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Soil Survey
of
The Alturas Area, California

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Bureau of Chemistry and Soils

In cooperation with the
University of California Agricultural Experiment Station

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SOIL SURVEY OF THE ALTURAS AREA, CALIFORNIA

By E. J. CARPENTER, United States Department of Agriculture, in Charge, and R. EARL STORIE, University of California

AREA SURVEYED

The Alturas area lies in the extreme northeastern part of the State of California (fig 1). It occupies the greater part of the central and eastern parts of Modoc County, several square miles in the southwestern part of Modoc County, and several square miles in the northeastern part of Lassen County. The total area is 891 square miles, or 570,240 acres. Because of the occurrence of certain physiographic features unfavorable to agricultural development the area surveyed consists of these three distinct and separate units, in each of which more or less agricultural development has taken place, and from which the more rough and mountainous intervening areas have been excluded.

FIGURE 1.—Sketch map showing location of the Alturas area, California.

The area lies about 400 miles by highway from San Francisco and about 200 miles in an air line due east of Crescent City on the Pacific Ocean.

The Round Valley unit, which is the smallest section of the survey, is in the southwestern part of Modoc County. On the south this unit joins with the earlier soil survey of the Big Valley (*5*).[1] Other boundaries of the unit are determined by the occurrence of mountainous or nonagricultural land. Ash Creek drains this unit and empties into Pit River to the west of the unit. Rush Creek and a number of smaller drainageways empty into Ash Creek within this unit and have formed a small intermountain valley of somewhat rounded configuration. Narrow strips of alluvium occupy the local stream bottoms, and in the lower part of the unit include a few small areas having poor drainage. Stream-laid deposits of older accumulation border the drainage valleys to which they slope with decreasing gradient from the surrounding mountains. About 25 square miles are embraced in this unit.

The other two units occupy the central and eastern parts of Modoc County and a small part of northeastern Lassen County. The central unit, the larger of the two, embracing about 806 square miles, is separated from the eastern unit by Warner Mountains, an uptilted

[1] Italic numbers in parentheses refer to Literature Cited, p. 54.

fault block with an elevation ranging from 6,000 to 9,000 feet above sea level. These mountains have a gradual slope westward, and streams issuing from the western slope find their way to the different forks of Pit River or, in the northern part of the central unit, into Goose Lake. At the time the field work was carried on in this area and for several years previous this lake was dry, but in seasons of normal rainfall the lake contains water the year round, and in several successive seasons of unusually heavy rainfall it may overflow through a faintly defined channel into North Fork Pit River. This fork of Pit River flows southward, paralleling the trend of Warner Mountains, and it intercepts the westward-flowing streams issuing from the mountains.

Several creeks in the southeastern part of the central unit join in Jess Valley, a structural basin, giving rise to South Fork Pit River. This fork pursues a westerly course for a few miles down the gently sloping western flank of Warner Mountains, thence it turns abruptly north, joining the North Fork at Alturas. It, likewise, intercepts the drainage from a number of creeks on the western slopes of Warner Mountains. The junction of North Fork and South Fork at Alturas gives rise to Pit River proper, which maintains a westerly course to the western edge of the area. On the north the river is bordered by a high lava plateau known locally as the Devil's Gardens. Here a number of drainageways entering the river from the south have given rise to an eroded and dissected surface configuration, with here and there remnants of the old lava plateau that no doubt covered this area to the south as far as the mountain structure just outside the southern boundary of the central unit.

The Oregon-California State line forms a part of the northern boundary of the central unit, and the other boundaries are drawn to include the greater part of the agricultural land, or land in private ownership. In most places the boundaries coincide with the boundaries of the Modoc National Forest.

Parts of Jess Valley, as well as the greater part of the alluvial bottoms bordering South Fork Pit River and Pit River proper, are poorly drained. Elsewhere drainage is well developed, except in local areas of ponded drainage or areas subject to seepage from higher land.

The eastern, or Surprise Valley, unit of the surveyed area embraces practically all the agricultural land within the State lying east of Warner Mountains. On the east these mountains drop abruptly to the valley floor, and many cliffs with sheer drops of 1,000 or more feet face the valley on the west.

The mountains are snowcapped during the winter, and on protected slopes snow frequently lasts the year round in seasons of normal precipitation. Many perennial streams and innumerable small intermittent creeks course down the eastern sides of the mountains through deeply entrenched canyons and have built a series of coalescing alluvial fans at their bases. The valley is an enclosed structural form known to geologists as a Graben, or dropped fault block (*4*). In form it is ovate, and it was at one time occupied by a comparatively deep lake, the shore line of which can be readily traced along the sides of the basin (*2*, *3*). The streams emptying

into the ancient lake built deltas at their mouths, and where not removed by subsequent erosion after the lake dried, these remain as high dissected terraces a hundred or more feet above the valley floor.

The central part of the valley is occupied mainly by a series of alkali lakes, over which the coalescing fans already referred to are spreading. The lakes are normally dry the greater part of the year and barren of vegetation, but in seasons of unusually high precipitation they may contain water during most of the year.

On the north, west, and south the fault scarp forms most of the boundary of this unit of the area. On the east the California-Nevada State line forms the boundary in the southeastern part of the Surprise Valley unit, and elsewhere along the eastern side of the area the boundary has been drawn to include a part of the lake beds in the central part of the valley.

Along the bases of the alluvial fans, where they spread out onto the old lake bed, are narrow strips of soils which have poor drainage and are variously affected with alkali. Seepage from springs and higher land has also contributed to poor drainage in local areas on the fans. The Surprise Valley unit includes about 251 square miles.

Elevations within the area range from about 4,500 feet above sea level around Alturas to about 4,200 feet in Round Valley, and 4,600 feet in Surprise Valley. Eagle Peak in Warner Mountains has an elevation of almost 10,000 feet, and this is the highest point adjacent to the surveyed area.

All that part of the area lying east of Warner Mountains was originally included in the Territory of Utah, and remained so until the organization of the Territory of Nevada when the present line between California and Nevada was surveyed.[2]

So far as is known, the first arrivals in this area settled in Surprise Valley near Fort Bidwell and Lake City in 1864. Prior to the first settlement many immigrants had passed through on their way to Oregon or to the California gold fields. They found the country inhabited by a warlike tribe of Indians, the Modocs, who waged many battles and killed many of the immigrants in or near the present area.

A few venturesome pioneers located on Pit River in 1870 and 1871, although no general movement was made to settle the area until the close of the Modoc wars in 1873.

In 1874 a bill was introduced into the California Legislature to create the county of Canby from the east end of Siskiyou County. The name was proposed in honor of General Canby who was killed during the Modoc Indian wars. Before passage of the bill, however, in February 1874, the name was changed to Modoc.

According to the United States Census report for 1930, the population of Modoc County is 8,038, all of which is classed as rural, or persons living in towns having a population of less than 2,500. The density of population is 2.1 persons a square mile. Figures are not available dealing directly with the population of the Alturas area, but it is estimated that at least 80 percent of the people in the county reside in the area surveyed.

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[2] Material on early history is taken from a printed address of E. C. Bonner on the occasion of the fiftieth anniversary (Mar. 10, 1924) of the organization of Modoc County.

Alturas is the county seat of Modoc County and is the largest town in the area, with a population of 2,338 in 1930. It is a division point on the Southern Pacific Railroad and an important shipping point in this section. Pine Creek, Willowranch, and Davis Creek are trading and shipping points of local importance in Goose Lake Valley. The town of Likely offers shipping and trading facilities to residents adjacent to South Fork Pit River, and Canby, in the western part of the area, affords similar conveniences to the people living in that vicinity. Cedarville is the largest town in Surprise Valley. It has stores, a bank, a newspaper, and many conveniences of a small town. Other towns of local importance in Surprise Valley that afford trading facilities to their respective communities are Fort Bidwell, Lake City, and Eagleville.

The most densely populated rural section is in Surprise Valley. Goose Lake Valley also is rather densely populated, but along South Fork Pit River and Pit River the ranch holdings are comparatively large and the population is rather scattered. Many sections in which the soils are shallow and water is not available for irrigation are uninhabited.

Prior to the building of the Oregon, California & Nevada Railroad (narrow gage) in 1910, this area was without transportation facilities. This road extended from Reno, Nev., northward through Honey Lake Valley to Alturas, Calif., and Lakeview, Oreg. In 1928 this railroad was acquired by the Southern Pacific Co. and the line broad gaged, making connections with the Sacramento-Ogden line of the Southern Pacific at Fernley, Nev. From Alturas the line was extended to Klamath Falls, Oreg., where it connects with the coast line of this company, thus affording good transportation facilities to this section of the area. Surprise Valley has no railroad, and all surplus agricultural commodities are hauled by highway to Alturas for shipment to outside markets. A recently constructed line of the Great Northern Railway skirts the western side of Big Valley and affords better transportation facilities to Round Valley than it formerly enjoyed.

A good paved highway leads from Alturas to Redding, where it makes connection with the Pacific Coast Highway. From Alturas, improved roads lead northward into Goose Lake Valley and southward to Likely, thence to Susanville. Two well-improved regularly used automobile roads connect Surprise Valley with the country to the west where railroad facilities are available. The more important road leads from Cedarville to Alturas through Cedar Pass, and the other through Fandango Pass, connecting the upper Surprise Valley section with Goose Lake Valley. A well-improved road extends from one end of Surprise Valley to the other, and at Cedarville a good road leads eastward into Nevada, making connection with the Victory Highway. The other roads are generally in fair condition and are passable throughout the year, except when blocked with snow or following unusually heavy rains.

Cattle and sheep are the chief agricultural exports, and they find ready markets in San Francisco, Los Angeles, and Omaha. Chilean alfalfa seed grown in Surprise Valley finds ready markets in the Western States.

CLIMATE

The climate is characterized by cold wet winters and warm dry summers. The wet winter season begins in November and continues into May, and during this season about 70 percent of the normal precipitation is received. The days are generally clear and cool, and freezing temperatures are recorded nearly every night. Occasionally temperatures several degrees below zero are experienced for several days at a time, although as a rule the extremely cold spells are of short duration. Much of the precipitation during the winter is in the form of snow which occasionally blankets the ground for periods of several weeks, although as a rule snow seldom lasts more than a few days at a time. Light snowfalls are sometimes experienced as early as October and as late as May.

Dry-farmed grain is generally sown in the fall, and it successfully withstands the freezing temperatures of winter. Cattle and sheep are generally brought in from the neighboring mountain ranges late in September or during October, and during the winter they are fed hay and concentrates to supplement the small amount of grazing available at this season of the year. The winters are not severe enough to require the building of shelters for livestock, except in the mountains where snow covers the ground throughout the winter and temperatures are low. The early and late snowfalls seldom last more than a few hours and do no damage to livestock on the open range or to crops.

The spring months are usually cool and wet, and crops make very slow growth. During the summer, daytime temperatures of 100° F. or higher are experienced occasionally, although, as a rule, the heat is not oppressive, and the nights are always cool. Though the rainfall during the summer is in general greater than in the interior valleys of California, which lie at lower elevations, it is not sufficient to be of appreciable value to crops. All crops grown in this area are irrigated where water is available, though as a rule dry-farmed grains can be successfully produced on the soils of better moisture-holding capacity.

The fall months are cool and pleasant, with frosts at night and some snow on the higher elevations. The days are generally bright and sufficiently warm to start a short growth of grass after the first good fall rains.

Cold and dry north winds occurring in April, May, and June may be followed by frost. Winds blowing from the southwest or west are of frequent occurrence during the spring and early summer, and these winds pick up an appreciable quantity of dust, especially from the dry lake beds, and distribute it over a wide area. They take up moisture from the soils during the summer, and at other times of the year they are generally cold and raw. During haying, they interfere somewhat with the handling of the crop.

Frosts may be experienced any month of the year, but as a rule the summer months are comparatively frost free. Table 1 gives frost data for Weather Bureau stations within the area.

TABLE 1.—*Frost data for three Weather Bureau stations in the Alturas area, Calif.*

Station	Length of record	Average date of last killing frost	Average date of first killing frost	Average length of growing season	Latest date of killing frost	Earliest date of killing frost
	Years			*Days*		
Alturas	18	June 18	Aug. 27	70	July 7	July 18.
Cedarville	37	May 23	Sept. 26	126	July 1	Aug. 15.
Fort Bidwell	21	May 27	Sept. 25	121	June 22	Sept. 20.

Late spring frosts do considerable damage to fruit blossoms, and early fall frosts frequently damage grain crops, vegetables, and flowers.

