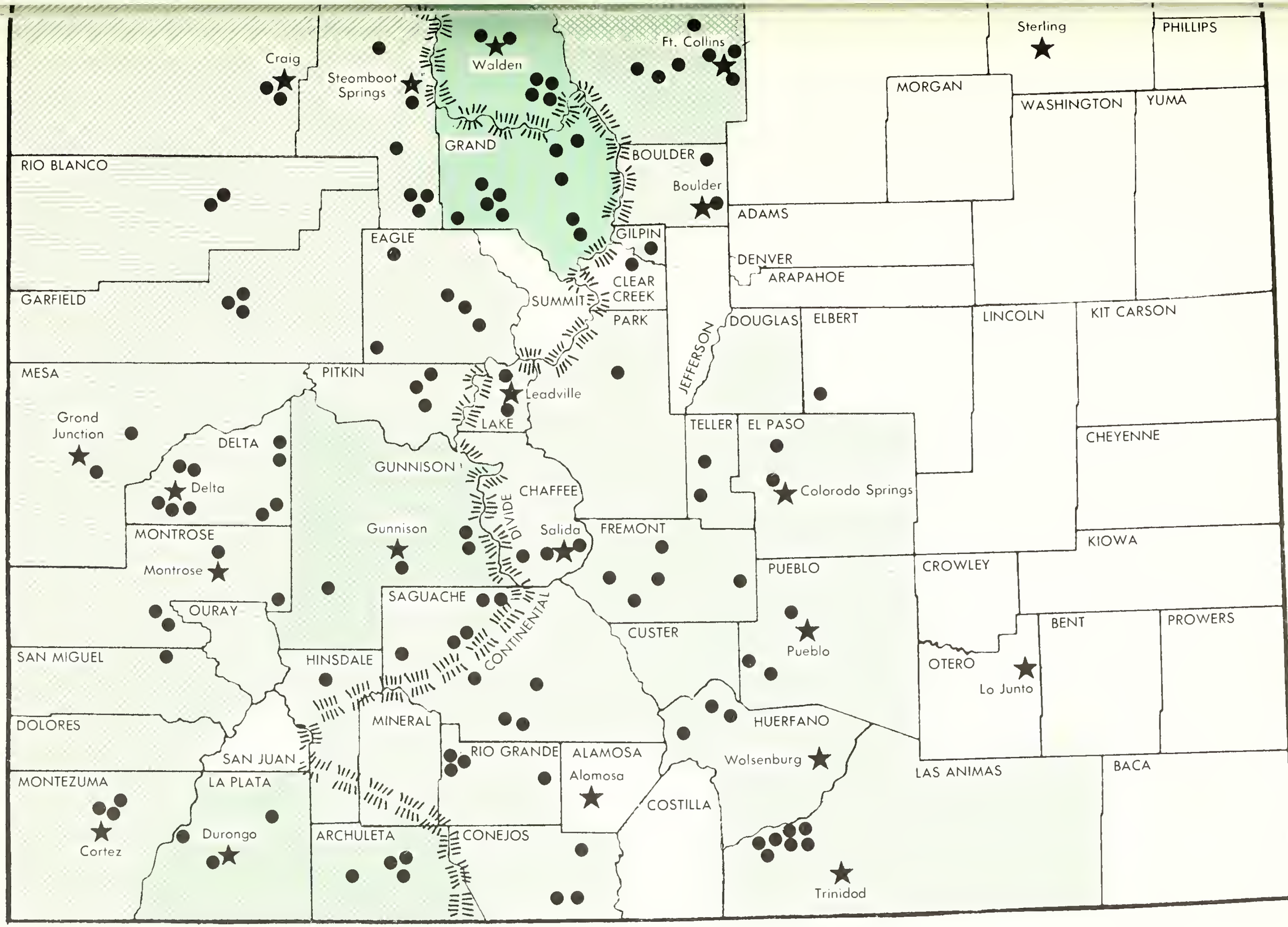
[3] International $\frac{1}{4}$-inch log rule board-foot volumes are used throughout this report unless otherwise stated.

[4] Miller, Robert L. Lumber production in Colorado, 1957. Rocky Mountain Forest and Range Expt. Sta. Forest Survey Release 1, 9 pp. 1962.

Increased use of chipped sawmill residues (such as shown at the left) by Lake States pulpmills probably is holding down demand for Colorado round pulpwood. Colorado presently supplies no pulp chips.



● Sawmill reported as operating in 1962

Saw log output by counties (million board feet, Intl. ¼″ rule)

No reported production

Less than 1

1 to 10

10 to 20

More than 20

Subunit boundary (Continental Divide)

COLORADO SAWMILLS AND SAW LOG PRODUCTION 1962

Table 1.--Output of timber products in Colorado by products and by species groups, in standard units, 1962

Product		Quantity		
		Total	Softwoods	Hardwoods
Saw logs	M bd. ft.[1]	184,645	183,490	1,155
Pulpwood	M std. cds.[2]	3	1	2
Fuelwood	M std. cds.	10	8	2
Commercial poles	M pieces	53	53	0
Posts (round and split)	M pieces	368	368	0
Mine timbers (round)	M cu. ft.	1,411	1,409	2
Miscellaneous industrial wood[3]	M cu. ft.	1,689	483	1,206
All products	M cu. ft.	36,433	34,740	1,693

[1] International ¼-inch log rule.
[2] Rough wood basis.
[3] Includes house logs, excelsior bolts, match splint logs, converter poles, and miscellaneous farm timbers.

Table 2.--Sawmill log receipts from Colorado timberlands by species, by subunits, and by county of origin, 1962

Subunit[1] and county	Species						All species	
	Ponderosa pine	Lodgepole pine	Douglas-fir	True firs[2]	Spruce[3]	Other species[4]	Volume	Percent
	Thousand board feet, International ¼-inch rule[5]							
WESTERN								
Archuleta	6,935	0	2,941	2,292	1,598	0	13,766	7.5
Delta, Mesa, Pitkin	1	69	21	298	3,763	162	4,314	2.3
Dolores, Montezuma, Ouray, San Miguel	1,167	0	0	0	7,655	370	9,192	5.0
Eagle	0	718	17	371	5,604	0	6,710	3.6
Garfield, Moffat, Rio Blanco	0	170	64	531	7,404	0	8,169	4.4
Grand	1,019	23,566	0	0	6,665	0	31,250	16.9
Gunnison, Hinsdale,[6] Mineral,[6] Saguache[6]	140	453	623	2,138	15,218	100	18,672	10.1
La Plata	111	0	0	94	17,456	0	17,661	9.6
Montrose	3,352	0	0	0	590	498	4,440	2.4
Routt	0	3,329	0	111	2,235	0	5,675	3.1
Total Western	12,725	28,305	3,666	5,835	68,188	1,130	119,849	64.9
Percent of total	10.6	23.6	3.1	4.9	56.9	.9	100.0	
EASTERN								
Boulder, Douglas, Gilpin, Park	35	62	22	7	2,121	0	2,247	1.2
Chaffee, Lake	152	1,442	935	1	330	0	2,860	1.6
Conejos, Hinsdale,[7] Mineral,[7] Rio Grande, Saguache[7]	320	1,381	1,332	81	5,427	8	8,549	4.6
Custer, Huerfano, Pueblo	4,002	143	456	205	9	4	4,819	2.6
El Paso, Teller	242	27	0	0	104	0	373	.2
Fremont	448	0	83	0	2,279	0	2,810	1.5
Jackson	210	23,522	0	231	5,652	0	29,615	16.0
Larimer	513	6,990	102	19	4,849	0	12,473	6.8
Las Animas	803	0	41	41	152	13	1,050	.6
Total, Eastern	6,725	33,567	2,971	585	20,923	25	64,796	35.1
Percent of total	10.4	51.8	4.6	.9	32.3	(8)	100.0	
STATE TOTAL	19,450	61,872	6,637	6,420	89,111	1,155	184,645	100.0
Percent of total	10.5	33.5	3.6	3.5	48.3	.6	100.0	

[1] The Continental Divide separates Colorado into western and eastern subunits.
[2] White and subalpine firs.
[3] Engelmann and blue spruces.
[4] Aspen and cottonwood.
[5] Scribner log-rule volumes can be approximated by multiplying table volumes by 0.89.
[6] The portion west of the Continental Divide.
[7] The portion east of the Continental Divide.
[8] Less than 0.05 percent.

Table 3.--Output of timber products in Colorado by species, 1962

Product	Species							All species	
	Ponderosa pine	Lodgepole pine	Douglas-fir	True firs[1]	Spruce[2]	Aspen and cottonwood	Other species[3]	Total	Percent
	Thousand cubic feet								
Saw logs	3,325	10,576	1,135	1,097	15,233	197	0	31,563	86.6
Pulpwood (round)	0	75	0	0	47	135	0	257	.7
Commercial poles	0	482	0	0	0	0	0	482	1.3
Mine timbers (round)	683	348	187	4	187	2	([4])	1,411	3.9
Miscellaneous industrial wood	0	38	9	0	93	1,176	0	1,316	3.6
Posts, fuelwood, miscellaneous farm timbers	175	670	121	60	190	156	32	1,404	3.9
Total	4,183	12,189	1,452	1,161	15,750	1,666	32	36,433	100.0
Percent of total	11.5	33.4	4.0	3.2	43.2	4.6	1	100.0	

[1] White, subalpine, and corkbark firs.
[2] Engelmann and blue spruces.
[3] Pinyon pine and minor hardwoods.
[4] Less than 0.5 thousand cubic feet.

