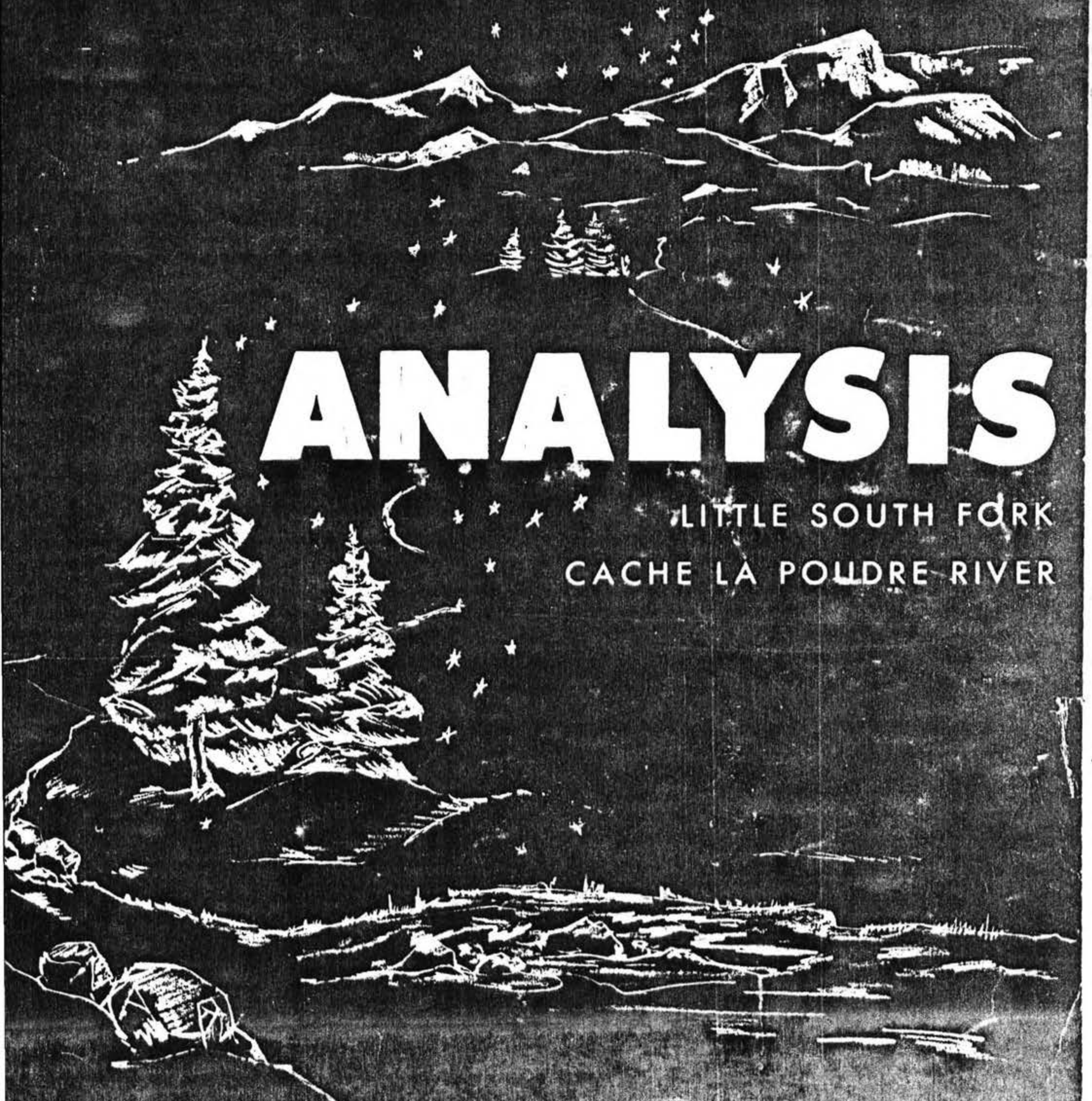
WATERSHED ANALYSIS

LITTLE SOUTH FORK CACHE LA POUDRE RIVER



PERATIVE WATERSHED MANAGEMENT UNIT COLORADO STATE UNIVERSITY

WATERSHED ANALYSIS

of the

LITTLE SOUTH FORK of the CACHE la POUDRE RIVER

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WATERSHED ANALYSIS

of the

LITTLE SOUTH FORK of the CACHE la POUDRE RIVER,

Larimer County, Colorado.

by

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COOPERATIVE WATERSHED MANAGEMENT UNIT
COLLEGE OF FORESTRY AND RANGE MANAGEMENT

Watershed Management 209
Fall 1962

Colorado State University,
Fort Collins, Colorado

PREFACE

The Cooperative Watershed Management Unit at Colorado State University, under the direction of Dr. Robert E. Dils, undertook in 1959 a projected series of watershed analyses designed to cover the entire drainage of the Cache la Poudre River. These analyses have been implemented through successive watershed analysis classes (WS 209) and to date have dealt with the North, Little South, and Big South Forks of the Cache la Poudre River.

The class of 1960--Loyd O. Barnett, Jr., James T. Krygier, Richard Lee, and Brian M. Reich--conducted the analysis of the Little South Fork. Developments since that time have dictated that the present class devote its attention to a reworking of that analysis. Chief among these is the recently concluded cooperative agreement between Colorado State University and the Roosevelt National Forest to conduct watershed studies on the Little South Fork. These studies will be designed to determine water yields as affected by present management, and possible future management for improving water yields.

Aside from the inherent educational function, it is the intent of this report to serve as the inventory and basic interpretive phases of a sound program of watershed research on the Little South Fork. It is hoped that it will play as well a role in the formulation of land management plans for the watershed, which the expected rapid development of the East Slope region of Colorado will demand. To these ends, this report expands upon and brings up to date the previous one.

The writers acknowledge their indebtedness to Dr. Robert E. Dils and Dr. James R. Meiman for the opportunity of carrying out this study, and for the continued guidance in all phases of this report which aided them toward its completion.

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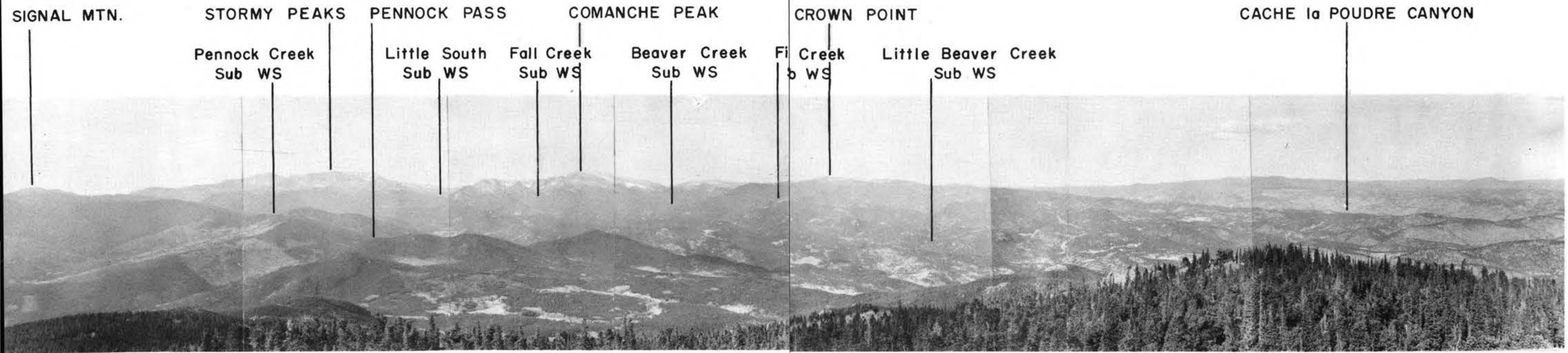

FRONTISPIECE – LITTLE SOUTH FORK CACHE la POUDRE RIVER WATERSHED

View from West Wte Pine Mountain

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APPENDIX

GENERAL DESCRIPTION

The Little South Fork of the Cache la Poudre is one of the larger tributaries of the Cache la Poudre River which in turn is tributary to the South Platte River. The early settlers in the region differentiated between the headwaters of the Cache la Poudre, which flows in a northerly direction, and the adjacent major southern tributary as the Big South Poudre and the Little South Poudre, respectively (5). The early clearness of these designations has been blurred by indiscriminate use of South Fork. Within this report, the writers will attempt to consistently refer to the watershed under analysis as the Little South Poudre.

The watershed is located entirely within Larimer County in north central Colorado, roughly 26 miles west of Fort Collins and 14 miles north of Estes Park. It is encompassed within 40°29' to 40°42' north latitude and 105°26' to 105°44' west longitude. Its area of slightly under 105 square miles consists of all or a part of the following townships:

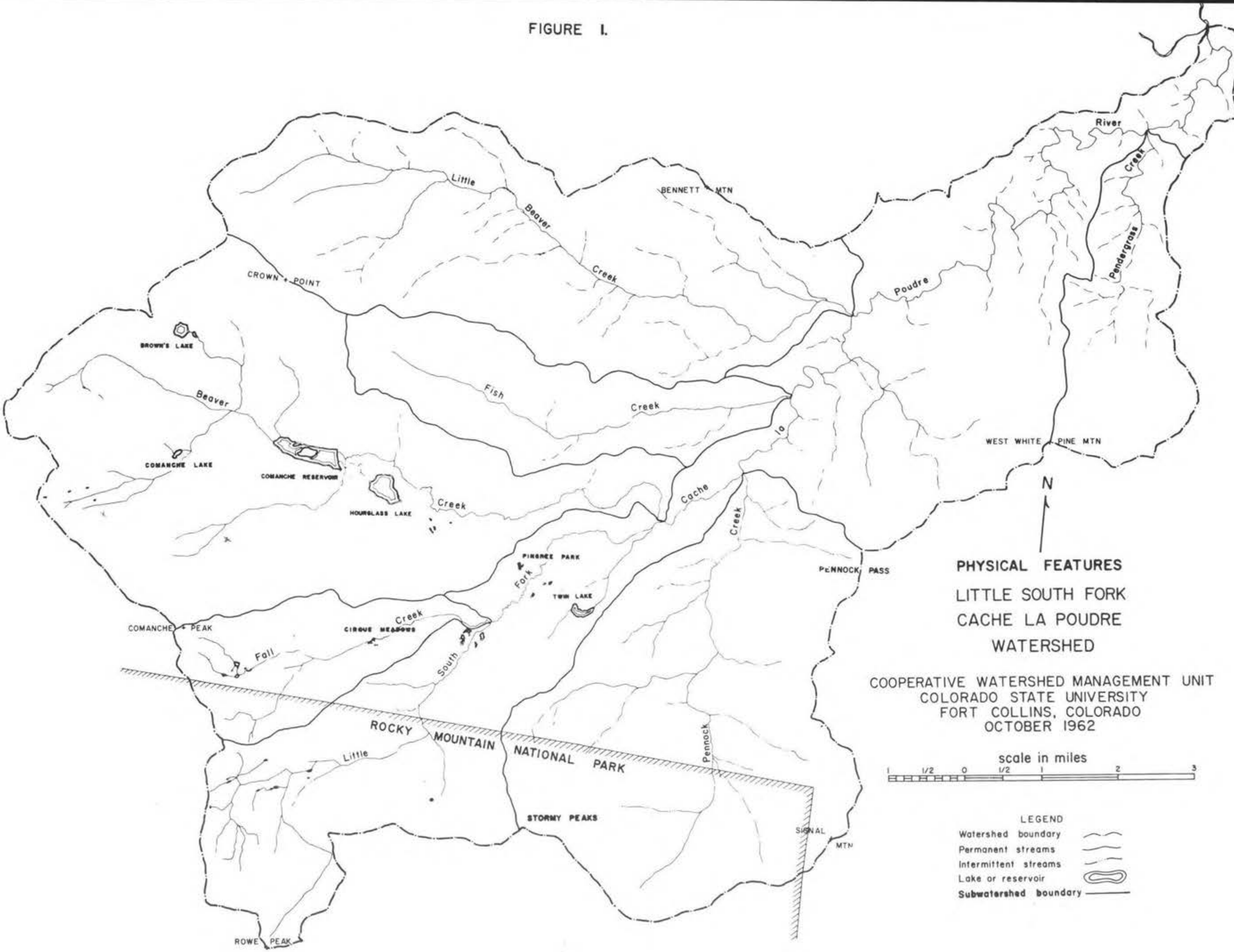
T6N R72W	T7N R72W	T8N R72W
T6N R73W	T7N R73W	T8N R73W
T6N R74W	T7N R74W	T8N R74W

For greater ease of analysis, the Little South Poudre has been divided into sub-watershed units (Figure 1). Aside from the main stem of the Little South Poudre, these are Little Beaver Creek, Fish Creek, Beaver Creek, Fall Creek, Pennock Creek, and Pendergrass Creek.

Parts of the watershed rim are formed by Bennett Mountain, Comanche Peak, Rowe Peak, Stormy Peaks, Signal Mountain, Pennock Pass, and West White Pine Mountain. These, together with Crown Point, are the major high elevation points of the watershed. Other major physical features include Brown's Lake, Comanche Lake, Comanche Reservoir, Hourglass Lake Reservoir, and Twin Lake Reservoir together with Cirque Meadows and Pingree Park (see Figure 1).

The Little South Poudre is a rugged mountain watershed of diverse scenic beauty, including alpine areas, glacial cirques, forested slopes, meadow parks, and the deep canyon of the main stem Little South Poudre near its mouth. The southern rim of the watershed lies within Rocky Mountain National Park; the remainder forms a part of the Roosevelt National Forest.

FIGURE I.


PHYSICAL FEATURES
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CACHE LA POUDRE
WATERSHED
COOPERATIVE WATERSHED MANAGEMENT UNIT
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO
OCTOBER 1962
scale in miles
1 1/2 0 1/2 1 2 3
LEGEND
Watershed boundary
Permanent streams
Intermittent streams
Lake or reservoir
Subwatershed boundary
N
Little Beaver Creek
BENNETT MTN
CROWN POINT
Poudre River
Pendergrass Creek
BROWN'S LAKE
Beaver Creek
Fish Creek
COMANCHE LAKE
COMANCHE RESERVOIR
HOURGLASS LAKE
WEST WHITE PINE MTN
Cache la
Creek
PINGREE PARK
TWIN LAKE
PENNOCK PASS
COMANCHE PEAK
CIRQUE MEADOWS
Fall Creek
South Fork
ROCKY MOUNTAIN NATIONAL PARK
Little
Pennock
STORMY PEAKS
SIGNAL MTN
ROWE PEAK

HISTORY OF LAND USE

Cultural History

As in much of the West, the early trappers and prospectors exerted the first pressure of the white man upon the resources of the Little South Poudre. Beaver and other fur-bearing animals were trapped during the first half of the nineteenth century until their numbers were virtually exhausted (42). Prospectors searched for gold and other minerals in the vicinity during the 1850s but found nothing of significance.

Although the first settlement of northern Colorado occurred on the lower Cache la Poudre River in 1844 (42), the discovery of gold at the confluence of Cherry Creek and the South Platte River in 1858 initiated the first big rush of settlers into the region. Permanent pressure of the white man upon the resources of the Little South Poudre properly dates from this signal event.

The first homesteads in the Little South Poudre were established during the early 1860s, thus beginning a 40-year period of virtually unchecked exploitation of natural resources. The area was withdrawn from homesteading in 1902 by the federal government. In 1905, the Little South Poudre was made a part of the Medicine Bow Forest Reserve, later named the Medicine Bow National Forest in 1907, the Colorado National Forest in 1910, and the Roosevelt National Forest in 1932. Sketchy fire and timber management practices were taking place on the national forest lands as early as 1908 (23).

The high southern rim of the watershed, composed of the headwater areas of Fall Creek, Little South Fork, and Pennock Creek, were included in the area of Rocky Mountain National Park, established in 1915.

A special act of Congress in 1912 granted Colorado State University the privilege of selecting a number of tracts of national forest land for use by the school. Separate tracts totaling 1600 acres were chosen in 1914. Summer forest research and instruction were begun by the school in 1915 at Pingree Park. The facilities there have been gradually improved and enlarged over the years toward a fuller program of research and instruction in forestry and related fields (30).

Except for the early homesteads, there has been no permanent settlement in the Little South Poudre. Some of the original homesteads still in private hands are used only for transient and summer residence today.

Access History

The first access for vehicular traffic into the Little South Poudre was the Buckhorn Road, built in 1868. It enters the watershed at Pennock Pass on the southeastern border and terminates at Pingree Park. It has been improved many times. The Flowers Wagon Road was built in 1881 from the head of Rist Canyon to North Park to service a short-lived mining boom in that area. It enters the watershed near the head of Pendergrass Creek on the eastern border, traverses the length of the Little Beaver sub-watershed, and leaves on the north-western border. Except for portions, the road is now used primarily as a Forest Service trail. The Pingree Road, a third main access route, was built in 1923. It enters the watershed near the mouth of Little Beaver Creek on the northern border and joins the Buckhorn Road on Pennock Creek. The road was improved by the CCC in 1933-1934 (30).

Major interior roads of the watershed include one built by the WPA in 1935 from Pingree Park to Cirque Meadows in the Fall Creek drainage. Roads were built in association with the construction of Hourglass, Comanche, and Twin Lake Reservoirs. The road to Hourglass and Comanche Reservoirs is not open to public use, however, since it crosses private land. There are several logging roads in the Pennock Creek drainage.

Of the major trails in the watershed, Mummy Pass and Stormy Peaks in Rocky Mountain National Park are reached by trails originating at Pingree Park. A trail following East Pennock Creek leads to Signal Mountain and thence along the southern rim of the watershed above Pennock Creek to Stormy Peaks. Trails from Comanche Reservoir lead to Mirror Lake outside the watershed and to Comanche Lake and Brown's Lake in the upper Beaver Creek drainage. Road and trail locations may be seen in Figure 37, page 56.

Past Timber Use

Practically all of the merchantable timber at lower elevations (principally ponderosa pine) was cut over during the 1860s, chiefly by high-grading (25). This cutting was facilitated by the first sawmill in the area, established in 1862 on the Cache la Poudre River near LaPorte. The advent of railroads in the region caused millions of ties to be cut in the upper reaches of the Cache la Poudre and Laramie Rivers. Tie camps were established at Pingree Park and on Pennock Creek in the Little South Poudre in 1868-69. Ties cut from these camps and many others were floated down the river for the building of the Denver & Pacific and the Union Pacific Railroads. By 1875, so many ties were being floated down that timber operators were required to post bonds for the protection of irrigation headgates (32).

By 1880, the demand for ties had slackened, but timber for other purposes was needed. Portable mills scattered throughout the watersheds served this early demand and heavy cutting continued. Uncontrolled timber harvests were not curbed until the gradual institution of timber management practices on the national forest lands took place in the early 1900s. Heavy cuts were made during World Wars I and II.

A great portion of the Little South Poudre was ravaged by a fire in 1890 (30). Many of the present lodgepole pine stands represent the reproduction following the fire. Since that time, only one major fire has occurred in the watershed--the Little South burn of 256 acres in 1954 (28). There have been numerous spot fires over the years. To aid in the control of fires, West White Pine Mountain Lookout was built in 1940.

Past Range Use

Grazing began with the first homesteads. Although the usable cattle range in the Little South Poudre is widely scattered, cattle were being grazed in the watershed by 1875. Until the national forests were established, the only limit on season of use and number of animals was the survival level (23). During the same period, sheep were grazed in the summer on the high alpine areas, although inaccessibility and a small area has always limited this use. The Little South Poudre is not prime grazing land, so except for isolated areas, the watershed has not suffered greatly from this use.

Past Recreation Use

The Little South Poudre has long been a favorite area for recreation, especially hunting, fishing, and camping. Early hunting for elk, deer, bear, and mountain sheep was done by professional hunters; in later years herds of elk and deer have provided recreational hunting for increasing numbers of sportsmen.

Heavy fishing pressure was early evident on the streams of the Little South Poudre and as a consequence stocking efforts were begun in the early 1900s and have continued to the present. Native, brown, rainbow, and eastern brook trout have all been stocked in an effort to accomodate the continued demand for fishing (1).

The early recreationists simply went into the mountains and camped wherever they found a desired location--a procedure which continues to this day. Two permanent recreation facilities--Tom Bennett Campground and Fish Creek Picnicground --have been constructed in the Little South Poudre by the Forest Service. These are located on Figure 37, page 56.

Past Water Use

Antoine Janis, the first permanent white settler in northern Colorado, stated that all of the original settlers of Colona (the present town of LaPorte) took up land and grew crops by irrigation from the Cache la Poudre River. Thus began in 1858-59 the intensive use and appropriation of water from the river (32).

In Colorado the appropriation doctrine of water use, first expressed in the Constitution of 1876, has guided and controlled the use of the Cache la Poudre water supply. Under this doctrine, which awards a prior right to prior uses, almost all waters of the Little South Poudre have been appropriated for use outside the watershed.

In 1882, the first water right for the Cache la Poudre was adjudicated on a priority date of June 1, 1860 (42). The first storage right on the Little South Poudre (Hourglass Reservoir) was adjudicated in 1898, followed by an enlargement in 1901. Twin Lake Reservoir was adjudicated in 1904 and Comanche Reservoir in 1923. The latter was enlarged in 1925. Table 1 presents decree number, amount, and date of adjudication of the five water storage rights on the Little South Poudre, all owned by the City of Greeley as a part of its municipal water supply system.

Inasmuch as Hourglass and Twin Lake Reservoirs are located in rather small drainages, a canal was constructed to bring Comanche Reservoir water into Hourglass, and canals from adjacent small watersheds bring additional water into Twin Lake Reservoir. All three reservoirs have earth dams to increase the capacity of the natural glaciated depressions (Figures 2 and 3). The coarse gravels used do not form a tight seal. A dam at Brown's Lake, built in 1903-04, washed out in 1906 and was not rebuilt (30). The outlet of Hourglass Reservoir has been condemned because of rotted timbers lining the outlet tunnel. The reservoir has not been allowed to fill for the last several years.

Uses of water within the watershed have consisted of limited streamside meadow irrigation and minor domestic use, principally at the Pingree Park campus. Almost all of these waters return to the stream.

Table 1

Water storage rights of the Little South Poudre

Right	Decree Number	Acre-feet	Adjudication
Hourglass Reservoir	35½	1529.5	8-9-1898
Hourglass Enlargement	---	59.1	8-8-1901
Twin Lake Reservoir	73	460.0	10-17-1904
Comanche Reservoir	133	1661.4	6-13-1923
Comanche Enlargement	134	967.6	6-18-1925
Total storage rights		4677.6	

Figure 2. Hourglass Reservoir with Stormy Peaks in the background.

Figure 3. The coarse gravel dam which forms Comanche Reservoir.

PHYSICAL DESCRIPTION

Physiography

Size and Shape

The Little South Poudre is made up of 104.93 square miles or 67,155 acres of steep mountainous terrain. The watershed's shape is roughly that of a tear drop with its axis lying in a southwest-northeast orientation. The compactness coefficient, defined by Wisler and Brater (45) as the ratio of the perimeter of the watershed to the circumference of a circle of equal area, for the entire watershed is 1.46. Compactness coefficients for the individual sub-watershed units range from 1.17 to 2.25.

Elevation

The elevation of the watershed ranges 6,850 feet. The most southerly point, Rowe Peak, is 13,400 feet; the most northerly point at the confluence of the Little South Poudre and Cache la Poudre Rivers is 6,550 feet. The calculated mean elevation is 9,709 feet. The area-elevation curve (Figure 4) indicates that nearly 80 percent of the watershed lies between 8,300 and 11,300 feet, with 10 percent below and 10 percent above this range. Calculations for the area-elevation curve (Table A)[1/] follow the method outlined by Linsley, Kohler, and Paulhus (12).

Slope and Aspect

The median slope of the watershed, as read from the slope-area curve (Figure 5) is 32.1 percent (12), compared with a calculated mean slope of 32.8 percent (45). Calculations for the slope-area curve are found in Table B.

Very steep slopes occur in almost every section of the watershed. The following tabulation represents the percentage of surface area at different slopes:

Percent Slope	Percent Area
0-5	2
5-10	7
10-20	18
20-30	21
30-50	37
50-70	12
70+	3

Since the main stem of the Little South Poudre is oriented generally toward the northeast, a large proportion of the slopes

1/All figures and tables referred to by letter are in the Appendix.