The rainfall throughout the valley section of the surveyed area is evenly distributed, as a rule, though the higher points and the adjacent valleys receive appreciably more moisture. As a rule, Surprise Valley receives a few inches more rainfall than does the country in the vicinity of Alturas and Canby. But because most crops are grown under irrigation, the distribution of rainfall in the valleys is relatively unimportant, so long as the seasonal precipitation is sufficient to maintain a perennial flow in the streams.

Tables 2 and 3 give the normal monthly, seasonal, and annual temperature and precipitation at Alturas and Fort Bidwell, respectively, both of which are within the area surveyed.

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Alturas, Modoc County, Calif.*

[Elevation, 4,460 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1908)	Total amount for the wettest year (1907)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	30.4	67	−23	1.45	0.67	1.82	7.8
January	27.6	69	−32	1.97	1.04	1.35	13.2
February	33.0	69	−20	1.36	.16	2.87	8.1
Winter	30.3	69	−32	4.78	1.87	6.04	29.1
March	38.0	79	−29	1.53	.26	4.13	6.9
April	46.0	87	11	1.19	.35	.39	2.8
May	51.4	98	15	1.09	1.31	1.21	.7
Spring	45.1	98	−29	3.81	1.92	5.73	10.4
June	59.2	98	25	.66	.42	1.68	0
July	67.2	104	29	.61	.21	.55	0
August	65.3	105	24	.23	.19	.27	0
Summer	63.9	105	24	1.50	.82	2.50	0
September	57.2	96	15	.69	.10	1.09	0
October	48.4	93	7	.84	1.42	1.90	.8
November	38.6	77	−2	1.03	.66	1.11	3.3
Fall	48.1	96	−2	2.56	2.18	4.10	4.1
Year	46.9	105	−32	12.65	6.79	18.37	43.6

TABLE 3.—*Normal monthly, seasonal, and annual temperature and precipitation at Fort Bidwell, Modoc County, Calif.*

[Elevation, 4,735 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1933)	Total amount for the wettest year (1867)
	°F.	°F.	°F.	Inches	Inches	Inches
December	31.2	61	−18	2.63	1.77	8.20
January	28.9	75	−21	3.31	1.89	12.00
February	32.8	85	−19	2.24	.87	4.80
Winter	31.0	85	−21	8.18	4.53	25.00
March	39.2	73	−6	2.03	.63	6.70
April	46.6	78	13	1.44	.55	1.30
May	54.5	90	20	1.19	1.13	(1)
Spring	46.8	90	−6	4.66	2.31	8.00
June	63.0	99	25	.88	.21	.60
July	70.6	105	27	.26	.25	.10
August	69.6	100	27	.21	.05	1.40
Summer	67.7	105	25	1.35	.51	2.10
September	60.3	97	20	.52	.48	2.80
October	49.6	87	12	.95	1.06	.80
November	38.7	72	1	2.03	.02	3.10
Fall	49.5	97	1	3.50	1.56	6.70
Year	48.8	105	−21	17.69	8.91	41.80

[1] Trace.

AGRICULTURE

The first settlements in the country now included in Modoc County were in Surprise Valley, and later settlements were made along Pit River. The many perennial streams flowing into Surprise Valley spread out over their fans and supplied abundant moisture for a luxuriant growth of native grasses. The abundance of water and feed led the early settlers to engage largely in livestock raising, as markets for cultivated crops were not available. Cattle could be driven to market or slaughtered for their hides and tallow or for beef, thus affording a source of income as well as food to the settlers.

Conditions for livestock raising were equally favorable in the Pit River Valley, although the presence there of warlike Indian tribes discouraged settlement for a time.

Only enough grain and vegetable crops were grown to supply the family or neighborhood needs. The occasional occurrence of frosts during the growing season also somewhat discouraged any attempt to grow any except the more hardy varieties of cultivated crops or fruits. Flour and grist mills were built at an early date at various places, and wheat was brought to them to be made into flour for family or neighborhood needs.

The United States Census for 1880 lists slightly more than 9,000 acres devoted to various cereal crops in Modoc County, and more than 21,000 acres devoted to hay crops. At this early date stockmen depended to a large extent on their animals finding forage on

the open range, and they therefore devoted less acreage to hay crops than at present. Aside from hay and cereal crops, the census mentions fruit crops valued at $1,284 and market-garden crops valued at $3,710.

According to the 1900 Federal census, the acreage of cereal crops had not increased appreciably in 1899. A very pronounced increase in the acreage devoted to hay and forage crops is shown, however, with more than 75,000 acres devoted to these crops, of which alfalfa occupied 6,374 acres. The value of animals sold and slaughtered far exceeded the value of any other commodity produced.

The 1920 census reports more than 11,000 acres devoted to cereal crops in 1919, indicating no appreciable increases in the acreage of these crops over that in 1879. The acreage of hay and forage crops continued to increase, and nearly 90,000 acres were devoted to their use. As practically no hay crops were sold outside the county, the data would indicate a rather rapid expansion of the livestock industry. The value of dairy products, excluding those used at home, was $214,305 as compared with $18,797 in 1899. Sheep and poultry raising also showed substantial increases in the numbers of animals and poultry as well as in value of the products.

The character of the present-day agriculture is shown by the census of 1930, which reports the value of all agricultural products in Modoc County in 1929 as $6,713,123, of which livestock alone was valued at $4,205,182. During the 3-year period—1929 to 1931—about 1,500,000 pounds of butterfat were produced in the area, with a value of $578,304.16. Dairy products, produced largely within the area in this 3-year period, were manufactured into 1,582,910 pounds of butter, 384,833 pounds of cheese, and 17,772 gallons of ice cream.[3] The value of dairy, as well as poultry, products shows a steady normal increase from year to year, and these industries will no doubt continue to expand as long as economic conditions warrant. Some of the land now devoted to the production of beef cattle could be utilized for dairy farming.

The 1930 census reports 53,193 cattle on the farms of Modoc County, on April 1, 1930, of which 4,525 were cows and heifers milked daily. The area is well adapted to the production of beef cattle and sheep, and the raising of these animals will no doubt continue to dominate the agriculture for some time to come. The 1930 census reports 110,099 sheep in Modoc County as of April 1. Surprise Valley is noted locally for the production of a good quality of Chilean alfalfa seed. The 1930 census reports for Modoc County 2,775 acres of alfalfa grown for seed in 1929, which produced 10,473 bushels.

The acreage of cereal crops has remained about the same over a period of many years and, though it may differ slightly from year to year, it is believed that no material change will take place in this acreage. Some fruits, such as apples, peaches, plums, and cherries, as well as truck crops and bush fruits, are grown on a commercial scale to supply local requirements. The value of such crops produced in Modoc County in 1929 was $56,180. Because of the danger of late spring frosts, the area is not well adapted to extensive commercial fruit production.

[3] Data on dairying supplied by J. C. Hays, Modoc County farm adviser.

The United States Census for 1930 reports 70,025 acres irrigated in Modoc County in 1929 as compared with 82,845 acres in 1919. Without provision for water storage the irrigated acreage will probably remain about the same.

Existing agricultural practices show little need for commercial fertilizers. In 1929, only 25 farms in Modoc County reported the use of fertilizers, at a total cost of $1,338.

On some of the larger cattle ranches, men are employed the year round, though as a rule little outside labor is hired except during the haying season. The owners of many of the larger cattle ranches contract the job of putting up the hay crop to men equipped for this work, but it is common practice for owners of the smaller ranches to exchange labor and equipment during the harvest season. Labor is in general plentiful, American born, and efficient.

The farms range in size from more than 10,000 acres in some of the larger cattle ranches to less than 80 acres in some of the irrigated ranches devoted to dairying or alfalfa-seed production. Most of the dry-farmed ranches embrace about 640 or more acres. The average size of ranches is now about 725 acres, as compared with 299 acres in 1880. Under the present system of livestock production, the smaller ranches have proved unprofitable and have gradually been absorbed by the larger ranches.

In 1930, 82.9 percent of the farms were operated by owners, 14.5 percent by tenants, and 2.6 percent by managers. The most common method of rental is on a share basis, the owner taking one-fourth of the crop or cream check. Where the dairy cattle are furnished by the owner he receives one-third of the cream check. Dry-farmed lands that are rented for cash generally return about 50 cents an acre to the owner.

The farm homes are well built, and, although mainly of an early type of architecture, most of them are large and equipped with some modern conveniences. Most of the barns are large and, although generally in need of repair, are of suitable construction for present needs.

Most of the farm work is done with horses or mules, although on some of the ranches light- or medium-weight tractors are in use. The 1930 census reports 107 tractors in the county. Most of the work animals are medium-weight Percheron or Clydesdale horses. The dairy cattle are of mixed breeds, and the Holstein-Friesian breed is gaining in popularity among the dairymen. Beef cattle are largely of the Hereford breed, and purebred bulls are in general use. The Shropshire and Hampshire breeds of sheep, with some Rambouillet, are most common.

The light- or medium-weight automobile and truck are in common use on the ranches. The 1930 census reports 647 automobiles and 121 motor trucks on the farms in Modoc County. Most farm homes are equipped with radios, and telephones are in general use throughout the area. Electricity for power and lighting is available in all the larger communities and some of the more thickly populated rural sections. The county has a well-organized farm bureau which is working in the interest of agricultural development.

The breeding and marketing of beef cattle is one of the most important agricultural pursuits in this area. Most of the cattle

marketed are bred locally, very few being shipped in for feeding or fattening. Cows are bred to drop their calves late in the spring, when range and pasture conditions are at their best and the cows are in good flesh. As soon as feed is plentiful and weather conditions are favorable in the spring, the cattle are moved from the valleys into the mountains which lie mostly in the Modoc National Forest. There they are kept as long as feed remains plentiful—until late in September or early in October—when they are brought back to the valley lands and pastured on the meadows during early fall. When weather conditions become more severe they are fed hay to supplement the small amount of grazing they obtain. In years of poor feed crops, or when hay is scarce, considerable concentrate, consisting of cottonseed cake or barley, together with a small quantity of hay, is fed to the range animals.

Most stockmen plan to have 1 ton of hay for each animal carried through the winter. If concentrate is fed to range animals to supplement the hay, most stockmen feed about 1 pound of concentrate and from 5 to 7 pounds of hay a day to each animal on pasture, and from 10 to 15 pounds of hay without pasture. Cattle in feed lots to be fattened for market are generally fed a daily ration consisting of from 2 to 4 pounds of concentrate and from 25 to 40 pounds of grass or alfalfa hay to each animal.

The steers are marketed when 2 years old, most of them shortly after they are brought in from the summer range if feed is scarce, but, as a rule, they are shipped to market as fat livestock during the winter, the heaviest shipments generally being made during January. The San Francisco market takes most of the livestock shipped from this area, and a few feeders are shipped each year to the Los Angeles or to eastern markets. Occasionally some of the larger ranches ship in some feeders in seasons of unusually good feed production, but this practice is not common.

The Alturas area is an important sheep-raising district. The sheep are pastured in the Nevada desert during the winter and taken to sections of the national forest set aside for sheep grazing during the spring and summer. They are seldom fed, except when the range is covered with snow or in seasons of low rainfall when feed and water are scarce. When sheep are fed, each animal is given about 3 pounds of grass hay and from 2 to 8 ounces of corn a day. A few sheep are fattened for market each year, particularly in Surprise Valley, though most of them are shipped directly to market or to feed lots in Sacramento Valley.

The local demand for fresh milk is small, and most of the dairy products are shipped to the local creamery in Alturas or to cheese factories in Lake City or Bieber for manufacture into butter or cheese. Dairy cattle are pastured on the irrigated meadows as long as there is sufficient pasture. When pasture becomes short, they are fed hay and concentrates. A few hogs are raised on the ranches devoted to general farm crops or dairying.

Poultry production is carried on mainly in connection with other general farm operations, although a few ranches are devoted exclusively to this industry. A good market for eggs shipped outside the area is available during the summer, and it would seem this industry might profitably be extended. Local demands are met only

from April 1 to August 1, eggs being shipped in for local consumption during the rest of the year. This causes the price to be from 2 to 4 cents higher than the San Francisco market price. Turkeys do well in this district, and more are raised each year, in connection with general farm operations.

As a rule, the meadows throughout the area are irrigated by continuous flooding, with the result that the grasses consist largely of bluejoint, Nevada bluegrass, and saltgrass, together with other water-loving grasses, as well as some ryegrass, western wheatgrass, and native clovers. The grasses are necessarily shallow rooted and require large quantities of water for their successful maturity. In seasons of low rainfall, when water is not available for continuous flooding, the grasses make a poor growth, with the result that there is a shortage of hay for winter feeding.

In the Surprise Valley section, especially on the steeper fans not so well adapted to continuous flooding, considerable alfalfa is grown, and good yields of hay and seed are obtained. Alfalfa hay yields from 2 to 4 tons an acre and the seed from 3 to 4 bushels, although yields of 1,000 pounds of seed have been reported.