Table 4.--Output of timber products by land ownership classes, Colorado, 1962

Product	Total volume	Land ownership classes				
		National Forest lands	Other public lands	Forest industry lands [1]	Other private lands	All ownerships
	M cu. ft.	Percent				
Saw logs	31,563	70.9	8.3	0.6	6.8	86.6
Pulpwood (round)	257	0.7	0	0	0	0.7
Commercial poles	482	0.6	0.1	0.3	0.3	1.3
Mine timbers (round)	1,411	2.9	([2])	0	1.0	3.9
Miscellaneous industrial wood	1,316	3.5	0	0	0.1	3.6
Posts, fuelwood, miscellaneous farm timbers	1,404	2.7	0.3	0.2	0.7	3.9
Total	36,433	81.3	8.7	1.1	8.9	100.0

[1] Lands owned by companies or individuals operating wood-using plants.
[2] Less than 0.05 percent.

Table 5.--Round and sawed timbers and lumber received at mines in Colorado, 1962

Round timbers			Sawed timbers and lumber		
All mines	Coal mines	Other mines	All mines	Coal mines	Other mines
Thousand cubic feet			Thousand board feet[1]		
1,411	861	550	17,137	1,862	15,275

[1] Lumber tally.

Table 6.--Lumber production and numbers of active sawmills by sawmill size classes in Colorado, 1957 and 1962

Sawmill size class (M bd. ft. per year)	1957[1]			1962		
	Lumber production		Active mills	Estimated lumber production[2]		Active mills[3]
	M bd. ft.[4]	Percent	Number	M bd. ft.[4]	Percent	Number
Less than 50	1,762	0.9	50	1,040	0.5	37
50-199	9,906	5.3	84	6,448	3.1	49
200-499	14,732	7.9	49	9,360	4.5	19
500-999	26,360	14.0	44	15,392	7.4	20
1,000-4,999	86,041	45.8	41	74,048	35.6	37
5,000 and over	49,071	26.1	6	101,712	48.9	8
Total	187,872	100.0	274	208,000	100.0	170

[1] Miller, Robert L. Lumber production in Colorado, 1957. Rocky Mountain Forest and Range Expt. Sta. Forest Survey Release 1, 9 pp., illus. 1955.
[2] Estimated from Census Bureau's lumber production total for Colorado's 1962 production (208 million board feet, lumber tally) on the assumption that lumber production was distributed among sawmill size classes in the same proportion as their reported saw log receipts.
[3] Sawmill size class estimated from saw log receipts rather than from lumber production.
[4] Lumber tally.

Table 7.--Output of timber products in Colorado and percentages of totals for major products, 1952, 1957, and 1962

Product		1952[1]		1957[2]		1962	
		Output	Percent[3]	Output	Percent[3]	Output	Percent[3]
Saw logs	M bd. ft.[4]	169,000	61	[5] 206,434	78	184,645	86
Pulpwood	M std. cds.[6]	15	3	33	7	3	1
All other[7] . . .	M cu. ft.	15,497	36	6,832	15	4,613	13
Total . . .	M cu. ft.	43,211	100	44,200	100	36,433	100

[1] U.S. Forest Service. Timber resources for America's future. U.S. Dept. Agr. Forest Resource Rpt. 14, 713 pp., illus. 1958. (Table 13, pp. 526-527.)
[2] Rocky Mountain Forest and Range Experiment Station, Annual Report, 1960.
[3] Based on cubic-foot volume equivalents for products whose outputs are shown in other standard volume units.
[4] International ¼-inch log rule.
[5] Miller, Robert L., and Alvin K. Wilson. Saw log production in Colorado and Wyoming, 1957. Rocky Mountain Forest and Range Expt. Sta. Forest Survey Release 3, 6 pp., illus. 1960.
[6] Rough wood basis. Includes round pulpwood only; i.e., does not include pulpwood from sawmill residues.
[7] Includes commercial poles, converter poles, round mine timbers, posts, fuelwood, house logs, excelsior bolts, match splint logs, and miscellaneous farm timbers.

Table 8.--Colorado lumber production, 1954-62

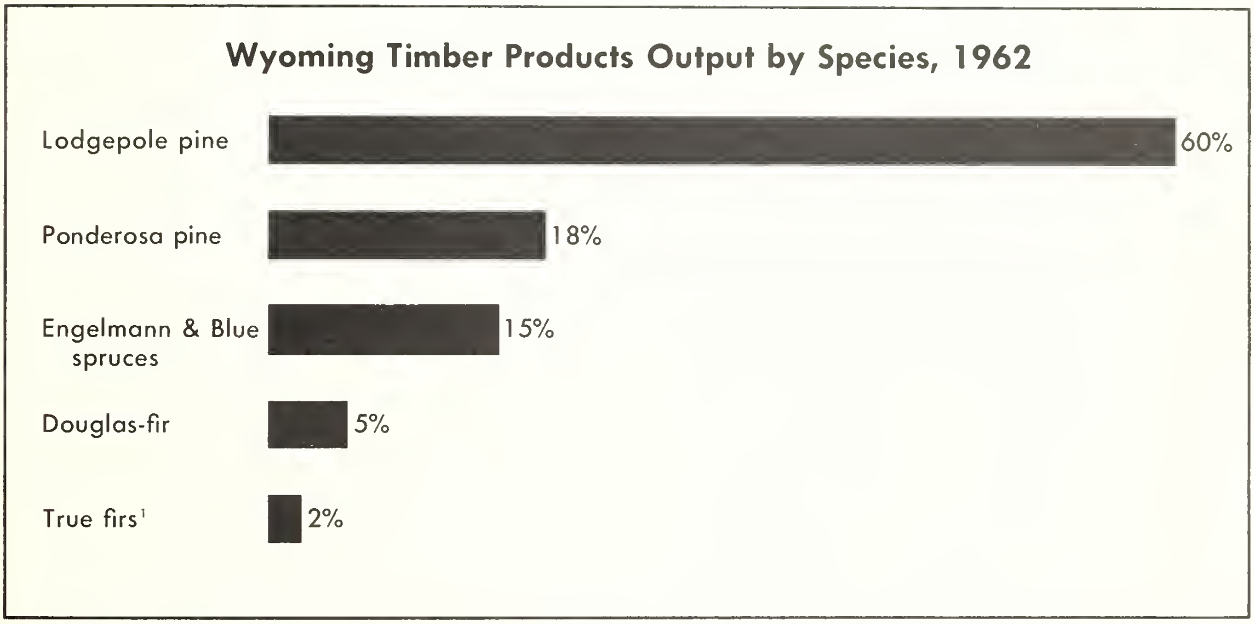
Year	Quantity	Year	Quantity
	MM bd.ft., lumber tally		MM bd.ft., lumber tally
1954	174	1959	227
1955	--	1960	181
1956	--	1961	197
1957	[1] 188	1962	208
1958	209		

Source: U.S. Bureau of the Census.
[1] Miller, Robert L. Lumber production in Colorado, 1957. Rocky Mountain Forest and Range Expt. Sta. Forest Survey Release 1, 9 pp., illus. 1959.

WYOMING

THE SITUATION IN 1962

Wyoming's total output of roundwood timber products in 1962 was nearly 21 million cubic feet--a gain of 31 percent since 1952.[5] The 1962 harvest included saw logs (for lumber), pulpwood, mine timbers, house logs, corral poles, converter poles, miscellaneous farm timbers, posts, and fuelwood. Lodgepole pine was the principal species harvested and accounted for 60 percent of the total.



[1] *White and subalpine firs.*

Public lands provided over 95 percent of the yield--the bulk of it coming from National Forests.

Saw logs, making up over 94 percent of the cubic-foot volume of all timber products, were by far the most important item. Almost 117 million board feet of saw logs were produced during 1962, and sawmills in Wyoming received most of this volume. A moderate volume of saw logs--nearly 10 million board feet--was exported to Idaho and South Dakota. Imports were slightly greater and amounted to about 11 million board feet and came from South Dakota, Utah, Colorado, and Idaho. Lodgepole pine, ponderosa pine, and Engelmann spruce were the chief species harvested, making up 58, 19, and 15 percent, respectively, of the total saw log volume.