FIGURE 4 - AREA-ELEVATION CURVE

Little South Poudre Watershed

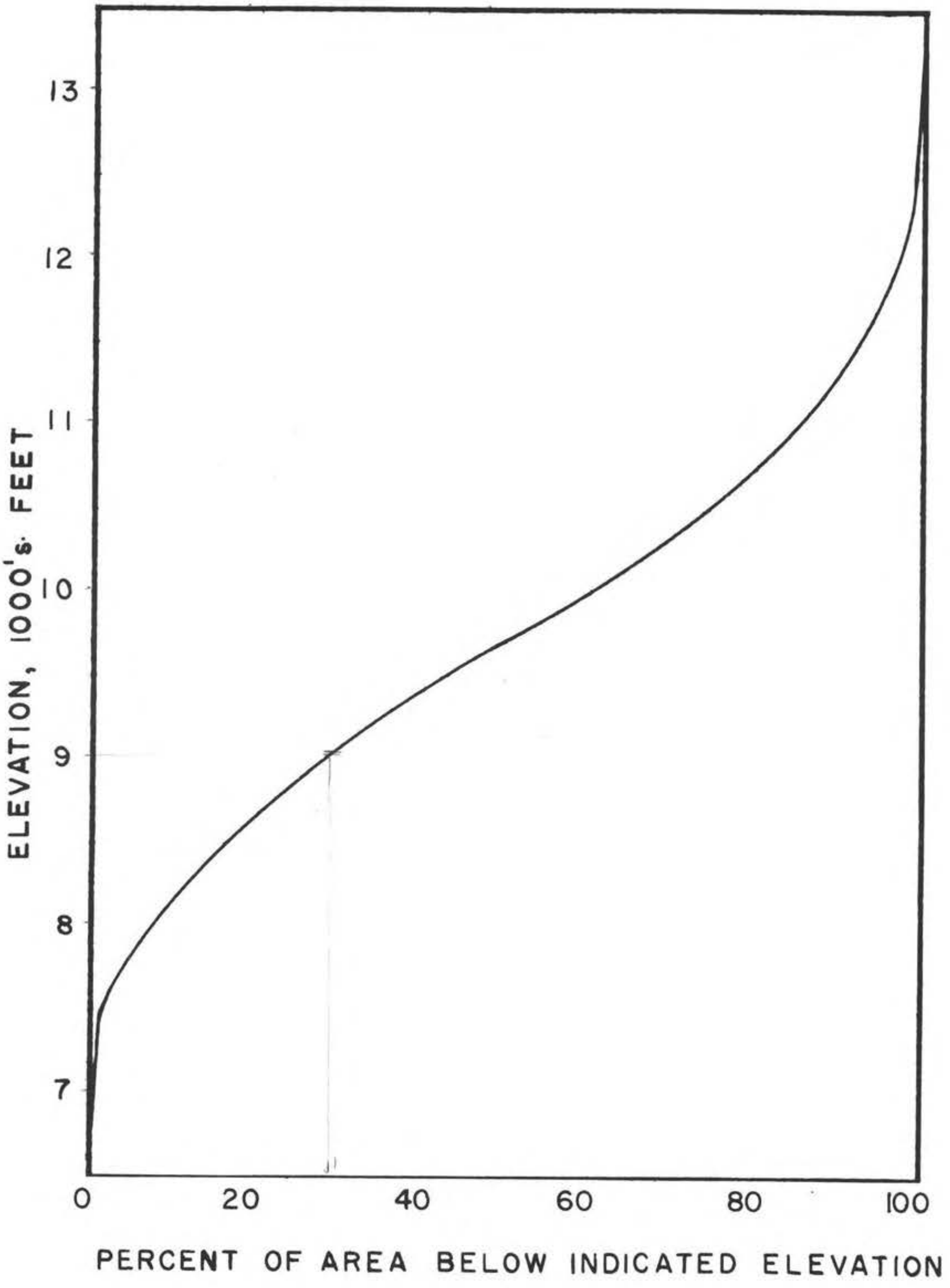
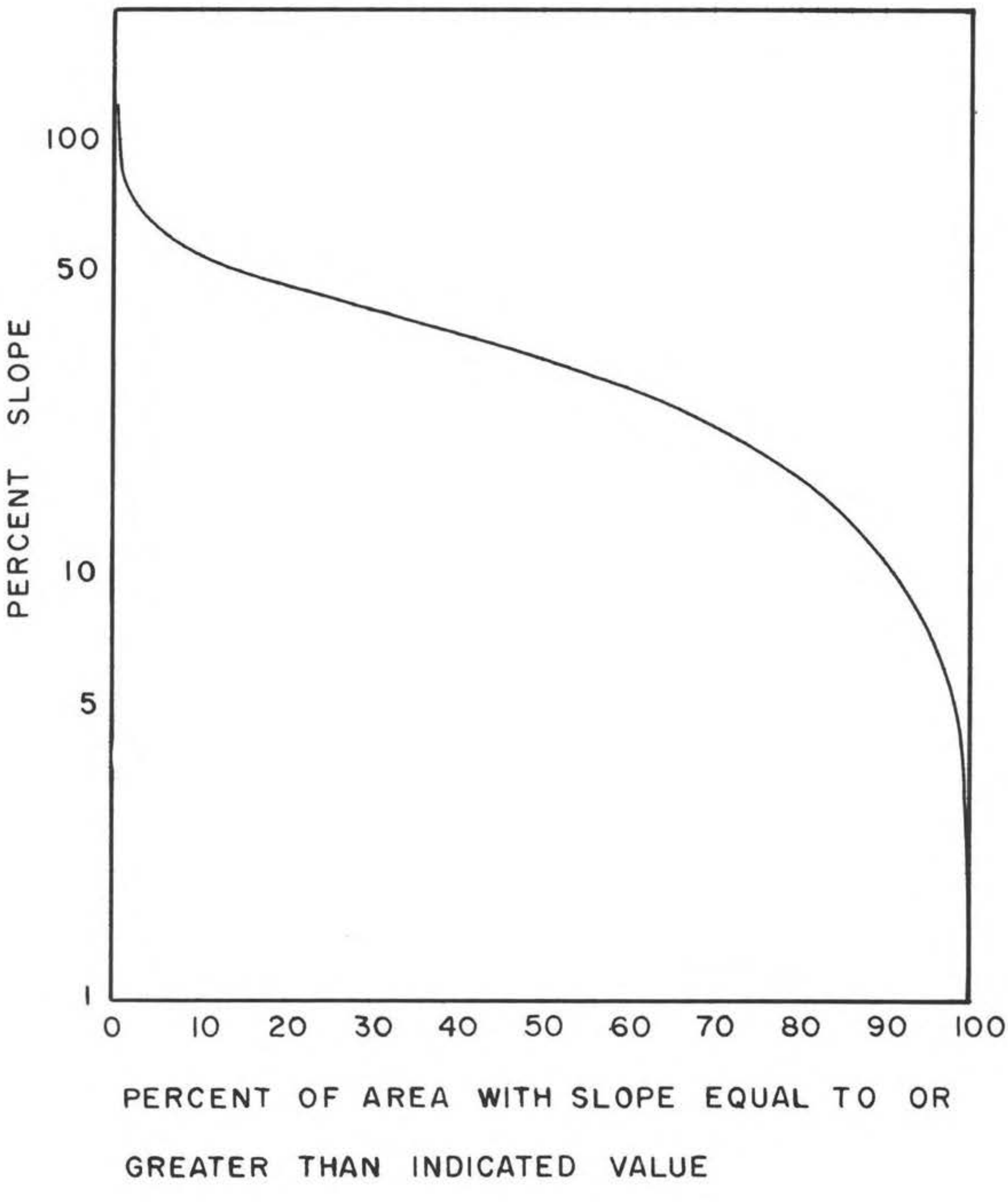


FIGURE 5- LAND SLOPE DISTRIBUTION

Little South Poudre Watershed



face southeast and northwest. The pattern of sub-watersheds is such, however, that all major aspects are represented to a significant extent.

Drainage Features

The drainage pattern for the entire watershed is dendritic. There are approximately 88 miles of permanent streams which gives a drainage density (total mileage of permanent streams divided by the area) of 0.856 miles of stream per square mile of area. Drainage densities of the sub-watersheds range from 0.59 to 1.36. The number of well-defined channels per square mile is 1.24.

A profile of the Little South Poudre is presented in Figure 6. There is an average fall of 264 feet per mile over its 20.2 mile length. The average stream slope, as determined by the method from Linsley, Kohler, and Paulhus (12), is five percent which represents a fall of 188 feet per mile.

Lakes and Reservoirs

Approximately 185 acres, or 0.3 of one percent of the surface area, is impounded water. Of this total, three reservoirs have a combined surface area of 127 acres. Comanche Reservoir (64 acres) and Hourglass Reservoir (44 acres) are located in the Beaver Creek drainage; Twin Lakes Reservoir (19 acres) is in the main stem of the Little South Poudre drainage.

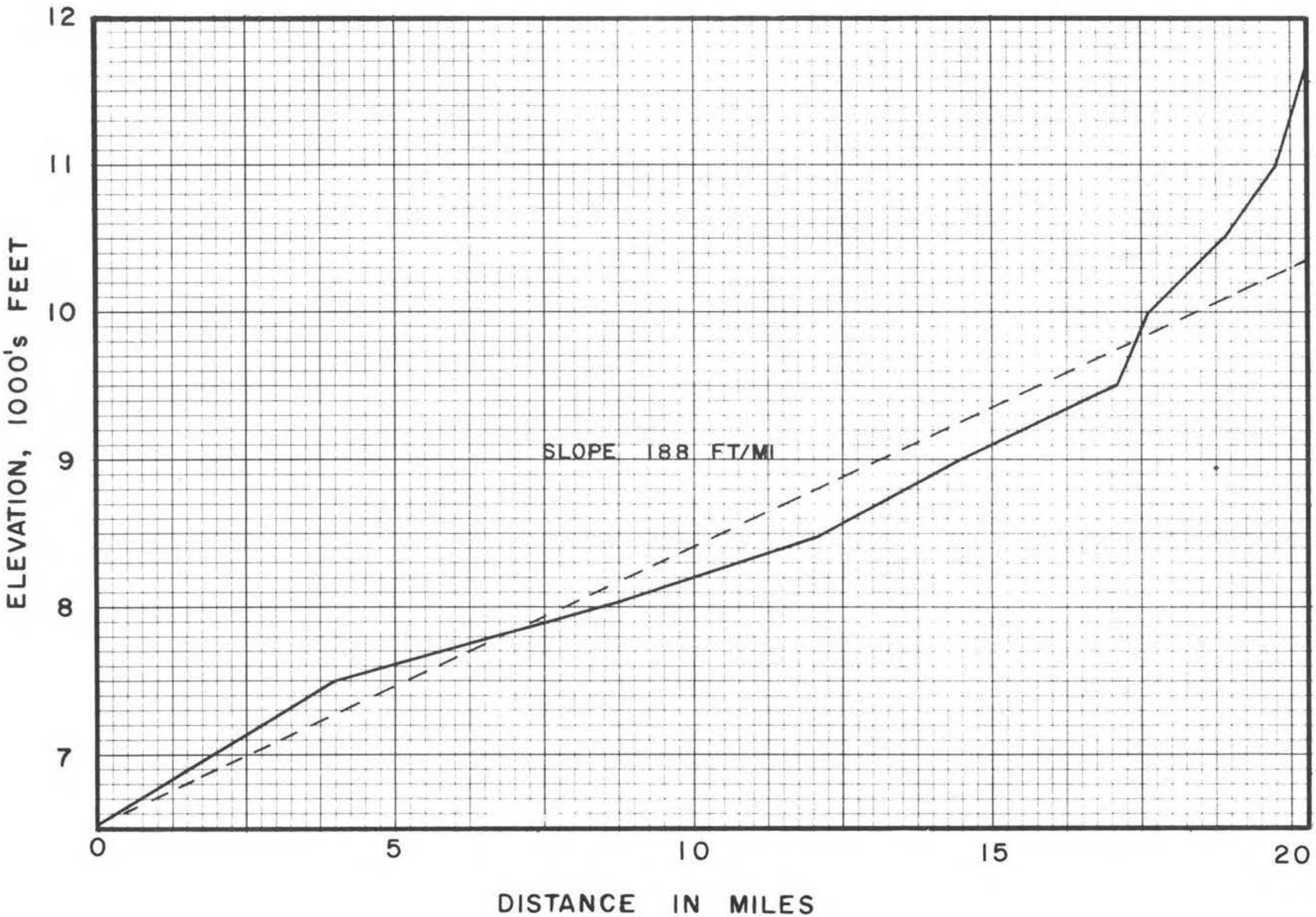
Two natural lakes, Comanche and Brown's, have a combined surface area of 27 acres. There are in addition about 50 smaller ponds which range in size from a fraction of an acre to three or four acres. Of the larger lakes and ponds, the Beaver Creek drainage contains Comanche Lake, Brown's Lake, and one pond; Little Beaver Creek has six small lakes or ponds; Fall Creek contains 10 small lakes. The main stem of the Little South Poudre has 18 small lakes or ponds, while Pennock Creek, Fish Creek, and Pendergrass Creek contain none.

Morphometric Parameters

A tabulation by sub-watershed units of surface areas, compactness coefficients, stream gradients, stream lengths, and drainage densities is presented in Table C in the Appendix.

A proposed analysis of the topographic factor in a watershed hydrograph, developed by Morisawa (16), is applied to the Little South Poudre in Table D.

FIGURE 6-PROFILE OF LITTLE SOUTH FORK CACHE LA POUDRE RIVE



Geology

The Little South Poudre forms a part of the north-central ction of the Colorado Front Range which is included in the Southern cky Mountain Province as described by Fenneman (3). The Wyoming sin lies west and northwest of the Front Range, the High Plains lie rtheast, and the Colorado Piedmont lies east.

storical Synopsis

The geologic history of the watershed is essentially that of e Front Range. The summary that follows is primarily from rcester's comments concerning the development of the Southern * cky Mountain Province (46).

In Jurassic times, 540 million years ago, displaced and/or tilted Paleozoic and Mesozoic sedimentary beds on the sides of the untain ranges were exposed to intensive erosion. These ranges were oded down to a peneplain by late Jurassic time, 150 million years o. This peneplain condition exposed granites and Pre-Cambrian cks, some of which are metamorphosed, that form the core of the lorado Front Range.

In the early portion of the Cretaceous Period, an epi- ntinental sea occupied much of western North America, including lorado, for 60 to 70 million years. The sea's onset was brought out by the formation of the Cretaceous Geosyncline which continued subside during the sea's occupancy. An enormous amount of diment was washed into the sea.

Late in the Cretaceous Period, the Laramide Revolution started e development of the Rocky Mountains. The general land rise ained off the sea, following which orogenic movements formed the esent Rocky Mountain ground plan by early Eocene times. Erosion the highlands was faster than the uplifting and the mountains re reduced to the Flattop peneplain by late Eocene times.

During early Oligocene times, volcanism and more vigorous lift formed new highlands. The planation of these highlands during te Miocene and early Pliocene times produced the Rocky Mountain South Park Peneplain. At that time, the peneplain's eastern ge must have coincided with the deposition of the Great Plains an elevation of 6,000 feet.

New uplift began in the late Pliocene Period. The uplift was parently differential in that contacts with the Great Plains are w about 1200 feet higher, and the remnants of the Rocky Mountain neplain are now at different elevations. For example, remnants ar the Colorado-Wyoming state line are 8,000 feet in elevation, while those in South Park, Colorado, are near 10,000 feet (46).

The late Pliocene uplift and ensuing events have given the Little South Poudre its present topographic expression. This period of erosion initiated by uplift has been named the "canyon-cutting cycle" by Van Tuyl and Lovering (41).

The exact number of glaciations of the Front Range that have occurred during Pleistocene times is undetermined. Jones and Quam (9) recorded three in Rocky Mountain National Park, but five possible glaciations have been suggested by Ray (19) and Wegemann (43). It is likely that at least two or three glaciations have occurred on the Little South Poudre, and it can be assumed that these coincide roughly with the Wisconsin glaciations (Table E) proposed by Richmond (22), for the east slope of the Park.

Typical land forms of mountain glaciation--cirques, threshold and kettle lakes, meadows, troughs, valley train remnants, moraines, and till--are common and represent prominent modification on approximately one-quarter of the watershed. Most of the land upstream from the junction of Beaver Creek and the main stem of the Little South Poudre has been glaciated. The meadow at Pingree Park and a similar meadow in the Beaver Creek drainage are thought to be filled-in glacial lakes created by morainal deposits (Figure 7).

Rock Type and Structure

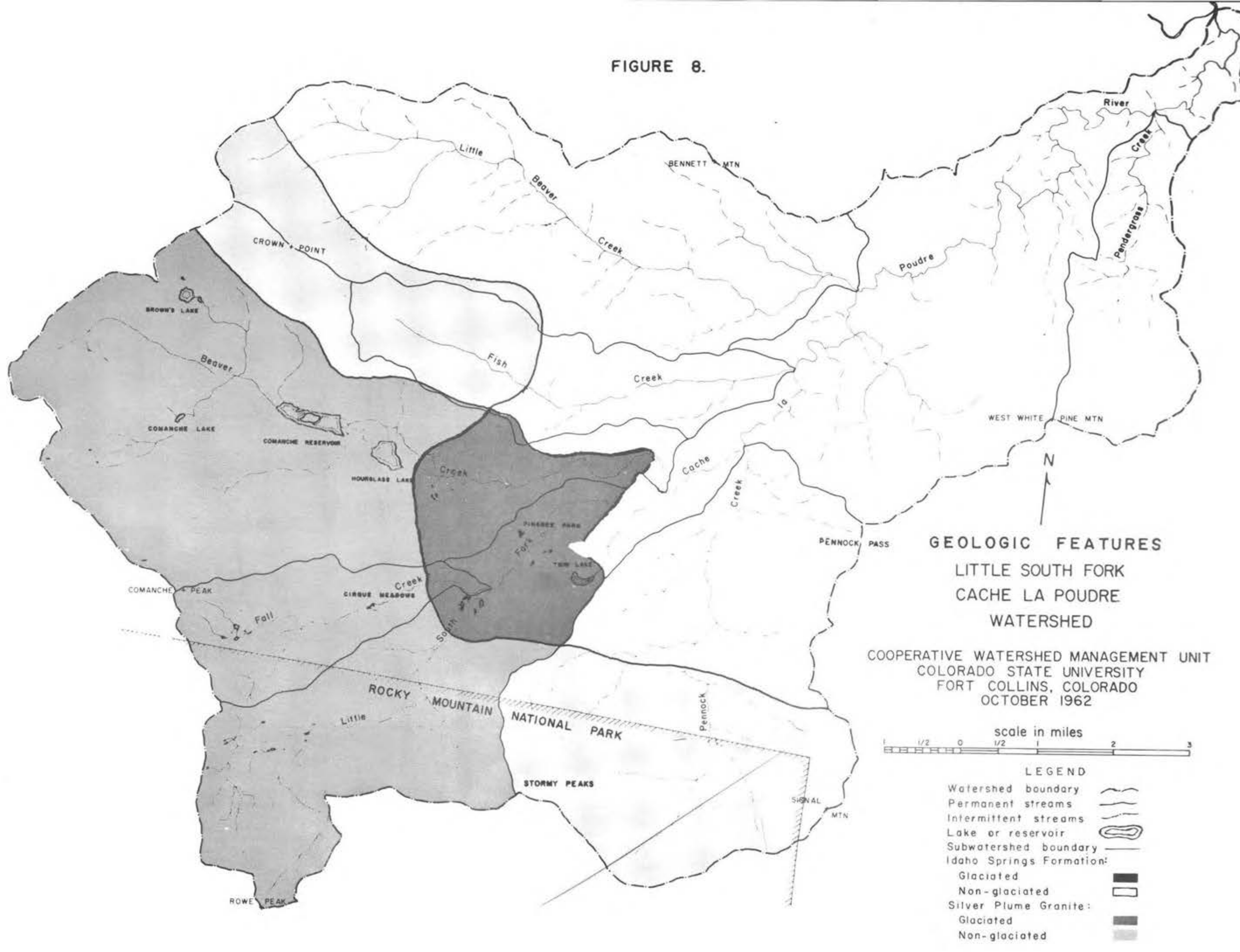
The Little South Poudre has not yet been thoroughly mapped for rock type and structure. Rock samples, chiefly quartz and orthoclase, were collected in field reconnaissance and identified; the geologic features of the watershed (Figure 8) and the brief descriptions of the formations, however, depend chiefly on a report by Lovering and Goddard (13) who gave detailed consideration to certain sections of the Front Range and extrapolated their results to a regional map.

The Little South Poudre lies on a transition between major granite and schist groups, with a corresponding mixture of rock types. Most of the ridges and outcrops in the northern part of the watershed are gneiss or fine-grained gneissic granite. Several areas, especially in the southern part, contain pure coarse-grained pegmatic or megmatic granite. Other areas, especially in the north, contain pure micaeous schists. Scattered in these deposits are other metamorphosed granites interbedded in schist outcrops.

The Silver Plume granite (SPg) consists of pinkish-gray feldspars, quartz, and slightly porphyritic biotite. The percentage of biotite varies and muscovite may be present in some facies. This granite is medium-grained and there is a general parallelism of the tabular feldspar crystals. In this area, it may be associated with Pikes Peak, Sherman, Cripple Creek, and Mount Rosa granites which are generally older and coarser-textured granites than the Silver Plume.

Figure 7. Pingree Park--a mountain meadow formed by glaciation. Note the lateral moraine in the background.

FIGURE 8.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Watershed boundary
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Subwatershed boundary
Idaho Springs Formation:
Glaciated
Non-glaciated
Silver Plume Granite:
Glaciated
Non-glaciated
N
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Creek
Pendergrass
Poudre
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Little
Pennock
STORMY PEAKS
SIGNAL MTN
ROWE PEAK

The Idaho Springs formation (ISs) is composed of some of the ldest rocks of the Front Range. It consists chiefly of quartz-iotite schists, quartz-biotite-sillimanite schists, and a etamorphosed shaley sediment.

Fuller (6) points out that the granites have numerous well-efined potholes left by the action of melting glaciers, while there re only a few poorly preserved potholes in the schists. This would eem to indicate that the schists are less resistant to erosion (as ell as being more fissile) than the granites.

Table 2 gives the surface area occupied by Silver Plume granite nd Idaho Springs schist under the presence or absence of glaciation see Figure 8).

Table 2

Area of glaciated and non-glaciated Silver Plume granite and Idaho Springs schist on Little South Poudre sub-watersheds.

Sub-watershed	Area sq. mi.	Area percent	Total sq. mi.
Little Beaver Creek			
SPg, non-glac.	3.99	22.0	
ISs, " "	14.12	78.0	18.11
Fish Creek			
SPg, non-glac.	2.64	40.0	
ISs, " "	3.96	60.0	6.60
Beaver Creek			
SPg, glac.	16.81	75.5	
SPg, non-glac.	2.32	10.4	
ISs, glac.	2.81	12.6	
ISs, non-glac.	0.33	1.5	22.27
Fall Creek			
SPg, glac.	3.99	92.5	
ISs, "	0.32	7.5	4.31
Little South Poudre (main stem)			
SPg, glac.	8.66	28.0	
ISs, glac.	3.40	11.0	
ISs, non-glac.	18.87	61.0	30.93
Pennock Creek			
SPg, non-glac.	9.39	53.5	
ISs, " "	8.16	46.5	17.55
Pendergrass Creek			
ISs, non-glac.	5.16	100.0	5.16

Soils and Vegetation

As is typical of most mountain watersheds, soil surveys of the Little South Poudre have not been undertaken. Even general soils information is lacking. A first approximation of the watershed soils was gained through a reconnaissance in which 17 sample soil profiles were observed. Areal distribution of the soils observed could not be determined from such a limited sample, but broad groupings could be discerned.

It is convenient to divide the soils and vegetation of the Little South Poudre into three elevational zones: the alpine above 11,200 feet, the subalpine from 11,200 to 9,500 feet, and the montane below 9,500 feet. Boundaries between the zones are not sharp; there exists a gradual transition from one to another, varying locally with the topography.

The major vegetative types of the watershed, together with location of the soil sample points, are shown in Figure 9. The areal extent of each type (plus reservoir area) is to be found in Table 3. (The areas in Table 3 were derived from existing vegetative cover maps and do not coincide precisely with the above arbitrary elevation zones.)

The Alpine

Comprising about ten percent of the watershed, the alpine zone is characterized by extensive gently to steeply rolling slopes which, in unglaciated areas, extend down to the upper limits of the sub-alpine forest (Figure 10). Where glacial action has occurred, the slopes often abruptly terminate in steep-walled cirques.

Rock is a primary component of alpine topography, occurring in extensive rock fields, in talus slopes, and distributed throughout the soils. In many instances, rock forms various types of patterned ground, the most obvious of which are rings, polygons, and streams. These are formed by frost heaving, solifluction and other forces related to gravity, saturated soil, and the alternate freezing and thawing of soil water (14).