SOILS AND CROPS

Agricultural development by irrigation is limited because of the water supply and soil conditions, such as surface relief, drainage, alkali, or shallowness. Areas adapted to dry-farming practices are also limited by alkali conditions or shallow or leachy soils. Only about 20 percent of the area surveyed is utilized for agriculture, and only a small percentage of the unutilized soils can be further developed under future irrigation or cultural practices. However, a part of the soils now dry farmed could be utilized for more profitable crops were water made available by storage.

A large proportion of the population resides on farms, and most of the people not living on farms are dependent for a livelihood on catering to the farming population.

It is estimated that at least 80 percent of the revenue of the farming population is derived from the breeding and marketing of livestock, principally beef cattle, with a smaller number of sheep. Dairying probably ranks next in importance, with grain crops ranking of nearly equal importance. The production of alfalfa seed is of relatively high importance, especially in the Surprise Valley section. Fruit, vegetable, and poultry production are agricultural industries of minor importance. Because feeding of the livestock is essential during the winter, the production of hay crops is very important. Most of the hay is fed to livestock on the ranch where it is produced, and only comparatively few ranches produce hay exclusively for sale or in excess of individual requirements.

Maximum crop production in this area can be obtained only with irrigation. As a rule, the water supply is sufficient for present crop requirements in seasons of normal rainfall, but following a season of low rainfall the water supply is apt to be short and crop production low.

Soil conditions play an important part in crop production in any area, but in this area the relationships between soils and plants are

different from those places where the farmer depends entirely on rainfall for moisture supply. Therefore, different agricultural practices are followed. Under continuous flooding of hayfields, the rooting habits of the grasses are necessarily restricted to the upper, better drained, and better aerated part of the soil. Crop yields under such a system may be as high on shallow soils as on soils much deeper and more favorable to root penetration. On soils utilized for dry-farmed crops, or crops produced under a periodic system of irrigation, the soil factor is of decided importance. In general, the deeper the soil, the better is its water-holding capacity and fertility. The presence or absence of a compacted clay or hardpan layer has an important bearing on the rooting habits of the plants grown on the soil. If a hard compacted layer is present, the rooting zone is necessarily limited, and the plants will draw their nutrient supply from a restricted zone from year to year, instead of making use of the entire soil within the normal rooting zone of the plants. The restriction of the rooting habits of plants by a high water table, either natural or created by irrigation practices, has the same effect as a hardpan or other impervious layer at a slight depth. Dry farming here is hazardous under the best conditions, and if the soils are shallow, leachy, or subject to an accumulation of alkali, the successful production of crops is much more difficult.

Topographic features differ in different sections of the area. Places of higher elevation receive more rainfall and a more even distribution of the rainfall throughout the year, although rainfall in the valley sections is influenced to greater or less extent by the neighboring mountain ranges. In areas of good air drainage, frost damage is less likely to occur than in areas of poor air drainage. Less run-off and erosion take place on areas of moderate or gentle slope than on areas of steeper slope. The run-off of moisture is an important loss where crops depend on rainfall for their moisture supply, and erosion tends to remove the upper surface soil from the steeper lands not devoted to close-growing plants. The presence of alkali salts tends to reduce crop yields, and small quantities of alkali may be very injurious if concentrated in the surface soil.

In the classification of soils according to the methods of the Bureau of Chemistry and Soils, the soils of a given area are placed in groups called series. Each series is given a name, generally taken from the locality in which the soil was first recognized and mapped. All soils in a series are of similar origin, color, drainage conditions, subsoil and substratum characteristics, and chemical composition, so far as this can be determined by field methods. Each series may include a number of soils having different textures, depending on the quantities of sand, silt, and clay in their surface soils. The series are therefore divided into soil types, and the soil type is the unit of mapping. Each soil type indicates the series to which it belongs and the texture of the soil, for instance, Bieber (series) sandy loam (texture). Minor variations within a type are designated as a phase of that type.

For purposes of discussion the soil series mapped in the Alturas area are placed in one of the following three groups: (1) Dark dull-brown or brownish-gray soils developed under conditions of good drainage, (2) dark-gray or black soils, and (3) gray or light-

gray alkali soils developed under conditions of poor drainage. Climatic influences and drainage conditions have given rise to different types of native vegetation that occupy the soil under natural conditions. Table 4 lists the soil series in each group and shows the predominant type of native vegetation growing on these soils.

TABLE 4.—*Native vegetation on the soils of the Alturas area, Calif.*

Soil group	Soil series	Native vegetation
Prevailingly dull dark-brown or brownish-gray soils [1]	Gleason	Fir and pine.
	Pentz	Juniper, or juniper and sage.
	Lassen	
	Modoc	Sage, grass, or no vegetation.
	Standish	
	Surprise	
	Gould	
	Bieber	
	Rough stony land	
Prevailingly dark-gray or black soils [2]	Pit	Do.
	Carson	
	Hovey	
	Antelope	
	Muck and peat	
Prevailingly gray or alkali soils [2]	Lahontan	Do.
	Canby	

[1] Normally well drained.
[2] Normally poorly drained.

Within each group are soils of different agricultural value, depending largely on the depth of soil over bedrock or substratum and the degree of soil development, as expressed by the amount of clay and compaction in the subsoil. They are prevailingly of granular structure, somewhat gritty texture, and of friable field character. However, the soils in each of the three groups have certain characteristics in common which make them better adapted to certain crops than the soils in other groups.

The dark dull-brown or brownish-gray soils are well drained under natural conditions, and, if not underlain by bedrock or a cemented substratum at a slight depth, are well adapted to crops of deep-rooting habits. The soils developed under conditions of retarded drainage consist of dark-colored soils well supplied with organic matter, and they are best adapted to shallow-rooted crops or water-loving grasses. The gray alkali soils are of low agricultural value and are in general poorly adapted to agricultural development unless freed of alkali.

Under present agricultural practices the darker colored soils are used almost exclusively in the production of native-grass hay. Grain for hay or seed is grown largely on the dark dull-brown or brownish-gray soils, and alfalfa is grown very largely on the soils of the Surprise series in this same group. Drainage conditions of the soils in this group make them better adapted to growing grain or alfalfa than are the more poorly drained soils. All the fruit and vegetable crops produced in the area are also grown on the soils of the first group. The darker colored soils, if well drained, would be equally or perhaps more productive of the crops mentioned than the dark dull-brown or brownish-gray soils, but under present conditions they seem especially well adapted to continuous flooding practices under which the grass hay of the area is produced. Grass hay and some

grain are produced on the less affected soils of the light-gray or gray alkali soils, but the acreage is comparatively small.

In the following pages the soils of the Alturas area are described, and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map, and table 5 gives their acreage and proportionate extent.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in the Alturas area, Calif.*

Type of soil	Acres	Per-cent	Type of soil	Acres	Per-cent
Gleason loam	7,104	1.2	Bieber gravelly sandy loam	19,200	3.4
Gleason stony clay loam	7,360	1.3	Bieber stony clay loam	35,584	6.2
Gleason stony clay loam, steep phase	83,840	14.7	Rough stony land	20,864	3.7
Gleason stony loam	5,888	1.0	Scab land	68,224	12.0
Pentz loam	11,648	2.1	Pit fine sandy loam	4,096	.7
Pentz loam, light-colored phase	8,192	1.4	Pit clay loam	13,888	2.4
Lassen stony clay	75,520	13.2	Pit mucky loam	12,416	2.2
Modoc loam	2,944	.5	Pit clay	6,208	1.1
Standish gravelly clay loam	7,424	1.3	Pit clay, light-textured phase	9,664	1.7
Surprise gravelly sandy loam	28,864	5.1	Carson clay loam	6,976	1.2
Surprise gravelly sandy loam, coarse-textured phase	1,600	.3	Carson clay adobe	5,632	1.0
Surprise gravelly sandy loam, shallow phase	576	.1	Hovey clay loam	6,528	1.1
Surprise gravelly sandy loam, dark-colored phase	5,440	1.0	Hovey clay	1,280	.2
Surprise gravelly sandy loam, calcareous-subsoil phase	4,288	.8	Antelope clay loam	1,984	.4
Surprise fine sandy loam	10,880	1.9	Antelope clay loam, gravelly phase	3,904	.7
Surprise fine sandy loam, shallow phase	4,288	.8	Antelope clay loam, heavy-textured phase	832	.1
Surprise fine sandy loam, dark-colored phase	2,176	.4	Antelope stony clay	1,216	.2
Surprise fine sandy loam, calcareous-subsoil phase	11,392	2.0	Muck and peat	960	.2
Surprise clay loam	704	.1	Lahontan fine sandy loam	3,712	.7
Gould clay loam	3,072	.5	Lahontan fine sandy loam, heavy-textured phase	10,304	1.8
Gould clay loam, gravelly phase	6,272	1.1	Lahontan fine sandy loam, friable-subsoil phase	7,488	1.3
Gould clay	2,432	.4	Lahontan fine sandy loam, gravelly phase	2,432	.4
Gould clay, deep phase	576	.1	Canby silty clay loam	5,504	1.0
Bieber sandy loam	23,872	4.2	Canby silty clay loam, noncalcareous phase	896	.1
Bieber sandy loam, calcareous-subsoil phase	3,072	.5	Canby silty clay loam, heavy-textured phase	1,024	.2
			Total	570,240	

DARK DULL-BROWN OR BROWNISH-GRAY SOILS

The group of dark dull-brown or brownish-gray soils includes 15 soil types, 12 phases of types, and 2 miscellaneous classifications of material.

The surface soils of the Gleason soils, under virgin conditions, to a depth ranging from 9 to 12 inches, consist typically of dark-brown or dark dull-brown friable material of moderate organic-matter content. The subsoils, to a depth ranging from 24 to 36 inches, are dark dull-brown or dull reddish-brown slightly compact material of about the same or slightly heavier texture than the surface soils. The lower part of the subsoil contains an appreciable quantity of partly decomposed basaltic rock fragments before grading into solid bedrock. These soils occupy hilly or mountainous areas and are well drained.

The soils of the Pentz series are characterized by dull brownish-gray or dull grayish-brown surface soils over dull grayish-brown slightly compact subsoils of about the same or slightly heavier texture. These soils are shallow, overlying bedrock of tuffaceous or

andesitic rocks at a depth ranging from 12 to 18 inches. The surface relief ranges from rolling to hilly, and the soils are subject to more or less erosion.

The soils of the Lassen series, as developed in this area, are characterized by dark dull-brown or dark dull reddish-brown surface soils 5 or 7 inches thick. The subsoils consist of dull reddish-brown or dark reddish-brown compact material of small cloddy, cubical, or coarse nut structure, when dry. Before grading into bedrock at a depth ranging from 12 to 18 inches the subsoils become somewhat yellow in color and contain appreciable quantities of partly weathered basaltic rock fragments which produce a rust-brown mottling. Many of the stones embedded in the lower part of the subsoil have a lime coating on the under sides, but the fine soil material is noncalcareous. These soils when wet are very stiff and plastic, but on drying they tend to become more granular.

The 7- to 9-inch surface soils of members of the Modoc series consist of dull grayish-brown firm material that breaks up readily to a granular structure. The subsoils, to a depth ranging from 36 to 40 inches, consist of moderately compact dull-brown or dull grayish-brown material of slightly heavier texture than the surface soils, which has a lumpy or cloddy structure when broken down. The lower part of the subsoil, to a depth of more than 6 feet, consists of brown, light grayish-brown, or light brownish-gray slightly compact material of about the same texture as the surface soil. These soils occupy alluvial fans and slightly elevated terraces having well-developed drainage. These fans and terraces are alluvial deposits derived from moderately weathered basic igneous rocks.

Soils of the Standish series are characterized by brown or dull-brown friable surface soils to a depth of 8 or 10 inches. The upper part of the subsoil, to a depth ranging from 24 to 34 inches, is light brownish-gray or grayish-brown calcareous more compact material which contains a few lime-cemented seams or lenses. The lower part of the subsoil, to a depth of 72 or more inches, is brownish-gray calcareous material generally of coarse texture. In many places the lower part of the subsoil contains an appreciable quantity of stones and gravel, and lime-cemented seams or lenses are also present. These soils occupy elevated terraces which were probably formed at the mouths of streams emptying into ancient lakes. The soil materials are derived largely from basic igneous rocks.