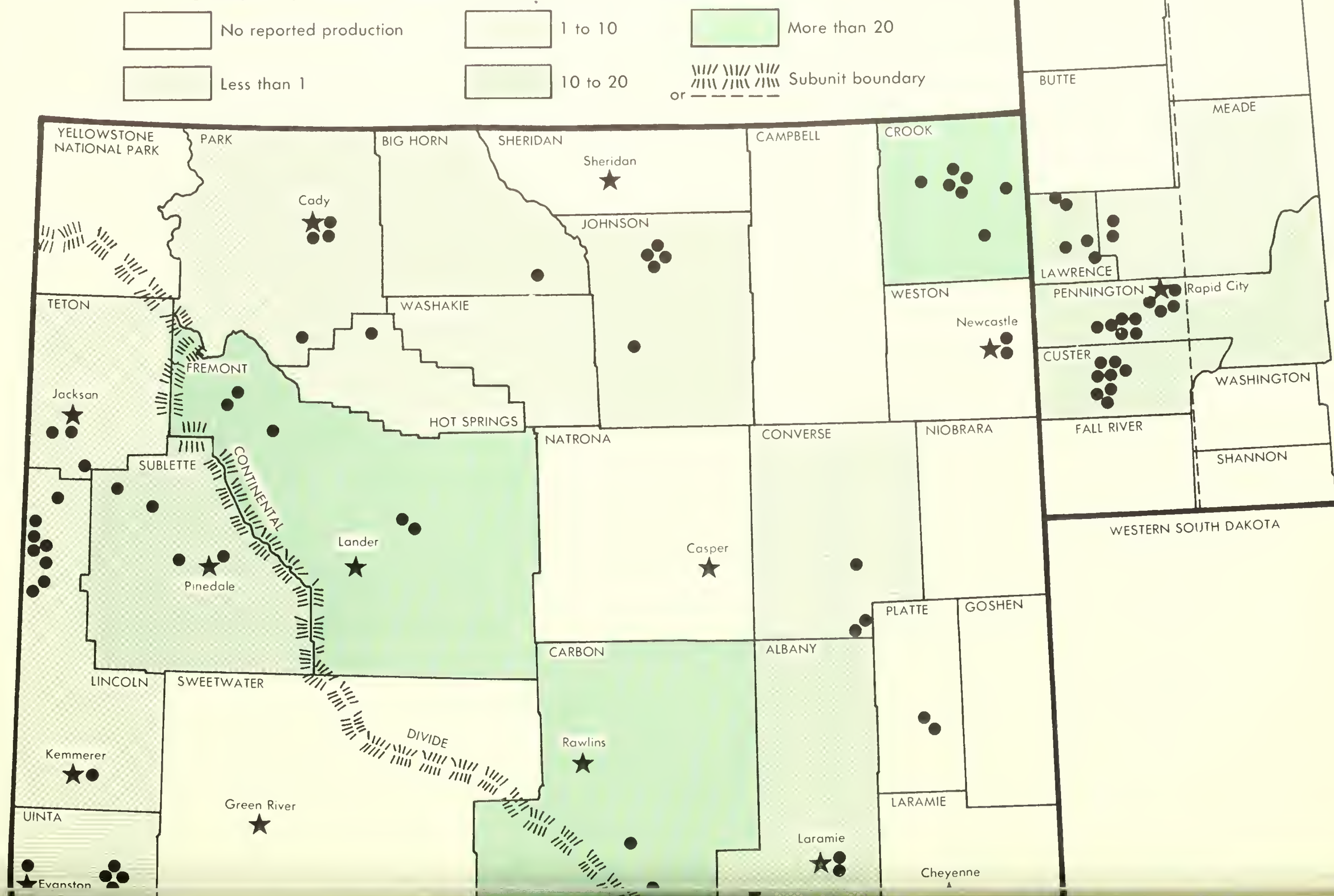
All other forest products accounted for 1,154,000 cubic feet or 6 percent of the total 1962 output, of which pulpwood comprised 40 percent.

[5] U.S. Forest Service, op. cit., page 1.

WYOMING AND WESTERN SOUTH DAKOTA SAWMILLS AND SAW LOG PRODUCTION 1962

● Sawmill reported as operating in 1962

Saw log output by counties (million board feet, Intl. ¼″ rule)



Sawmills like the one shown below were using nearly 50 percent more saw logs in 1962 than in 1952. In recent years the number of active mills in Wyoming has declined--as evidenced by the 29 percent decrease in operational mills from 1957 to 1962.

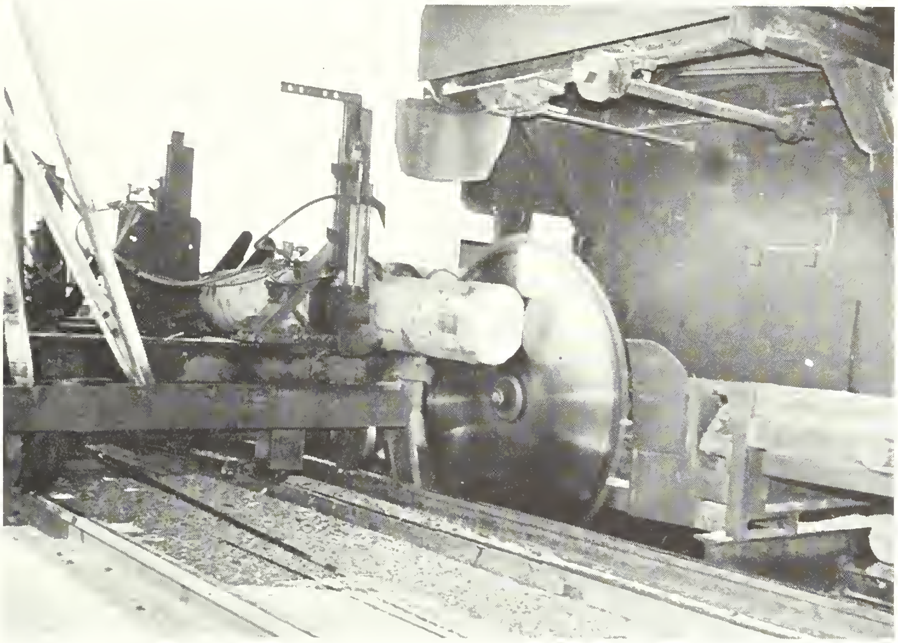


Photo: Courtesy of Colorado State University, School of Forestry

TRENDS SINCE 1952

Total output from roundwood in 1962 was 31 percent higher than in 1952 and 7 percent greater than in 1957.[6] Production of saw logs in 1962 was 49 percent greater than in 1952 and production of pulpwood--while it represented only a minor volume--increased fourfold during the same period. The production of all other timber products has declined steadily since 1952. In 1962 the output of products other than saw logs and pulpwood sagged to 19 percent of the 1952 volume, paralleling Colorado's diminishing harvest of these products and concurrent accelerating production of saw logs.

In spite of this marked increase in saw log yield, the number of active sawmills in Wyoming fell from 107 in 1957[7] to 76 in 1962, the only recent years for which this information was available.

The greatest concentration of sawmills in Wyoming and western South Dakota together is in the Black Hills region straddling the State line. In addition to the mills shown, there were an estimated 20 active mills in Wyoming and 3 active mills in western South Dakota, all small, for which no saw log reports were received in the 1962 products survey. Such mills in Wyoming received about 4.7 percent of that State's saw log output in 1962; in western South Dakota such mills received about 2.2 percent of the total. However, in 1962 the average mill sawed almost 1.4 million board feet (lumber tally) or one-third more than its counterpart cut in 1957.

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[6] U.S. Forest Service. Annual report, 1960, Rocky Mountain Forest and Range Expt. Station. 1961.

[7] Miller, Robert L., and Alvin K. Wilson. Lumber production in Wyoming, 1957. Rocky Mountain Forest and Range Expt. Station Forest Survey Release 2. 9 pp. 1959.

Table 9.--Output of timber products in Wyoming by products and by species groups, in standard units, 1962

Product		Quantity		
		Total	Softwoods	Hardwoods
Saw logs	M bd. ft.[1]	116,523	116,523	0
Pulpwood	M std. cds.[2]	4	4	0
Fuelwood	M std. cds.	1	1	0
Mine timbers (round)	M cu. ft.	54	54	0
Miscellaneous industrial wood[3]	M cu. ft.	448	433	15
Posts (round and split) . . .	M pieces	79	79	0
All products	M cu. ft.	20,771	20,756	15

[1] International ¼-inch log rule.
[2] Rough wood basis
[3] Includes house logs, corral poles, converter poles, commercial poles, and miscellaneous farm timbers.

Table 10.--Sawmill log receipts from Wyoming timberlands by species, by subunits, and by county of origin, 1962

Subunit[1] and county	Species						All species	
	Ponderosa pine	Lodgepole pine	Douglas-fir	True firs[2]	Engelmann spruce	Other species[3]	Volume	Percent
	Thousand board feet, International ¼-inch rule							
WESTERN								
Lincoln, Uinta	61	912	3,515	593	2,755	0	7,836	6.7
Sublette[4]	0	13,809	93	1	991	0	14,894	12.8
Teton[4]	0	396	549	122	374	0	1,441	1.2
Total, Western	61	15,117	4,157	716	4,120	0	24,171	20.7
Percent of total	.3	62.5	17.2	3.0	17.0	0	100.0	
EASTERN								
Albany, Carbon	782	23,175	0	1,614	9,136	0	34,707	29.8
Big Horn, Hot Springs, Washakie	0	1,048	681	0	1,212	27	2,968	2.6
Converse, Weston	254	0	0	0	0	0	254	.2
Crook	21,087	0	0	0	0	0	21,087	18.1
Fremont	0	24,563	139	737	1,166	0	26,605	22.8
Johnson	0	2,899	227	0	12	0	3,138	2.7
Park	0	1,269	327	0	1,997	0	3,593	3.1
Total, Eastern	22,123	52,954	1,374	2,351	13,523	27	92,352	79.3
Percent of total	24.0	57.3	1.5	2.6	14.6	([5])	100.0	
STATE TOTAL	22,184	68,071	5,531	3,067	17,643	27	116,523	100.0
Percent of total	19.0	58.4	4.8	2.6	15.2	([5])	100.0	

[1] The Continental Divide separates Wyoming into western and eastern subunits.
[2] White and subalpine firs.
[3] Whitebark pine.
[4] Parts of Sublette and Teton Counties extend east of the Divide, but all log receipts were from the west side.
[5] Less than 0.05 percent.

Table 11.--Saw log receipts of Wyoming sawmills, by source areas, 1962

Source area	Volume	Percent
	Thousand bd. ft.[1]	
Wyoming	106,910	90.3
Idaho and Utah	2,940	2.5
South Dakota and Colorado	8,502	7.2
Total	118,352	100.0

[1] International ¼-inch log rule.

Table 12.--Output of timber products in Wyoming by species, 1962

Product	Species: Ponderosa pine	Lodgepole pine	Douglas-fir	True firs[1]	Spruce[2]	Aspen and cottonwood	Other species[3]	All species: Total	Percent
	Thousand cubic feet								
Saw logs	3,735	11,460	931	516	2,970	0	5	19,617	94.4
Pulpwood (round	0	464	0	0	0	0	0	464	2.2
Mine timbers (round)	1	53	0	0	0	0	0	54	.3
Miscellaneous industrial wood	0	24	0	0	0	15	0	39	.2
Posts, fuelwood, miscellaneous farm timbers	0	509	20	0	68	0	0	597	2.9
Total	3,736	12,510	951	516	3,038	15	5	20,771	100.0
Percent of total	18.0	60.2	4.6	2.5	14.6	.1	(4)	100.0	

[1] White and subalpine firs.
[2] Engelmann and blue spruces.
[3] Limber and whitebark pines.
[4] Less than 0.05 percent.