Retzer (20) has proposed that alpine soils be classified into three great soil groups: Alpine Turf, Alpine Meadow, and Alpine Bog. The classification is based on the degree of drainage present in each soil group. The most dominant group, Alpine Turf, is well drained and has well developed horizons. They occur on the higher convex slopes. Alpine turf soils vary in depth from 14 to 32 inches, the shallower soils being on southern aspects. They are black to brown mineral soils with a high content of organic residues; the B horizons vary considerably in thickness and amount of rock. In

FIGURE 9

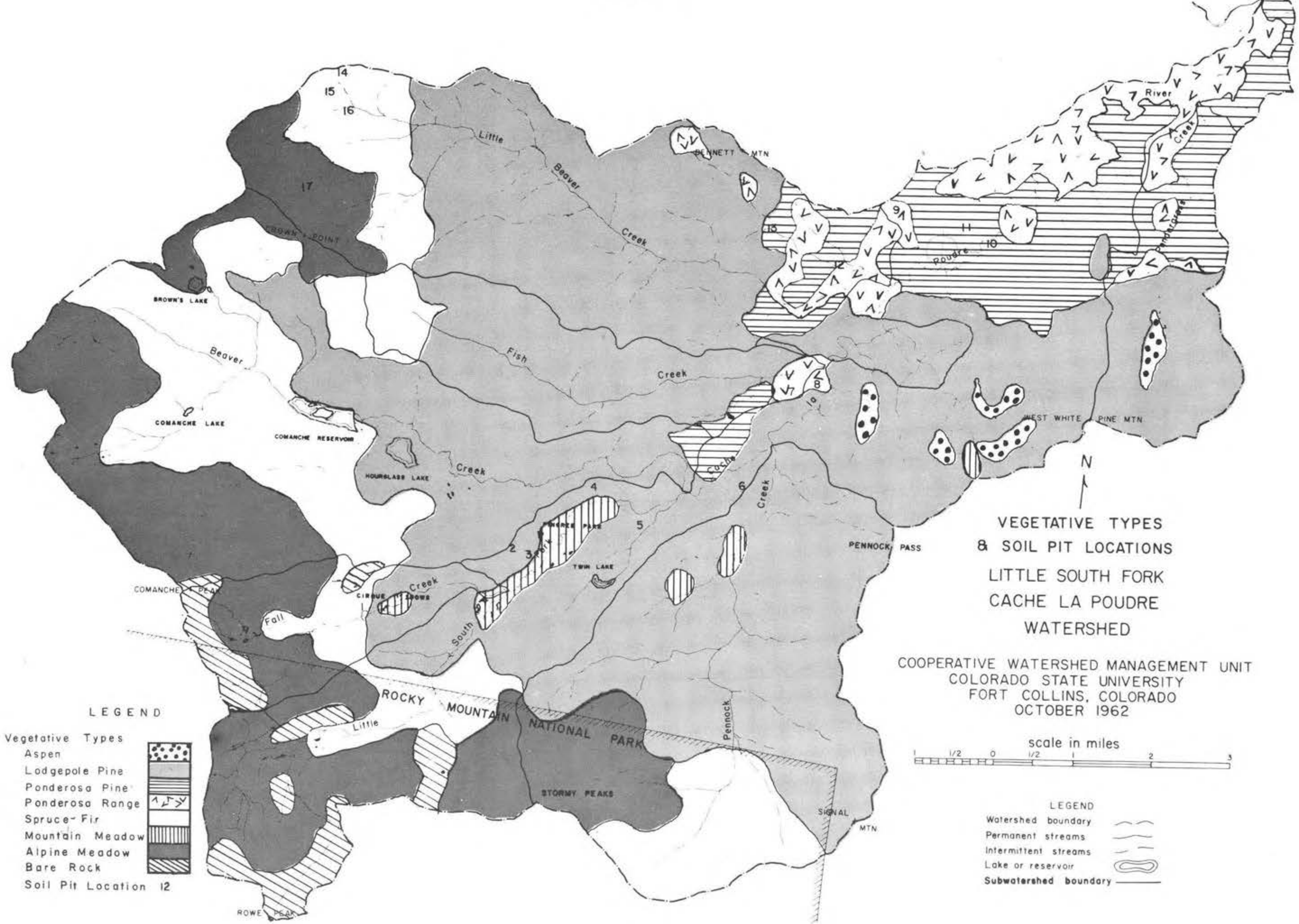

VEGETATIVE TYPES
& SOIL PIT LOCATIONS
LITTLE SOUTH FORK
CACHE LA POUDRE
WATERSHED
COOPERATIVE WATERSHED MANAGEMENT UNIT
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO
OCTOBER 1962
LEGEND
Vegetative Types
Aspen
Lodgepole Pine
Ponderosa Pine
Ponderosa Range
Spruce-Fir
Mountain Meadow
Alpine Meadow
Bare Rock
Soil Pit Location 12
scale in miles
1/2
0
1/2
1
2
3
LEGEND
Watershed boundary
Permanent streams
Intermittent streams
Lake or reservoir
Subwatershed boundary
N
BROWN'S LAKE
COMANCHE LAKE
COMANCHE RESERVOIR
HOURGLASS LAKE
TWIN LAKE
BENNETT MTN
WEST WHITE PINE MTN
PENNOCK PASS
COMANCHE PEAK
ROCKY MOUNTAIN NATIONAL PARK
STORMY PEAKS
SIGNAL MTN
ROWE PEAK
Little Beaver Creek
Beaver Creek
Fish Creek
Pennock Creek
Little South
Poudre
River
Fall Creek
14
15
16
17
13
12
11
10
9
8
7
6
5
4
3
2
1

Table 3

Areal extent of the major vegetative types (plus reservoir area) in the Little South Poudre watershed.

Type	Area Acres	Area Percent
Timber		
Lodgepole Pine	31,650	47.1
Spruce-Fir	11,200	16.7
Ponderosa Pine	6,350	9.5
Aspen	500	0.7
Subtotal	49,700	74.0
Range		
Alpine	11,200	16.7
Ponderosa-Chaparral	3,200	4.8
Mountain Meadow	770	1.1
Subtotal	15,170	22.6
Bare Rock	2,100	3.1
Reservoir Area	185	0.3
Total	67,155	100.00

Figure 10. The alpine zone between Fall Creek and Beaver Creek drainages. The small watershed in the center is Hourglass Creek. (USFS photo)

areas of sparse vegetation, the surface is covered with a layer of coarse gravel (21).

A soil profile west of Crown Point in the watershed exhibited a silt loam, dark brown A horizon four inches thick with high organic matter content and thickly matted with roots. The A horizon grades into a yellowish-brown, sandy loam B horizon, eleven inches thick. The parent material is residual and formed from weathered schist.

Vegetation on Alpine Turf soils varies from dense sods of kobresia2/ to areas largely void of plants except for a few forbs. Distribution of species appears to be governed by elevation, exposure, and local soil variations (20). In the Little South Poudre, the kobresia sods appear to be limited to that portion of the alpine within Rocky Mountain National Park, which has been closed to grazing since the early 1900s. Elsewhere, sods of sedges, bluegrasses, and golden avens dominate.

Alpine Meadow soils are closely associated with Alpine Turf soils and the two commonly occur in complexes. Generally Alpine Meadow soils occupy the lower and concave slopes of the alpine on alluvium or glacial till. Being imperfectly drained, they are intrazonal and have A-C profiles. The soil survey of the Fraser Alpine Area (21) indicates these soils vary considerably in thickness, color, and texture. A modal soil has an A horizon four inches thick, an A-C horizon of seven inches, and a C horizon of twenty inches overlying stratified alluvial-colluvial parent materials. The soils are wet or moist yearlong. A normal cover of vegetation is dominated by willows, sedges, and hairgrass.

Alpine Bog soils are undrained, as the name indicates, and are developed from organic residues in small depressions or basins. These soils are intrazonal without distinct horizonation, consisting of a fibrous peat mixed with silt about two feet deep. The soil is extremely acid. Dense stands of willows, sedges, and hairgrass occur on Alpine Bog soils (20).

The Subalpine

The subalpine zone extends from about 11,200 to 9,500 feet elevation. Much of this zone in the Little South Poudre has been glaciated, resulting in deep valleys and steep slopes with prominent rock outcrops (Figure 11). The subalpine is almost entirely forested and is commonly referred to as the spruce-fir zone. Three great soil groups occur in the subalpine zone: Podzol, a hydromorphic bog soil associated with Podzols on steep slopes, and Lithosol.

2/Scientific names are listed in Table R.

Figure 11. Headwaters of the Little South Poudre--a good example of the subalpine zone. The glaciated land form is heavily forested. Notice the alpine zone on the far slopes.

Podzol soils exhibit various stages of development depending on the environmental factors influencing soil formation. The parent materials are derived from igneous and metamorphic rocks and from glacial till. There is an abundance of rocks throughout the profile. Several Podzol profiles were examined in the upper Little Beaver Creek drainage. Podzol soils are characterized by a dark colored organic mat on the surface two to four inches thick and a leached gray A2 horizon of about three to five inches. Except in weakly developed Podzols, the A1 horizon is absent. Texture is a uniform sandy loam (Figure 12). Strongly developed Podzol soils are associated with the spruce-fir type (Engelmann spruce and subalpine fir) while lodgepole pine may predominate on weakly developed Podzols. The herbaceous vegetation under both types is primarily vaccinium with minor amounts of various grasses, sedges, and forbs (Figure 13).

Associated in complexes with the Podzols are small areas of bog soils that occur around seeps and springs. These hydromorphic soils typically consist of about two feet of plant material in various stages of decay underlaid by a mineral layer (21). These soils support dense stands of herbaceous and woody vegetation.

The Lithosols are poorly developed (azonal) soils occurring on ridge tops and steep southern slopes. They have A-C profiles, generally less than 20 inches deep, and are very coarsely textured--gravelly to stony loamy sand. Lithosols are known to occur on coarse granite (pegmatite) and almost certainly on other parent materials as well. Lodgepole pine, with an understory of vaccinium and scattered other herbaceous plants, is usually associated with Lithosols, but ponderosa pine occurs on these soils also.

The Montane

All of the Little South Poudre below 9,500 feet elevation lies within the montane zone. It is not as well defined as the alpine or subalpine zones and as a result it contains a wide variety of topography, soils, and vegetation types (Figure 14). Generally, the montane soils may be divided into five main groups: Gray Wooded, Regosol, Lithosol, Chestnut-Chernozem Intergrade, and Chernozem.

Gray Wooded soils are probably the most extensive group on the watershed. The upper elevation (roughly 9,000+ feet) soils in this group have slightly different horizon development and are called Cold Zone Gray Wooded. The parent materials of both types are primarily residual, formed from gneiss and schist, or have developed from glacial till. The five Gray Wooded and Cold Zone Gray Wooded profiles sampled had deep litter accumulation ranging from one-half to over two inches. In most, a felt layer of organic matter had developed. A dark brown, sandy loam A horizon, about ten inches deep, grades into a brownish, gravelly sandy loam B horizon of about six to eight inches in the Gray Wooded soils. The Cold

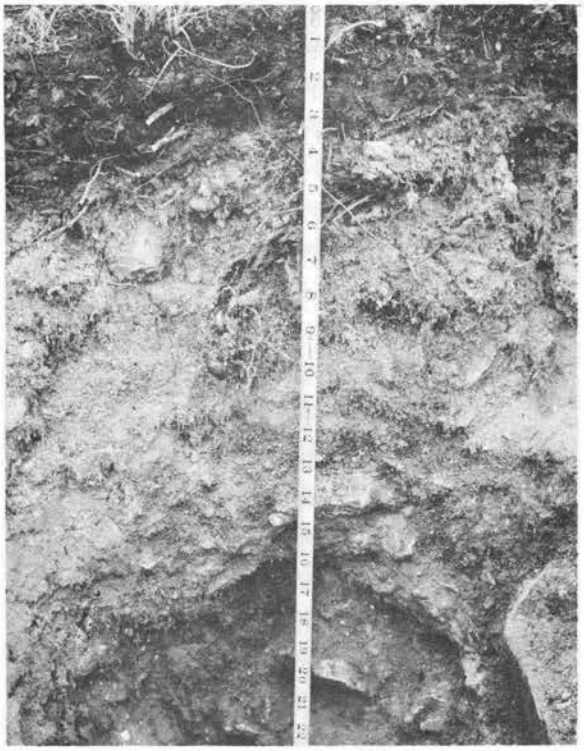


Figure 12. Typical Podzol soil profile showing a well developed, leached gray A_2 horizon of about 10 inches.

Figure 13. Understory vegetation, primarily vaccinium, in the spruce-fir zone. (Photos by Hans Keller)

Figure 14. Mouth of Fish Creek subwatershed, showing a wide variety of vegetation types in the montane zone.

one Gray Wooded soils differ chiefly in the depth of these horizons, he A being four to six inches deep and the B about ten inches. In ost cases, the C horizon is very stony, and total depth may vary rom one and one-half to four feet (Figure 15).

Open stands of ponderosa pine, Douglas-fir, and lodgepole pine often mixed), with various types of shrubby and herbaceous under-tories, are associated with the Gray Wooded soils (Figure 16).

The Regosols are relatively deep azonal soils with A-C profiles ormed by deposition in the valley bottoms of main drainages. They re gravelly textured throughout the profile, with organic accumu-ations in the upper layer. A Chernozemic-Regosol occurs under deep rganic accumulation along some drainages. These are loamy soils ith blocky structure as opposed to the practically structureless rue Regosols. Both types of Regosols range from one to several eet in depth. Their parent materials are usually of gneiss, chist, and granite originating on alluvium, colluvium or glacial ill. The true Regosols are associated with lodgepole pine, while rass or aspen stands commonly occur on the Chernozemic-Regosols Figure 17).

The Lithosols in the montane zone do not generally differ from hose occurring in the subalpine zone. These azonal, very shallow, oarsely textured soils again dominate the ridge tops and steep outhern slopes.

The Chestnut-Chernozem Intergrade soils occur primarily on arent materials of colluvial or residual origin. They show well eveloped horizonation of perhaps one and one-half feet of loam to ravelly sandy loam. The A horizon tends to be a dark reddish gray, our to fourteen inches deep, while the dark brown B horizon is ix to eight inches thick. The vegetation is an open stand of onderosa pine and grassland or grass openings within the trees Figure 18).

The Chernozems are deep grassland soils developing on alluvial nd colluvial material along intermittent stream bottoms (Figure 19). hese soils may be eight feet or more deep with good horizon evelopment. Soil texture varies from loam to sandy loam in the ery dark brown A horizon of perhaps 24 inches; the brown B horizon s a clay loam of undetermined thickness. Fine meadows have eveloped on the Chernozem soils; where overgrazing has caused soil ompaction and reduced vegetative cover, however, gullying has aken place (Figure 20).

Figure 15. Gray Wooded soil profile, showing the surface organic matter accumulation and the dark brown, sandy loam A horizon.

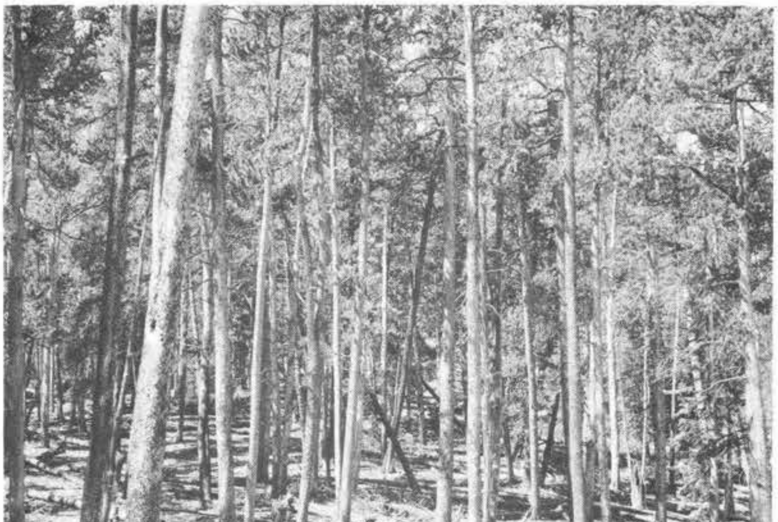


Figure 16. Lodgepole pine stand near Hourglass Reservoir--a common timber species occurring on Gray Wooded soils.

Figure 17. Valley bottom of the main stem Little South Poudre. The meadow has Chernozemic-Regosol soil.

Figure 18. Open stands of ponderosa pine and grassland openings, typical of vegetation on Chestnut-Chernozem Intergrade soils.

Figure 19. Jack's Gulch in the Little Beaver Creek drainage. A fine example of the meadows which develop on Chernozem soils.

Figure 20. Gullying in the Chernozem soils of Jack's Gulch, brought about by past overgrazing.

ppendix Data

Detailed information from the seventeen sample soil profiles n the watershed may be found in the Appendix. Table F lists the ite characteristics and Table G the horizon thickness, color, eaction, and texture of each sample profile.

Figures A, B, and C are pictures of sample soil profiles. ncluded are Podzol, Gray Wooded, Cold Zone Gray Wooded, Lithosol, egosol, Chernozemic Regosol, Chestnut-Chernozem Intergrade, and hernozem soils.

CLIMATE

General Climate

The climate of the Little South Poudre is typical of the climate higher elevations in the Colorado Front Range of the Rocky untains. Temperatures are less extreme than on the plains to the st, but averages are lower due to the higher elevation. Temperure patterns undoubtedly show the effect of cold air drainage, pecially in the cirques and glaciated valleys.

There is precipitation during all months of the year. From June rough September, precipitation usually is a result of intense nvectional activity; rainfall often occurs on only a portion of the tershed. During the winter months, precipitation usually falls as ow, generally as a result of major frontal disturbances in the mosphere. Snow accumulates over much of the watershed during the nter, its depth increasing with elevation to timberline. In the pine zone, although precipitation probably continues to increase th elevation, snow depths may vary tremendously due to wind transrtation and redeposition.

The prevailing winds are considered to be from the southwest, t topography modifies wind directions to a great extent, just as modifies the other climatic factors.

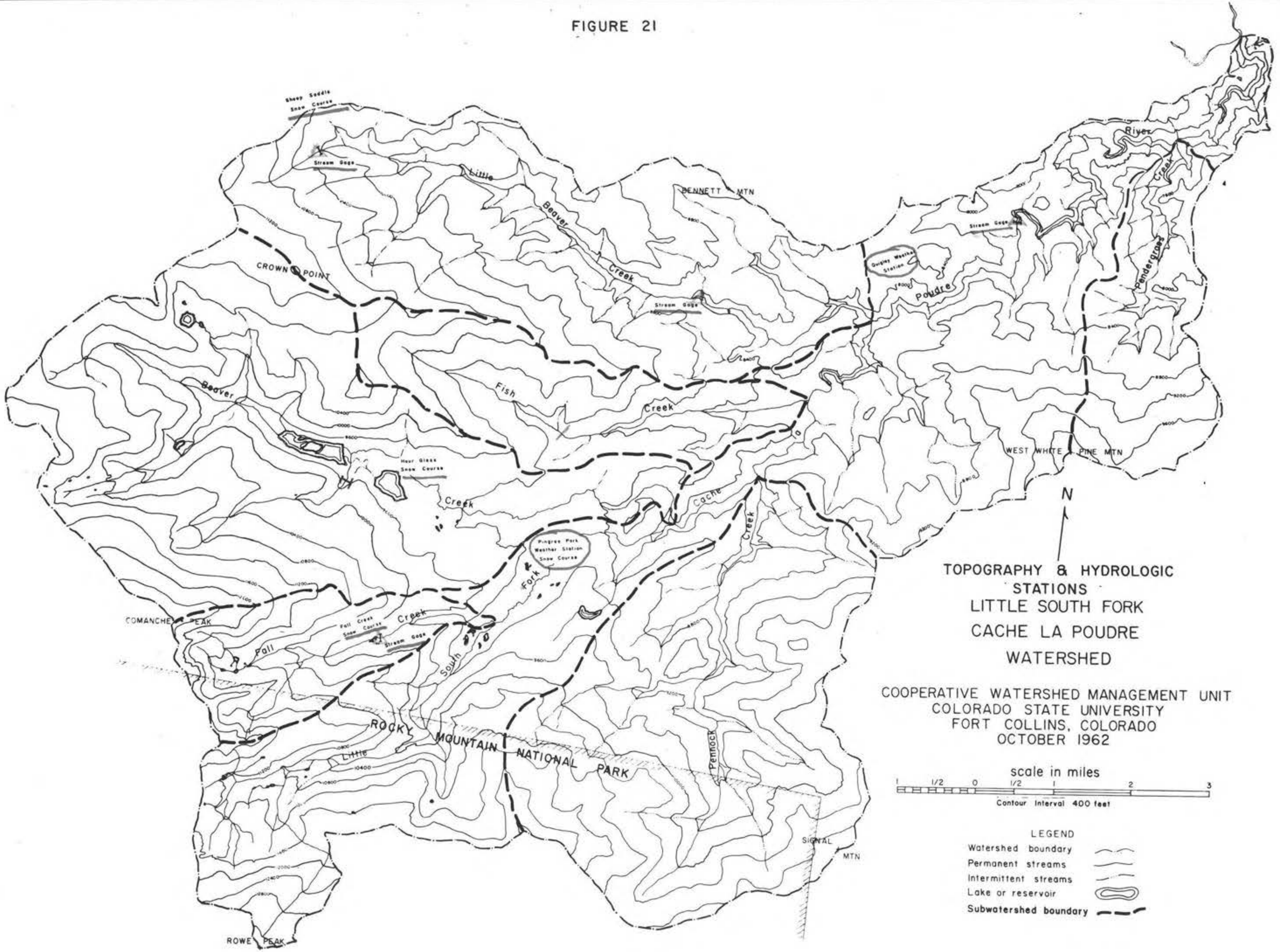
Climatic Data

Most of the climatic data available at the time this analysis s written was obtained at two weather stations in the watershed tablished by Colorado State University. This information is pplemented by that obtained from four snowcourses in the watershed. e location of these points is shown in Figure 21.

The first weather station established was at Pingree Park, in proximately the center of the watershed at an elevation of 9,000 et. The climatic factors being measured and recorded are temperure, humidity, precipitation, wind direction and velocity, and aporation from a Class A pan (during the frost-free period). U.S. rest Service fire danger ratings have also been determined during e summer forestry camp session since 1957. During the first year record, access to the station was limited in the winter and records e fragmentary as a result. Views of the Pingree Park station are own in Figures 22 and 23.

A second weather station was established in June, 1962, near igley Mountain not far from the mouth of Little Beaver Creek, at elevation of 8,200 feet. Climatic data being measured and

FIGURE 21



TOPOGRAPHY & HYDROLOGIC STATIONS
LITTLE SOUTH FORK
CACHE LA POUDRE
WATERSHED

COOPERATIVE WATERSHED MANAGEMENT UNIT
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO
OCTOBER 1962

scale in miles
1 1/2 0 1/2 1 2 3
Contour Interval 400 feet

LEGEND
Watershed boundary
Permanent streams
Intermittent streams
Lake or reservoir
Subwatershed boundary

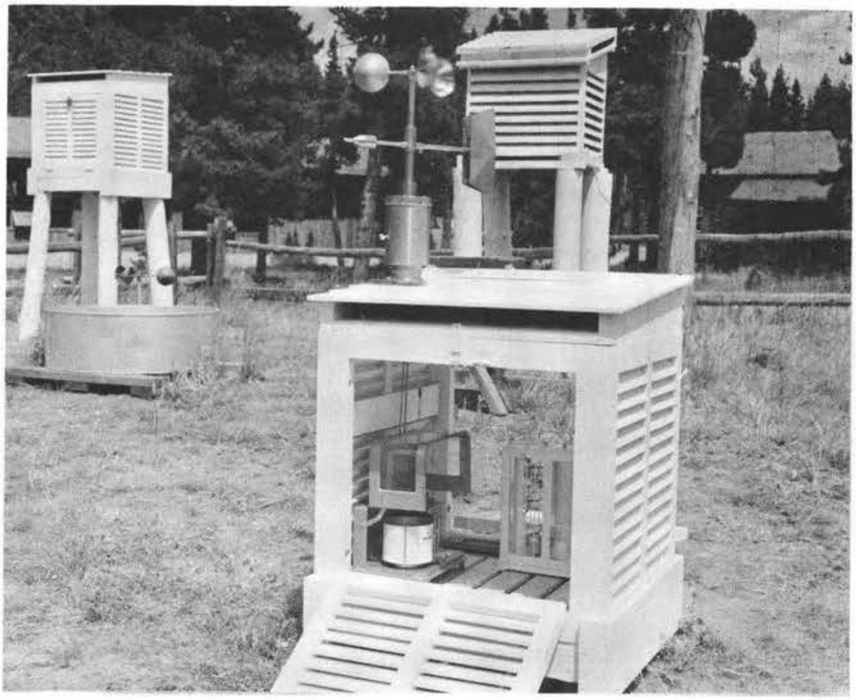


Figure 22. Instrumentation at the Pingree Park weather station.

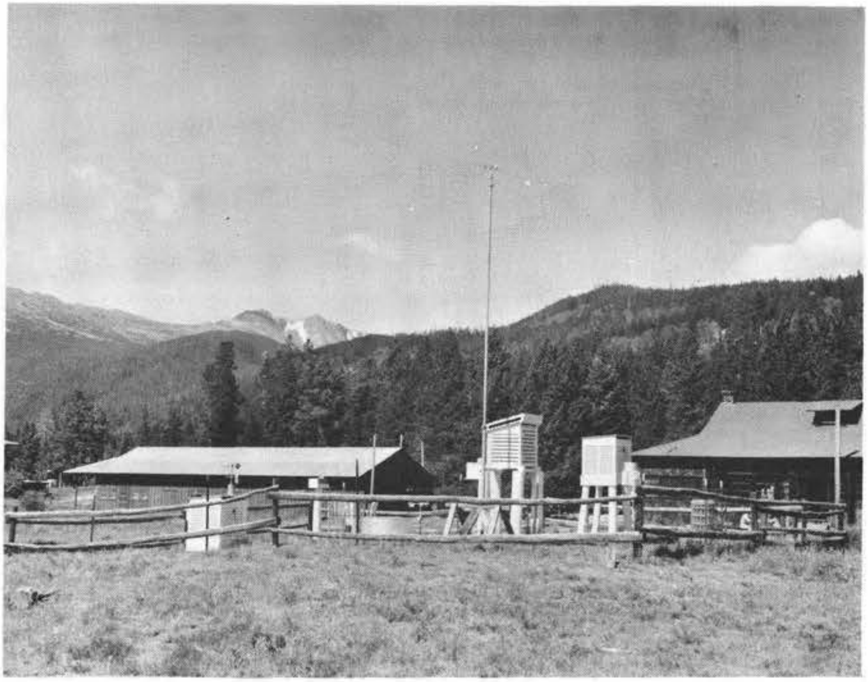


Figure 23. Pingree Park weather station.

recorded are temperature, humidity, precipitation, and total wind mileage. Figure 24 is a view of the Quigley station and surroundings.