The soils of the Surprise series have dark-brown, dark dull-brown, or, in places, dark rich-brown granular and friable surface soils from 8 to 14 inches thick. The upper part of the subsoils, to a depth ranging from 30 to 44 inches, consists of slightly compact dull-brown, light-brown, or rich-brown material of similar or only slightly heavier texture than the surface soils. The lower part of the subsoils, to a depth of 6 feet or deeper, is dull-brown or light-brown friable material, in most places of about the same texture as the surface soils. These soils occur on well-drained alluvial fans or stream bottoms, composed largely of material outwashed from rocks of basic igneous origin.

Soils of the Gould series, as developed in this area, are characterized by dark rich-brown, dark reddish-brown, or chocolate-brown surface soils to a depth of 8 or 10 inches. The subsoils, to a depth

ranging from 15 to 36 inches, consist of dark dull reddish-brown or dull chocolate-brown compact heavy-textured material that is of prismatic structure but breaks into a small cubical or nut structure when disturbed. The heavy compact subsoil rests directly on a dull-brown or dull yellowish-brown substratum firmly cemented with silica and iron. These soils occupy alluvial fans or terraces of a former period of accumulation.

The 3- or 4-inch surface soils of the members of the Bieber series consist of dark dull grayish-brown or dark dull brownish-gray material of firm consistence, that breaks up under slight pressure to a fine-granular structure. The upper part of the subsoil, to a depth of 7 or 8 inches, consists of dark dull grayish-brown or dark dull-brown slightly compact material that breaks up to a medium cloddy structure. The lower part of the subsoil, to a depth ranging from 10 to 18 inches, consists of lighter brown or lighter reddish-brown compact heavy-textured material that breaks up to a small nut structure. This material rests directly on a firmly consolidated substratum. These soils ocupy old terraces of a former period of accumulation and may be derived from weathered substratum material or represent, in part at least, a secondary deposition over the consolidated material. The soil materials are largely of basic igneous origin.

Gleason loam.—Gleason loam is a productive soil in seasons of good moisture supply, but it dries out rather quickly. Fall-sown grains generally give better yields than those sown in the spring. The land is easily cultivated, and the surface relief of most areas is favorable to cultural operations.

This soil is most extensively developed north of Gleason Creek and bordering Thom Creek. Most of the small scattered bodies occur along the bases of the higher mountains.

About 30 percent of the land is under cultivation and devoted exclusively to the production of dry-farmed grain. Crop yields vary, depending on the seasonal moisture supply. In good seasons the yield of wheat averages about 14 bushels an acre. Some barley and rye are grown, and yields are comparable with those of wheat. In dry seasons the grains are cut for hay, and they yield from one-half to 1 ton an acre. Uncultivated areas of this soil are utilized for grazing sheep or cattle.

Gleason stony clay loam.—Gleason stony clay loam occupies somewhat more mountainous situations than Gleason loam. This soil, as a rule, is slightly shallower, is of somewhat heavier texture, has a better moisture-holding capacity, and, where the land is not too stony, crops do as well as on the deeper loam soil. The stone content varies, some areas containing comparatively few stones but others being so stony as to preclude the possibility of profitable removal of the stones under present economic conditions.

As mapped, this soil includes one body lying 2 miles south of Round Valley School, that is much redder than typical. This represents undifferentiated Aiken soil material, as mapped in other parts of the State, and if it were more extensive it would be recognized as a distinct type of the Aiken series.

The largest typical area of Gleason stony clay loam occurs along the foot slopes of Warner Mountains both north and south of Thom Creek. A large number of bodies, embracing from 10 to 160 or more

acres each, occur along the foot slopes of the higher mountains throughout the surveyed area.

About 5 percent of this soil has been cleared of stones and is under cultivation. The crops grown are similar to those grown on Gleason loam, and yields are equally good. Some fruit is grown for family use and returns good yields. Uncultivated areas afford fair grazing.

Gleason stony clay loam, steep phase.—The steep phase of Gleason stony clay loam consists of rough mountainous areas of Gleason stony clay loam, which are mainly adapted to grazing and forestry. Under future development some small areas of soil of this phase may have surface relief favorable to cultural practices. Owing to the rough mountainous relief and difficulty of mapping in detail, this soil may include variations and departures from typical, not differentiated on the map. Parts of Warner Mountains included in the Alturas area as well as the mountainous areas south and west of Canby, are mapped with this phase.

Gleason stony loam.—Gleason stony loam is moderately well supplied with organic matter under virgin conditions, and the soil is easily cultivated when cleared of stones, which can be done at small expense in most places. It has a comparatively high water-holding capacity.

This soil is most extensively developed on Sugar Hill, where it occupies an area of several square miles. A number of areas are at the base of Warner Mountains, from Pine Creek south to Fandango Creek. In Surprise Valley a number of bodies occupy similar positions at the base of the mountainous areas between Fort Bidwell and Lake City, and one body is in the extreme northeastern part of the area.

Under virgin conditions most of this soil is forested, and it is valued for forestry and grazing. About 2 percent of the land is under cultivation and devoted to grain production. The yields are similar to those obtained on Gleason loam.

Pentz loam.—Pentz loam has low water-holding capacity and is of little agricultural value.

This soil is extensively developed in the rolling hill country between South Fork Pit River and Pit River, as far west as Opahwah Butte. A few small areas occur outside this general section, one about 2 miles northeast of Kelly Hot Spring and another at Davis Creek.

Only a few acres are under cultivation, and the yields of dry-farmed grain are generally low and uncertain. Under virgin conditions the soil is covered with juniper, sage, and a scant growth of grass. Aside from the small amount of grazing the land affords, it is valued only for the juniper posts and firewood cut on it.

Pentz loam, light-colored phase.—Pentz loam, light-colored phase, is a shallow soil of low water-holding capacity and rather low agricultural value. Gravelly areas of this soil are indicated on the map by gravel symbols, and such areas are in general of lower value than the gravel-free areas.

Soil of this phase occurs in rolling or hilly areas, and drainage is well developed. Some of the largest areas are developed south and west of McBrien Lake, although a large number, ranging in size

from a few acres to more than a square mile, occur on the outer edge of the valley extending from Alturas westward beyond Canby. Two important bodies outside this general area are 2 miles north of Alturas and just north of Dorris Reservoir, respectively. A number of small bodies border West Valley in the southeastern part of the Alturas, or central, unit of the surveyed area. A small area is in Round Valley, and one of about the same size is on the northern slope of Sugar Hill.

Less than 1 percent of the land is under cultivation to dry-farmed grain, and the rest is largely covered with juniper which is valued for fuel and fence posts. This soil is not productive of cultivated crops and affords very little grazing.

Lassen stony clay.—Lassen stony clay is a difficult soil to handle under cultivation, and its shallowness renders it of little or no agricultural value. Although this soil has a high water-holding capacity, it also has a high wilting point, as the clay gives up moisture to plants very slowly.

This is one of the more extensive soils of the area, covering more than 100 square miles. It extends from near Pine Creek, southeast of Alturas, south to the valley of South Fork Pit River, east of Likely. A large body lies south of South Fork Pit River, southeast of Likely. This soil is extensively developed along the west side of North Fork Pit River in a body that extends to a point within about 8 miles of the Oregon-California State line, along the west side of Goose Lake, and a body including several square miles lies along the north boundary of the area north of Del Wama Springs.

As mapped, this soil includes some rough stony areas that are unsuited to any type of agricultural development. Only a few acres of the typical soil are under cultivation, in connection with other soils, or are irrigated from springs for the production of grass hay.

Modoc loam.—Modoc loam is easily cultivated and has a high water-holding capacity. The subsoil is moderately compact, but it is favorable to root penetration, and the soil has a high potential value for irrigation or the production of dry-farmed crops. Gravelly areas have somewhat less value for agriculture because of the tendency of the gravel to interfere with cultural operations and the tendency of the soil to dry out more quickly.

This soil occurs in a large number of rather small scattered bodies in all parts of the area. It is most extensively developed in the vicinity of Canby, where several bodies border Pit River both on the north and south sides. Three small areas occur north of Pit River in the vicinities of Lone Star School and east of Clover Swale School. South of Pit River a body lies about 2 miles southeast of McBrien Lake, and others are north and south of Red Star School. A small body including about 50 acres occurs on Parker Creek just north of Hopewell School, and a smaller one is in the small valley 4 miles south of Paola. Two gravelly areas border South Fork Pit River just north of Widgeon. A few small bodies occur in Round Valley, and several are in Jess Valley. This soil is developed in three areas in Surprise Valley, the larger, of gravelly character, is at the mouth of Soldier Creek, and the others are about 1½ miles north of that point.

Modoc loam is nearly all under cultivation and used principally in the production of dry-farmed wheat and barley, although some

small areas are irrigated and used in the production of alfalfa and grass hay. The yields under irrigation are very good. In seasons of normal rainfall, dry-farmed wheat yields from 12 to 30 bushels an acre and barley somewhat more. Better yields are reported in unusually favorable seasons under good cultural practices. This soil is fertile and, under irrigation, would respond well to applications of organic matter. It seems to be well adapted to all crops suited to the local climatic conditions.

Standish gravelly clay loam.—Standish gravelly clay loam is of granular friable character, is moderately well supplied with organic matter, and the upper part of the soil material has fair water-holding capacity. The lower part of the subsoil, however, in many places is open, porous, and of low water-holding capacity. The areas with the more open subsoil, if irrigated, would require a great deal of water to mature a crop.

This soil is confined largely to the Surprise Valley section of the area surveyed. Some of the most typical bodies border the mountains in the vicinity of Eagleville. North of Eagleville a large number of various-sized areas occupy similar positions as far as the northern boundary of the surveyed area, one of the largest and most important of these occurring at Fortynine School north of Cedarville. Two areas border South Fork Pit River east of Likely, and a third is 2½ miles southeast of Paola.

About 25 percent of the land is under cultivation, and the rest supports a native cover of sage and grass and is utilized as grazing land. The cultivated areas are used in the production of dry-farmed wheat and barley, with small acreages of rye. The yields are somewhat less than on Modoc loam. If irrigated this soil would be adapted to a wide range of crops requiring good drainage for their successful maturity.

Surprise gravelly sandy loam.—Surprise gravelly sandy loam is one of the more extensive soils of the area surveyed, that is developed for agriculture. It is easily tilled and well adapted to cultivated crops. In most places the gravel in this soil constitutes about 10 percent of the soil mass, although much more is present in some places than in others. As a rule, the upper fan slopes bordering stream courses contain more gravel than do areas farther down the slopes. The gravel interferes somewhat with cultural operations and slightly reduces the water-holding capacity of the soil.

As mapped, many areas of this soil bordering soils of the Standish series have more or less lime in the subsoil. This soil also includes several bodies that are more reddish brown or richer brown than typical. Such areas occur 2 miles south of Eagleville, a short distance northwest of Cedarville, and at the foot of the mountains between Lake City and the Fandango Pass road.

In Surprise Valley an almost continuous body of the typical soil, ranging from one-fourth mile to 2 miles in width, extends from the vicinity of Eagleville northward as far as Lake City, a large area is north of Fort Bidwell, and numerous smaller bodies occur at other places in the valley. This soil is also extensively developed in the northern end of Goose Lake Valley and in the vicinity of Garret. Elsewhere in the Pit River Valley the bodies are small and widely scattered, some of the largest lying south and east of Clover Swale School. A number of small areas are in Jess Valley.

About 70 percent of Surprise gravelly sandy loam is under cultivation, and about 10 percent of the cultivated area is irrigated. Areas not under cultivation support a growth of sagebrush and grass, which afford fair pasture. Wheat and barley are the principal crops grown under dry-farming practices, with wheat occupying about 50 percent of the cultivated acreage. The Galgalos variety of wheat, a beardless soft white wheat, is most commonly grown. The yields range from about 5 to 30 bushels an acre, and the average is about 15 bushels. Barley yields average about 20 bushels an acre. Some oats and rye are produced on this soil each year and return good yields. Rye is generally cut for hay, and in seasons of low rainfall most other grains which will not mature a crop of seed are cut for hay.

Under irrigation this soil is devoted almost exclusively to the production of alfalfa, and smaller areas are used in the production of grass for hay. Alfalfa is cut an average of three times a season for hay, and it yields about 3 tons an acre. If a seed crop is desired, one cutting for hay is made, and the next growth is left to mature seed. Yields of alfalfa seed range from 100 to 1,000 pounds an acre, although the average is about 200 pounds. If alfalfa is grown in connection with the dairy industry, 1 or 2 cuttings of hay are generally had, and the fields are then pastured. This soil is productive, generally well farmed, and has a wide crop adaptation.

Surprise gravelly sandy loam, coarse-textured phase.—The coarse-textured phase of Surprise gravelly sandy loam consists of coarse gravelly sand to a depth of more than 6 feet. This soil is developed on old beach deposits along the shores of Goose Lake. It supports a few willows in local areas and some grass along the lower parts, as it grades out over heavier textured material. Soil of this phase is valueless aside from the small amount of grazing it affords.