Table 13.--Output of timber products by land ownership classes, Wyoming, 1962

Product	Total volume	Land ownership classes: National Forest lands	Other public lands	Forest industry lands[1]	Other private lands	All ownerships
	M cu. ft.	Percent				
Saw logs	19,617	84.3	5.7	2.2	2.2	94.4
Pulpwood (round)	464	2.2	0	0	0	2.2
Mine timbers (round)	54	0.2	0.1	0	(2)	0.3
Miscellaneous industrial wood	39	0.1	0	0	0.1	0.2
Posts, fuelwood, miscellaneous farm timbers	597	2.6	0.1	0.1	0.1	2.9
Total	20,771	89.4	5.9	2.3	2.4	100.0

[1] Lands owned by companies or individuals operating wood-using plants.
[2] Less than 0.05 percent.

Table 14.--Round and sawed timbers and lumber received at mines in Wyoming, 1962

Round timbers			Sawed timbers and lumber		
All mines	Coal mines	Other mines	All mines	Coal mines	Other mines
- - - - - Thousand cubic feet - - - -			- - - - Thousand board feet[1] - - - - -		
54	33	21	3,532	43	3,489

[1] Lumber tally.

Table 15.--Lumber production and numbers of active sawmills by sawmill size classes in Wyoming, 1957 and 1962

Sawmill size class (M bd. ft. per year)	1957[1]			1962		
	Lumber production		Active mills	Estimated lumber production[2]		Active mills[3]
	M bd. ft.[4]	Percent	Number	M bd. ft.[4]	Percent	Number
Less than 50	1,121	1.0	14	103	0.1	14
50-199	3,198	2.9	29	8,446 (50-499)	8.2 (50-499)	38 (50-499)
200-499	7,162	6.6	26			
500-999	10,326	9.5	16	4,017	3.9	5
1,000-4,999	47,792	44.0	19	26,986	26.2	12
5,000 and over	39,092	36.0	3	63,448	61.6	7
Total	108,691	100.0	107	103,000	100.0	76

[1] Miller, Robert L., and Alvin K. Wilson. Lumber production in Wyoming, 1957. Rocky Mountain Forest and Range Expt. Sta. Forest Survey Release 2, 9 pp., illus. 1959.

[2] Estimated from Census Bureau's lumber production total for Wyoming's 1962 production (103 million board feet, lumber tally) on the assumption that lumber production was distributed among sawmill size classes in the same proportion as their reported saw log receipts.

[3] Sawmill size class estimated from saw log receipts rather than from lumber production.

[4] Lumber tally.

Table 16.--Output of timber products in Wyoming and percentages of totals for major products 1952, 1957, and 1962

Product	1952[1]		1957		1962	
	Output	Percent[2]	Output	Percent[2]	Output	Percent[2]
Saw logs . . . . . M bd. ft.[3]	77,999	77	[4]109,188	94	116,523	95
Pulpwood . . . . . M std. cds.[5]	1	([6])	--	--	4	2
All other[7] . . . . M cu. ft.	3,603	23	[8]1,190	6	690	3
Total . . . . M cu. ft.	15,861	100	19,388	100	20,771	100

[1] U.S. Forest Service. Timber resources for America's future. U.S. Dept. Agr. Forest Resource Rpt. 14, 713 pp., illus. 1958. (Table 13, pp. 526-527.)

[2] Based on cubic-foot volume equivalents for products whose outputs are shown in other standard volume units.

[3] International ¼-inch log rule.

[4] Miller, Robert L., and Alvin K. Wilson. Saw log production in Colorado and Wyoming, 1957. Rocky Mountain Forest and Range Expt. Sta. Forest Survey Release 3, 6 pp., illus. 1960.

[5] Rough wood basis. Includes round pulpwood only; i.e., does not include pulpwood from sawmill residues.

[6] Less than 1 percent.

[7] Includes commercial poles, converter poles, posts, round mine timbers, fuelwood, and miscellaneous farm timbers.

[8] Rocky Mountain Forest and Range Expt. Sta. Annual Report, 1960.

Table 17.--Wyoming lumber production, 1954-62

Year	Quantity
	Millions of board feet lumber tally
1954	81
1955	--
1956	--
1957	[1]109
1958	105
1959	107
1960	99
1961	97
1962	103

Source: U.S. Bureau of the Census.

[1] Miller, Robert L., and Alvin K. Wilson. Lumber production in Wyoming, 1957. Rocky Mountain Forest and Range Expt. Sta. Forest Survey Release 2, 9 pp., illus. 1959.

WESTERN SOUTH DAKOTA

THE SITUATION IN 1962

The total timber output of western South Dakota[8]--principally the Black Hills--was 11.2 million cubic feet of roundwood products, a 17 percent increase over the 1952[9] output. Aside from an insignificant quantity of [redacted] spruce saw logs, the entire output consisted of ponderosa pine. About 84 percent of the total production came from public lands, chiefly National Forest lands.

Saw logs, with a volume of nearly 39 million board feet, were the most important product harvested and accounted for 58 percent of the total output. All but 7 million board feet went to sawmills in South Dakota; Wyoming mills received all the saw log exports, and Wyoming was the sole supplier of the 8.5 million board feet of saw logs imported into western South Dakota.

Pulpwood production totaled 3 million cubic feet and accounted for some 27 percent of the total output, making it the second most important product harvested. All the pulpwood was shipped to mills in the Lake States.

All other products--commercial poles, posts, piling, fuelwood, and miscellaneous farm timbers--made up 1.7 million cubic feet or 15 percent of the total output of timber products. No round timbers were received at mines in 1962; however, nearly 11 million board feet (lumber tally) of sawed material was delivered to mines other than coal mines.

TRENDS SINCE 1952

Pulpwood production was the only segment of the timber products industry in western South Dakota that showed any growth between 1952 and 1962, increasing from 500 to 34,000 standard cords during that period. Saw log production by 1962 had declined slightly (about 3 percent) from the 1952 level, suggesting that little growth in the sawmill industry is possible in that portion of the State where mills have long been established and consumed the full allowable annual cut for many years. Output of all other forest products in 1962 was only about half that of 1952, resembling the situations in Colorado and Wyoming where demand for these products is also diminishing.

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[8] Western South Dakota includes all of Harding, Butte, Lawrence, and Fall River Counties, plus the portions of Meade, Pennington, and Custer Counties that lie west of the 103d meridian.

[9] U.S. Forest Service, op. cit., page 1.

These ponderosa pine pulp sticks are awaiting shipment from the Black Hills to a pulpmill in the Lake States. Increased output of pulpwood since 1952 has offered opportunities for expanded forest management.

Table 18.--Output of timber products in western South Dakota by products and by species groups, in standard units, 1962

Product		Quantity		
		Total	Softwoods	Hardwoods
Saw logs	M bd. ft.[1]	38,958	38,958	0
Pulpwood	M std. cds.[2]	34	34	0
Fuelwood	M std. cds.	1	1	0
Commercial poles and piling.	M pieces	91	91	0
Posts (round and split). . .	M pieces	599	599	0
Miscellaneous farm timbers .	M cu. ft.	447	447	0
All products	M cu. ft.	11,235	11,235	0

[1] International ¼-inch log rule.
[2] Rough wood basis.

Table 19.--Sawmill log receipts from western South Dakota timberlands by county of origin, 1962

County	Quantity[1]	Percent
	Thousand board feet[2]	
Custer	18,646	46.1
Lawrence, Meade	10,209	25.2
Pennington	10,103	25.0
Total Western	38,958	96.3
Total Eastern	[3]1,500	3.7
STATE TOTAL	40,458	100.0

[1] Practically all ponderosa pine but includes an insignificant quantity of spruce.
[2] International ¼-inch log rule.
[3] Data furnished by Lake States Forest Experiment Station.

Table 20.--Saw log receipts of western South Dakota sawmills by source areas, 1962

Source area	Volume	Percent
	M bd. ft.[1]	
Western South Dakota	31,790	79.1
Wyoming	8,400	20.9
Total	40,190	100.0

[1] International ¼-inch log rule.

Table 21.--Output of timber products in western South Dakota by species, 1962

Product	Species: Ponderosa pine	Species: [redacted] spruce	All species: Total	All species: Percent
	- - - - Thousand cubic feet - - - -			
Saw logs	6,492	1	6,493	57.8
Pulpwood (round)	3,060	0	3,060	27.2
Commercial poles and piling	548	0	548	4.9
Posts, fuelwood, miscellaneous farm timbers	1,134	0	1,134	10.1
Total	11,234	1	11,235	100.0
Percent of total	100.0	([1])	100.0	

[1] Less than 0.05 percent.

Table 22.--Output of timber products by land ownership classes, western South Dakota, 1962

Product	Total volume	Land ownership classes: National Forest lands	Other public lands	Forest industry lands [1]	Other private lands	All ownerships
	M cu. ft.	- - - - - - - -	- - - - -	Percent	- - - - -	- - - - - - - -
Saw logs	6,493	53.7	0.2	2.5	1.4	57.8
Pulpwood (round)	3,060	16.3	0.3	0	10.6	27.2
Commercial poles and piling	548	4.5	([2])	0.2	0.2	4.9
Posts, fuelwood, miscellaneous farm timbers	1,134	9.4	([2])	0.5	0.2	10.1
Total	11,235	83.9	0.5	3.2	12.4	100.0

[1] Lands owned by companies or individuals operating wood-using plants.
[2] Less than 0.05 percent.