Information on the depth and water equivalent of the snowpack on the watershed is provided by periodic sampling of the snow courses. The oldest of these is the Hourglass snow course located in a timbered area near Hourglass Lake. The elevation is 9,500 feet. This course has been sampled since 1938 by the Soil Conservation Service as a part of the Federal-State Cooperative Snow Survey (35). Data from this course are given in Table H of the Appendix.

The Cooperative Watershed Management Unit at Colorado State University established three more snow courses in 1961. The Fall Creek snow course is located 100 yards northwest of the Fall Creek stream gage. The course lies along an old logging road in a cutover area (Figure 25) at an elevation of 9,770 feet. The Pingree Park snow course is located in a lane in the timber near the Pingree Park weather station. The elevation of this course is 9,010 feet. The Sheep Saddle snow course is located in timber near the top of the ridge above the Upper Little Beaver Creek stream gage, at an elevation of 10,400 feet. Data from the Fall Creek, Pingree Park, and Sheep Saddle snow courses are presented in Table I of the Appendix. Figure 26 shows the method of snow sampling.

Although not used in this analysis, other climatological data in the Little South Poudre have been collected by the Colorado State University Botany Department. These data were taken at False Mummy Pass, in connection with an alpine ecology study. The Colorado Game and Fish Department has also been collecting climatological data as part of a study on deer ecology. Recorded temperature and humidity measurements, total wind mileage, precipitation and snow depth are included in the information being collected.

Precipitation

The mean annual precipitation on the Little South Poudre is estimated to be between 18 and 22 inches. This estimate is based on precipitation records from surrounding watersheds (Table J) as well as on two years of data from the Pingree Park weather station (Tables K and L).

Assuming that the major portion of precipitation falls as snow during October through April, 36 percent of the total annual precipitation fell as snow during 1960-61 and 57 percent during 1961-62. As seen in Figure 27, these two years show marked seasonal variation, and possibly represent extremes of total annual precipitation.

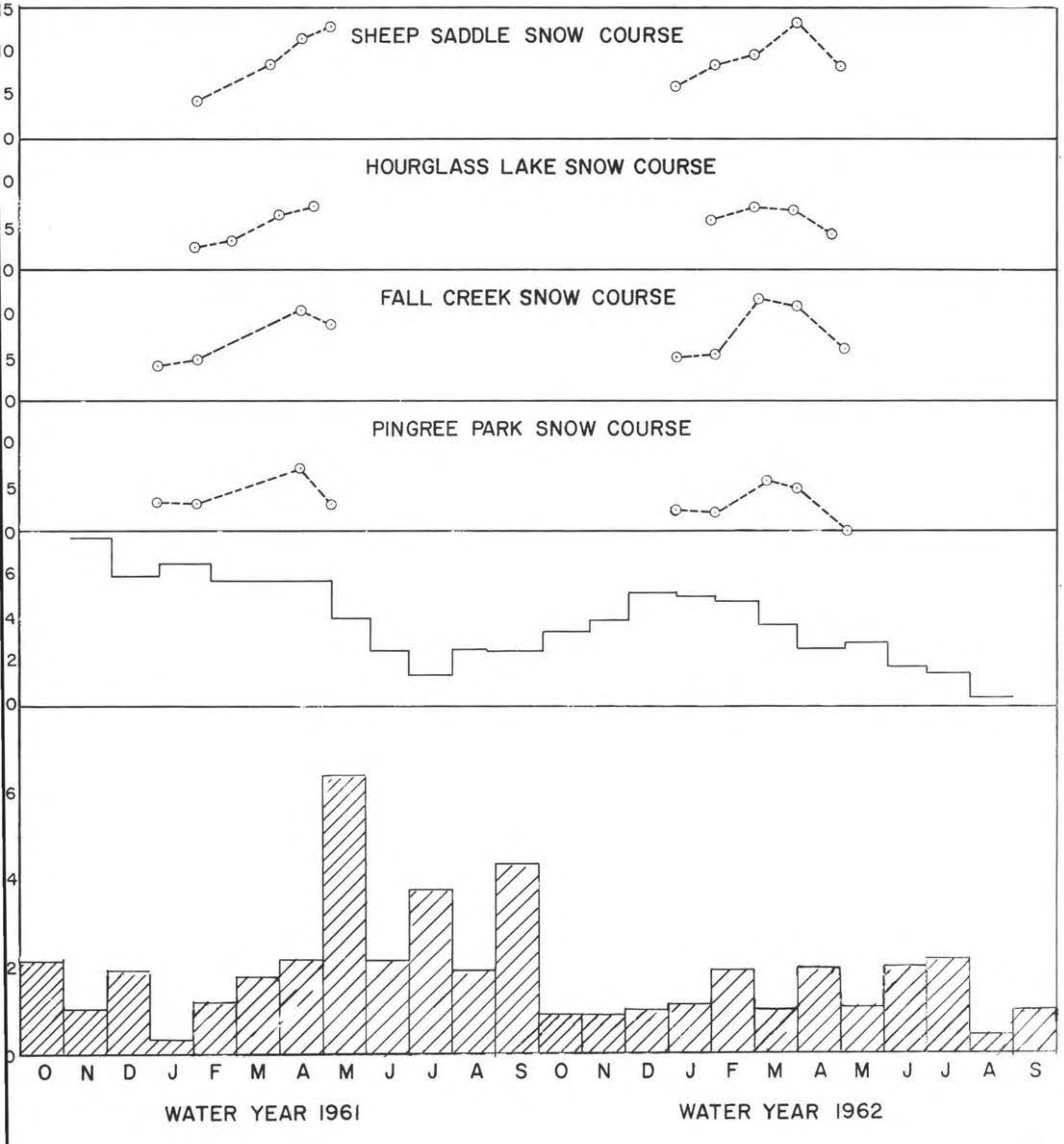
During the summer of 1962, a study of summer precipitation on the watershed was made. A network of 20 standard rain gages was established. Using data from this network and from the two

Figure 24. Quigley weather station showing the open park-like conditions found in the lower elevations of the watershed.

Figure 25. Fall Creek snow course--located along an old logging road in a cutover area.

Figure 26. Snow sampling on the Fall Creek snow course.

FIGURE 27 - SUMMARY OF PRECIPITATION AND WIND MEASUREMENTS
WATER YEAR 1961 AND 1962



ecording rain gages at the weather stations, three isohyetal maps ere drawn. These appear as Figures D, E, and F in the Appendix. hey are of interest primarily because they show the large variation n rainfall patterns on the watershed, and point out the danger of aking general statements concerning precipitation on the entire atershed[3].

Selected precipitation intensities recorded during 1961 and 1962 t the Pingree Park weather station are listed in Table M. Rainfall ntensity estimates for the area were also taken from Technical aper 40 by the U. S. Weather Bureau (37). This information is resented in Table N.

emperature and Wind Measurements

Temperature records at the Pingree Park weather station are ifficult to interpret because there are breaks in the record. xtremes recorded at Pingree Park are -45°F. on January 9, 1962, nd 83°F. on July 6, 1962. The influence of cold air drainage into ingree Park should be considered in evaluating future records.

Average wind velocities for 1961 and 1962 are shown in Figure 27. seems significant that wind velocities are highest during months hen precipitation falls as snow, particularly during months when the nsity of newly-fallen snow is likely to be quite low.

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he summer precipitation study was part of a National Science oundation Research Participation Program carried out by the ollege of Forestry and Range Management, Colorado State University.

WATERSHED HYDROLOGY

Streamflow Measurements

Four U. S. Geological Survey stream gaging stations have been installed in the Little South Poudre. One is located on the main stem of the Little South Poudre, two are on Little Beaver Creek, and one is on Fall Creek (see Figure 21).

A water stage recorder was installed on the main stem of the Little South Poudre in August, 1956, and has provided generally good records. It is located at an elevation of 7,597 feet, and measures runoff from 90.3 square miles or 86 percent of the watershed area. The view looking upstream to this station is shown in Figure 28.

The other three stream gaging stations employ gas purged, servo-manometer systems which give continuous records of stage. The control sections of these stations are covered and heated during the winter months to inhibit icing.

At the Upper Little Beaver gaging station, a Parshall flume is used during periods of high flows, and a 90 degree, v-notch is attached to measure low flows (Figure 29). The station is located at an elevation of 10,000 feet, and measures runoff from 0.89 square miles. Records begin in October, 1960.

A broadcrested weir sixteen feet wide provides the control for the Lower Little Beaver gaging station. At an elevation of 8,350 feet, the station has a drainage area of 11.4 square miles. Except for brief periods of icing, excellent records have been provided since October, 1960. Figures 30 and 31 are views of the Lower Little Beaver Station.

The Fall Creek gaging station makes use of a natural control to measure runoff from 3.46 square miles of the high cirques in this sub-watershed. The station is located at an elevation of 9,765 feet. Excellent records have been available since October, 1960. The Fall Creek gaging station is shown in Figures 32 and 33.

Present plans of the U. S. Forest Service indicate that streamflow measurements will be intensified by the construction of additional gages. Installations are planned on upper and lower Hourglass Creek in the Beaver Creek sub-watershed, on the main stem of the Little South Poudre near the park boundary, on Fish Creek near its mouth, and on upper Pennock Creek.

Figure 28. The Little South Poudre stream gaging station--a water-stage recorder. The view is upstream.

Figure 29. The Upper Little Beaver stream gaging station. The v-notch weir used to measure low flows is in place. The view is downstream.

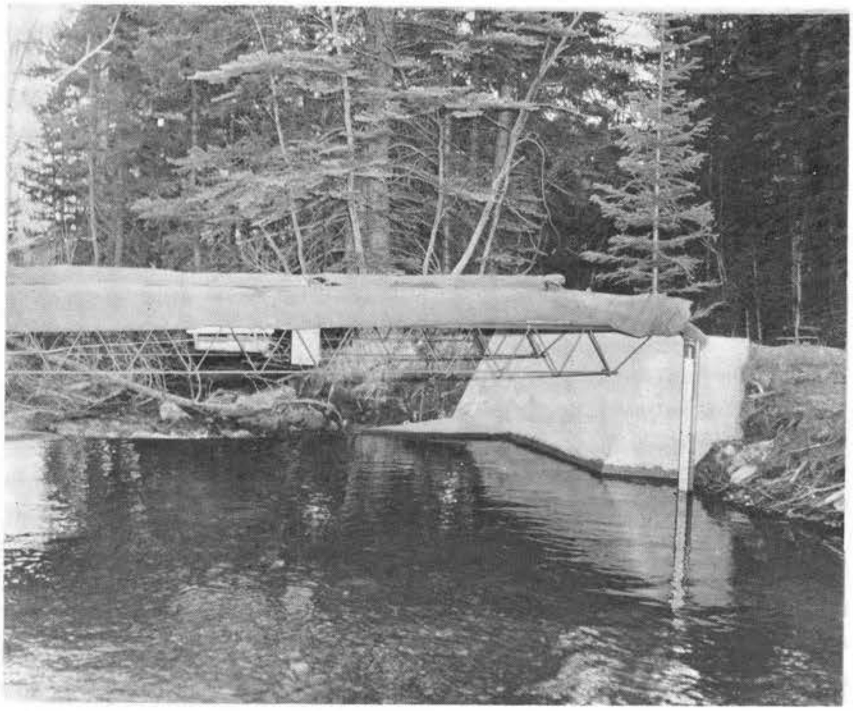


Figure 30. The Lower Little Beaver stream gaging station. Note the cover and heater used to prevent icing of the control section. The view is downstream.

Figure 31. The Lower Little Beaver stream gaging station showing the broadcrested weir used as a control.

Figure 32. Fall Creek gaging station. The natural control is covered and heated to prevent icing.

Figure 33. Fall Creek gaging station. The gas purged servo-manometer gaging station is shown.

Surface Runoff

Annual Runoff

The average annual runoff measured at the Little South Poudre gaging station for the five water years 1957 through 1961 was 50,375 acre feet. This amount is equal to 10.4 inches of runoff from the 90.3 square miles of watershed above the gaging station. To arrive at an average annual runoff value for the entire watershed, the area below the gaging station must be considered. This area amounts to fourteen percent of the watershed area, and includes Pendergrass Creek and the lower canyon of the Little South Poudre. Water yield from this area is believed to be slightly less than the average for the entire watershed. Ten inches is therefore considered to be a fair average runoff for the watershed. Using this figure, the estimated average annual runoff volume at the mouth of the watershed is 56,000 acre feet. It is important, however, to note that this average is based on but five years of data, and that during this period of record, deviations range from 25 percent below to 40 percent above the five year average at the Little South Poudre gaging station.

If the average annual precipitation is within the estimated range of 18 to 22 inches, water yield from the watershed is 45 to 55 percent of the annual precipitation.

Distribution of Runoff

The average monthly distribution of runoff for five water years of record at the Little South Poudre gaging station is shown in Table 4 and Figure 34. Runoff volumes for the month of June have amounted to 36 to 46 percent of the total runoff for each year. This is the general pattern of runoff distribution expected in the Rocky Mountains where melt water from the snowpack provides a large proportion of the streamflow.

Table 5 and Figure 35 indicate that the runoff distribution patterns for the water year 1962 were similar at each of the four gaging stations. Distribution at the Fall Creek gaging station, however, shows a lower precentage of total runoff occurring during June, and larger percentages in July, August, and September. This might be attributed to temporary storage of snowmelt water in the basin. The cirque lakes, glacial deposits, and the meadow immediately above the gaging station indicate that subsurface flow is slowed, thus prolonging the contribution of snowmelt to streamflow.

Quality of Runoff

Visual observations during periods of high flows have indicated that very little sediment is being carried by the streams of the

Table 4

Monthly distribution of runoff measured at the Little South Poudre gaging station (39), (40)

Month	Water Year					Monthly	Percent
	1957	1958	1959	1960	1961		Average
	Acre-feet					Total	Annual
Oct.	1,120	1,690	928	1,210	736	5,684	2.26
Nov.	875	1,060	859	920	655	4,369	1.73
Dec.	651	801	553	492	615	3,112	1.24
Jan.	605	680	430	369	615	2,699	1.07
Feb.	613	680	389	288	444	2,414	0.96
Mar.	756	766	536	476	492	3,026	1.20
Apr.	1,060	1,120	934	938	748	4,800	1.90
May	6,240	14,910	4,010	5,000	7,610	37,770	15.00
June	27,630	18,840	17,630	15,920	23,580	103,600	41.13
July	20,990	5,810	6,380	7,360	8,260	48,800	19.37
Aug.	6,830	4,510	4,190	3,530	5,060	24,120	9.58
Sep.	3,310	1,580	1,260	1,340	3,990	11,480	4.56
Total	70,680	52,447	38,099	37,843	52,805	251,874	100.00

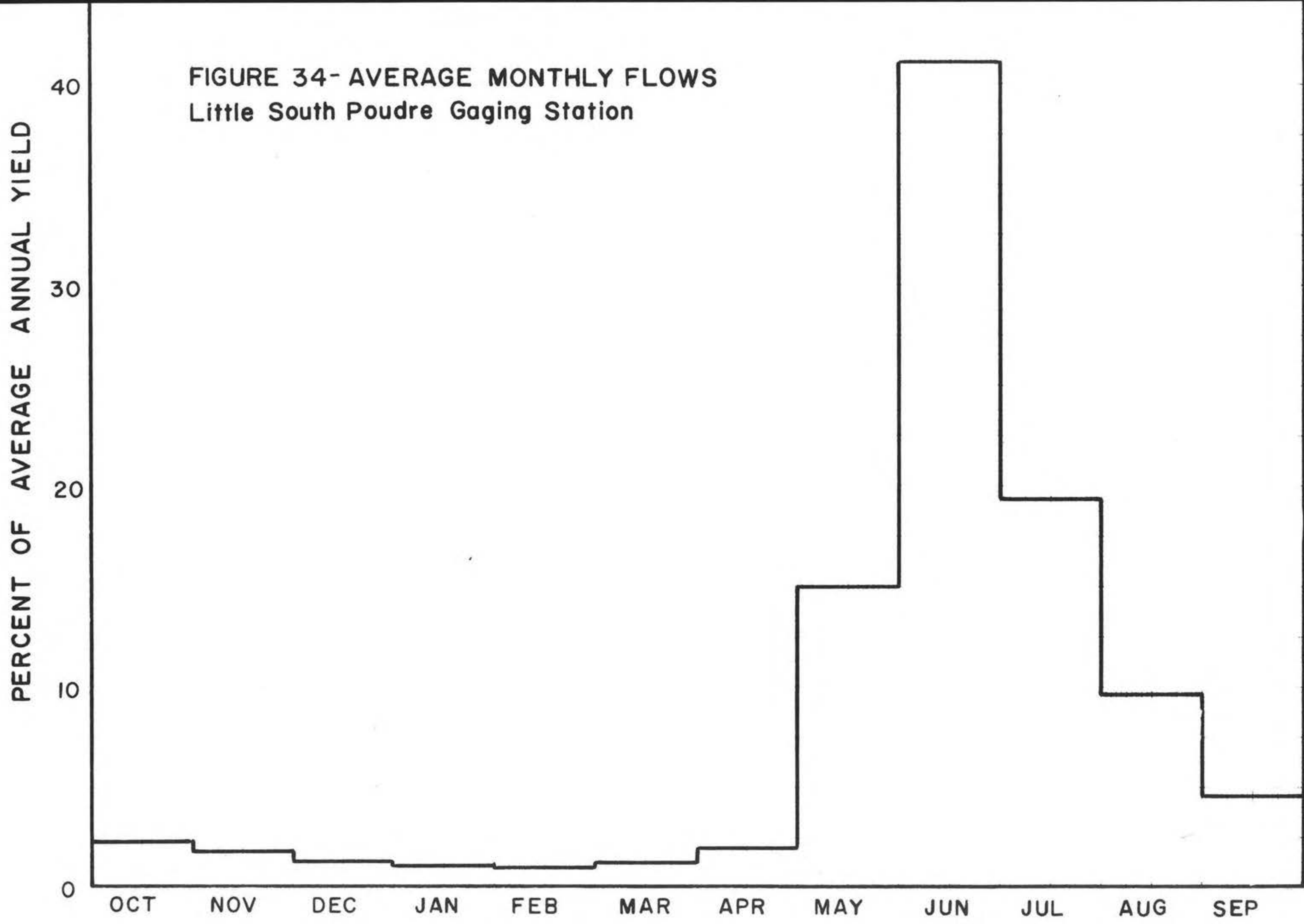


FIGURE 34- AVERAGE MONTHLY FLOWS
Little South Poudre Gaging Station

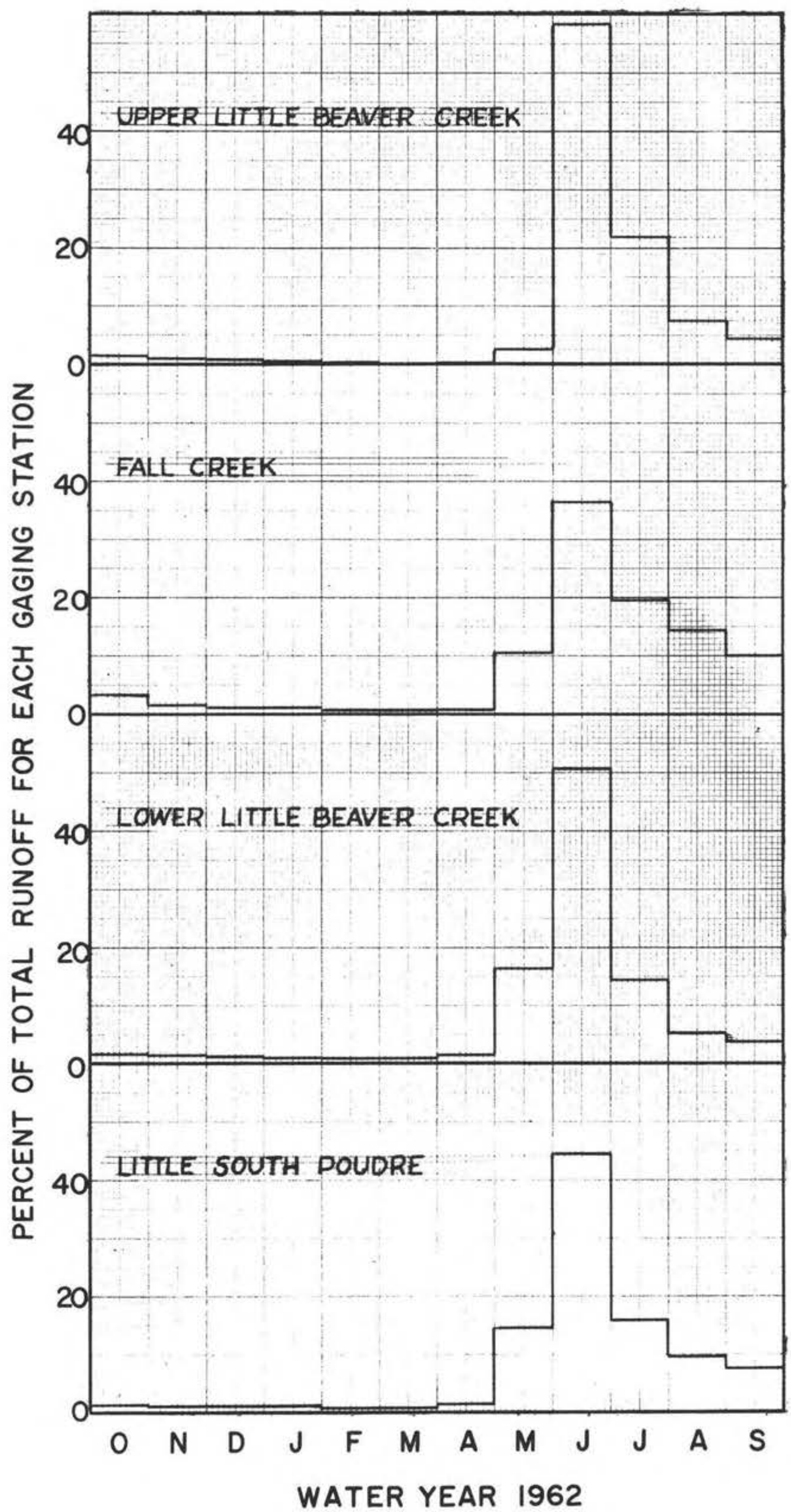
Table 5

Monthly distribution of runoff measured at four gaging stations--water year 1961 (40)

Month	Fall Creek		Upper Little Beaver		Lower Little Beaver		Little South Poudre	
	a-f	%	a-f	%	a-f	%	a-f	%
Oct.	153	3.3	12.0	1.5	115	1.7	736	1.4
Nov.	70	1.5	8.2	1.0	105	1.6	655	1.2
Dec.	46	1.0	6.5	0.8	88	1.3	615	1.2
Jan.	47	1.0	4.7	0.6	76	1.1	615	1.2
Feb.	27	0.6	2.8	0.4	67	1.0	444	0.8
Mar.	24	0.5	2.0	0.3	69	1.0	492	0.9
Apr.	34	0.7	1.4	0.2	111	1.7	748	1.4
May	484	10.4	21.0	2.7	1080	16.3	7610	14.4
June	1730	37.0	456.0	58.5	3360	50.8	23580	44.6
July	910	19.5	171.0	21.9	952	14.4	8260	15.7
Aug.	680	14.5	59.0	7.6	347	5.2	5060	9.6
Sep.	468	10.0	35.0	4.5	257	3.9	3990	7.6
Total	4673	100.0	799.6	100.0	6227	100.0	52805	100.0

FIGURE 35 - RUNOFF DISTRIBUTION

by gaging station, water year 1962



Little South Poudre. This has been substantiated by the measurements of Hansen (8). The purity of water in the watershed has been further demonstrated by the difficulties experienced in determining fish populations by shocking methods. Lack of sufficient dissolved minerals results in poor conduction of an electric current in these waters.

The Snowmelt Hydrograph

The melting of snow in the Rocky Mountains depends largely on warm air and wind, but the pattern of snow disappearance is largely a function of direct solar radiation. The radiation intensity is a function of slope and aspect; accordingly, south slopes at low elevations are usually bare before other areas. East and west slopes at the same elevations and south slopes at high elevations follow. North slopes at high elevations usually melt bare last. In forested watersheds, such as the Little South Poudre, snowmelt water usually enters the stream channels as subsurface and groundwater flow, surface runoff occurring only in localized situations (7).

Melting begins at the surface of the snowpack when the temperature of the snow has been increased to 0°C. The melt water percolates into the snowpack, but runoff begins only when the water-holding capacity of the snowpack has been satisfied (4). Figure 36 is the snowmelt hydrograph for water year 1959, constructed from mean daily discharge values at the Little South Poudre gaging station.