Surprise gravelly sandy loam, shallow phase.—The shallow phase of Surprise gravelly sandy loam has a surface soil and upper subsoil layer similar to the corresponding layers of the typical soil. At a depth ranging from 30 to 45 inches the subsoil layer is underlain by a firmly consolidated substratum. Soil of this phase occurs only in two small areas having a combined acreage of about 500 acres. The largest body is at Red Star School, and the other is on the south side of Pit River in the vicinity of Lone Star School. Most of the last-mentioned area is irrigated and used in the production of alfalfa; the other is partly under cultivation and used for dry-farmed grain. Yields are slightly less than on the typical soil.

Surprise gravelly sandy loam, dark-colored phase.—The 10- or 12-inch surface soil of Surprise gravelly sandy loam, dark-colored phase, consists of gravelly sandy loam material corresponding to the typical Surprise soils but of somewhat darker color. The upper part of the subsoil, to a depth ranging from 18 to 30 inches, is also darker in color than the typical subsoil. In Surprise Valley where soil of this phase grades out onto the lake beds the lower part of the subsoil may be slightly calcareous and of dark-gray color. Such areas are small and could not be differentiated on the soil map. This soil owes its dark color largely to cultural or irrigation practices. Where subject to seepage or where irrigated by continuous flooding the dark color is developed, owing to the accumulation of organic matter.

Soil of this phase is moderately extensive in the vicinity of Eagleville, and smaller areas are developed on the lower or mid-fan slopes throughout Surprise Valley. The soil is also extensively developed in upper Goose Lake Valley in the vicinity of Oregon School, in a number of small areas south of that place, and in several bodies in Jess Valley.

Some areas, particularly in upper Goose Lake Valley, contain some stone, which somewhat reduces their value. Practically all this dark-colored soil is under cultivation, and about 90 percent of the cultivated land is irrigated. Areas not under irrigation are used in the production of dry-farmed grain, and they give as good or better yields than the typical soil. The irrigated areas are used almost exclusively in the production of wild-grass hay under continuous flooding practices, although some alfalfa is grown by using periodic irrigation. The yields of alfalfa are comparatively high, ranging from 1 to 3 tons an acre, but in dry seasons the yields are materially reduced. It is believed this soil could be used more profitably, with a saving in water and greater assurance of a crop, in the production of alfalfa or other crops using a periodic type of irrigation.

Surprise gravelly sandy loam, calcareous-subsoil phase.—Surprise gravelly sandy loam, calcareous-subsoil phase, is not developed for agriculture to any extent. This soil is rather poor in content of organic matter and in many places contains more or less alkali. Under cultivation it is easy to handle because of its light texture, but, on the other hand, the sandy character of the material lowers its water-holding capacity, making it somewhat droughty. Some areas of this phase are very gravelly, but in others the gravel content is small or lacking. The gravel interfere with cultural operations and render the soil more droughty than it otherwise would be.

Soil of this phase is most extensively developed in Surprise Valley about 3 miles south of Cedarville; a large area borders South Fork Pit River, about 3 miles south of Alturas, and a number of bodies occur in this same general vicinity; others border the south edge of Pine Creek Valley, and many others occur throughout the surveyed area, associated with other alluvial soils.

Less than 5 percent of this soil is under cultivation and is used almost exclusively in the production of dry-farmed grain. Uncultivated areas are covered with sage and grass and are utilized for grazing. Crops suffer from lack of moisture rather quickly on this soil in dry years, but yields are fair in years of normal rainfall. Where alkali conditions are favorable, this soil is adapted to deep-rooted crops under irrigation.

Surprise fine sandy loam.—Surprise fine sandy loam has a better moisture-holding capacity than Surprise gravelly sandy loam. This soil is easily handled under cultivation and is otherwise well adapted to cultural operations. In Surprise Valley, areas of this soil bordering Standish gravelly clay loam, as well as those on the lower fan slopes, have a decidedly calcareous subsoil in some places. This soil is not extensive, though it is developed in a large number of small bodies throughout the surveyed area. It generally occupies narrow stream bottoms and is associated, as a rule, with soils of much lower value.

In Surprise Valley there is an area just north of Cedarville, one of appreciable size is in the southern part of the valley, near Eagle-

ville, and numerous others, including from 10 to 50 acres, occur at other places in this section. In Pit River Valley, the soil is most prominently developed in a great number of comparatively small areas bordering Rye Grass Swale and its tributaries. In Goose Lake Valley a large number of comparatively small bodies, with a total area of not more than a square mile, occupy stream bottoms and alluvial fans.

This soil is fairly important in a number of the stream valleys tributary to North Fork Pit River, and in Round Valley it is developed in several areas of appreciable size.

More than 80 percent of the land is under cultivation. Dry-farmed grain crops occupy about 60 percent of the cultivated area, and the rest is irrigated and used for alfalfa- and grass-hay production. Yields are as good as, or slightly better than, those obtained on Surprise gravelly sandy loam. This soil is as productive as any soil in the area and is well adapted to crops requiring a deep rooting zone and good drainage.

Surprise fine sandy loam, shallow phase.—The shallow phase of Surprise fine sandy loam has a surface soil and upper subsoil layer similar to those of typical Surprise fine sandy loam. At a depth ranging from 40 to 50 inches, soil of the shallow phase is underlain by a firmly consolidated substratum, which limits the rooting zone and reduces the water-holding capacity of the soil.

This soil occurs only in the Pit River Valley section. It is most typically and extensively developed in a large number of areas between Alturas and Canby, some of the largest lying south and east of Kelly Hot Spring. A few small areas are in the vicinity of Likely and in West Valley.

About 60 percent of the land is under cultivation, and the rest, which is carpeted with sage and grass, affords fair grazing. Most of the cultivated areas are dry farmed, although a few are under irrigation and return fair yields of alfalfa. Alfalfa stands are not so long lived on this soil as on typical Surprise fine sandy loam, and, after the first few years, yields decline slightly, owing largely to the tendency of irrigation water to collect over the surface of the substratum and kill the roots at that point. Dry-farmed grain yields slightly less than on Surprise gravelly sandy loam. Under irrigation, care should be exercised to prevent water-logging of the soil material directly above the substratum.

Surprise fine sandy loam, dark-colored phase.—The surface soil of Surprise fine sandy loam, dark-colored phase, consists of material of somewhat darker brown or darker grayish-brown color than typical, extending to a depth ranging from 24 to 30 inches. Below this depth the subsoil is of typical basic color, but it contains some rust-brown mottlings. Texturally, in degree of compaction, and character of soil material, the soils are similar. The dark color of this soil is due to cultural operations and the methods of irrigation.

Only one area of this soil is developed outside of Surprise Valley, and that is in Jess Valley. In Surprise Valley the soil is most typically developed in the vicinity of Owl Creek School and in several bodies a few miles north of that place. A few small scattered areas are near the bases of the alluvial fans throughout this section. All this land is under irrigation and used almost exclusively in the production of grass hay. Yields are very good in seasons of normal

rainfall, but partial crop failures are common in seasons of low rainfall. This soil is well adapted to the production of all crops suited to local climatic conditions, where a periodic type of irrigation is used.

Surprise fine sandy loam, calcareous-subsoil phase.—Surprise fine sandy loam, calcareous-subsoil phase, is a soil of good water-holding capacity but of rather low organic-matter content. The soil occupies stream bottoms and lower alluvial-fan slopes that have poorly developed subdrainage, although surface drainage in most places is well developed. Most of this soil has a low or moderate content of alkali. The land is easily cultivated and can be maintained in good tilth under careful cultural practices.

This soil is widely developed in a large number of small areas throughout the extent of the surveyed area. Two large bodies are in Surprise Valley, one about 4 miles east of Fort Bidwell and the other about 1½ miles north of Cottonwood School. Many bodies are scattered throughout the valley. In Pit River Valley this soil is most extensively developed in the vicinity of Alturas and along South Fork Pit River to a distance of a few miles south of Alturas; large areas border Rye Grass Swale and other tributaries of Pit River, as well as Pit River west of Alturas; and a few bodies are in Goose Lake Valley. A few small included areas are of lighter gray color than typical.

About 30 percent of this soil is under cultivation and devoted largely to the production of dry-farmed grains. Irrigated land constitutes perhaps as much as 20 percent of the cultivated area and is used for grass-hay production. Wheat and barley, produced under dry-farming practices, yield about the same as on typical Surprise fine sandy loam, except where alkali conditions are unfavorable. The soil should be well adapted to general farm crops under irrigation, but care should be exercised to keep alkali below the feeding zone of plant roots.

Surprise clay loam.—Surprise clay loam is a soil of very good water-holding capacity and good fertility. Under virgin conditions it is moderately well supplied with organic matter, but it is slightly harder to handle under cultivation than other soils of this series, although it can be readily worked into a loose mellow seed bed.

As mapped, this soil includes some undifferentiated areas of loam texture and others that are slightly darker than typical. One darker colored area is at Cove Ranch on the west side of Goose Lake. Some areas contain some lime in the subsoil at a depth ranging from 50 to 60 inches, particularly areas near the lake bottoms in Surprise Valley.

The largest area of this soil is 2 miles northeast of Eagleville, a smaller body occurs along the west side of South Fork Pit River about 1½ miles southwest of McArthur, and three small areas are in Round Valley, 2½ miles northeast of Gleason Creek School, and in a small valley 2 miles south of Likely, respectively.

This soil is largely under irrigation and is devoted to the production of grass hay. In most places some clover is mixed with the native wild grasses, which improves the feeding value of the hay. The yields are as good on this soil as on any soil in the area. This soil should be well adapted to alfalfa production under a periodic type of irrigation.

Gould clay loam.—Gould clay loam is a granular, friable soil, but it is rather poorly adapted to the production of cultivated crops. Under dry-farming practices the soil has a tendency to dry out quickly, owing to its slight depth. If the land were irrigated, the impervious substratum would limit the water-holding capacity of the soil and the rooting habit of plants. This soil would respond best to frequent light irrigations or the production of grass hay under continuous-flooding practices.

This soil includes some areas of stony character that further limit its value for agriculture. Such areas are shown on the soil map by stone symbols.

Gould clay loam is confined largely to the southern end of Goose Lake Valley, and a number of small areas occur along the west side of Goose Lake, especially in the vicinity of Hanson Ranch and Cove Ranch. In Pit River Valley a small area is just east of McBrien Lake, and others occur about 4 miles southwest of Canby.

This soil under virgin conditions is covered with a stunted growth of sage and a scant growth of grass. Some areas have been cleared and utilized in the production of dry-farmed grain. The soil has little potential value for agriculture.

Gould clay loam, gravelly phase.—The gravelly phase of Gould clay loam is low in organic matter, and the soil has low water-holding capacity. The gravel constitutes from 10 to 20 percent of the soil mass and materially interferes with cultural operations. Some areas in which the soil is somewhat deeper than typical have some agricultural value.

Soil of this phase is developed in an area covering about 6 or 7 square miles south and west of Davis Creek in Goose Lake Valley, and a small area occurs in this valley about 3 miles southeast of Willow-ranch. In Pit River Valley areas occur a mile west of Power House on Pine Creek and 3½ miles southwest of Canby. An area of about 50 acres is in Round Valley.

Less than 1 percent of the land is under cultivation, and the rest supports a native cover of stunted sage and scant grass, that is of little value for grazing. About 160 acres are under irrigation and used in the production of grass hay and alfalfa. Yields of grass hay are comparable to those obtained on other shallow soils of the area, and alfalfa yields fairly well, although, in general, the stands are short lived. Dry-farmed grain generally returns low yields.

Gould clay.—Gould clay is a soil of little agricultural value, although a part of the land is used in the production of grass hay under continuous flooding practices. This soil has a fair water-holding capacity, but, owing to its heavy texture, crops can make little use of the moisture under dry-farming practices. The impervious substratum limits the rooting zone of crops grown on this soil. Some areas contain an appreciable quantity of stones scattered throughout the soil, and such areas are indicated by stone symbols on the accompanying map. The stones in the soil further limit its agricultural value.

This soil occurs in a number of bodies throughout that part of the area west of Warner Mountains. It is typically developed in a number of small areas on the west side of Goose Lake and in Goose Lake Valley, particularly in the section south of Davis Creek. A number

of bodies border Gleason Creek and other tributaries of North Fork Pit River, and several small areas occur along the outer margin of the valleys of South Fork Pit River and Pit River.

Less than 1 percent of this soil is under cultivation, and it is devoted entirely to the production of grass hay under continuous flooding practices. The yields are usually fair in seasons of good water supply. The soil has little potential value under future development.