Table 23.--Lumber production and numbers of active sawmills by sawmill size classes in western South Dakota, 1962

Sawmill size class (M bd. ft. per year)	Estimated lumber production [1]		Active mills [2]
	M bd. ft. [3]	Percent	Number
Less than 50	192	0.4	5
50-199	1,056	2.2	7
200-499	2,544	5.3	6
500-999	2,448	5.1	3
1,000-4,999	14,496	30.2	5
5,000 and over	27,264	56.8	2
Total	48,000	100.0	28

[1] Estimated from Census Bureau's lumber production total for South Dakota's 1962 output (50 million board feet, lumber tally) adjusted by western South Dakota's percentage of the State's total saw log receipts (96.3 percent) and the assumption that lumber production was distributed among sawmill size classes in the same proportion as their reported saw log receipts.
[2] Sawmill size class estimated from saw log receipts rather than from lumber production.
[3] Lumber tally.

Table 24.--Output of timber products in western South Dakota and percentages of totals for major products, 1952 and 1962

Product		1952 [1]		1962	
		Output	Percent [2]	Output	Percent [2]
Saw logs	M bd. ft. [3]	39,997	65	38,958	58
Pulpwood	M std. cds. [4]	(5)	--	34	27
All other [6]	M cu. ft.	3,378	35	1,682	15
Total	M cu. ft.	9,618	100	11,235	100

[1] U.S. Forest Service. Timber resources for America's future. U.S. Dept. Agr. Forest Resource Rpt. 14, 713 pp., illus. 1958. (Table 13, pp. 526-527.)

[2] Based on cubic-foot volume equivalents for products whose outputs are shown in other standard volume units.

[3] International ¼-inch log rule

[4] Rough wood basis. Includes round pulpwood only; i.e., does not include pulpwood from sawmill residues.

[5] Less than 500 standard cords.

[6] Includes commercial poles, piling, posts, fuelwood, and miscellaneous farm timbers.

Table 25.--Western South Dakota lumber production, 1954-62

Year	Quantity
	Millions of board feet lumber tally
1954	37
1955	--
1956	--
1957	--
1958	72
1959	--
1960	52
1961	46
1962	50

Source: U.S. Bureau of the Census.

SURVEY PROCEDURES

The survey of saw log receipts at sawmills was based on a list of mills prepared in the latter part of 1962. That list was made as complete as possible through reviews by Forest Service personnel. All listed mills were contacted by mail early in 1963 to obtain data on their saw log receipts for 1962. All mills outside the three States that were considered possible recipients of logs from Colorado, Wyoming, or western South Dakota were also asked to report. Field sampling provided data for estimating, within acceptable error limits, the receipts of sawmill operators who did not furnish mail reports (nonrespondents).

The estimated total saw log receipts and the standard errors for those parts of the total receipts for Colorado, Wyoming, and western South Dakota that were estimated by field sampling nonrespondents were:

	Estimated total receipts	Standard error[1]	Standard error as percent of total
	(M bd. ft.)	(M bd. ft.)	
Colorado	184,645	±2,878	1.56
Wyoming	116,523	±4,149	3.56
Western South Dakota	38,958	±775	1.99

[1] The odds are 2 to 1 that the true totals for the States are within the estimate ± the standard error.

Similar procedures were used in the survey of round timbers received at mines in Colorado and Wyoming during 1962. Lists of mines were compiled from a mining industry directory[10] and nonrespondents were sampled by field contacts. The standard error of the estimated portion of round mine timber receipts from Colorado timberlands was 164 cubic feet, or 0.01 percent of the State total. Therefore, the odds are 2 to 1 that the actual State total is 1,410,677 ± 164 cubic feet. For round mine timber receipts from Wyoming, the standard error for the estimated portion was 1,125 cubic feet, or 2.09 percent of the State total. Again, at 2 to 1 odds, the true Wyoming total lies in the range 53,845 ±1,125 cubic feet. No use of round mine timbers in 1962 was reported for western South Dakota because none of the respondents or field-sampled nonrespondents indicated any use of this product.

Reports were obtained by mail and field contacts made with all plants known to have received round pulpwood, commercial poles, and miscellaneous industrial wood from Colorado, Wyoming, and western South Dakota in 1962; in addition, the National Forests on which these products were harvested also reported. Accordingly, all these estimates are considered to be without sampling error.

Estimates of the 1962 production of posts, fuelwood, and miscellaneous farm timbers for all three States were obtained from reports furnished by National Forests, State Foresters, Bureau of Land Management, Bureau of Reclamation, and the Bureau of Indian Affairs, and supplemented by trend estimates of farm use of these products obtained from the Bureau of the Census.[11] Since this procedure precluded the calculation of a sampling error, none has been assigned.

[10] Mining World Catalog, Survey and Directory Number, 1962, Miller Freeman Publications.
[11] Census Bureau: 1959 Census of Agriculture, vol. II, General Report.

DPSU/1496-13

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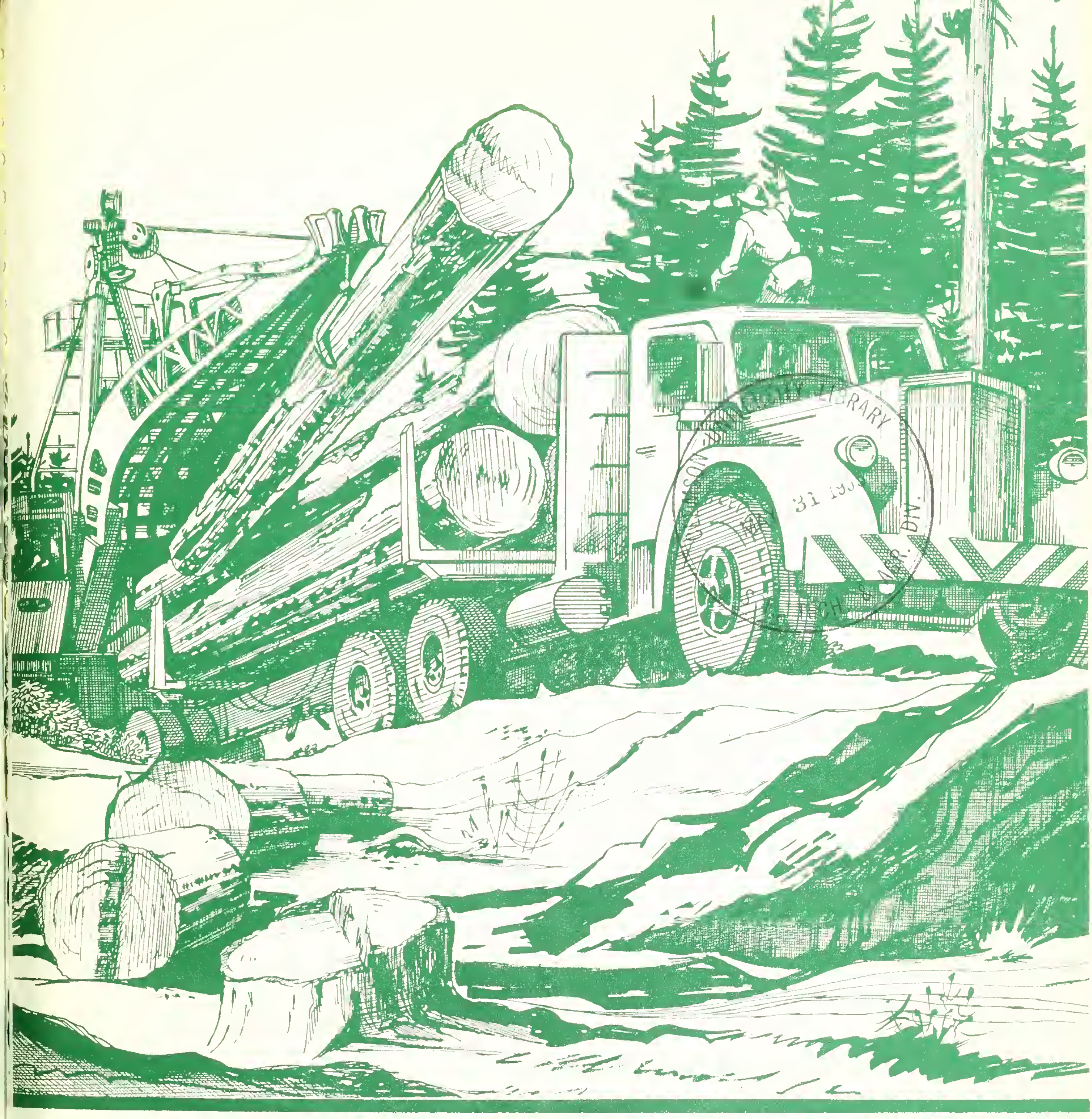
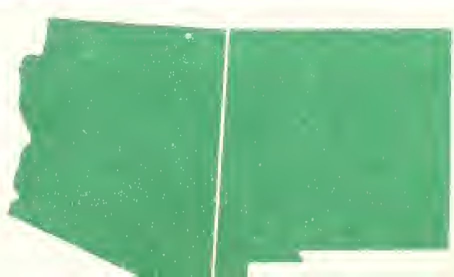


IMBER PRODUCTS OUTPUT IN ARIZONA AND NEW MEXICO, 1962

Forest Service, U.S. Department of Agriculture
1964



This report summarizes survey information collected in 1963 on the 1962 output of roundwood products from the forests of Arizona and New Mexico. The term "roundwood" designates products that were received at plants "in the round" (as logs or bolts) for the first steps in manufacture. Accordingly, the data presented here do not include pulpwood made from sawmill or veneer plant residues (slabs, edgings, trim ends, shavings, sawdust, lathe cores), nor do they include fuelwood or any other items (industrial or domestic) made from these residues.