Temporary drops in discharge on the rising limb of the snowmelt hydrograph probably are a result of cold spells during the melt period. A close examination of the snowmelt hydrograph reveals the smaller daily hydrographs resulting from one day's melt. The shape of the daily melt hydrographs probably reflect temperature fluctuations rather than basin characteristics.

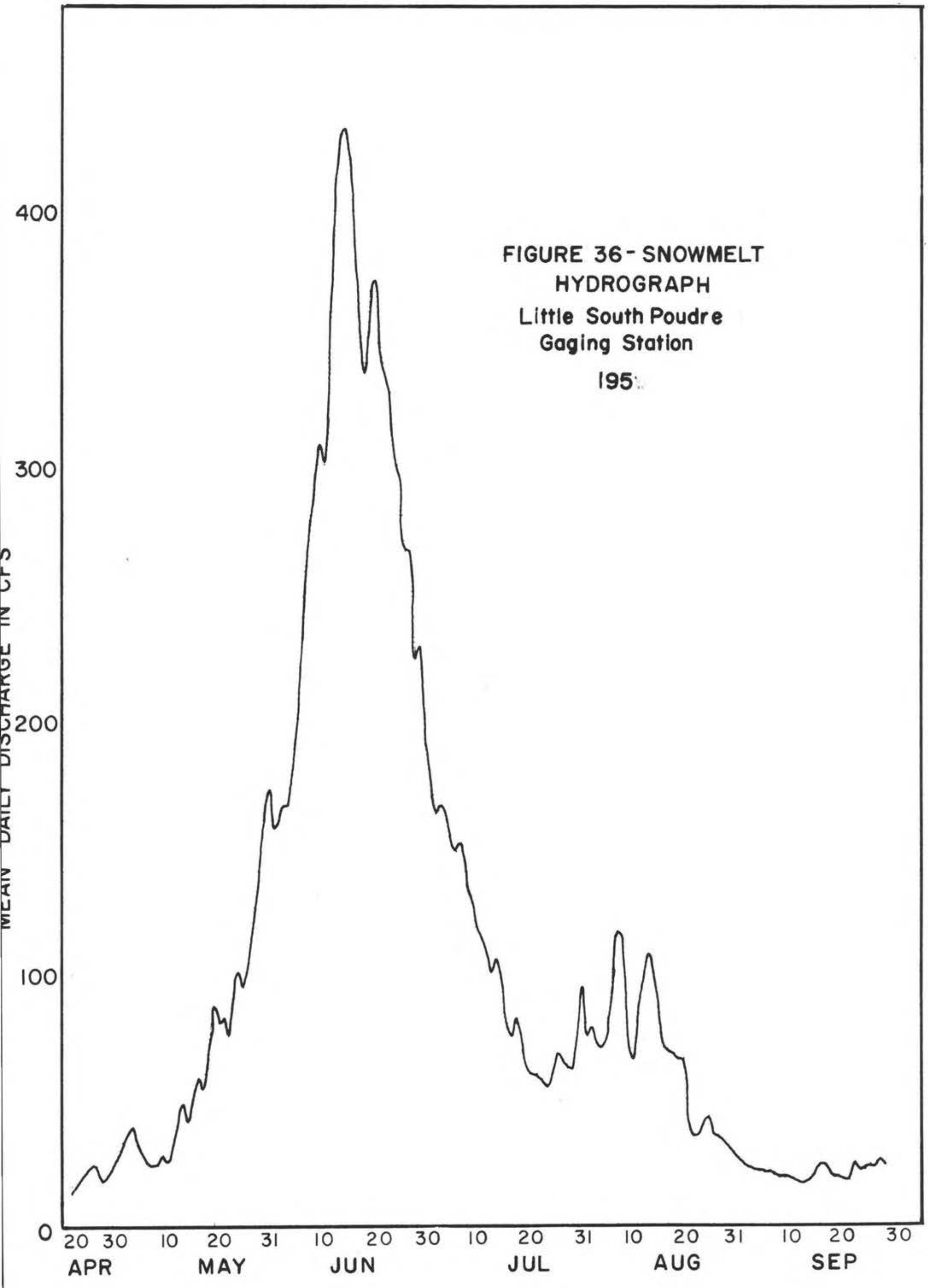


FIGURE 36 - SNOWMELT HYDROGRAPH
Little South Poudre Gaging Station
195

LAND OWNERSHIP

There are fourteen landowners within the Little South Poudre. Of these, the U. S. Government controls over 90 percent of the area. The bulk of the federal lands form a part of the Roosevelt National Forest, administered by the U. S. Forest Service. The remainder is a part of Rocky Mountain National Park, administered by the National Park Service. Small tracts of land are owned by ten individuals or private organizations, two municipal governments (Fort Collins and Greeley, Colorado), and the Colorado State Board of Agriculture (Colorado State University). The type and size of land ownership in the watershed is detailed in Table 6. The pattern of land ownership is presented in Figure 37. A summary of non-federal land owners may be found in Table .O of the Appendix.

Most of the tracts of land under private ownership are 160 acres or less in size, indicating their origin as homesteads taken out under the provisions of the Homestead Act. Ownership of these lands is fairly stable, only infrequently changing hands. Fort Collins and Greeley have purchased several homesteads as part of their community water supply developments.

The lands under state control were selected in 1914, under special act of Congress, for use by Colorado State University. The state has traded land within the watershed and plans to trade more (probably with the Forest Service) to consolidate holdings.

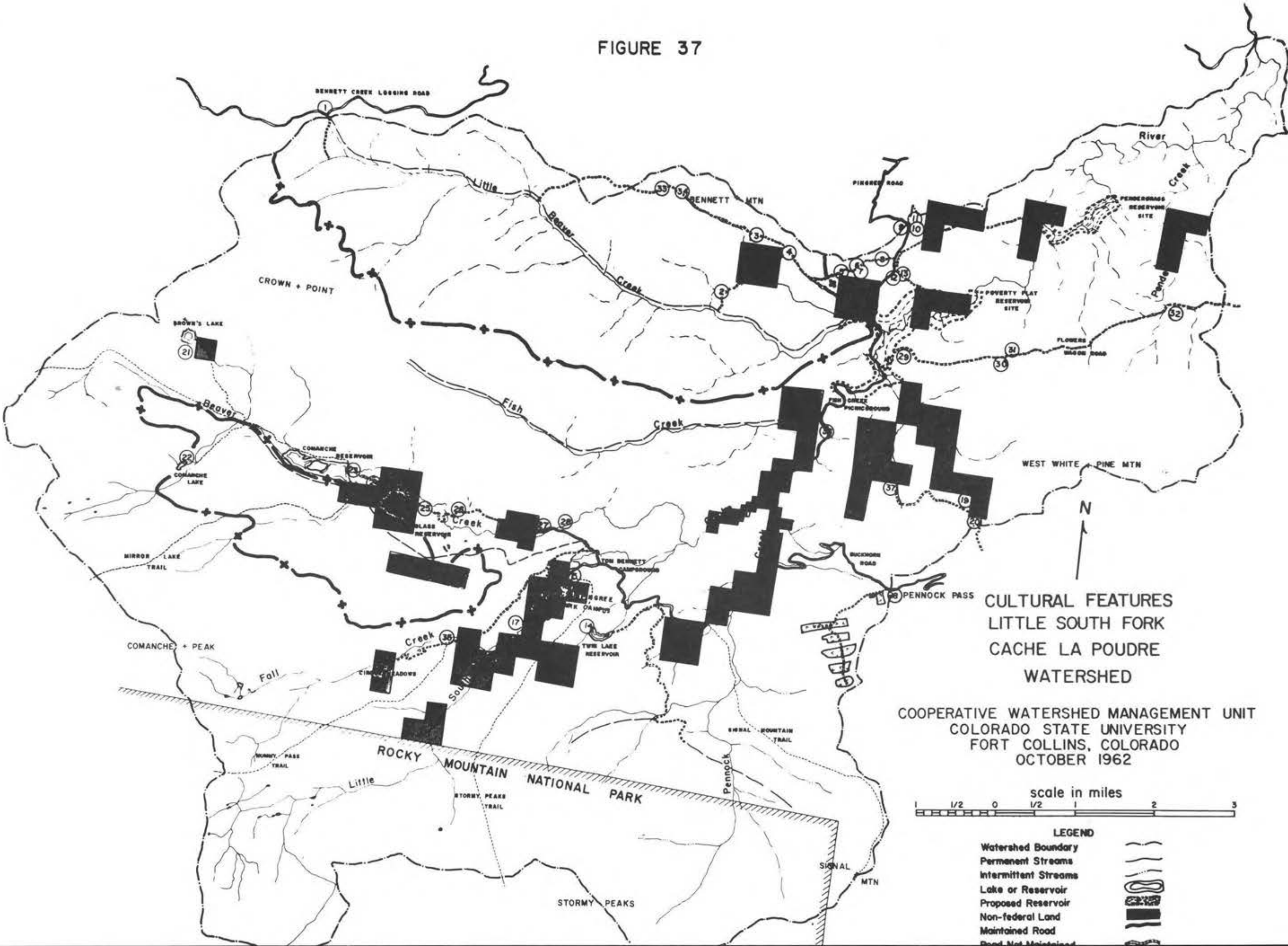
The Forest Service is attempting to consolidate the land under its administration in order to facilitate management of the land resource. It hopes to purchase several isolated tracts and to negotiate land for land exchanges.

Table 6

Type and Size of Land Ownership

Type of Ownership	Area Acres	Percent of Area
National Forest	54,310	80.9
National Park	8,550	12.7
Colorado State University	1,030	1.5
Municipal	800	1.2
Private	2,465	3.7
Total	67,155	100.0

FIGURE 37


BENNETT CREEK LOGGING ROAD
PINGREE ROAD
BENNETT MTN
Little
Beaver
Creek
River
Creek
Pendergrass
PENDERGRASS RESERVOIR SITE
POVERTY FLAT RESERVOIR SITE
FLOWERS WAGON ROAD
CROWN + POINT
BROWN'S LAKE
Fish
Creek
FISH CREEK PICNIC GROUND
WEST WHITE + PINE MTN
Beaver
COMANCHE RESERVOIR
COMANCHE LAKE
Creek
GLASS RESERVOIR
TOM BENNETT CAMPGROUND
MIRROR LAKE TRAIL
BUCKHORN ROAD
PENNOCK PASS
TWIN LAKE RESERVOIR
COMANCHE + PEAK
Creek
Fall
South
SIGNAL MOUNTAIN TRAIL
ROCKY MOUNTAIN NATIONAL PARK
Pennock
Little
STORMY PEAKS TRAIL
SIGNAL MTN
STORMY PEAKS
N
CULTURAL FEATURES
LITTLE SOUTH FORK
CACHE LA POUDRE
WATERSHED
COOPERATIVE WATERSHED MANAGEMENT UNIT
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO
OCTOBER 1962
scale in miles
1 1/2 0 1/2 1 2 3
LEGEND
Watershed Boundary
Permanent Streams
Intermittent Streams
Lake or Reservoir
Proposed Reservoir
Non-federal Land
Maintained Road

RESOURCE MANAGEMENT --- PRESENT AND FUTURE

Timber Resources

Three major commercial timber types occur within the Little South Poudre: lodgepole pine, spruce-fir, and ponderosa pine. Lodgepole pine predominates over most of the watershed, probably because of fires during the last 100 years (Figure 38). Engelmann spruce and subalpine fir dominate the subalpine zone (Figure 39). Open stands of ponderosa pine occur in the lower elevations of the watershed (Figure 40). Much of the ponderosa pine was exploited during the tie cutting period. In the lower watershed the terrain is extremely steep, much of it accessible only by foot; the ponderosa pine on these areas is therefore of little commercial value.

In addition to these major timber types, isolated patches of limber pine occur on high, rocky ridges. Limited numbers of Colorado blue spruce and Douglas-fir are found adjacent to the streams in the lower reaches of the watershed (Figure 41). Intermixed with the other timber types are small stands of aspen, none of commercial size or extent (Figure 42). Due to insufficient volume, these species have but slight commercial value.

Based on Roosevelt National Forest timber type maps it is estimated that sawtimber volumes within the watershed (excluding Rocky Mountain National Park) amount to 130 million board feet of lodgepole pine, 115 million board feet of Engelmann spruce-subalpine fir, and 30 million board feet of ponderosa pine. There is also a very large, but undetermined, amount of pole size timber available.

The net annual growth increment of timber over eleven inches diameter breast high, on the Roosevelt National Forest, is a little less than 40 board feet per acre. The net annual growth of pole size timber is about 12.5 cubic feet per acre (Table 7). Mortality, ranging from about 20 to almost 50 percent, is largely due to disease, since present timber stands are past their economic as well as pathological rotation age. Losses to insects are slight. Under more intensive management it is likely that net annual growth would be between 100 to 200 board feet per acre. Rotation ages are: 120 years for lodgepole pine, 140 years for spruce-fir, and 140 years for ponderosa pine-Douglas-fir. It is apparent that at present growth rates only trees in a few areas will reach sawtimber size in these rotation periods.

The present effect of pathogens on the timber resources is extremely varied. Dwarf mistletoe infestation is heavy in the lodgepole pine in the Pennock Creek sub-watershed but is relatively

Figure 38. Lodgepole pine timber type near Pennock Pass. Stand was thinned in 1930s by the Civilian Conservation Corps; picture was taken in 1962.

Figure 39. Spruce-fir timber type in the vicinity of Crown Point.

Figure 40. Ponderosa pine timber type near the watershed border at Quigley Mountain.

Figure 41. Streamside vegetation--Little Beaver Creek, looking upstream from lower stream gage.

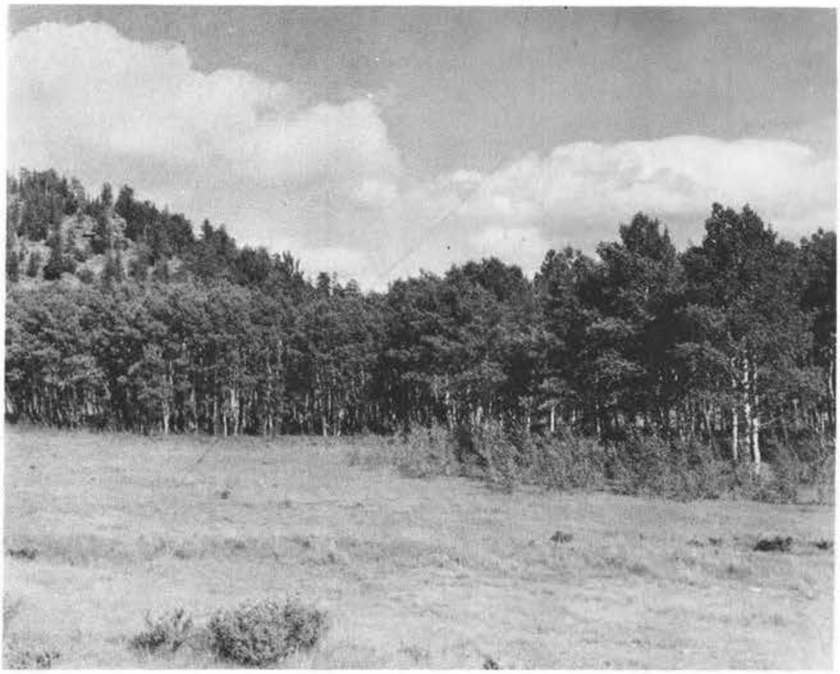


Figure 42. Aspen stand, showing the typical dense growth and grove-like pattern of this species.

Table 7

Annual growth increment by species in sawtimber and pole size classes.

Species	Annual Growth[1] DBH 11.0" bd. ft. Gross	Mortality	Net	DBH 5.0-10.9" cu. ft. Gross	Mortality	Net
Douglas-fir	7.39	2.66	4.73	2.72	1.05	1.67
Ponderosa pine	9.84	1.93	7.91	3.16	0.62	2.54
Lodgepole pine	22.11	10.45	11.66	8.23	3.56	4.67
Spruce fir	23.00	8.97	14.03	6.66	3.05	3.61
Totals	62.34	24.01	38.33	20.77	8.28	12.49

1/Based on 384 plots from the 1958 Forest Survey on the Roosevelt National Forest(24).

light in the rest of the watershed. Dwarf mistletoe is also present on ponderosa pine but is limited in èxtent. Two rots, western red rot and white pocket rot, are rather widespread with an incidence of as high as 50 percent in overmature stands. Insect populations in the Roosevelt National Forest are now endemic after epidemic outbreaks in 1947 and 1948. The Black Hills beetle was evident in ponderosa pine as early as 1930. Control has been achieved by felling and burning the infected trees. The Douglas-fir beetle is present, but no control has been developed. Since Douglas-fir has only limited extent and economic importance in the Little South Poudre, this pathogen is not considered serious.

The timber management program for the watershed, as for the Central Rocky Mountain area generally, is limited by a dearth of markets for the timber products. Lumber is produced, for a local market, at only two major mills. Although there is an abundance of small timber for posts, poles, and pulping processes, markets are even more limited. There are no pulp mills or other forest industries in the immediate area and none are likely in the near future. At present, the nearest pulp mill is in Wisconsin. There is a possibility that one will soon be located on the western slope of Colorado.

There is now one commercial timber sale in progress on the watershed. It is located in the Pennock Creek drainage approximately one mile south of Pennock Pass. Sawtimber, posts, poles and mine props are being produced. The expected volume cut on 111 acres is: 1,213 thousand board feet (MBM) of lodgepole pine, 32 MBM of subalpine fir, 111 MBM of Engelmann spruce, and 80 MBM of Douglas-fir. As in most sales on the Roosevelt National Forest, scale is determined at the mill, not in the woods.

Two future sales are planned prior to 1971. They are located in the Beaver and Little Beaver Creek drainages. The areas to be cut are 944 and 2,457 acres, with expected total volumes of all types of 9,918 MBM and 20,000 MBM respectively. These areas to be cut are variably distributed within the general areas designated on Figure 37. Cutting has been deferred on the Beaver Creek sale for from three to five years, pending construction and calibration of two streamgages on Hourglass Creek.

Range Resources

The Little South Poudre is typical of the Central Rocky Mountain coniferous forest grazing region as classified by Stoddart and Smith (33). Three range types occur within the watershed: dry meadow, wet meadow, and the alpine. The dry meadow is the most extensive on the watershed. It occurs as open parks and as herbaceous understory in the open stands of ponderosa pine and aspen at the lower elevations (Figure 43). The steeper south-facing slopes are practically devoid of timber. Bunchgrasses--wheatgrass, bluegrass, fescue, brome, Junegrass, and mountain muhly--are a major portion of the forage. There is a variety of sedges and forbs; bitterbrush and mountain mahogany are the most common shrubs. The dry meadow type provides year-long range for big game and supports summer herds of cattle as well.

The heavily timbered areas of the spruce-fir zone provide little or no suitable forage. Adjacent to the streams, however, are a number of wet meadows which vary widely in size. Dense populations of hairgrass, timothy, sedges, rushes, and forbs occur in these meadows, varying with the degree of wetness. Willow is the most common shrub (Figure 44). The wet meadow type provides good forage for cattle from the middle of June to late September or October.

The vegetation of the alpine zone is characterized by bluegrass, timothy, redtop, sedges, and numerous forbs as well as willow patches (Figure 45). The forage is utilized by big game during the summer months. Exclusive of Rocky Mountain National Park, the alpine zone also supports sheep from July 11 to August 31.

Much of the private land within the watershed is grazed to varying extent. Grazing rights on the municipal land are awarded through a bid process. There are five grazing allotments on the federal land which support approximately 350 head of cattle (900 animal unit months or AUM) and 2,000 head of sheep (665 AUM) during the summer. Forest Service terms on the cattle allotments call for riding and salting in order to distribute the use. The sheep allotments in the alpine zone are planned for progressive herding; each portion being grazed only once each season (29).

Due to a combination of overgrazing and drought during the 1930s, gullying of the lower watershed occurred, principally in Jack's Gulch. After another prolonged drought, portions of the lower watershed range were again in a poor condition during the early 1950s. Invader plants constituted a high percentage of the plant cover and there was a noticeably larger amount of bare ground. Further gully erosion was halted by substantially reducing the number of animals on the allotments. The peavine in Jack's Gulch was sprayed with 2,4-D in 1957 and a drift fence constructed to exclude cattle from the upper, wetter areas of Jack's Gulch and the Little Beaver Creek drainage until later in the grazing season. Regulated use has greatly aided the recovery of range conditions in these areas (Figures 46 and 47).

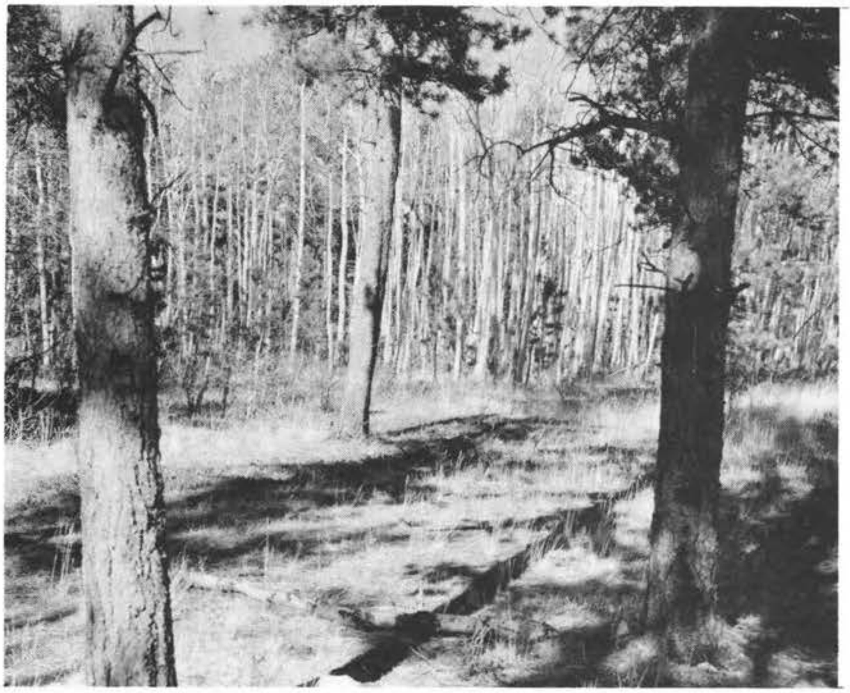


Figure 43. Typical dry meadow type under ponderosa pine and aspen stands.

Figure 44. Pingree Park--a good example of the wet meadow type. Pingree Park campus in background.

Figure 45. The alpine range type--near Crown Point.

Figure 46. A well-stabilized old gully in Jack's Gulch.

Figure 47. An old gully headcut in Jack's Gulch. Notice the brush in the stabilized gully.

Water Resources

Almost all water of the Little South Poudre has been appropriated use outside the watershed as a part of the priority system aching to the entire Cache la Poudre River Drainage. There are a appropriated diversions for streamside meadow irrigation within watershed, but the total area irrigated is very small (25-30 acres) the great majority of the irrigation water returns to the stream. overall effect is so minor that no attempt is made to regulate amount of water diverted (44). There is only minor use of face and/or ground water for domestic purposes within the water- d. The five water storage rights on the Little South Poudre are ed by the City of Greeley, Colorado, as a part of its municipal er supply. The water stored is released during the summer months. ough a complex canal and water transport system (not on the water- d) and a flexible district-wide method of management, water can be ught down at almost any time during the summer and either used ediately or stored a second time. Most often, Greeley obtains its er from an irrigation company and then makes available to the pany an equal amount from its own sources of supply. Water from Little South Poudre reservoirs is usually brought down con- rently and at a steady rate, thus avoiding frequent streamflow ctuations. From 25 to 50 cubic feet per second (cfs) is released m the Comanche-Hourglass Reservoir combination and up to 15 cfs m Twin Lake Reservoir. The reservoirs can be emptied in about ee weeks (44).

A reservoir site on the mainstem of the Little South Poudre ow the junction of Little Beaver Creek has been surveyed by the eau of Reclamation. The Cities of Fort Collins and Greeley have o considered the construction of a reservoir near this site. The posed reservoir sites are shown on Figure 37. If built, water hts from the three upper reservoirs would be transferred to the ones. The upper reservoirs would then be maintained only for reational use. No plans beyond the initial surveys for these ervoirs have been made.

Wildlife Resources

One of the more important resources of the watershed is its ndant wildlife which provide recreation for hunters, fishermen, outdoor enthusiasts.

A sizeable elk herd ranges the watershed year-long. During the mer the elk are found in the alpine and subalpine zones, primarily hin Rocky Mountain National Park. Smaller numbers also range ough the upper portions of Beaver Creek, and Little Beaver Creek ainages. The herd winters in the lower Little Beaver Creek area.

The summer deer herds are concentrated primarily in the nderosa pine and ponderosa pine-chaparral stands of the lower ershed. A few animals are found at the higher elevations up to l above timberline. Despite good condition winter ranges on the ershed, most of the deer migrate to the north side of the Cache Poudre River where open south slopes are more numerous.

The elk and deer herds of the overall Cache la Poudre drainage considered to be among the best managed herds in the state. Due the accessibility from population centers and consequent heavy nting pressure, the herds can be kept within the winter range pacity. Length and type of hunting season are adjusted annually a means of management for maximum production of game and maintance of adequate range. Hunter use and game kill for Colorado te Game Management Unit 19, of which the watershed is a part, listed in Table P of the Appendix.