Gould clay, deep phase.—The surface soil of most areas of the deep phase of Gould clay is of clay texture, but the soil includes some areas of slightly lighter textured materials. Soil of this phase has more or less stone in both the surface soil and subsoil, and under cultivation it has been necessary to remove the stones from the surface. It differs from the typical soil chiefly in the greater depth of soil material. As a rule, this deep soil rests on an impervious substratum at a depth ranging from 48 to 60 inches, and in some places it may be 6 feet or more to the impervious layer.

This soil occurs entirely in lower Goose Lake Valley, where it borders the mountains at the mouths of Roberts, Linville, and Franklin Creeks. About 80 percent of the land is cleared and used in the production of grass hay. Uncleared areas are covered with juniper, sage, and some grass, and they afford fair grazing. This soil should be fairly well adapted to the production of general farm crops under irrigation.

Bieber sandy loam.—Bieber sandy loam is granular, friable, easily cultivated, and can be maintained in good tilth with little trouble. As mapped, this soil includes some areas, particularly along the north side of Pit River, that are of fine sandy loam texture. As such areas are of essentially the same agricultural value as the typical soil, they are not differentiated on the map. The soil has low water-holding capacity, on account of its shallowness, and it is little used for dry-farmed crops. The cemented substratum limits the rooting zone of plants, and under irrigation care must be exercised to prevent water-logging of the soil above the substratum if deep-rooted crops are grown. Some included areas, which do not have an appreciable accumulation of clay over the substratum, have slightly higher agricultural value. A few bodies of this character are east of Mattes.

Bieber sandy loam is one of the more extensive soils. It is prominently developed in a large number of bodies in Pit River Valley, particularly at Alturas and northeast of that place. A large number of areas are in the valley section from Alturas west to the boundary of the area. Especially large bodies border Rye Grass Swale, and some are at Likely and about 6 miles north of that place. A few small areas are in the Goose Lake Valley along the western side of Goose Lake.

About 10 percent of the land is under cultivation, and the rest is covered with sage and a scant growth of grass and is used as grazing land. The cultivated areas are used to some extent in the production of grass hay where water is available for irrigation, but most of the cultivated area is used for the production of dry-farmed grain. Yields of wheat range from 8 to 14 bushels an acre in normal seasons, but in seasons of low rainfall the grain crops may be a failure, al-

though they usually make sufficient growth to be of value for hay or forage. This soil has limited agricultural value, because of its low water-holding capacity and shallowness.

Bieber sandy loam, calcareous-subsoil phase.—The calcareous-subsoil phase of Bieber sandy loam has a dull-gray or dull brownish-gray surface soil of low organic-matter content, underlain by dull-brown or dull grayish-brown slightly compact material of heavier texture and pronounced small cloddy or nutlike structure (pl. 1, *A*), grading into partly consolidated gray or yellowish-gray material which is intermittently calcareous.

Soil of this phase occupies areas of rolling or hilly surface relief and under virgin conditions supports a vegetation dominated by juniper and sage. The soil material appears to be developed from weathered old-lake or mineral-spring deposits. As mapped, this soil includes small areas in which the surface soil is of heavier texture than typical.

This soil has fair water-holding capacity and is utilized to some extent in the production of dry-farmed grain crops. It is confined mainly to the western part of the area, where it occupies bodies aggregating about 3 square miles, in the vicinity of Kelly Hot Spring. An inclusion of the heavier textured soil occurs in an area of about 600 acres, 4 miles north of Alturas, and smaller bodies lie 1½ miles northeast of Surprise and bordering Pine Creek 1½ miles east of Paola.

About 5 percent of the land is cultivated, and the rest is covered with juniper and sage. Wheat and barley are the principal crops grown, and yields ranging from 10 to 15 bushels of wheat and slightly more of barley are obtained in normal seasons. When cut for hay these crops yield about 1 ton an acre, although lower yields and an occasional failure are experienced in unusually dry seasons.

Bieber gravelly sandy loam.—Bieber gravelly sandy loam is of lower agricultural value than Bieber sandy loam, because of the presence of gravel that constitute from 10 to 20 or more percent of the soil mass. The gravel interfere with cultural operations and tend to make the soil dry out more quickly than it otherwise would. Some areas of this soil, particularly east of Alturas, have more or less lime in the substratum and lower part of the subsoil, but such areas are not typical and if more extensively developed would have been classified in another series. This soil as mapped also includes small soil areas without appreciable clay in the subsoil and others having little or no gravel, but such areas are of infrequent occurrence.

Bieber gravelly sandy loam is one of the more extensive soils. It is developed in comparatively large areas throughout the section west of Warner Mountains, but none of it occurs in Surprise Valley. In Goose Lake Valley it occupies a large area on both sides of Fandango Creek just east of Willowranch, and many smaller areas occur throughout Goose Lake Valley. In Pit River Valley one of the largest bodies lies about 3 miles east of Alturas, and one, almost equally as large, is just north of that town. The soil is extensively developed in the vicinity of Opahwah Butte and Canby, and many areas border the valley of South Fork Pit River and the numerous tributaries of North Fork Pit River. The soil also occurs in Round Valley in several comparatively large areas.

About 5 percent of this soil is now under cultivation or has been under cultivation at various times in the past. A few acres are irrigated, in connection with alfalfa- or grass-hay production. The yields under irrigation are usually satisfactory, though lower than on the deeper soils. Dry-farmed grains return somewhat lower yields than on Bieber sandy loam. This soil is of low value for agriculture, but under cultivation it should be best adapted to shallow-rooted crops. Where irrigated it should be given frequent light applications of water, unless it is used in the production of grass hay under continuous-flooding practices.

Bieber stony clay loam.—Bieber stony clay loam is one of the more extensive soils. It contains various quantities of stone, some areas having the surface almost covered with them, but in all areas they are sufficiently numerous that the expense of removal before the soil could be cultivated would be high. As a rule, the impervious substratum is reached at less depth in this soil than in other soils of the series, in most places occurring at a depth ranging from 8 to 15 inches.

This soil is prominently developed along the east side of North Fork Pit River; a large number of bodies occur along the outer margin of Goose Lake Valley at the base of the mountainous areas; a large body is along the north side of Pit River Valley west of Alturas; and many areas border Pit River Valley and the valley of South Fork Pit River. Various-sized areas occur in Round Valley and Jess Valley.

Only small areas are under cultivation in connection with better soils. The yields of grass hay produced under continuous-flooding practices are about the same as on other shallow soils. Owing to the shallowness of the soil and the cost of removing stones before the land can be cultivated, this soil is not considered of very great value.

Rough stony land.—Rough stony land consists of areas too rough and too stony to be of any agricultural value. This land consists for the most part of basaltic rim rock and talus slopes of basaltic lava flows, with little or no soil covering. In places shallow areas of soil support a scattered growth of juniper and some grass that affords a little grazing. This land occurs extensively in Round Valley and on the west side of the valley of South Fork Pit River. Elsewhere it is largely confined to narrow areas of rim rock.

Scab land.—Scab land consists of areas of shallow stony soils, in which most of the weathered soil material developed on basaltic lava flows is not more than 10 or 12 inches thick. The surface relief, although regionally generally level or gently sloping and plateaulike, is in most places of irregular configuration, and the land is decidedly marked by irregular boulders, stones, and outcrops of basaltic bedrock, which in many places almost completely cover the surface.

The soil consists of undifferentiated soils of the Gleason and Lassen series, mainly of loam, clay loam, and clay texture. The land affords some scant grazing, but it is otherwise of little or no agricultural value, although it may locally include small patches which might be capable of supporting hardy dry-land crops in favorable seasons. The areas are difficult to traverse, as there are few roads.

Scab land is extensively developed on the lava plateau north of Canby and Alturas, south of Alturas in the hilly eroded country lying between South Fork Pit River and Pit River, and extending from Parker Creek southward to the junction of West Valley Creek and South Fork Pit River. Other small areas occur in Jess Valley south of Coyote Creek, on the west side of Goose Lake in the vicinity of Westside School, and bordering the valley lands or on the lava plateaus west of Warner Mountains.

DARK-GRAY OR BLACK SOILS

The soils of the Pit series are characteristized by dark grayish-brown, dark-gray, or black surface soils to a depth ranging from 9 to 12 inches. The subsoils consist of dull brownish-gray, dark brownish-gray, or dark grayish-brown material of about the same texture as the surface soils and without appreciable compaction. In most places the lower part of the subsoil is mottled with rust brown and in a few places contains some gypsum. In may places some members of the Pit series have peaty or mucky subsoil layers, and the surface soils contain appreciable organic matter. These soils occupy flat stream-bottom areas and are poorly drained.

The soils of the Carson series are characterized by dark-gray or black surface soils to a depth ranging from 8 to 15 inches and subsoils of similar or grayer or browner color, that contain appreciable quantities of lime and in places some gypsum. These soils occupy poorly drained areas and are subject to more or less alkali accumulation. The subsoils of the Carson soils, as occurring in this area, to a depth of 6 feet or deeper, are friable, without appreciable evidence of compaction or clay accumulation.

The surface soils of members of the Hovey series, to a depth ranging from 12 to 20 inches, consist of dark brownish-gray or black material that is comparatively high in organic matter and ranges from mildly to decidedly calcareous. The subsoils range from dark dull brown in the better drained areas to dark gray, light gray, or light yellowish gray in the more poorly drained areas. In a few places these soils have a slightly cemented layer in the subsoil. The subsoils are slightly compact but are readily penetrated by plant roots to a depth of 6 feet or deeper. The lower part of the subsoils contains a moderate or high amount of lime, and the soils, as a rule, show some evidence of alkali.

The 7- to 10-inch surface soils of members of the Antelope series are very dark dull-brown, dark grayish-brown, or dark brownish-gray friable material of good organic-matter content. The upper part of the subsoil, to a depth ranging from 24 to 36 inches, consists of dark dull-brown, dark grayish-brown, or dark brownish-gray moderately compact material of about the same texture as the surface soil. The lower part of the subsoil, to a depth ranging from 30 to 50 inches, consists of pale-brown or dull brownish-gray slightly compact material of about the same texture as the surface soil. The lower subsoil layer is underlain by a partly consolidated substratum of light-brown or pale yellowish-brown material that in many places has some lime in the upper part, but which is mainly siliceous. These soils have well-developed surface drainage, but subdrainage is restricted, and, as a rule, they are subject to some seepage.

Pit fine sandy loam.—Pit fine sandy loam is slightly browner than the other members of the Pit series, and the subsoil, as a rule, is more or less stratified with various-textured sediments. This soil is well supplied with organic matter and is easily cultivated. It has a fairly good water-holding capacity and is adapted to irrigation and cultural practices. Surface drainage is in general fairly well developed, but subdrainage is restricted. Some included areas of this soil have a sandy loam or very fine sandy loam surface soil.

The largest areas of Pit fine sandy loam occur along North Fork Pit River, and numerous small bodies lie along nearly all streams tributary to this fork. Along many of the streams in Goose Lake Valley, and bordering Pit River in the vicinities of Alturas and Del Wama Springs, as well as elsewhere throughout the surveyed area, this soil is associated with others developed in the bottom lands.

This soil is well suited to agricultural use. About 90 percent of the land is under cultivation and is devoted largely to the production of alfalfa and grass hay, with a small acreage in dry-farmed grain. Crop yields are slightly lower than on Pit clay loam.

Pit clay loam.—Pit clay loam is well supplied with organic matter, and the land is easily cultivated. It has a good water-holding capacity, and crops yield well. Some areas, shown on the map by gravel symbols, are very gravelly, and they are slightly more difficult to handle under cultivation and have a poorer water-holding capacity.

This soil occurs on the lower alluvial fans and in stream bottoms throughout the extent of the area surveyed. In Surprise Valley a number of bodies are near Lake City and north of that place; two rather large areas are near Fort Bidwell, and smaller ones are south of that town; other small areas occur in the vicinities of Cedarville and Eagleville, and in the extreme southern part of the valley. With the exception of a comparatively large area 3 miles northwest of Davis Creek, this soil in the Goose Lake Valley is confined to small bodies ranging in size from 10 to 30 acres. In Pit River Valley the soil occurs in small widely separated bodies in most of the stream bottoms tributary to Pit River, some of the largest lying along Pine Creek southeast of Alturas, along West Valley Creek, and in the vicinity of Likely. Comparatively large areas are in Round Valley and Jess Valley.