The detailed results of this survey are presented in a series of tables. The highlights of 1962 production and major production trends between 1952 and 1962 are discussed. Data for saw log output are presented in more detail than for other products because of the predominance of saw logs in the States' total production.

Forest products surveys in the Rocky Mountain States and western South Dakota are part of the Intermountain Forest and Range Experiment Station's program for periodic appraisals of the forest situation. In western South Dakota, eastern Wyoming, Colorado, New Mexico, and Arizona, products surveys and other phases of Forest Survey work are conducted cooperatively with the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

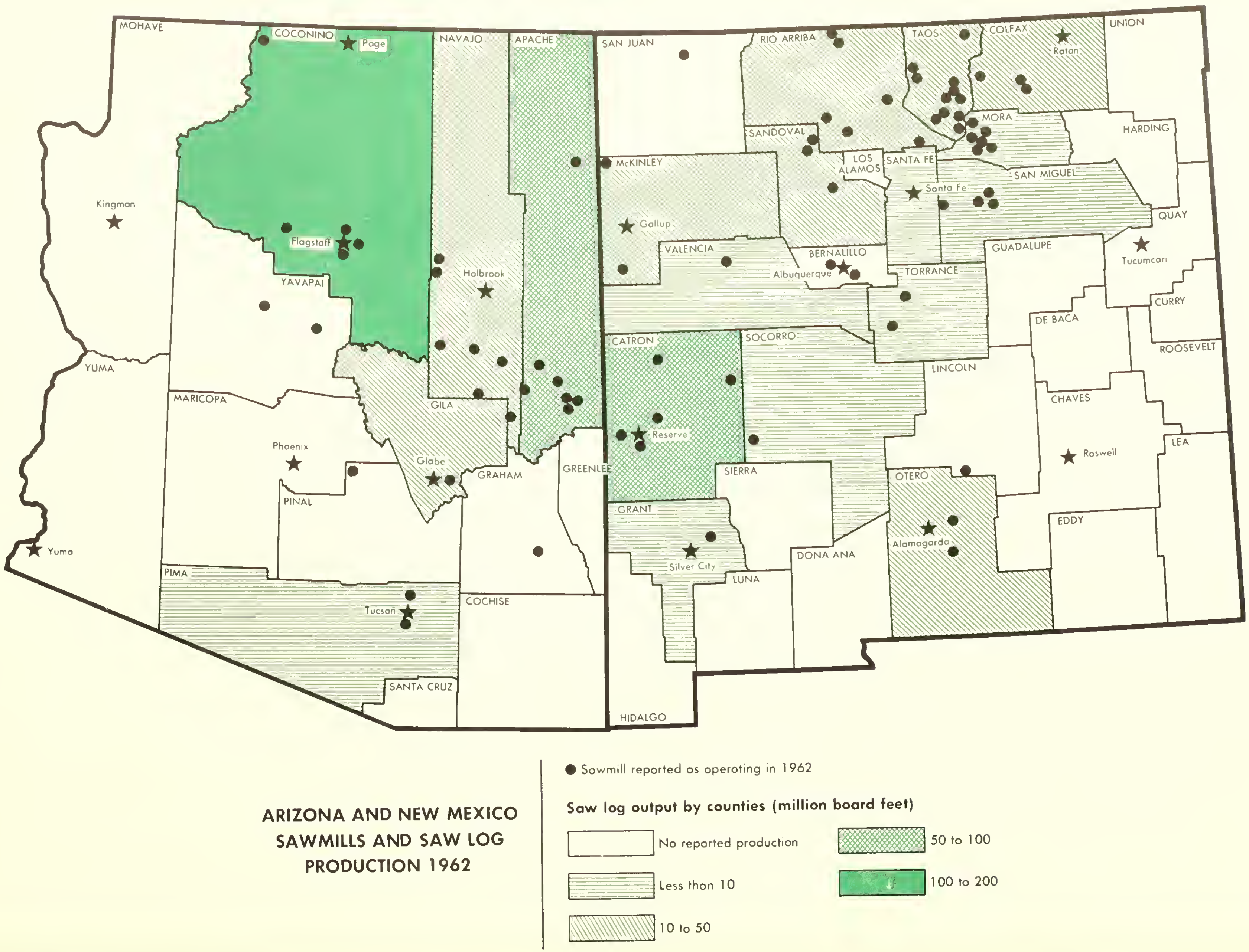
TIMBER PRODUCTS OUTPUT

IN

ARIZONA AND NEW MEXICO, 1962

Alvin K. Wilson

1964



ARIZONA AND NEW MEXICO SAWMILLS AND SAW LOG PRODUCTION 1962

U.S. Forest Service
Research Paper INT-15
1964

TIMBER PRODUCTS OUTPUT

IN

ARIZONA AND NEW MEXICO, 1962

Alvin K. Wilson
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FOREST SERVICE — U.S. DEPARTMENT OF AGRICULTURE

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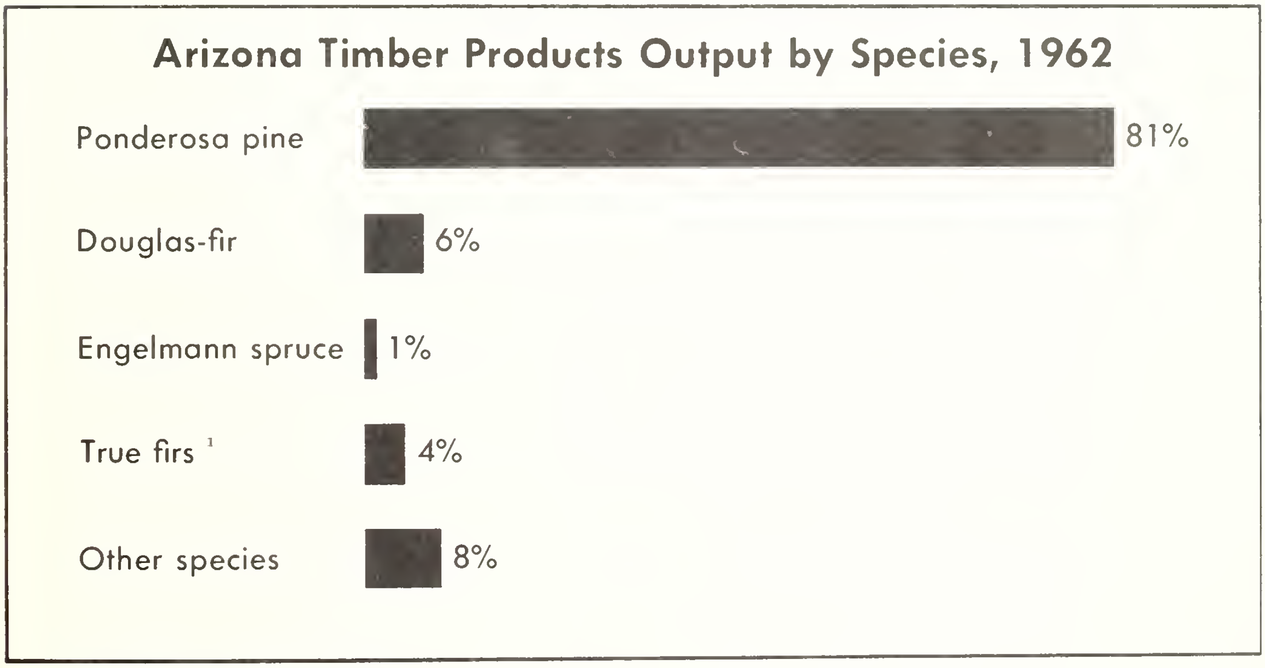
ARIZONA

THE SITUATION IN 1962

The output of all roundwood products originating in Arizona in 1962 totaled 65.5 million cubic feet--less than 1 percent more than in 1952 but over 6 percent more than production in 1960. These products included saw logs (for lumber), pulpwood, commercial poles, mine timbers, miscellaneous industrial wood (converter poles, excelsior bolts, charcoal wood, and house logs), posts, fuelwood, and miscellaneous farm timbers.

Ninety-one percent of this total came from public lands; National Forests supplied 69 percent and other public lands 22 percent of the total. More than half of the remaining 9 percent came from forest industry lands.[1] Four-fifths of all products were cut from ponderosa pine.



[1] *White, subalpine, and corkbark firs.*

Saw logs comprised 76 percent (342 million board feet)[2] of the total roundwood cut in Arizona, all of which went to Arizona sawmills.

The greatest concentration of sawmills is in central Arizona (see frontispiece). In addition to the mills shown there were an estimated two active sawmills in Arizona and 24 active mills in New Mexico, all small, for which saw log reports were not received in the 1962 products survey. In Arizona these mills received less than 1 percent of the State's saw log output. Such mills in New Mexico received about 9.1 percent of that State's 1962 saw log output. Some 68 percent of the saw logs cut in Arizona came from public lands; ponderosa pine made up 86 percent of the total saw log cut.

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[1] Lands owned by companies or individuals operating wood-using plants.

[2] International $\frac{1}{4}$-inch log rule volumes are used throughout this report.

Pulpwood production in Arizona started in 1961 and by 1962 was second in importance (on the basis of volume) among the State's roundwood products. Production in 1962 was 88,000 cords (12 percent of all roundwood products volume), all of which was ponderosa pine from National Forest lands.

Other timber products (utility poles, round mine timbers, miscellaneous industrial wood, posts, fuelwood, and miscellaneous farm timbers) made up the remaining 12 percent of the total output. Of the 8 million cubic feet of wood in these products, nearly 7 million cubic feet was cut for fuelwood.

TRENDS SINCE 1952

Output data for estimating the production trend in roundwood products in Arizona are incomplete. Data that include the output of all roundwood products are available only for the years 1952, 1960, and 1962. Census Bureau lumber production figures--useful for estimating total output trends when saw logs for lumber are predominant among roundwood products--do not provide a satisfactory basis for estimating the trend in Arizona because the saw log percentage is not consistently high[3] and lumber production figures are available for only five of the years from 1952 through 1962.