An increasing number of fishermen are using the watershed for both eam and lake fishing. Native or cutthroat, rainbow, brook, and wn trout are all found in some of the lakes and streams of the ershed.

A major fisheries problem of the upper watershed is the prolific roduction of brook trout. The overpopulation has caused a nting of growth; in many sections of the streams, there are few h larger than five to six inches. The small size of these fish pled with the relative inaccessibility of these streams produces fishing pressure. Thus the problem is perpetuated. In recent rs, large brown trout have been stocked in several sections of streams to help combat the problem. Being more cannibalistic, brown trout reduce the populations of brook trout, with ultant greater growth of the remaining fish.

The scattered alpine lakes, particularly Brown's Lake, are eiving increasing fishing use. Another focus of increasing hing pressure is the main stem of the Little South Poudre, ticularly in the stretches adjacent to roads. The Colorado e and Fish Department stocks it with catchable-size rainbow trout a "put-and-take" basis.

Recreation Resources

Recreation is rapidly becoming one of the dominant uses of the ional forests, and this is particularly true of the Little th Poudre. Its proximity to the population centers of Fort lins, Greeley, Boulder, and Denver is expected to increase creation use tremendously by the year 2000. Using 1946 as a base ar, the expected increase in recreation visits of all types is 00 percent by 1976 and 3100 percent by 2000. Increases of 1800 d 4200 percent respectively are anticipated for combined hunting, shing, hiking, and riding visits (27). Table 8 details present d future recreational use.

At present there are two improved recreation areas within the tershed, Tom Bennett Campground and Fish Creek Picnicground (Figure), with a combined capacity of seventy-five persons. Over the ree summer holidays and their accompanying weekends, use at these mpgrounds exceeds several times the capacity. During the summer ason from Memorial Day to Labor Day, 1961, use of these campgrounds s 17,500 visits or 35,000 visitor days (17). Although no figures e available for the rest of the watershed, its use is surely mmensurate with use of the campgrounds. There is ample evidence over-use at the established campgrounds as well as at the numerous promptu ones scattered throughout the easily accessible reaches the watershed.

The National Forest Recreation Survey (NFRS) has listed 42 ssible recreation facilities in the Little South Poudre watershed. ese include 31 campgrounds, three scenic overlooks, five hiking d riding areas, a scenic area, a geologic area, and a winter sports ea. Portions of the scenic and hiking areas are outside the water- ed. A description of the possible recreation facilities may be und in Table Q of the Appendix. The potential scenic area extends m Comanche Peak to the vicinity of Crown Point; the geologic area tends from the cirques in the Fall Creek drainage to Pingree Park. designated, these areas will be managed for their scenic and logic value.

Additional recreation facilities are proposed at Brown's Lake, manche Lake, and Fall Creek.

The wilderness values of Rocky Mountain National Park add yet other dimension to the recreation resources of the Little South udre.

Fire Protection

Except for the extensive fire of 1890, which burned from Big ver Creek near Comanche Reservoir to the Cache la Poudre Canyon, re has been only one other large fire recorded on the watershed). It razed 256 acres in 1954 on Quigley Mountain. From 1930 ough 1962, only 30 fires have occurred. There is some evidence a widespread fire in the spruce-fir type, but it is very ancient.

Table 8

Present and anticipated recreational use on National Forest lands

Type of use	Use in thousand visits per year[1]				
	1946	1957	1966	1976	2000
Camping	3.3	18	67	115	200
Picnicking	17.0	19	162	130	330
Winter sports	--	--	10	10	25
Other	3.0	150	165	250	450

1/Based on estimates for Poudre District, Roosevelt National Forest, and estimates of breakdown provided by Wayne Parsons, Recreation Forester, Roosevelt National Forest (17).

Figure 48. The entrance to Fish Creek Picnicground.

Lightning fires, generally restricted to less than one-half acre in size, have been the greatest cause of previous fires. In future years the increased recreational use of the watershed will undoubtedly bring about more man-caused fires. It is expected that improved, rapid fire-detection systems will keep these fires confined to relatively small areas.

During the fire season from late spring to early autumn, the Forest Service maintains a lookout tower on West White Pine Mountain. Following widespread lightning storms, contract aircraft are used for reconnaissance flights. The increasing numbers of visitors to the watershed improve rapid detection of small fires.

The fire suppression manpower is located within the watershed during a large part of the fire season in the form of the summer camp student body at Pingree Park. Additional manpower could be drawn from the settlements along the Cache la Poudre River. Should a large fire occur, the well-developed fire suppression organization of the Forest Service would be brought to bear upon it.

Roads and Developments

The present road system is rapidly becoming inadequate. Expenditures for new road construction, road re-alignment, widening, and maintenance can be anticipated. The Pingree Park road from the junction of the Buckhorn Road to Pingree Park has been surveyed for re-alignment. Timber access roads in the Beaver and Little Beaver drainages will be built in connection with future timber sales (see Figure 37).

Two major physical developments have been initiated. William Morgan, the largest private land owner in the watershed, has begun selling building lots in an attempt to introduce summer homes in the area. Paradise Valley Enterprises, Incorporated, has also surveyed building lots on its property near Hourglass Reservoir.

INTERPRETATIONS AND RECOMMENDATIONS

Interpretations

In assessing the potential of the Little South Poudre resources--
ber, range, water, and recreation--it is apparent that their value
not evenly balanced. The value of the timber resource is handi-
ped by the pronounced lack of markets for watershed timber products--
ituation which shows no promise of change in the near future. The
ication of timber management practices could materially upgrade
duction, but in the absence of established markets little incentive
need to do so exists. Current and planned timber sales notwith-
nding, the value of the watershed timber resource may be said to
largely unrealized.

The Little South Poudre is not primarily grazing land. The
ted amounts of forage available are devoted toward year-long
port of big game animals and summer grazing of small numbers of
stock. Except for a few areas, range condition is good. The
e resource of the watershed appears to be used to best advantage;
value is realized but minor.

As a water-producing area, the Little South Poudre has a very
present and future value. The water released from the snow-
during the summer is of excellent quality, even during peak
s. The watershed as a whole is therefore in excellent condition
thus the central goal of management should be oriented toward
cipating and preventing damage to the watershed as other uses
ease. The value of the water resource is largely realized but
be increased by watershed management practices which might alter
r yield timing, increase quantity, and maintain high water
ity.

The potential value of the watershed as a recreation area is
very large. Hunting, fishing, camping, and other forms of
eational activity are increasing rapidly. The recreation resource
he watershed is in a process of realization. The problem of
gement will be to guide and control recreation use so that it
not reduce the value of other watershed resources.

Considerations for Watershed Management

amflow Timing

Of an estimated 18 to 22 inches of annual precipitation, two-
ds comes as snow. Snow accumulation generally varies directly
elevation, but actual and "effective" precipitation may differ
iderably, particularly in the alpine zone, due to wind transport
now.

A comparison of compactness coefficients, drainage densities, and
am gradients for the Little South Poudre indicate that the

ershed has a well developed drainage system which tends toward a gh percentage of yield in a short period of time. At the present ne, 40 to 50 percent of the annual runoff of approximately 10 inches curs during the month of June. The hydrograph from the watershed a typical snowmelt hydrograph. Manipulation of the watershed to due the peak and decrease the slope of the recession curve is the st promising approach to water yield management in the Little uth Poudre. The watershed lends itself to such an approach in at:

1. The topography of the headwater areas, along with the high elevational range, seems to be ideally suited for alpine snowfield management to improve the runoff regime. Natural catchment basins, where the extent of snowfields could be augmented by induced drifting, are abundant in the headwater areas. The reduction of peak runoff occasioned by the delayed melting of larger drifts would be abetted by the nature of the alpine soils. Alpine Turf soils (the predominant soil of the alpine) are typically light textured and shallow, averaging about 20 inches in depth to the parent rock. These soils have a high percentage of large pores, with consequent rapid percolation rates and high capacity for detention storage. Provided there is adequate vegetative cover, infiltration rates are likewise high.

2. The glaciation of the median elevational ranges of much of the watershed facilitates delayed yield through increased subsurface flow. Information from the Fall Creek drainage (lower percentage of total yield at peak of the hydrograph and a more gentle recession curve) indicates a large storage capacity. The Podzol soils, typical of the subalpine zone, also encourage subsurface flow. The thick organic horizon on the surface provides for rapid infiltration rates. The coarse texture, over 55 percent sand, results in a high percentage of large pores and correspondingly high percolation rates. Depth of the entire regolith may be up to 80 inches, resulting in high capacity of detention storage--a desirable feature in regard to water yield.

3. Generally speaking, the landform, geology, and soils of the lower watershed do not encourage subsurface flow. The zone of significant snow accumulation, however, lies above this area. Although the upland soils of the montane zone are generally coarse-textured with high percolation rates, there is virtually no detention storage because of their shallowness. Because of the generally more open nature of the vegetation and the steepness of much of the landform, infiltration rates are low. The valley bottoms, however, are of value in managing for reduced peak flows. The Chernozemic-Regosol and Chernozem soils which characterize these areas are relatively deep. They therefore possess a high detention capacity during the spring runoff peak which in turn increases streamflow later in the summer.

Although the major water rights in the watershed are owned by municipalities, these rights are traded for water the year around; thus the principal use of water from this watershed is for irrigation. The most desirable distribution would be a more uniform yield throughout the growing season. In the absence of major storage structures in the watershed or on the Cache la Poudre River, it is believed that a change in streamflow timing could best be approached through snowfield management programs in which the advantageous physical characteristics of the watershed are utilized.

Water Yield

It has been adequately proved that water yield can be increased in the subalpine zone at the Fraser Experimental Forest; however, these increases have been accompanied by higher peak flows. The conditions of the subalpine zone of the Little South Poudre are similar to those at Fraser. Exact recommendations have not been worked out, but it can be assumed that cutting of the spruce-fir type in blocks or strips will result in some increase in streamflow should future need warrant the effort. It may be that the greatest value of timber in the watershed is not based on wood fibre, but on the water produced by its harvest.

Recommendations

Land Use Practices

Practical steps in management of the Little South Poudre must be taken even though information on the land resource is incomplete. The watershed is being used at ever-increasing intensities and inevitable changes are occurring in total land use and in the type of use. Since the principal vegetative cover is generally intact and only minor erosion is evident, it is apparent that the general philosophy of management in the coming years must be one of directing the increased use within the context of protecting the resources of the watershed. It follows that many of the serious problems of land use are potential; their development will bear a direct relationship to intensity of use and quality of management.

The priority of uses on the watershed should be in this order:

water, recreation and wildlife, timber, and grazing. This sequence is based on need, demand, and the capacity of the watershed to supply the various uses.

The following problems and/or recommendations are recognized:

1. <u>Access and zoning</u>: These are problems warranting careful consideration and planning. Private ownership and developments in some areas restricts the use of public land. Moreover, perhaps 60 percent of the watershed is inaccessible except by foot. The intensification of land use will entail the construction of roads. However, roads may contribute increased sediment to the streams. They may also conflict with a wilderness type use which is presently thought to be the optimum use of some alpine and subalpine areas.

   The road system should be designed as an all-purpose network to adequately serve resource management needs. This will entail continuing effort to gain access through some privately held lands or, alternately, constructing roads which avoid these lands. All new roads should be so constructed and maintained as to minimize the transport of sediment to the streams.

   Although a major part of the watershed is suited for general recreational use, a few suitable areas should be set aside at least temporarily to maintain near-pristine conditions. Some of the glaciated area is in this category: upper Beaver Creek, upper Fall Creek, and the upper main stem of the Little South Poudre.

   Some existing and poorly maintained roads--notably the Flowers Wagon Road--could be improved and spurs constructed for timber harvest, recreation, and other uses.

2. <u>Campgrounds</u>: Over-use of the two campgrounds along the main stem of the Little South Poudre and the occurrence of numerous impromptu campsites pose problems in watershed deterioration, pollution, and lack of optimum enjoyment for which the area is well suited. Soil compaction is evident on both campgrounds and although serious die-outs of trees have not been observed, it can be assumed that this type of damage will soon reduce the esthetic value of present sites.

   Campground and picnic facilities should be increased in the lower watershed to reduce use of present campgrounds and as a measure of zoning. Every effort should be made to locate these units away from the streams in order to prevent pollution. The relatively shallow water table in many areas may provide water supplies to the campgrounds from wells. Automatic pumping of water to high land from the streams is another possibility worthy of consideration. There are many park-like areas and meadows in the watershed which should be suitable for campground use.

3. Overland travel: Jeep travel away from improved roads is causing gully erosion in the watershed. Evidence of such erosion is present in many steep-gradient meadows, particularly in the alpine area near Brown's Lake.

   Additional signs should be placed at the entrance to critical areas asking jeep travelers to keep out and warning them of the erosion problem. If proper locations can be found, barriers should be constructed. Patrol by recreation-fire control guards may be effective. If these approaches do not bring the problem under control, it is recommended that some type of improved road be constructed where necessary.

4. Wildlife: The deer and elk populations on the watershed appear to be well managed. There is sufficient hunting pressure to maintain the herds within the winter range capacity. Since the deer herds migrate in winter to the north side of the Cache la Poudre River, the principle winter use is by elk. Overgrazing problems could arise in alpine and subalpine areas in the future.

   The maintenance of adequate range for deer and elk--in particular winter elk range in the lower watershed--should be included in future land use programs.

   In similar vein, the present beaver population on the watershed does not appear to be excessive. It should be kept within the capacity of the area in the future. Abandoned dams should be broken as a measure of streamflow control.

5. Grazing: Despite general reduction in allotments, the alpine areas are overgrazed in spots. Past heavy use by sheep has broken the turf in these spots and erosion has progressed. Revegetation is difficult on the severe alpine sites and denudation persists for long periods where overgrazing occurs.

   The alpine areas are too high for cattle grazing. There is strong evidence that sheep grazing in the alpine area of the watershed is uneconomic (small numbers and short grazing season). Therefore, eventual elimination of domestic livestock grazing from the alpine should be the management goal. In the lower portions of the watershed, it is recommended that the present type of management be maintained.

6. Logging: Gullying can be anticipated on almost any timber sale, and especially so on steep slopes of shallow soils such as are found on much of the watershed. Many such areas now support a good vegetative cover, but logging may permanently damage them and impair water quality as a result of subsequent and long-continuing erosion.

   Protection forests should be delineated and maintained as they are until it has been adequately demonstrated that these environments can be logged without permanent damage. In the absence of present timber markets, such zoning may be coordinated with wilderness-type recreation use.

   Observations of erosion should be made and analyzed on the first timber sales in the drainage or under similar conditions in other nearby drainages. Criteria should be developed for road damage, skid trail layout, water bar spacing, and other erosion prevention measures that will minimize soil movement. The criteria should be incorporated in timber sale contracts and judiciously enforced.

7. Timberline: The spruce-fir type provides the bordering edge of timberline. It has been adequately demonstrated that once this edge is cut regeneration is difficult. Subsequent lowering of timberline occurs with increased erosion and the increased occurrence of snow slides.

   Timberline should be maintained at the present locations by delimiting a buffer zone in the spruce-fir type wherein no cutting would be permitted.

ratershed Recommendations

The following is a brief listing of recommendations for some sent and anticipated problems in the subwatersheds of the Little th Poudre. The list is of course not exhaustive, but at least of the major problems will be touched upon.

Little Beaver Creek

1. Observations of surface flow around the upper stream gage have been reported and should be investigated.
2. A proposed access road in connection with future timber sales presently follows the stream closely. It is recommended that the road be constructed at some distance from the creek in order to preserve good water quality.
3. The old Flowers Wagon Road should be rehabilitated to

provide good access to the drainage. Perhaps it could serve as the timber access road. It would certainly provide better access to the stream gaging stations and to recreational developments which may be located in the drainage.

4. It is recommended that one or more campgrounds be located in the drainage (preferably along meadows or parks) to better control camping.

5. A fairly advanced gully in Jack's Gulch should receive treatment, particularly at the headcut.

√ Fish Creek

1. No access road into the drainage presently exists. As a result, recreation in the form of fishing and hiking is the chief use and there are no major problems. For the near future, the area should be continued in this use.

√ Beaver Creek

1. Cross-country jeep travel to Brown's Lake from the vicinity of Crown Point is producing erosion at several points. It is recommended that this travel be curbed if possible through the use of warning signs and barriers. If this is ineffective a road should be constructed.

2. In order to better control camping, a campground at Hourglass Lake and at least minimal facilities at Brown's and Comanche Lakes should be constructed.

3. Private land is so located that access to the upper drainage is seriously impeded. An attempt to gain access through trading or buying the appropriate land would be advantageous.

4. Particularly if such access is gained, drainage of the road to Comanche Reservoir should be improved.

√ Fall Creek

1. Sanitation facilities are needed where the Mummy Pass Trail leaves the Cirque Meadows Road.

2. In view of the water storage features of the drainage, it is believed that timber harvest would not be beneficial.

3. The trails in the drainage should receive continued maintenance, particularly where Tote Gote use is increasing.

Little South Poudre (mainstem)

1. The road to Twin Lake is in need of waterbars and relocation of segments of the road to control erosion.

2. The proposed relocation and widening of the Pingree Park Road should be carefully evaluated for proper drainage and effect on the stream channel.

3. Treatment of sewage from the Pingree Park Campus is needed to preserve water quality. If summer homes become established in the drainage to a significant extent, close watch of the sewage disposal systems is recommended.

4. If REA and telephone lines are installed to the Pingree Park Campus, there should be careful attention paid to the location and post treatment of the installations.

5. Additional campgrounds should be installed to relieve the pressure on the two existing ones.

Pennock Creek

1. A timber sale is in progress. Its effects on stream sedimentation should be closely observed with a view to establishing criteria for road drainage and timber harvesting methods to be followed in this landform and timber type.

2. Since the Pennock Creek drainage is principally the lodgepole timber type, further harvesting should be postponed pending stream gage calibration which would facilitate further studies.

Pendergrass Creek

1. This drainage is presently receiving very little use and as a result there are no major problems. If the Flowers Wagon Road is improved, careful forethought on the impact of increased recreational use will be required.

SUGGESTED RESEARCH

1. Geologic studies as related to hydrology which might include examination of glacial soils and of the water storage factor of moraines and other glacial features.

2. Study of campground influences on soil stability, soil compaction, and water quality.

3. A standard soil survey of the entire watershed.

4. Evaluations of the effects planned timber sales have on streamflow and on snow accumulation in the logged areas.

5. Range condition and trend studies in the alpine and the influence of alpine grazing on water yield.

6. Evaluation of the role of wet meadows in water yield--particularly snow accumulation, runoff and ground water storage.

7. A comparative water yield study of alpine and timbered watersheds or smaller areas.

8. Study of wind redeposition of snow and the influence of natural and artificial barriers.

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Table A

Area - Elevation Calculations

vation 0 feet)	Tally	Accumulated tally	Per cent area below elevation	Mean zonal elevation	Moment about M.S.L.
65					
	1	1	0.2	6,750	6,750
70					
	4	.5	1.2	7,250	29,000
75					
	20	25	6.1	7,750	155,000
80					
	44	69	16.7	8,250	363,000
85					
	54	123	29.8	8,750	472,500
90					
	63	186	45.1	9,250	582,750
95					
	59	245	59.5	9,750	575,250
100					
	57	302	73.3	10,250	584,250
105					
	46	348	84.5	10,750	494,500
110					
	38	386	93.7	11,250	427,500
115					
	21	407	98.8	11,750	246,750
120					
	3	410	99.5	12,250	36,750
125					
	1	411	99.8	12,750	12,750
130					
	1	412	100.0	13,250	13,250
135					
otals	412	412	100.0	----	4,000,000

$$\text{Mean elevation} = \frac{4,000,000}{412} = 9,709 \text{ feet.}$$

Table B

Slope - Area Calculations

cent pe	Tally	Accumulated tally	Per cent area above slope	Mean zonal slope (%)	Moment about M.Z.S.
0					
	3	3	2.9	75	225
0					
	3	6	5.9	65	195
0					
	9	15	14.7	55	495
0					
	17	32	31.4	45	765
0					
	23	55	53.9	35	805
0					
	22	77	75.5	25	550
0					
	16	93	91.2	15	240
0					
	8	101	99.0	7.5	60
5					
	1	102	100.0	2.5	2.5
0					
tals	102	102	100.0	----	3,337.5

Mean slope = $\frac{3,337.5}{102}$ = 32.7 per cent.

Table C

Surface area, compactness coefficient, stream gradient, stream length, and drainage density of the sub-watersheds of the Little South Poudre

Sub-watershed	Area sq.mi.	Compactness coefficient	Stream gradient %	Stream length mi.	Drainage density
Little Beaver Creek	18.11	1.33	7.5	12.2	0.67
Fish Creek	6.60	1.46	7.9	5.6	0.85
Beaver Creek	22.27	1.37	5.3	15.1	0.68
Fall Creek	4.31	1.35	10.6	4.8	1.14
Little South Poudre (main)	30.93	2.25	5.0	20.2	1.08
(trib.)				13.1	
Pennock Creek	17.55	1.17	6.5	10.4	0.59
Pendergrass Creek	5.16	1.36	10.8	7.0	1.36

$$\text{Compactness coefficient} = \frac{0.28\ (\text{perimeter, miles})}{\text{area}}$$

$$\text{Stream gradient} = \frac{\text{head to mouth relief}}{\text{distance}}$$

$$\text{Drainage density} = \frac{\text{stream length}}{\text{surface area}}$$

Table D

Geomorphic Hydrology
Proposed Analysis

The hydrograph is one of the more important indicators of tershed behavior. It is difficult to break the hydrograph down to zones of influence resulting from climatic, vegetal, soil, and pographic factors. Some attempts have been made, one of which was Potter (18). He ran regression analyses on several Appalachian ateau watersheds in an attempt to relate certain morphometric rameters to the hydrograph. He arrived at this equation for peak tensity:

$$\log q_{max} = -1.421 + 0.170 \log A - 0.554 \log T + 0.929 \log P + 0.449 \log S$$

Where qmax is the peak intensity of runoff in cfs per acre, r a 10-year recurrence interval.

A is area in acres

T the topographic factor, is the ratio of longest length of principal stream to square root of average channel slope from head to mouth.

P the rainfall-intensity factor, is the average ratio of rainfall intensity for 10-, 25-, and 50-year recurrence intervals for a particular location, to similar values derived from long-term rainfall records for Columbus, Ohio.

S frequency of rainfall is the average ratio of the product of annual rainfall and number of excessive storms for the 10-, 25-, 50-year recurrence records for a particular location, to similar values derived from long-term rainfall records for Columbus, Ohio.

The vegetation factor was not introduced by Potter because its atistical test was not significant for these basins. The effects water storage in the soil was indirectly measured by the variables used.

Morisawa (16) continued a portion of Potter's work on these palachian watersheds, and has perhaps arrived at more efficient rameters for the topographic factor. They are, in her words:

"Discharge and runoff intensity in these watersheds of the Appalachian Plateau are closely correlated with stream length, area, and frequency of first-order streams and inversely related to stream gradient, relief ratio, and circularity ratio. Analysis of simple correlations of hydrology and geomorphic features provided a basis for choice of properties for use in multiple regressions on peak intensity of runoff."

Definitions:

L, stream length -- ...total cumulative length of all stream segments of all orders contained in basin...

F_1, frequency of first-order streams -- density of number of first-order streams per unit area.

R_h, relief ratio -- ...ratio of total relief of a basin to its longest dimension parallel to the principal drainage line...

R_c, circularity ratio -- ...ratio of the area of a basin to the area of a circle with the perimeter of the given basin...

Morisawa's topographic parameters for the Little South Poudre atershed appear on page 92. It was felt that since the Little outh Poudre watershed has had such a complex geologic and physioraphic evolution it would be worthwhile to break the entire waterhed down into its tributary components.

To continue with Morisawa's article, "Substitution of first-order stream frequency, relief ratio, and circularity ratio, each as topographic quantities in Potter's regression of area, rainfall, and topography on peak flow, and calculation of new regression coefficients provided equations greatly reducing average standard error. An equation substituting a product of these three factors ($F_1 \cdot R_c \cdot R_h$) for T resulted in a regression with high correlation, significant at the 0.001 level. A multiple regression, then, of area, rainfall, and topography on peak intensity of runoff provides a means of predicting runoff intensity for watersheds on the Appalachian Plateau."

Morisawa's morphometric parameters for the
Little South Poudre Watershed

– ershed	Stream length mi.1/	Stream gradient ft/mi.	Frequency 1st order no/mi.	Relief ratio	Circul. ratio	Drainage density
tle aver reek	45.2	393.9	3.31	0.079	0.531	2.50
h eek	17.9	419.4	5.76	0.102	0.429	2.70
ver eek	33.8	279.2	1.53	0.093	0.503	1.52
l eek	9.6	557.6	2.78	0.167	0.535	2.23
tle South udre nainstem)	125.6	263.7	7.79	0.075	---	4.06
nock eek	68.6	341.3	7.29	0.124	0.742	3.91
dergrass eek	27.7	569.0	14.15	0.144	0.529	5.37
ire tershed	328.3	263.7	5.58	0.075	0.440	3.13

orisawa (15) indicated two major methods for measuring stream engths from maps:

1. Measuring indicated streams
2. Measuring indicated streams plus V-shaped contoured channels having no indicated streams.

orisawa found greater accuracy on small watersheds using the econd method; the above stream lengths were measured by this ethod.