About 95 percent of this soil is irrigated in connection with grass-hay production, and small irrigated areas are devoted to alfalfa production in Surprise Valley. Unirrigated areas are used in the production of dry-farmed grains. Grass hay yields from 1 to 3 tons an acre in favorable seasons. Partial crop failures are sometimes experienced in seasons of unusually low rainfall, when water for continuous flooding is not available. Alfalfa grown on this soil is used largely in connection with the dairy industry, and when cut for hay it yields about 3 tons an acre. Wheat and barley are the principal grain crops grown under dry-farming practices, although some oats and rye are produced from season to season. Wheat yields average about 15 bushels an acre and other grains slightly more.

Pit clay loam is well adapted to the production of the general farm crops grown in the area. Continuous flooding under irrigation is not generally considered good cultural practice in maintaining fertility.

Pit mucky loam.—Pit mucky loam has a high content of organic matter that increases the water-holding capacity of the soil and makes it more loose and friable than Pit clay loam. The upper part of the surface soil contains much undecayed fibrous organic material, but the organic matter in the deeper layers of soil is in general well decomposed.

This soil occurs in low marsh areas and on the alluvial fans in localities subject to seepage. In Goose Lake Valley a number of areas border Goose Lake. The soil occupies the greater part of the bottom lands of the valley of South Fork Pit River, and smaller bodies occur in the bottom lands bordering Pit River, and in Surprise Valley, especially between Lake City and Fort Bidwell.

All this land is under cultivation and is irrigated by continuous flooding for the production of grass hay. The yields are as good or slightly better than on Pit clay loam.

Pit clay.—Pit clay is well supplied with organic matter and is a fertile soil, but it is difficult to handle under cultivation and gives up moisture to crops very slowly.

This soil is developed in a number of small areas in Surprise Valley and is extensive on the bottom lands of Pit River. Comparatively large bodies occur along Joseph Creek and Clover Swale, and a number of areas are in the upper and lower ends of Goose Lake Valley.

The soil is utilized almost exclusively in the production of grass hay, and yields are about the same as on Pit clay, light-textured phase.

Pit clay, light-textured phase.—For grass-hay production, the light-textured phase of Pit clay is as well adapted as the lighter textured soils of the Pit series, but under cultivation this soil would be more difficult to handle. It has a higher water-holding capacity than the lighter textured soils and is well adapted to either irrigation or dry-farming practices.

Soil of this phase occurs in a large number of bodies associated with others developed on stream bottoms or alluvial fans throughout the area surveyed. It is especially well developed in Surprise Valley in the vicinity of Fort Bidwell, in the southern part of the area near Eagleville, and south of that place. Large areas in Pit River Valley occur south and southeast of Alturas at the mouths of Pine Creek and Fitzhugh Creek. In Goose Lake Valley a comparatively large body lies along Fandango Creek, and there are many other bodies throughout the surveyed area.

All this soil is under cultivation, and practically all of it is irrigated. A few dry-farmed areas are used in the production of grain which returns good yields. Irrigated areas are used almost exclusively in the production of grass hay, and very small acreages are devoted to alfalfa. The yield of hay is similar to or slightly better than that on Pit clay loam. This soil is fertile and well adapted to the production of cultivated crops.

Carson clay loam.—Carson clay loam is well supplied with organic matter, and it is mellow and easily cultivated. Some areas are more nearly of loam texture, and there are many bodies in which lime is not reached above a depth of 4 feet. The soil in general is well adapted to cultivated crops, although some areas

have an appreciable alkali accumulation. The alkali-affected areas are mainly in Surprise Valley bordering the lake bottoms.

This soil is comparatively important in the vicinity of Lake City and in the southern end of Surprise Valley, and numerous bodies occur throughout that section of the surveyed area. In Pit River Valley several areas are developed along the outer margin of the bottom lands of South Fork Pit River. Small but comparatively important bodies are just east of Alturas, in the vicinity of McBrien Lake, and associated with other bottom soils north and west of Canby. This soil is not extensive in Goose Lake Valley, although a few small areas border the lake north and west of Davis Creek.

The land is largely under irrigation and is used in the production of grass hay or alfalfa. Alfalfa yields well, and the stands are generally vigorous and long-lived. Areas having an alkali accumulation are better adapted to the production of grass hay.

Carson clay adobe.—Carson clay adobe is difficult to handle under cultivation unless it is worked at the proper moisture content, when the soil works down fairly readily to a granular seed bed. This soil is of good fertility, but, because of the difficulty of handling, it is probably best adapted, under present economic conditions, to the production of grass hay. Most of the areas in Surprise Valley contain more or less alkali, as do a few bodies in other localities.

Comparatively large areas of this soil are at the northern and southern ends of Surprise Valley, and a number of bodies, ranging in size from 10 to 40 acres, occur elsewhere throughout that section. In Pit River Valley the largest areas border Pit River west of Opahwah Butte and occur in Clover Swale, but elsewhere most of the areas are small and unimportant.

About 85 percent of the land is under cultivation, of which about 80 percent is irrigated and used in the production of grass hay. Dry-farmed areas are used in the production of wheat, barley, and rye. Yields are high in favorable seasons but generally poor in seasons of low rainfall. Grass hay yields from 1 to 3 tons an acre.

Hovey clay loam.—The surface soil of Hovey clay loam is well supplied with organic matter, and the soil, though of heavy texture and slightly compact, is granular and readily penetrated by plant roots, air, and moisture. Some areas have been pastured when wet, with the result that the surface soil has been puddled, and the surface is hummocky and uneven. This soil takes water readily and retains it fairly well.

Hovey clay loam is most typically and extensively developed in Surprise Valley, and a few areas are associated with the bottom soils along South Fork Pit River. In Surprise Valley the soil is prominently developed in scattered areas in the vicinity of the lakes.

The land is largely under irrigation, but, occurring as it does at the lower end of the alluvial fans, water for irrigation is not always very plentiful, and crop yields are in general uncertain. When plenty of water is available, grass hay, to which the soil is probably best adapted, yields from 1 ton to slightly more than 2 tons an acre.

Hovey clay.—Hovey clay is not extensive, and it is of little agricultural importance. It has a fair content of organic matter, is granular and friable, and can be worked easily, although it has an

appreciable content of alkali. It is utilized only in the production of grass hay.

This soil occurs in only three areas in Surprise Valley—one, about 1,000 acres in extent, borders Middle Alkali Lake just east of Cedarville; the others occur, respectively, 2 miles east and 3 miles southeast of Cottonwood School.

The land is irrigated, although the uncertain water supply makes crop yields equally uncertain. Under favorable conditions, yields are about the same as on Hovey clay loam.

Antelope clay loam.—The surface soil of Antelope clay loam is granular, loose, and friable, and the land is easily cultivated when handled under good cultural practices. Some areas of this soil have been pastured when wet, with the result that the soil has been trampled and puddled. As mapped, some variations of lighter and heavier texture are included. The soil takes water readily and has a good water-holding capacity. The depth to the substratum differs. In most places it is about 40 inches, but in some included areas it is greater.

The largest body of this soil is at the mouth of Davis Creek, a smaller area borders Fandango Creek, and small bodies occur on both sides of Goose Lake. Outside of Goose Lake Valley, the soil is very inextensive. A small area lies three-fourths mile south of Canby, a somewhat larger one borders Parker Creek, and two very small bodies are near Crook School southeast of Likely.

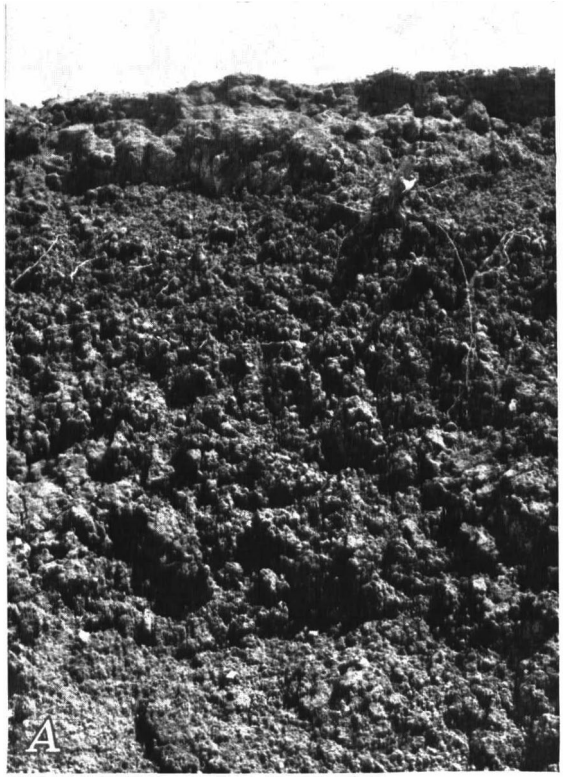
Most of the land is irrigated and used in the production of grass hay, but a few acres are dry farmed and return good yields of wheat and barley. This soil is adapted to general farm crops, but under periodic irrigation care must be exercised to prevent water-logging of the soil above the impervious substratum.

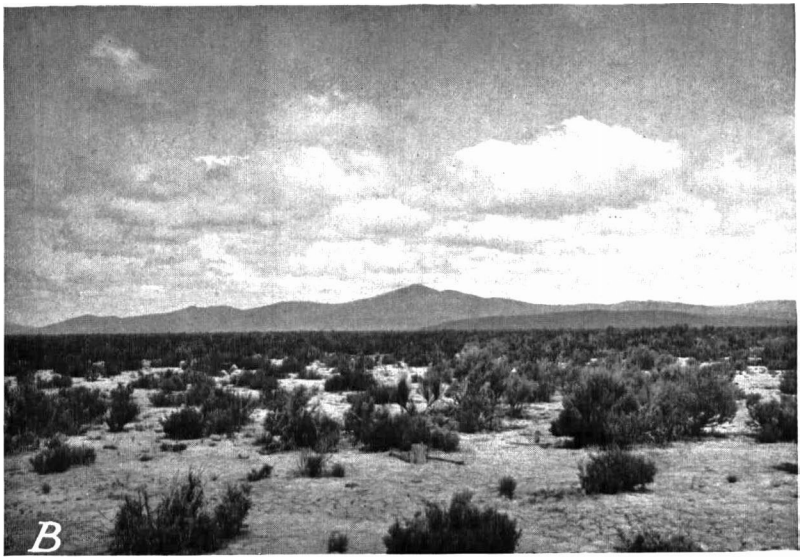
Antelope clay loam, gravelly phase.—The gravelly phase of Antelope clay loam does not differ from the typical soil in any respect except that the surface soil and subsoil contain more or less gravel. The gravel decreases the water-holding capacity of the soil and makes it dry out quicker than it otherwise would. They also interfere with cultural operations and thereby decrease the agricultural value of the soil. The gravel, as a rule, do not constitute more than 20 percent of the soil mass.

Areas of the gravelly phase are confined largely to Goose Lake Valley in the vicinities of Garret and Willowranch. A few bodies are in Pit River Valley in the vicinities of Canby and Opahwah Butte, and a few small areas occur in the vicinity of Likely.

Nearly all this gravelly soil is under cultivation, with about 75 percent used in the production of grass hay under irrigation. Dry-farmed areas are utilized principally in the production of wheat and barley, and some rye and oats are produced from season to season. Wheat yields range from 8 to 20 bushels an acre and barley somewhat more. In seasons of low rainfall, partial failure of grain and hay crops is not uncommon.

Antelope clay loam, heavy-textured phase.—The surface soil of the heavy-textured phase of Antelope clay loam consists of materials of somewhat heavier textures than typical. This soil has a





A, Part of soil profile showing structure in the B horizon of Bieber sandy loam, calcareous-subsoil phase; *B*, widely spaced native vegetation and crusted surface of Canby silty clay loam.

comparatively high water-holding capacity. It is harder to work than typical Antelope clay loam, but it is not especially difficult to handle.

Several small bodies of this soil lie along the highway south of Davis Creek in Goose Lake Valley, and several areas of different sizes are north of Fandango Creek. The land is largely irrigated in connection with the production of grass hay.

Antelope stony clay.—Antelope stony clay is a dense heavy-textured intractable soil that is very difficult to handle under cultivation. The surface soil and subsoil contain more or less stones ranging in size from a few inches to 12 inches in diameter. Before the land can be utilized, the stones must be removed from the surface. This soil has good water-holding capacity and is generally fertile, but its agricultural value is limited by its heavy texture and stone content.

The largest areas occur at Nevada School in Goose Lake Valley and just north of that place; small areas lie about 1½ miles north of Westside School on the west side of Goose Lake, and near the mouth of Canyon Creek south of Opahwah Butte.

About 90 percent of the land is under irrigation and is used in the production of grass hay, for which the soil seems best adapted. A small acreage is used in connection with other soils in the production of grain crops which give fair returns in favorable seasons.