The available data for total products output show a 5-percent decline from 1952 to 1960, followed by a 6-percent gain from 1960 to 1962 and suggest an upward swing in Arizona's production.[4] Additional indications of an improving outlook are furnished by some recent industry developments in the State. Among these was the completion of the Southwest Timber Industries pulpmill at Snowflake in late 1961. With an annual pulp production of 140,000 tons,[5] this mill has not only provided a significant new market for roundwood, but also a market for chipped sawmill residues from its own and other sawmills.

The same company, also in 1961, began operation of the State's first wood-treating plant at Prescott, producing as major products treated poles and crossties from ponderosa pine. As of 1962, the plant was budgeted to produce 10,000 poles, and 50,000 to 70,000 crossties annually.[6]

More recently, plans for a tissue-towel mill, located on the site of the former Arizona Pulp and Paper Company mill at Flagstaff, have been confirmed. The new mill has timber cutting rights in the Flagstaff area and is expected to be in operation late in 1964,[7] providing still another timber outlet of economic importance to the State.

As in other Rocky Mountain States, there has been a definite reduction in the numbers of operating sawmills in the last several years, but the production per mill has increased. In 1960, 38 active sawmills produced 330 million board feet of lumber--8.7 million board feet per mill. In 1962, 28 mills produced 326 million board feet of lumber or 11.6 million board feet per mill.

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[3] Saw logs for lumber rose from 58 percent of total output in 1952 to 94 percent in 1960, then fell to 76 percent in 1962.

[4] In contrast, lumber data show a 28-percent rise from 1954 (data not available for 1952) to 1960 and a 1-percent decline from 1960 to 1962, suggesting entirely different trends from those of total roundwood production.

[5] Western Conservation Journal 20(6): 62-64. Directory of western pulp and paper mills. Dec. 1963-Jan. 1964.

[6] Forest Industries 89(10): 98-99. Arizona plant treats pine. 1962.

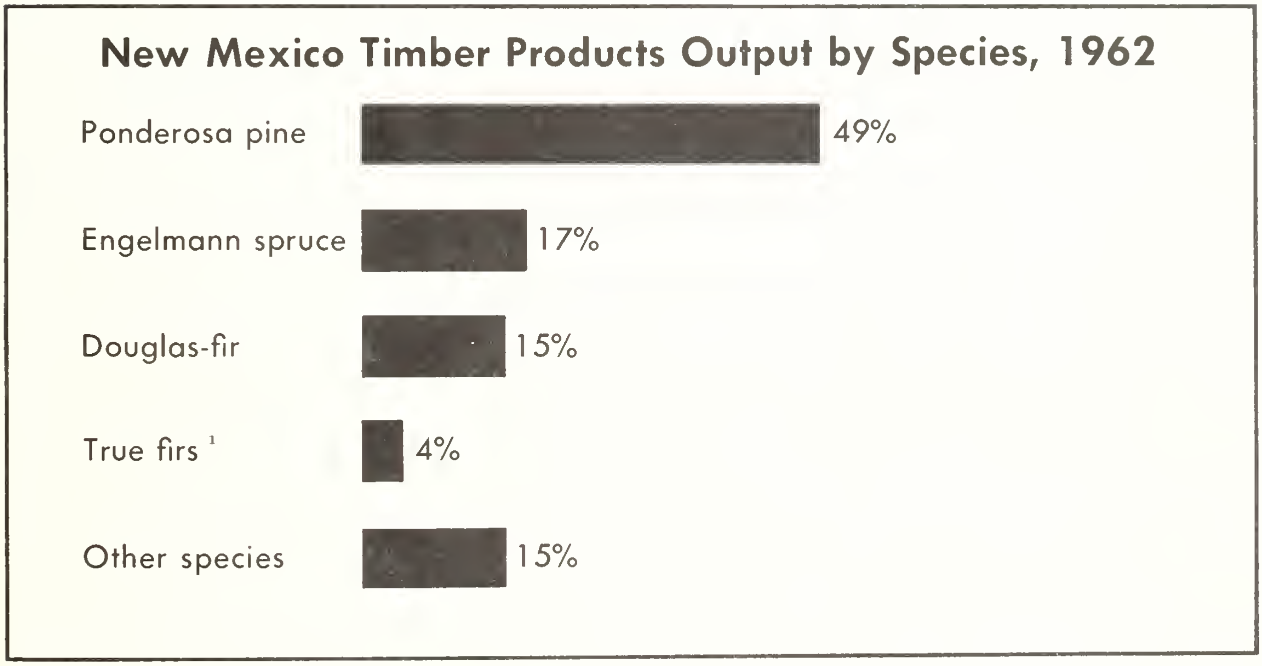
[7] Pulp and Paper 38(11): 8. New tissue mill set for Arizona. 1964.

NEW MEXICO

THE SITUATION IN 1962

New Mexico's timber products in 1962 included saw logs for lumber, commercial poles, posts, mine timbers, fuelwood, miscellaneous industrial wood (excelsior bolts, converter poles, and house logs), and various farm timbers.

The total output of roundwood products from New Mexico's forests was 46.3 million cubic feet in 1962--14 percent more than in 1952 but 13 percent less than in 1960. Forty-three percent of the 1962 production came from National Forests and 21 percent came from other public lands, principally Indian lands; the remaining 36 percent came from privately owned forests. Nearly half the output was ponderosa pine.



[1] *White, subalpine, and corkbark firs.*

Saw logs accounted for nearly four-fifths (78 percent) of all roundwood production in 1962. Of the 248 million board-foot total, 218 million board feet went to mills in New Mexico and the remainder went to mills in Arizona and Colorado. More than half (54 percent) of all saw logs were ponderosa pine.

Posts, fuelwood, and miscellaneous farm timbers (as a group) were next in importance on a volume basis. These items totaled nearly 10 million cubic feet, or more than one-fifth of the total of all products.

Round mine timbers, miscellaneous industrial wood, and utility poles made up the remaining 1 percent of the State's roundwood products.

TRENDS SINCE 1952

The statistical data for developing production trends in New Mexico have the same deficiencies as those for Arizona. Data for all roundwood products are available only for the 3 years--1952, 1960, and 1962. Census Bureau lumber production data not only are incomplete for the 1952-62 period, but also do not appear well correlated with the output of roundwood products.[8] For all roundwood products, there was a 14-percent volume increase from 1952 to 1962 which encompassed a 30-percent gain from 1952 to 1960 and a 13-percent decline from 1960 to 1962.

New Mexico also has experienced a reduction in the total number of operating sawmills from 1960 to 1962 and an accompanying rise in the output per active mill. In 1960, some 228 million board feet of lumber was cut in 117 mills; the average output per mill was 1.9 million board feet. In 1962, 85 mills produced 245 million board feet of lumber, an average output of 2.9 million board feet per mill. The numbers of operating sawmills declined in almost every mill production class from smallest to largest, but the decrease was most noticeable among mills producing less than 500,000 board feet per year.

SURVEY PROCEDURES

The survey of saw log receipts was based on listings of sawmills for each State, which were prepared late in 1962 and made as complete as possible through reviews by Forest Service personnel. Operators of mills on each State list were contacted by mail to obtain data on their log receipts in 1962. Also, all sawmills in neighboring States that were considered to be possible recipients of logs from Arizona and New Mexico were asked to report. Field sampling provided data for estimating, within acceptable error limits, the receipts of sawmill operators who did not furnish a report by mail.

For Arizona, total saw log receipts in 1962 were estimated to be 341,757,000 board feet, and the standard error for that part of the total estimated by field sampling was 2,719,000 board feet, or 0.80 percent of the total. The odds, then, are 2 to 1 that the true State total was between 339,038,000 and 344,476,000 board feet. For New Mexico, total saw log receipts were estimated to be 247,620,000 board feet, with a standard error for the estimated portion of 3,215,000 board feet (1.30 percent of the total). At 2 to 1 odds, the true total for New Mexico was between 244,405,000 and 250,835,000 board feet.

In both States, estimates for round pulpwood, commercial poles, and miscellaneous industrial wood are based on reports from all plants known to receive these roundwood products and are considered to be without sampling error.

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[8] Both saw logs output (for lumber) and all roundwood products output show a marked rise from 1952 to 1960, followed by a decline from 1960 to 1962. Census Bureau lumber production data show a small increase from 1954 (data for 1952 are not available) to 1960, followed by a stronger rise from 1960 to 1962.

Estimates of the 1962 production of round mine timbers were derived from data collected in an intensive survey of Arizona and New Mexico mine timber receipts in 1960,[9] adjusted by data from a 20-percent sampling of mines for 1962 receipts of timbers, and supplemented by U.S. Bureau of Mines statistics for coal and ore production from underground mines.[10] Because of the trend estimation technique used, no sampling error can be assigned.

Estimates for 1962 output of posts, miscellaneous farm timbers, and fuelwood were based on reports furnished by the National Forests, Bureau of Land Management, Bureau of Reclamation, and the Bureau of Indian Affairs, supplemented by trend estimates derived from U.S. Bureau of the Census publications for farm use of these products.[11] As with mine timbers, the estimation technique precluded the calculation of a sampling error.

[9] Intermountain Forest and Range Experiment Station file compilations.

[10] U.S. Bureau of Mines minerals yearbooks preprints: (1) Technologic trends in the mineral industries (metals and nonmetals except fuels) and (2) Coal-bituminous and lignite. 1960 and 1961. (Comparable data for 1962 were not available at time of compilations.)

[11] U.S. Bureau of the Census. U.S. Census of Agriculture: 1959. Vol. II, General report statistics by subjects. 1,485 pp. Washington, D.C.: U.S. Govt. Printing Office. 1962.