Table E

Proposed correlation of Rocky Mountain National Park glaciations with the Wyoming glaciations suggested by Eliot Blackwelder (2).

Geologic Time	Glacial Stages and Substages
Recent	
Little Ice Age	Neoglaciation
glacial	Gannett Peak
interstadial	Spanish Valley
glacial	Temple Lake
interstadial	Castle Valley
Pleistocene	
Wisconsin	Pinedale
Mankato	Late Pinedale
Cary-Mankato Interval	Pack Creek
Cary	Early Pinedale
Tazewell-Cary Interval	Lackey Creek
	Bull Lake
Tazewell	Late Bull Lake
Iowan-Tazewell Interval	Porcupine Ranch
Iowan	Early Bull Lake

Table F

Site characteristics of sample soil profiles

Sample number 1/	Tentative classification	Vegetative type - Parent material	Aspect	Slope %	Elevation feet
1	Podzol	Spruce-fir Glacial till	N	10	9,500
2	Cold Zone Gray Wooded	Lodgepole pine Glacial till	E	55	9,400
3	Cold Zone Gray Wooded	Lodgepole pine Glacial till	E	45	9,300
4	Regosol	Lodgepole pine Glacial till	Level	0-5	9,000
5	Gray Wooded	Douglas-fir Residium	NE	35	8,900
6	Lithosol	Ponderosa pine Residium	SE	25	8,400
7	Chestnut Chernozem Intergrade	Grass Colluvium	E	15	7,900
8	Chernozemic Regosol	Grass Alluvium	NE	0-5	7,900
9	Chestnut-Chernozem Intergrade	Ponderosa pine Grass Residium	SE	10	8,200
10	Gray Wooded	Ponderosa pine Residium	SW	20	8,500

Continued-

Table F (continued)

Sample number	Tentative classification	Vegetative type - Parent material	Aspect	Slope %	Elevation feet
11	Gray Wooded	Lodgepole pine Douglas-fir Residium	N	30	8,300
12	Chernozem	Grass Alluvium-Colluvium	E	5	8,200
13	Chernozemic Regosol	Aspen Colluvium-Alluvium	E	5	8,400
14[2]	Podzol	Spruce-fir Residium	SE	25	10,700
15[2]	Podzol	Spruce-fir Residium	SE	40	10,400
16[2]	Podzol	Spruce-fir Residium	NE	30	10,300
17	Alpine Turf	Herbaceous Residium	Level	0-2	11,400

1/The approximate location of samples is shown on Figure 9 of the text.
2/Data taken from Keller, Hans (10).

Table G

Thickness, color, reaction, and texture of sample soil profiles

Sample number[1]	Horizon	Horizon thickness inches	Color value[2]	Reaction pH[3]	Texture[4]
1	A02	1.25	----	---	----
	A2	3	5YR 5/2	5.6	Loamy sand
	B2	24	7.5YR 5/6	6.2	Gravelly loamy sand
2	A02	2			
	A1	2	5YR 4/2	---	Sandy loam
	A2	2	5YR 5/2	6.8	Sandy loam
	B2	10	7.5YR 5/2	6.4	Sandy clay loam
	C	6	10YR 6/3	6.3	----
3	A02	1	----	---	----
	A	6	10YR 4/2	6.6	Sandy loam
	B2	10	10YR 6/2	6.4	Sandy clay loam
4	A01,A02	0.5	----	---	----
	A1	5	7.5YR 4/2	6.4	Gravelly loamy sand
	A-C	7	10YR 6/2	6.4	Gravelly sand
	C1	6	10YR 6/2	6.2	Sandy gravel
	C2	4	10YR 7/1	6.0	Sand
	C3	2	10YR 6/2	6.4	Gravel
	C4	24+	10YR 7/1	6.6	Sand
5	A01	1	----	---	----
	A11	2	10YR 4/2	7.0	Sandy loam
	A12	4	7.5YR 4/2	6.8	Sandy loam
	A2	1	7.5YR 5/2	6.8	Gravelly sandy loam
	B2	8	10YR 5/3	6.6	Gravelly sandy clay loam
	C	2	10YR 6/3	6.4	----

Continued-

Table G (continued)

Sample number	Horizon	Horizon thickness inches	Color value	Reaction pH	Texture
6	A1	6	10YR 3/2	6.8	Gravelly loamy sand
	C	8	5YR 6/3	6.4	Stony loamy sand
7	A1	2	5YR 4/2	7.0	----
	A2	12	5YR 3/2	7.0	Loam
	B2	6+	5YR 4/3	6.8	Gravelly sandy clay loam
8	A02	1.5	----	---	----
	A11	7	5YR 4/2	5.4	Loam
	A12	6	5YR 4/2	6.2	Loamy sand
	A-C	6	7.5YR 3/2	5.6	Sand
	C	12+	7.5YR 4/4	6.4	Gravelly sand
9	A01	0.25	----	---	----
	A02	1.25	----	----	----
	A1	4	5YR 4/2	5.8	Gravelly sandy loam
	B2	8	7.5YR 4/2	6.0	Sandy loam
	C1	3	10YR 5/3	6.8	Gravelly massive
	C2	-	10YR 6/3	6.6	----
10	A01	0.25	----	---	----
	A02	0.1	----	---	----
	A1	1.5	5YR 3/2	6.8	Sandy loam
	A2	4	10YR 5/3	6.4	Gravelly sandy loam
	A2-B2	4	7.5YR 5/4	6.0	Sandy loam
	B21	0.75	5YR 4/3	6.0	Sandy clay loam
	B22	5	10YR 5/4	5.8	Gravelly sandy clay loam

Continued -

Table G (continued)

Sample number	Horizon	Horizon thickness inches	Color value	Reaction pH	Texture
11	A01	0.75	----	---	---
	A02	0.75	----	---	---
	A1	0.75	5YR 3/2	6.4	Loam
	A21	4	5YR 4/2	6.6	Sandy loam
	A22	5	5YR 5/3	6.8	Sandy loam
	A2-B2	5	7.5YR 5/4	7.0	Gravelly sandy clay loam
12	A11	0.25	----	---	Sandy loam
	A12	12	10YR 3/2	6.6	Sandy loam
	A3	12	10YR 3/2	6.8	Sandy loam
	B2	24+	10YR 5/3	7.0	Clay loam
13	A02	0.25	----	---	
	A11	7	5YR 3/2	6.0	Gravelly loam
	A12	6	10YR 3/2	5.8	Gravelly loam
	A-C	8+	10YR 3/2	6.6	Gravelly loam
14[5]	A00	0.25	----	---	---
	A1	0.8	10YR 4/2	5.8	Sandy loam
	A2	2.5	10YR 5/5	5.1	Sandy loam
	B2ir	10+	10YR 6/4	5.2	Gravelly sandy loam
15[5]	A00	0.25	----	---	---
	A01	0.40	----	---	---
	A1	3	10YR 4/2	5.0	Sandy loam
	A2	8	10YR 6/3	4.6	Sandy loam
	B2ir	9	10YR 5/4	4.8	Sandy loam
	B3	4+	10YR 5/4	5.0	Very sandy loam

Continued-

Table G (continued)

Sample number	Horizon	Horizon thickness inches	Color value	Reaction pH	Texture
16 5/	A00	0.8	----	---	---
	A01	0.8	----	---	---
	A02	2.0	----	---	---
	A2	12	10YR 6/3	4.5	Sandy loam
	B2ir	8	10YR 4/4	4.6	Gravelly sandy loam
	B3	4+	10YR 5/4	4.6	Gravelly sandy loam
17	A11	2	10YR 3/2	---	Silt loam
	A12	2	10YR 2/2	---	Silt loam
	B2	4	10YR 5/6	---	Sandy loam
	B2ir	7	10YR 6/4	---	Loamy sand
	C	-	10YR 7/4	---	Weathered schist

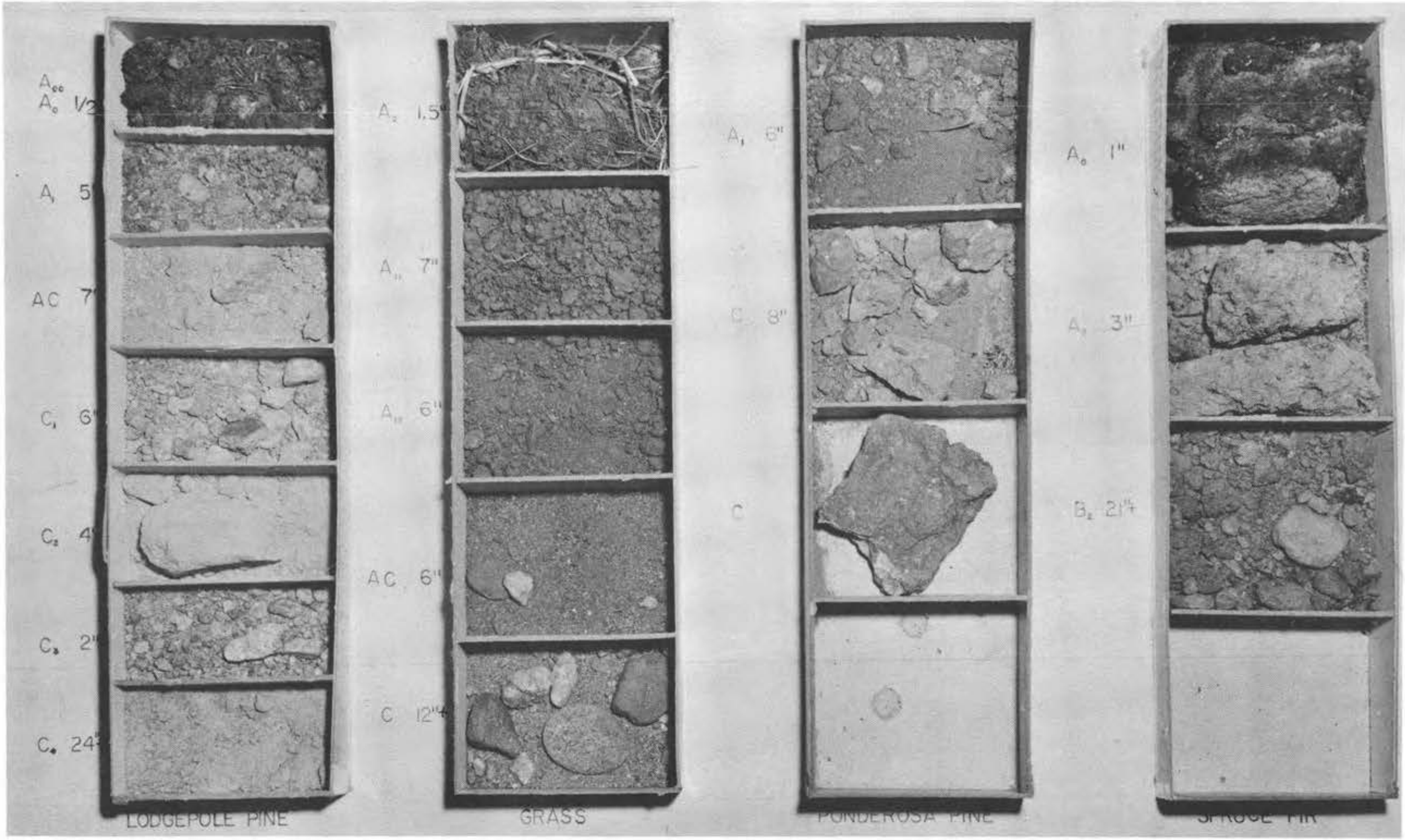
1/The approximate location of samples is shown on Figure 9 of the text.

2/Color values are from Munsell Color Charts using dry soils.

3/pH was determined roughly by a colorimetric method using chlorophenol red, phenol red, and bromthymol blue.

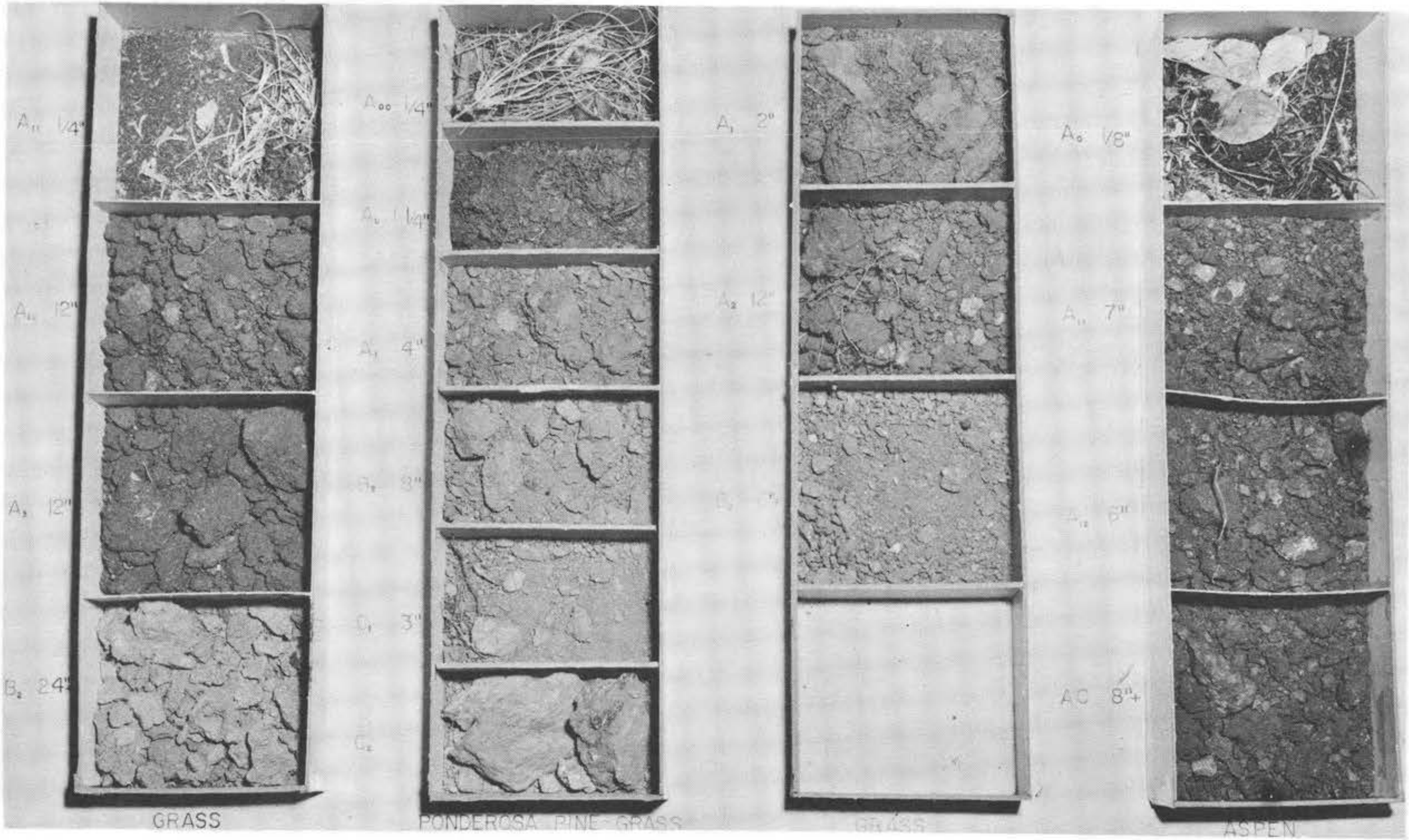
4/Textural class was determined by "feel" according to the criteria specified in the Soil Survey Manual (36) for samples 1-13. The hydrometer method was used for samples 14-17.

5/Data taken from Keller, Hans (10).



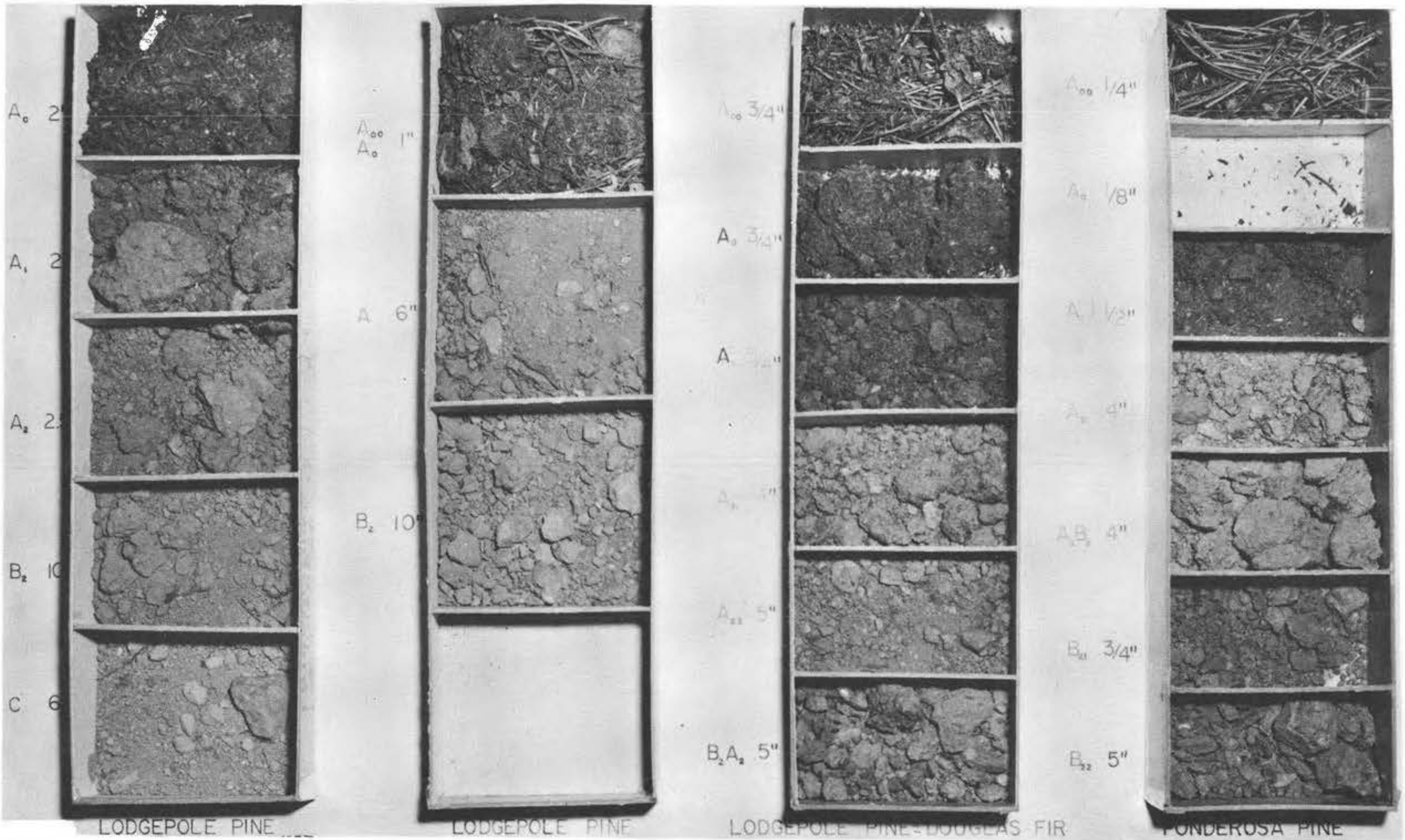
REGOSOL CHERNOZEMIC REGOSOL LITHOSOL PODZOL

Figure A. Samples of four soil profiles. The Regosol was located in deep glacial outwash; the Chernozemic Regosol in the deep alluvial bottom of the mainstem Little South Poudre; the Lithosol over coarse granite on a 25% slope; and the Podzol in the glacial till of Fall Creek at an elevation of 9,500 feet.



CHERNOZEM CHESTNUT-CHERNOZEM INTERGRADE CHERNOZEMIC REGOSOL

Figure B. Samples of four soil profiles. The Chernozem (left) was located in the deep, well-drained, colluvial meadow of Jack's Gulch. The Intergrade (left) occurred under an open pine stand at the road junction to Jack's Gulch; the other (right) on colluvial and alluvial debris from an intermittent side stream as it entered the broad bottom of the mainstem Little South Poudre. The Chernozemic Regosol was located at the head of Jack's Gulch in a poorly drained flat.



COLD ZONE GRAY WOODED — GRAY WOODED

Figure C. Samples of four soil profiles. These soils were most extensive in the watershed and occurred under forest cover at elevations ranging from 8,300 - 9,400 feet. The sample at the left was located beyond glacial moraine on a 55% slope, while its neighbor was located a short distance downslope in glacial till. The Gray Wooded soils at the right were taken on north (left) and south (right) slopes.

Table H

Yearly depth and water equivalent of snow
Hourglass Lake Snow Course

	February		March		April		May	
ar	Snow In.	Water In.	Snow In.	Water In.	Snow In.	Water In.	Snow In.	Water In.
38	--	--	22.3	5.2	30.7	7.9	20.0	6.9
39	21.1	4.3	30.8	6.1	28.6	8.4	20.1	6.8
40	17.6	3.7	19.9	5.0	22.8	6.7	11.8	4.1
41	11.5	2.2	11.7	2.5	19.8	4.2	19.1	6.7
42	20.5	2.9	22.7	5.7	26.1	6.9	35.3	10.2
43	34.5	9.4	--	--	41.1	14.6	23.4	10.9
44	6.8	0.7	13.9	1.7	--	--	--	--
45	20.8	3.7	29.2	7.5	--	--	--	--
46	23.4	3.7	26.9	5.4	24.2	5.8	3.8	1.0
47	19.5	4.6	--	--	33.4	8.5	32.2	8.1
48	--	--	27.4	6.6	33.3	8.8	25.8	6.6
49	--	--	30.4	9.2	40.9	10.8	33.1	11.5
50	22.8	3.9	26.5	5.3	29.6	13.0	27.4	7.0
51	33.3	6.3	27.0	8.4	40.8	12.2	40.9	14.6
52	26.7	7.0	51.5	15.1	28.6	11.2	26.1	12.2
53	15	3.2	18	4.1	33	8.1	28	7.7
54	12	3.2	12	3.4	28	5.6	5	1.1
55	--	--	16	4.9	27	6.1	8	2.3
56	--	--	37	9.6	33	10.8	31	9.7
57	--	--	29	6.0	29	8.6	29	10.2
58	19	2.6	19	4.0	33	7.2	29	9.2
59	--	--	25	5.3	35	9.4	24	7.4
60	--	--	18	3.7	17	4.8	7	1.8
61	11	2.5	17	3.3	25	6.2	24	7.3
62	12	5.6	27	7.1	26	6.9	13	4.0
e.	19.3	4.1	24.3	5.9	29.8	8.4	22.5	7.3
	4.7:1		4.1:1		3.5:1		3.1:1	

Table I

Yearly depth and water equivalent of snow
Colorado State University Watershed Management Unit Snow Courses

Year	January		February		March		April		May	
	Snow in.	Water in.	Snow in.	Water in.	Snow in.	Water in.	Snow in.	Water in.	Snow in.	Water in.
Fall Creek										
1961	18.8	4.0	18.0	4.7	--	--	32.9	10.4	25.7	8.7
1962	18.4	5.0	29.4	5.3	42.4	11.7	39.5	10.9	15.2	6.0
Pingree Park										
1961	15.5	3.3	13.7	3.1	--	--	25.4	7.1	15.0	3.1
1962	15.8	2.4	20.0	2.1	29.1	5.7	22.5	5.0	0.0	0.0
Sheep Saddle										
1961	--	--	20.7	4.4	40.6	8.5	44.1	11.4	35.0	12.8
1962	21.6	6.0	27.0	8.4	41.4	9.6	41.7	13.4	27.7	8.3

Table J

Mean monthly and annual precipitation
at stations near the Little South Poudre watershed.

Station name	Elev. feet	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
		Inches												
Estes Park	7525	.58	.91	1.27	2.32	2.12	1.60	2.60	2.04	1.41	1.33	.95	.78	17.89
Fort Collins	4985	.34	.57	1.02	2.09	2.79	1.53	1.56	1.40	1.35	1.13	.48	.45	14.71
Fry's Ranch	7500	.51	.80	1.17	2.26	1.97	1.42	2.34	1.55	1.40	1.70	.81	1.00	16.93
LaPorte	5053	.40	.72	1.13	2.19	2.77	1.48	1.83	1.41	1.28	1.14	.53	.56	15.44
Manhattan	7400	.48	.77	1.42	1.83	2.57	.85	2.22	1.22	1.13	.48	.21	.73	13.91
Moraine	7775	.75	1.10	1.51	2.06	2.06	1.32	2.35	1.61	1.33	1.14	.63	.73	16.59
Red Feather Lakes	8227	.88	.89	1.25	3.08	2.58	1.44	2.46	1.35	.99	1.62	1.32	.69	18.55
Waterdale	5200	.32	.60	1.21	2.20	2.68	1.86	1.83	1.54	1.41	1.23	.55	.52	15.94

Years of Records: Estes Park, 44; Fort Collins, 70; Fry's Ranch, 20; LaPorte, 38; Manhattan, 6; Moraine, 27; Red Feather Lakes, 9; Waterdale, 58.