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Table 1.--Output of timber products in Arizona and New Mexico, by products and by species groups, in standard units, 1962

Product	Unit	ARIZONA			NEW MEXICO		
		Total	Softwoods	Hardwoods	Total	Softwoods	Hardwoods
Saw logs	M bd. ft.[1]	341,757	341,757	0	247,620	247,620	([2])
Mine timbers (round)	M cu. ft.	556	556	0	410	410	0
Miscellaneous industrial wood[3]	M cu. ft.	389	34	355	91	91	([2])
Miscellaneous farm timbers	M cu. ft.	97	77	20	183	160	23
Pulpwood (round)	M std. cds.[4]	88	88	0	0	0	0
Fuelwood	M std. cds.	97	80	17	134	131	3
Commercial poles	M pieces	9	9	0	3	2	1
Posts (round and split)	M pieces	173	171	2	235	230	5
All products converted to	M cu. ft.	65,529	63,981	1,548	46,259	45,992	267

[1] International ¼-inch log rule.
[2] A small quantity of hardwoods has been combined with the softwood volume to avoid disclosing individual operations.
[3] Includes converter poles, excelsior bolts, charcoal wood, and house logs.
[4] Rough wood basis.

Table 2.--Sawmill log receipts from Arizona and New Mexico timberlands by species and county of origin, 1962

State and County	Species					All species	
	Ponderosa pine	White pine group[1]	Douglas-fir	True firs[2]	Engelmann spruce	Volume	Percent
	Thousands of board feet, International ¼-inch log rule[3]						
ARIZONA							
Apache, Greenlee	80,480	381	9,909	7,541	1,528	99,839	29.2
Coconino	167,622	0	8,405	7,867	2,590	186,484	54.6
Gila, Navajo, Pima	44,844	129	6,210	3,318	933	55,434	16.2
Total	292,946	510	24,524	18,726	5,051	341,757	100.0
Percent of total	85.7	.1	7.2	5.5	1.5	100.0	
NEW MEXICO							
Catron, Grant, Otero, Soccoro, Valencia	64,849	1,579	13,990	3,661	1,668	85,747	34.6
Colfax, Mora, San Miguel	4,031	9	10,455	2,520	13,959	30,974	12.5
McKinley, Sandoval, Santa Fe, Torrence	33,537	17	6,871	2,268	3,331	46,024	18.6
Rio Arriba	21,671	45	4,466	2,411	11,643	40,236	16.3
Taos	9,594	0	11,295	791	22,959	44,639	18.0
Total	133,682	1,650	47,077	11,651	53,560	247,620	100.0
Percent of total	54.0	.7	19.0	4.7	21.6	100.0	

[1] Includes whitebark, limber, and bristlecone pines. New Mexico data also includes a small quantity of aspen.
[2] Includes white, subalpine, and corkbark firs.
[3] Scribner log rule volumes can be approximated by multiplying table volumes by 0.89.

Table 3.--Output of timber products in Arizona and New Mexico by species, 1962

State and product	Species					Total	Percent
	Ponderosa pine	Douglas-fir	True firs[1]	Engelmann spruce	Other species[2]		
	Thousand cubic feet						
ARIZONA							
Saw logs	42,477	3,556	2,715	733	74	49,555	75.6
Pulpwood (round)	7,947	0	0	0	0	7,947	12.1
Poles	125	0	0	0	0	125	.2
Mine timbers (round)	476	40	31	8	1	556	.9
Miscellaneous industrial wood	33	0	0	0	356	389	.6
Posts, fuelwood, miscellaneous farm timbers	2,220	14	9	0	4,714	6,957	10.6
Total	53,278	3,610	2,755	741	5,145	65,529	100.0
Percent of total	81.3	5.5	4.2	1.1	7.9	100.0	
NEW MEXICO							
Saw logs	19,384	6,826	1,690	7,766	239	35,905	77.6
Poles	17	0	8	0	8	33	.1
Mine timbers (round)	221	78	19	89	3	410	.9
Miscellaneous industrial wood	90	0	0	0	1	91	.2
Posts, fuelwood, miscellaneous farm timbers	3,090	23	0	23	6,684	9,820	21.2
Total	22,802	6,927	1,717	7,878	6,935	46,259	100.0
Percent of total	49.3	15.0	3.7	17.0	15.0	100.0	

[1] White, subalpine, and corkbark firs.
[2] Whitebark pine, limber pine, bristlecone pine, pinyon pine, juniper, aspen and other hardwoods.

Table 4.--Output of timber products by land ownership classes, Arizona and New Mexico, 1962

State and product	Total volume	Land ownership classes				
		National Forest lands	Other public lands	Forest industry lands[1]	Other private lands	All ownerships
	Thousand cu. ft.	Percent				
ARIZONA						
Saw logs	49,555	55.0	12.9	4.5	3.2	75.6
Pulpwood (round)	7,947	12.1	0	0	0	12.1
Poles	125	.2	0	0	0	.2
Mine timbers (round)	556	.6	.2	.1	([2])	.9
Miscellaneous industrial wood	389	.3	.1	.1	.1	.6
Posts, fuelwood, miscellaneous farm timbers	6,957	1.1	8.4	.6	.5	10.6
Total	65,529	69.3	21.6	5.3	3.8	100.0
NEW MEXICO						
Saw logs	35,905	40.6	8.8	0	28.2	77.6
Poles	33	.1	0	0	0	.1
Mine timbers (round)	410	.5	.1	0	.3	.9
Miscellaneous industrial wood	91	.2	0	0	([2])	.2
Posts, fuelwood, miscellaneous farm timbers	9,820	1.6	11.9	0	7.7	21.2
Total	46,259	43.0	20.8	0	36.2	100.0

[1]Lands owned by companies or individuals operating wood-using plants.
[2]Less than 0.05 percent.

Table 5.--Lumber production and numbers of active sawmills by sawmill size classes in Arizona and New Mexico, 1960 and 1962

State and sawmill size class (M bd. ft. per year)	1960[1]			1962[2]		
	Lumber production		Active mills	Lumber production		Active mills[3]
	Thousand bd. ft.[4]	Percent	Number	Thousand bd. ft.[4]	Percent	Number
ARIZONA						
Less than 50	35	([5])	1	0	0	0
50 to 199	880	0.3	7	1,200	.4	5
200 to 499	489	.1	1	700	.2	3
500 to 999	1,221	.4	2	0	0	0
1,000 to 4,999	41,474	12.6	15	17,300	5.3	7
5,000 and over	285,760	86.6	12	306,800	94.1	13
Total	329,859	100.0	38	326,000	100.0	28
NEW MEXICO						
Less than 50	1,466	0.6	27	300	0.1	12
50 to 199	9,390	4.1	21	2,400	1.0	16
200 to 499	4,704	2.1	17	3,500	1.5	10
500 to 999	18,684	8.2	15	11,800	4.8	16
1,000 to 4,999	62,162	27.3	24	56,400	23.0	19
5,000 and over	131,367	57.7	13	170,600	69.6	12
Total	227,773	100.0	117	245,000	100.0	85

[1] Miller, Robert L. Lumber production in Arizona and New Mexico, 1960. U.S. Forest Serv. Rocky Mountain Forest and Range Expt. Sta. Res. Note RM-29, 8 pp., illus. 1964.
[2] Estimated from Census Bureau's 1962 lumber production totals for Arizona (326 million board feet, lumber tally) and New Mexico (245 million board feet) on the assumption that lumber production was distributed among sawmill size classes in the same proportion as their reported saw log receipts.
[3] Mill size class estimated from saw log receipts rather than from lumber production.
[4] Lumber tally.
[5] Less than 0.05 percent.

Table 6.--Output of timber products in Arizona and New Mexico, and percentages of totals for major products, 1952, 1960, and 1962

State and product	1952 [1]		1960 [2]		1962	
	Output	Percent [3]	Output	Percent [3]	Output	Percent [3]
ARIZONA						
Saw logs . . . . . . M bd. ft. [4]	239,997	58	348,016	94	341,757	76
Pulpwood . . . . . . M std. cds. [5]	0	0	0	0	88	12
All other [6] . . . . . M cu. ft.	27,647	42	3,586	6	8,027	12
Total . . . . . M cu. ft.	65,087	100	61,589	100	65,529	100
NEW MEXICO						
Saw logs . . . . . M bd. ft. [4]	110,993	43	273,891	86	247,620	78
All other [6] . . . . . M cu. ft.	23,416	57	7,179	14	10,354	22
Total . . . . . M cu. ft.	40,731	100	53,028	100	46,259	100

[1] U.S. Forest Service. Timber resources for America's future. U.S. Dept. Agr. Forest Resource Rpt. 14, 713 pp., illus. 1958. (Table 13, pp. 526-527.)

[2] Intermountain Forest and Range Experiment Station unpublished summary tables for timber products surveys of Arizona and New Mexico made in 1961 to estimate products output for 1960.

[3] Based on cubic-foot volume equivalents for products whose outputs are shown in other standard volume units.

[4] International ¼-inch log rule

[5] Rough wood basis. Includes round pulpwood only; i.e., does not include pulpwood from sawmill and veneer plant residues.

[6] Includes commercial poles, round mine timbers, miscellaneous industrial wood, posts, fuelwood, and miscellaneous farm timbers.

Table 7.--Arizona and New Mexico lumber production, 1952-1962

Year	Lumber production	
	Arizona	New Mexico
	Million board feet, lumber tally	
1952	--	--
1953	--	--
1954	258	222
1955	--	--
1956	--	--
1957	--	--
1958	303	241
1959	--	--
1960	330	228
1961	326	226
1962	326	245

Source: U.S. Bureau of the Census. No separate data available for 1952, 1953, 1955, 1956, 1957, and 1959.

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