Data compiled from records of U. S. Weather Bureau (31), (38).

Table K

Monthly precipitation--Pingree Park recording raingage
Water year 1961, (total for water year = 29.38)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
						Inches						
1		0.05							0.10		0.20	
2									0.55			0.37
3		0.02	0.30			0.28		0.50	0.25			0.75
4		0.17	0.73		0.07					T		0.42
5			0.31		0.01					0.60		
6			0.07				1.00		T			
7		0.12						0.55	T	0.19	0.10	
8		0.33				0.03		0.10		0.20	0.10	
9	0.07									0.15	0.08	
10			0.10								0.05	
11										0.12		
12		0.01			0.06			0.15		0.22	0.25	
13								3.85			0.53	
14		0.05				0.08		0.15	0.15		0.07	
15	0.44	0.12				0.07		0.38	0.20	0.10		
16				0.01	0.03		0.03	0.32		0.06	0.15	0.10
17	0.91		0.05		0.11		0.09		T		0.05	0.08
18	0.18		0.07	0.08	0.01		0.17		T			
19	0.05		0.12				0.20		0.25	0.08		0.28
20								0.16		0.05		0.12
21			0.06				0.06			0.55		0.51
22					0.10		0.18					0.90
23					0.18				T			0.35
24							0.45		0.30		0.17	0.05
25	0.02			0.05	0.15	1.33		0.22		0.10		
26			0.03	0.23	0.50			0.09				
27		0.19	0.12						0.05	T	0.05	
28		0.01								0.15		
29	0.45								0.28	0.52		0.43
30									0.05	0.20	0.10	0.02
31										0.50		
Total	2.12	1.07	1.96	0.37	1.22	1.79	2.18	6.42	2.18	3.79	1.90	4.38

Table L

Monthly precipitation--Pingree Park recording raingage
Water year 1962, (total for water year = 15.82)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar. Inches	Apr.	May	June	July	Aug.	Sept.
1	0.18								0.55	0.05		
2		0.05				0.10						
3			0.20									
4		0.18	0.03	0.10			0.16					
5							0.19					
6			0.03	0.08								
7				0.08			0.50		0.46			
8			0.28	0.60	0.10		T		0.21			0.15
9	0.07		0.05			0.25					0.04	0.05
10						0.20						
11												
12		0.33			0.07					0.45	0.05	
13		0.04		0.23						0.10		
14								0.04		0.08		
15				0.05	0.40							
16								0.10	0.30	0.09	0.05	
17		0.10						0.15				
18			0.05					0.05	0.30			
19												
20					0.12				0.05			0.45
21		0.04	0.20		0.29	T	0.20	0.10				0.25
22	0.05							T				
23					0.05	0.05				0.60	0.25	
24					0.22				0.05	0.46		
25			T		0.50			0.16		0.10		0.09
26		0.12	0.13		0.05		0.55	0.09				
27	0.07							0.25		0.05		0.03
28	0.05					0.23	0.10					
29	0.51				0.15	0.10	0.30	0.10	0.10		0.10	
30		0.07	0.05					0.05				
31						0.10				0.22		
Totals	0.93	0.93	1.02	1.14	1.95	1.03	2.00	1.09	2.02	2.20	0.49	1.02

FIGURE D.

ISOHYETAL MAP

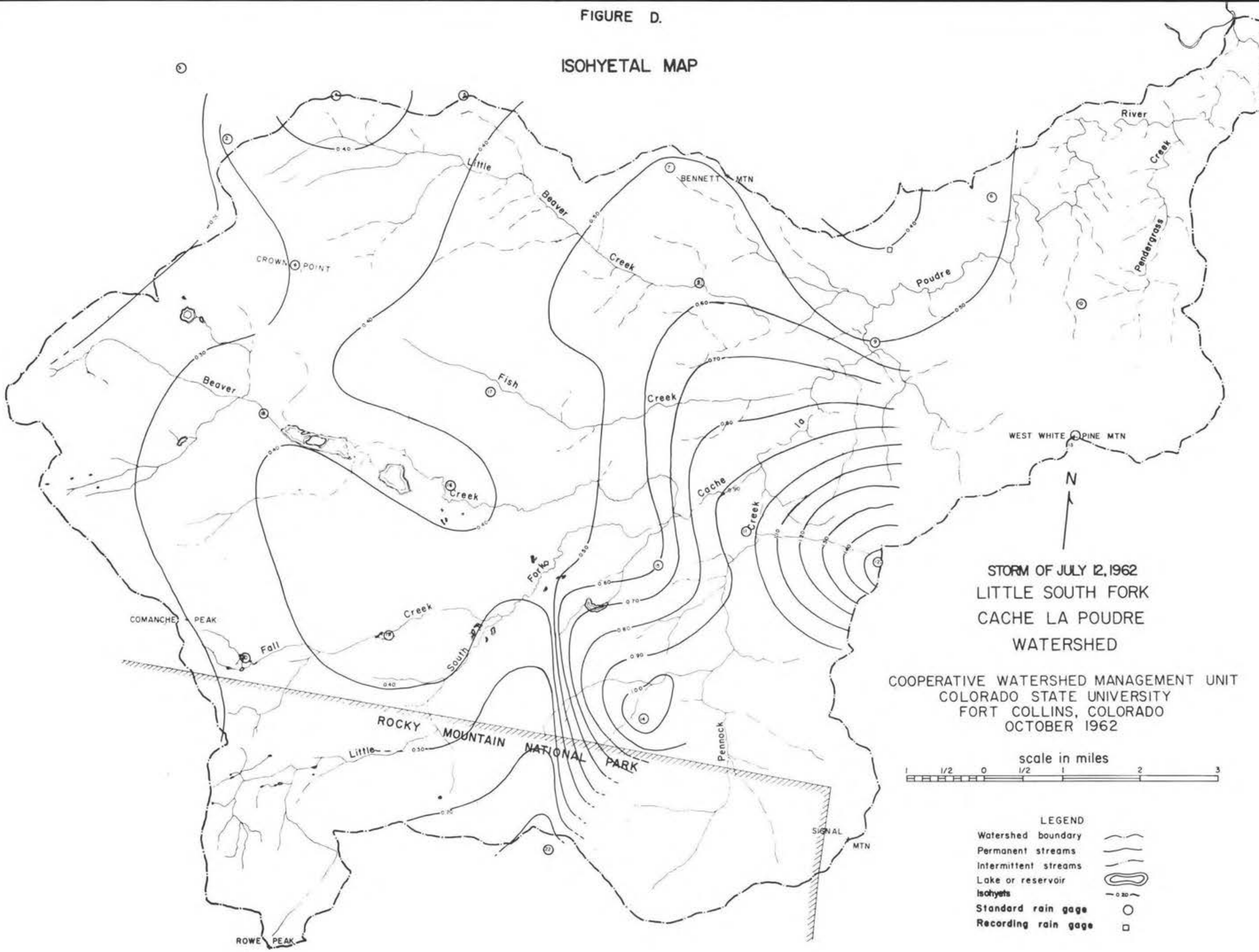


FIGURE E.

ISOHYETAL MAP

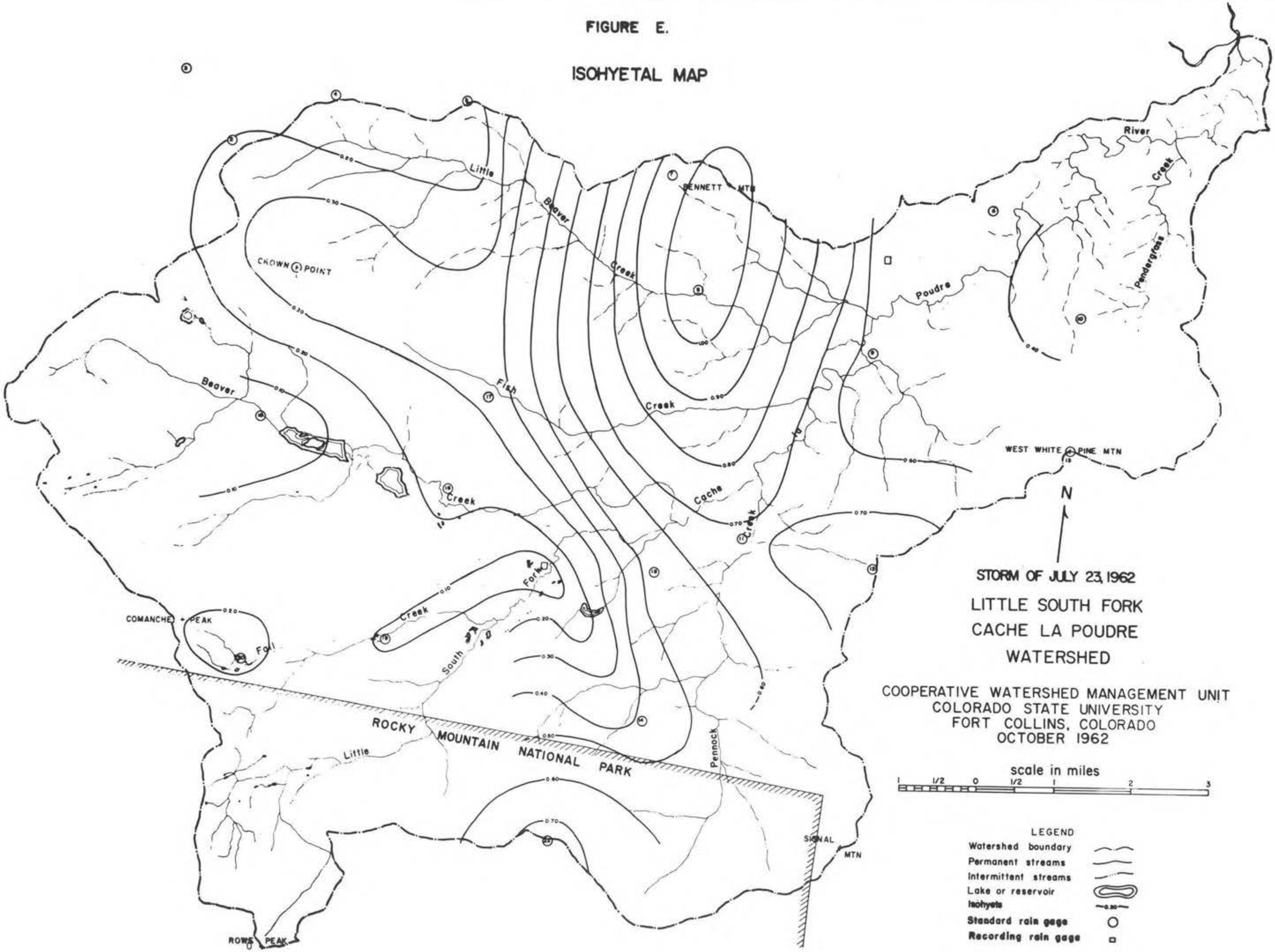


FIGURE F.

ISOHYETAL MAP

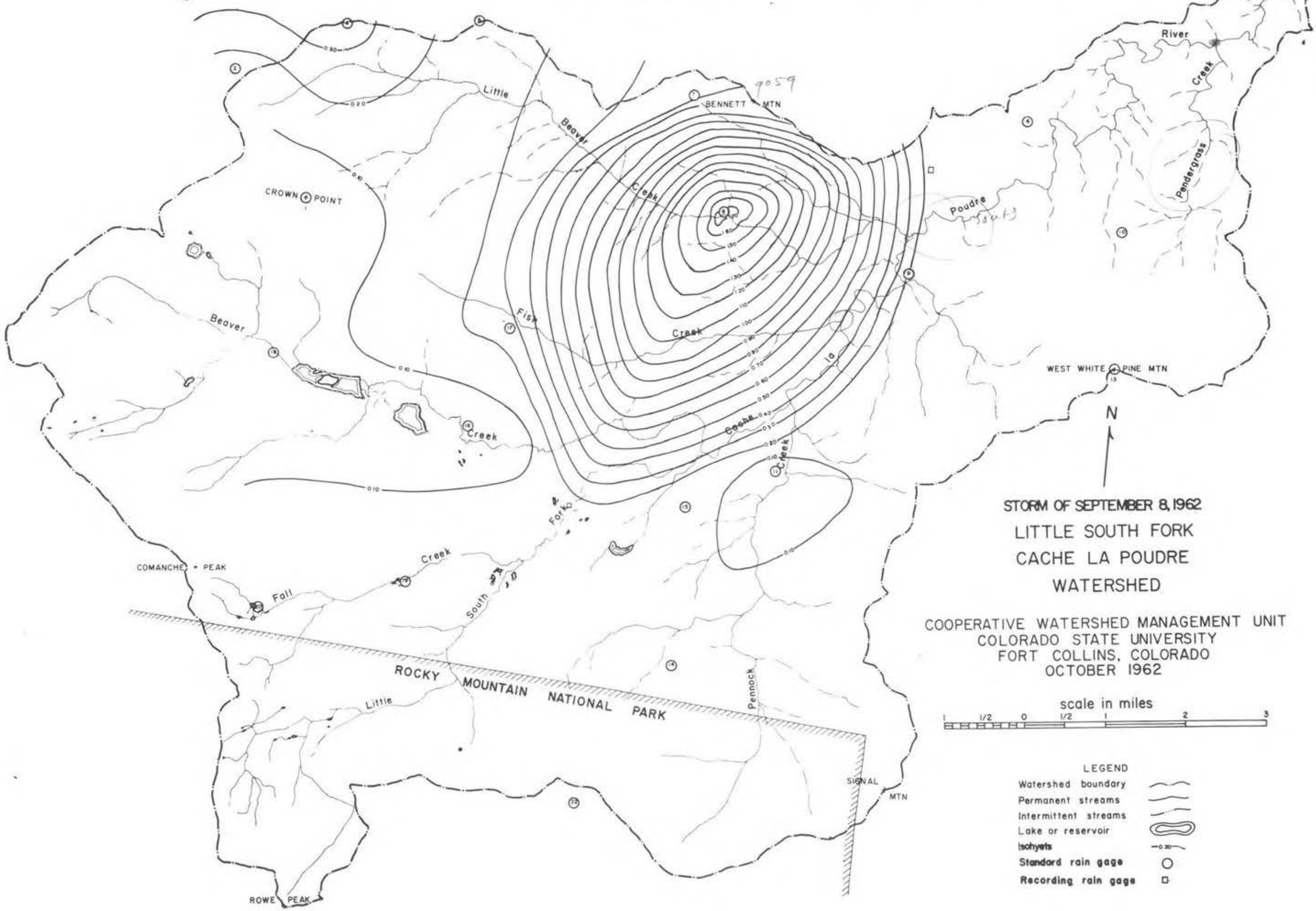


Table M

Selected precipitation intensities
Pingree Park recording raingage

Date	Time interval	Rainfall Inches
-18-62	15 minutes	0.30
-12-62	90 minutes	0.40
-26-62	5 hours	0.50
-13-61	24 hours	3.85

Table N

Rainfall estimates as taken from
United States Weather Bureau
Technical Paper 40

Frequency	Storm volume (inches)			
	15 min.	30 min.	1 hour	6 hour
10 year	0.7	1.0	1.4	2.0
25 year	0.9	1.3	1.6	2.4

Table O

Summary of non-federal landownership in the Little South Poudre watershed[1]

		Acres	
lorado State Board of Agriculture olorado State University)			
T7N - R72W			
Section 6 -	$E\frac{1}{2}$ of NW	80	
	$W\frac{1}{2}$ of NE	80	
T7N - R73W			
Section 16 -	$W\frac{1}{2}$ of SW	80	
	$E\frac{1}{2}$ of $W\frac{1}{2}$ of SE of SW	10	
	$E\frac{1}{2}$ of SE of SW	20	
Section 17 -	SE of SE	40	
Section 18 -	SW of NW	40*	
	$S\frac{1}{2}$ of $S\frac{1}{2}$	160	
Section 20 -	SW of SW	40	
Section 21 -	$SW\frac{1}{4}$	160	
Section 29 -	NW of NW	40	
Section 30 -	$E\frac{1}{2}$ of SE	80	
	SW of SE	40	
	SW of NW	40	
T7N - R74W			
Section 13 -	NE of NW	40	
	NW of NE	40	
	SE of NE	40*	
	Total acres		1,030
ty of Fort Collins, Colorado			
T8N - R72W			
Section 19 -	$W\frac{1}{2}$ of SW	80	
	NE of SW	40	
	NW of SE	40	
Section 20 -	$E\frac{1}{2}$ of SW	80	
	SE of NW	40	
	SW of NE	40	
	Total acres		320

Continued -

ble O (continued)

ties of Fort Collins and Greeley, Colorado

		Acres	
T8N - R72W			
Section 30 - W½ of SW		80	
NE of SW		40	
NW of SE		40	
T8N - R73W			
Section 25 - SW¼		160	
Section 26 - NW of SW		40	
SW of NW		40	
Section 27 - NE of SE		40	
SE of NE		40	
	Total acres		480

ambers Lake Company

T7N - R74W			
Section 3 - NE of SW		40*	
	Total acres		40

xter, Carl E. and Grace A.
and
akel, June[2]

T7N - R73W			
Section 17 - E½ of NE of NW		20	
SW of NE of NW		10	
N½ of SE of NW		20	
NW of NE		40	
N½ of SW of NE		20	
N½ of SE of SW of NE		5	
NE of SW of SW of NE		2.5	
	Total acres		117.5

enig, Frank R. and/or Hazel B.

T7N - R73W			
Section 16 - W½ of W½ of SE of SW		10	
Section 20 - E½ of NE		80	
NE of SE		40	
Section 21 - NW of NW		40	
	Total acres		170**

Continued -

ble O (continued)

<u>mbert, Ray and Edwina</u>

	Acres	
T7N - R72W		
Section 6 - NW of SE	40	
Lot 4	40	
Lot 7	40	
T8N - R72W		
Section 31 -Lot 4	40	
T7N - R73W		
Section 1 - $SE\frac{1}{4}$	160	
$S\frac{1}{2}$ of NE	80	
Section 12 - $W\frac{1}{2}$ of NE	80	
Total acres		480

<u>redith, Agnes B.</u>

	Acres	
T7N - R72W		
Section 5 - SW of SW	40	
Section 6 - $S\frac{1}{2}$ of SE	80	
Section 8 - NW of NW	40	
Total acres		160

<u>rgan, William E. and Lilla B.</u>

	Acres
T7N - R73W	
Section 2 - $NE\frac{1}{4}$	160
$E\frac{1}{2}$ of SE	80
$S\frac{1}{2}$ of SW of SE	20
Section 10 - SE of NE of SE	10
$E\frac{1}{2}$ of SW of NE of SE	5
$W\frac{1}{2}$ of NE of SE of SE	5
$E\frac{1}{2}$ of NW of SE of SE	5
Section 11 - NW of NE	40
$W\frac{1}{2}$ of SW of NE	20
SW of SE of SW of NE	2.5
$E\frac{1}{2}$ of SE of NE of NW	5
SE of NE of NE of NW	2.5
SW of NE of NE of NW	2.5
$W\frac{1}{2}$ of SE of NE of NW	5
$E\frac{1}{2}$ of NE of SE of NW	5
SE of SE of NW	10
$S\frac{1}{2}$ of SW of SE of NW	5
NE of SW of SE of NW	2.5
$W\frac{1}{2}$ of NE of SE of NW	5

Continued -

ble O (continued)

rgan, William E. and Lilla B.

N½ of NW of NE of SW	5	
SW of NW of NE of SW	2.5	
NE of NE of NW of SW	2.5	
S½ of N½ of NW of SW	10	
N½ of SE of NW of SW	5	
SW of SE of NW of SW	2.5	
SW of NW of SW	10	
E½ of W½ of NW of SE	10	
W½ of E½ of NW of SE	10	
SE of NE of NW of SE	2.5	
NE of SE of NW of SE	2.5	
NW of SW of NE of SE	2.5	
SW of NW of NE of SE	2.5	
Section 14 - W½ of SW	80	
SE of NW	40	
NE of SW	40	
Section 22 - NE¼	160	
Total acres		777.5**

radise Valley Enterprises, Inc.

T7N - R73W		
Section 7 - SW of SW	40*	
Section 18 - NW of NW	40*	
T7N - R74W		
Section 12 - SE of SE	40*	
Section 13 - NE of NE	40*	
Total acres		160**

tterson, Gladys M.

T7N - R73W		
Section 11 - SW of SE	40	
Section 14 - W½ of NE	80	
NW of SE	40	
Total acres		160

eadman, Vern and Veda

T8N - R72W		
Section 22 - N½ of NW	80	
SW of NW	40	
NW of SW	40	
Total acres		160

Continued -

ble 0 (continued)

epah Manufacturing Company

T7N - R73W			
Section 20 - W½ of SE	80		
SE of SW	40		
NW of SW	40		
Section 29 - NE of NW	40		
Section 30 - NW of NW	40		
		Total acres	240
		Total: non-federal land	4,295

Summary compiled from Larimer County Assessors Office (11) and from Land Status Records, Roosevelt National Forest (26), as of December 1962.
Sky Ranch Lutheran Camp, Inc., of the American Lutheran Church has entered into a contract to purchase this tract of land.
Includes area of reservoir.
Less fractions of area in building lots.

Table P

Hunting pressure and game kill
Game Management Unit 19[1]

	Deer			Elk		
		Kill			Kill	
ear	Hunting pressure	Bucks	Does & fawns	Hunting pressure	Bulls	Cows
1950	----	870	1162	----	7	3
1951	----	671	0[2]	----	2	4
1952	1498	928	30	----	8	0
1953	----	860	1231	----	5	0
1954	1457	766	0	75	5	0
1955	2019	515	576	41	10	0
1956	1395	689	0	65	7	0
1957	2456	760	790	70	3	0
1958	1848	805	0	149	7	0
1959	3139	856	1500	136	9	0

1/ Compiled from data supplied by H. W. Swope, Regional Game Manager, Colorado State Game and Fish Department (34).
2/ Years with 0 indicate antlered only seasons.

Table Q

Proposed recreation developments in the Little South Poudre[1/]

Type	Figure 37 number	Name	Acreage
mpgrounds			
	2	Recluse Paradise	30
	3	Trail Grove	24
	4	Forest Col	19
	5	Rockwell Meadows	25
	6	Kyle Gulch	31
	7	Blue Belle	48
	8	Ben Flowers	48
	9	Coman Springs	52
	10	Quigley Mountain	39
	11	Yellow Pine	38
	15	Pingree Park Moraine	16
	17	Fall Creek	16
	18	Pennock Pass	29
	19	Monument Meadows	62
	20	White Rock	19
	21	Brown's Lake	--*
	22	Comanche Lake	--*
	24	Paradise Valley	16
	26	Limber Pines	40
	27	Beaver Creek	36
	28	Meadow Edges	36
	29	Monument Col	15
	30	Seven Pines	78
	31	Doghair	12
	32	Pendergrass Creek	8
	33	Jack's Gulch	22
	34	Flowers Trail	22
	35	Fall Creek	--*
	36	Derby	22
	37	Monument Gulch	8
mpgrounds and ater recreation			
	13	Rockwell	46
	14	Twin Lake	38
	23	Comanche Reservoir	7
	25	Hourglass	42
erlooks			
	1	Little Beaver Creek	7
	12	Cirques	3
	16	Pingree Park	2

Appendix, National Forest Recreation Survey (27).
Not proposed in NFRS.

Continued -

ontinued -

Table Q

Type	Name	Acreage
Scenic area	Comanche	14,260
	Includes the high western rim of the watershed from the Fall Creek Cirques to vicinity of the saddle northwest of Crown Point. Not all of the area is within the Little South Poudre.	
ologic area	Comanche Peak - Pingree Park	5,053
	Includes the headwaters of Fall Creek and the mainstem Little South Poudre, which have good examples of glaciation during the Wisconsin era. The area includes the Mirror Lake Cirque outside of the watershed.	
i area	------------	190
	Located in the Beaver Creek drainage just east of Hourglass Lake.	
king and riding areas	Crown Point	1,760
	Flowers Trail	2,440
	Comanche Reservoir	2,240
	Jack's Gulch and Bennett Creek (most of the area is outside the watershed)	12,000
	Pingree Park	3,580

Table R

Scientific names of plants listed in this report

Common Name	Scientific Name
Aspen	Populus tremuloides
Bluegrass	Poa spp.
Bitterbrush	Purshia tridentata
Bromegrass	Bromus spp.
Colorado blue spruce	Picea pungens
Douglas-fir	Pseudotsuga menziesii
Engelmann spruce	Picea engelmannii
Fescue	Festuca spp.
Golden avens	Geum rossii
Hairgrass	Deschampsia caespitosa
Junegrass	Koeleria cristata
Kobresia	Kobresia myosuroides
Limber pine	Pinus flexilis
Lodgepole pine	Pinus contorta
Mountain mahogany	Cercocarpus montanus
Mountain muhly	Muhlenbergia montana
Peavine	Lathyrus spp.
Ponderosa pine	Pinus ponderosa
Redtop	Agrostis spp.
Rush	Juncus spp.
Sedge	Carex spp.
Subalpine fir	Abies lasiocarpa
Timothy	Phleum spp.
Vaccinium	Vaccinium spp.
Wheatgrass	Agropyron spp.
Willow	Salix spp.