Muck and peat.—Muck and peat consist of light brownish-gray fibrous peaty material and dark-gray or black mucky material consisting principally of decayed organic matter and more or less mineral matter. As occurring in this area the peaty material generally constitutes a surface layer ranging from 10 to 20 inches in thickness over the darker mucky layer of the subsoil. The fibrous peaty material has little value for agriculture until it is decayed, but the more thoroughly decomposed mucky material is in general very productive.

Muck and peat occur only in Jess Valley, where they are used only in the production of grass hay. The yields are very good, and the soil is probably best adapted to this use under existing conditions. Land of this kind can be safely pastured even while wet.

GRAY OR LIGHT-GRAY ALKALI SOILS

The soils of the Lahontan series are characterized by light-gray or dull-gray calcareous 4- to 7-inch surface soils that contain little organic matter and are hard and deflocculated when dry. The upper part of the subsoil, to a depth ranging from 12 to 20 inches, is pinkish-gray moderately compact calcareous material of heavy texture and of tight cloddy structure. The lower part of the subsoil, to a depth of 72 or more inches, is light-gray or light yellowish-gray tight compact highly calcareous material that in places contains lime-cemented seams or lenses. The lower part of the subsoil is of about the same or of heavier texture than the surface soil, though it is generally of stratified character. These soils are developed on old lake deposits and contain various amounts of alkali. As occurring in this survey they include some dark-colored variations.

The soils of the Canby series have gray or light-gray surface soils, to a depth of 4 or 5 inches, that are of porous, vesicular structure, light texture, and low organic-matter content. When dry the material is firm and spongelike, and when wet it is friable. The surface soils grade abruptly into dense compact silty clay or clay loam of columnar structure, that continues to a depth ranging from 18 to 24 inches. Overlying the clay layer is a gray siliceous deposit about one-fourth inch thick. The lower part of the subsoil, to a depth of 6 feet or deeper, consists of light brownish-gray or light yellowish-gray calcareous material of lighter texture, that is firm, dense, and without structural form.

Lahontan fine sandy loam.—Lahontan fine sandy loam has a tendency to run together and bake on drying, and when dry the soil takes water very slowly, but when wet moisture readily penetrates the material. The tight compact character of the soil when dry is unfavorable to root penetration or the movement of air.

This soil occurs only in Surprise Valley, where conspicuous areas lie east of Lake City and others in the extreme southern part of the valley. A large number of smaller bodies occur adjacent to alkali lakes of this section.

About 15 percent of this soil is under irrigation, in connection with better soils, and the land is used in the production of grass hay. Yields are generally low. Virgin areas are covered with sagebrush or greasewood and are of little value for grazing.

Lahontan fine sandy loam, heavy-textured phase.—The heavy-textured phase of Lahontan fine sandy loam differs from the typical soil in having a surface soil of loam or clay loam texture. The subsoil also is heavier in texture and generally more compact and tight. Most of this heavy-textured soil is not so well adapted to crop production as is typical Lahontan fine sandy loam.

This soil, which is extensive, occurs only in Surprise Valley, where it is most prominently developed east of Fort Bidwell and Lake City and in the southern part of the valley. Smaller areas occur in other parts.

Several hundred acres of this soil, largely of loam texture, are irrigated in the vicinity of Fort Bidwell, but elsewhere the land is mostly covered with sage or greasewood and is utilized to a small extent for grazing. Yields of grass hay range from one-half ton to 2 tons an acre. The soil contains some alkali, and saltgrass is the principal vegetation on irrigated areas of higher alkali content.

Lahontan fine sandy loam, friable-subsoil phase.—Lahontan fine sandy loam, friable-subsoil phase, is easily cultivated and can be maintained in a loose granular condition under cultivation, though if not cultivated it tends to become hard and baked on drying. It takes water under irrigation rather slowly but has good water-holding capacity and retains moisture well under cultivation.

A great number of very small areas, each embracing from 1 to 5 acres or less, are associated with the bottom soils of Pit River, and some occur on the lower fans of Surprise Valley, all of which could not be indicated on the soil map because of their small extent. Most bodies of this character occupy slightly elevated positions and, as a rule, contain some alkali. As mapped, soil of this phase also in-

cludes three small areas of clay loam texture—one bordering Rattlesnake Creek on the north, where this stream empties into Pit River about 3 miles west of Alturas; a second one-half mile north of Willowranch; and the third a mile northwest of Kelly Hot Spring.

A large number of typical bodies of this phase of Lahontan fine sandy loam are scattered throughout the surveyed area. Most of them are comparatively small, embracing from 10 to 60 acres, though some larger areas are developed in the vicinities of Alturas and Likely and bordering the south and west sides of Goose Lake. A great number of smaller bodies occur west of Davis Creek in the vicinity of Goose Lake and near the various alkali lakes in Surprise Valley.

About 70 percent of this soil is under cultivation, with perhaps 80 percent of the cultivated area devoted to the production of grass hay or alfalfa. The rest of the cultivated land is used in the production of wheat and barley. Much saltgrass and other alkali-resistant grasses occur on the irrigated areas, and fields of grain are generally somewhat spotted, owing to alkali injury. Alfalfa is grown on the areas less affected with alkali and yields from 2 to 3 tons of hay an acre. This soil is well adapted to agriculture where alkali conditions are favorable.

Lahontan fine sandy loam, gravelly phase.—The gravelly phase of Lahontan fine sandy loam differs from the typical soil in having a content of gravel of small or medium size, that constitutes from 15 to 25 percent of the soil mass. The gravel interfere with cultural operations and reduce the water-holding capacity of the soil. Some areas are included with this soil in mapping, in which the surface soil is of sandy loam texture.

A number of areas of this soil are developed in the central part of Surprise Valley in the vicinity of and south of Cedarville, a few areas occur near Goose Lake west and northwest of Davis Creek, and a small area is located in the valley of South Fork Pit River north of Widgeon.

Less than 20 percent of this soil is under cultivation. Virgin areas are covered with greasewood or sage and alkali grasses and are used for grazing. In general the soil occupies elevated mounds that are unfavorable to irrigation practices, although some areas of favorable relief are irrigated and produce fair yields of grass hay. The soil contains some alkali and has little value for agriculture.

Canby silty clay loam.—Canby silty clay loam is developed in a great number of areas of different sizes throughout the extent of the surveyed area. Some of the more prominent are in the vicinity of Canby and bordering Clover Swale; a number of smaller areas occur in Pit River Valley west and east of Alturas; and two bodies are in Goose Lake Valley—one just west of Garret and the other a mile west of Westside School. In Surprise Valley, two small areas are in the vicinity of Menlo Baths, and a third lies about 4 miles south of that place.

This soil occupies shallow depressions or poorly drained areas and in places is devoid of vegetation. In general, it supports a stunted growth of sage and is little valued for grazing (pl. 1, *B*).

The soil contains more or less alkali and is not used for crop production. Roots penetrate the heavy clay subsoil with difficulty, and, owing to unfavorable drainage and alkali conditions, the land has little potential agricultural value.

Canby silty clay loam, noncalcareous phase.—Canby silty clay loam, noncalcareous phase, has a surface soil and subsoil similar to typical Canby silty clay loam. The subsoil, however, contains no lime and in many places is underlain by a slightly consolidated substratum.

Soil of this phase is developed only in a small valley about 3 miles south of Opahwah Butte. It is not under cultivation, nor is it apt to be of value under future development.

Canby silty clay loam, heavy-textured phase.—Canby silty clay loam, heavy-textured phase, has a deep-brown or purplish-brown surface soil that in many places is covered with a thin layer of ash-gray material. The upper part of the subsoil, to a depth ranging from 36 to 44 inches, is deep purplish-brown material that is tight and compact and contains more or less lime and gypsum. The lower part of the subsoil, to a depth of 6 feet or deeper, is light purplish-brown or brownish-gray highly calcareous material that in many places contains slightly cemented layers or a somewhat consolidated substratum. This soil occupies local shallow poorly drained depressions and flats, and it contains more or less alkali.

This heavy-textured soil occurs in several areas west of Davis Creek and north of Willowranch. In Pit River Valley are three small areas—one 2 miles south, another 4 miles south, and the third 3 miles southwest of Opahwah Butte. None of the land is under cultivation, and it has little potential agricultural value.

GROUPING OF SOILS ACCORDING TO PHYSICAL CHARACTERISTICS OF IMPORTANCE IN PLANT GROWTH

In table 6 (*7*, *8*) the soils are grouped in six grades on the basis of those properties which have importance in determining the growth of plants. This includes a weighing of such soil characteristics as depth of the soil profile, texture, structure, and density of the surface soil and subsoil, reaction, alkali and salt content, and drainage conditions. These ratings are based on soil characteristics alone; and local climatic conditions, availability of irrigation water, accessibility to markets, and similar important land factors are not considered. The table makes a comparison of these soils with other soils of California and with one another, irrespective of location.

Soils of grade 1 are considered to be of excellent quality and suitable for a wide range of crops; those in grade 2 are of good quality and suitable for most crops; the soils in grade 3 are somewhat limited in their uses by extremes of texture, drainage, or other soil factors; those in grade 4 are suitable for few crops except pasture grasses or timber, because of undesirable soil or topographic features; soils in grade 5 are for the most part of very poor quality for any cultivated crops, owing to shallowness of the soil, stoniness, or other undesirable features; and those soils placed in grade 6 are of such poor quality as to be essentially nonarable or nonagricultural.

TABLE 6.—*Grouping of soils in the Alturas area, Calif., according to physical characteristics of importance in plant growth*

Grade	Soil type	Remarks; use
1	Surprise fine sandy loam	Deep and friable; hay, alfalfa, and truck.
1	Surprise fine sandy loam, dark-colored phase	Deep and friable; hay, alfalfa, and potatoes.
1	Modoc loam	Deep and friable; alfalfa.
1	Surprise clay loam	Deep and friable; alfalfa and hay.
1	Pit clay loam	High in organic matter, drainage fair; all crops of the area.
2	Pit fine sandy loam	High in organic matter, drainage poor; all crops of the area.
2	Pit clay, light-textured phase	Silty clay loam or clay, poorly drained; mainly grass hay.
2	Surprise fine sandy loam, calcareous-subsoil phase.	Deep and friable, slight alkali; alfalfa, hay, and truck.
2	Surprise gravelly sandy loam	Deep, friable, low gravel content; alfalfa and grain.
2	Surprise gravelly sandy loam, dark-colored phase.	Deep and friable; alfalfa and hay.
2	Surprise fine sandy loam, shallow phase	Impervious substratum at 40 to 50 inches; alfalfa
2	Carson clay loam	Poor drainage and in some places alkali; hay and grass.
2	Hovey clay loam	Friable, in most places slight alkali; pasture, grain, and alfalfa.
2	Pit mucky loam	High in organic matter, poorly drained; grass hay.
2	Muck and peat	Organic soil, poorly drained; use depends on drainage.
3	Carson clay adobe	Poor drainage and in some places alkali; grass and hay.
3	Surprise gravelly sandy loam, calcareous-subsoil phase.	Deep, friable, slight alkali; alfalfa.
3	Gleason loam	2 to 3 feet deep, rolling to hilly; fair grain soil.
3	Gleason stony loam	40 to 50 inches deep; grain and pasture.
3	Lahontan fine sandy loam, friable-subsoil phase	Friable subsoil, alkali; grain and alfalfa.
3	Pit clay	Heavy, restricted drainage; grass and hay.
3	Hovey clay	Organic clay, alkali; pasture, grain, and alfalfa.
3	Standish gravelly clay loam	Leachy; grain.
3	Surprise gravelly sandy loam, shallow phase	30 to 45 inches to impervious substratum; use limited by depth.
3	Antelope clay loam	Averages 3½ feet to hardpan substratum; pasture.
4	Lahontan fine sandy loam, gravelly phase	Gravelly, alkali; pasture and grain.
4	Bieber sandy loam, calcareous-subsoil phase	Variable texture, hilly; pasture and grain.
4	Gould clay, deep phase	4 to 5 feet to impervious substratum; pasture.
4	Bieber sandy loam	Shallow; pasture.
4	Antelope clay loam, gravelly phase	Low water-holding capacity; pasture.
4	Gleason stony clay loam	2 feet deep, stony and rough; pasture, grain in less stony areas.
4	Lahontan fine sandy loam, heavy-textured phase.	Clay loam, contains considerable amounts of alkali; pasture, grain in areas containing less alkali.
4	Bieber gravelly sandy loam	Shallow, gravelly; pasture.
5	Antelope clay loam, heavy-textured phase	Clay; pasture, some grain.
5	Surprise fine sandy loam, calcareous-subsoil phase (alkali).	Strong alkali.
5	Gould clay loam	Shallow, very stony, infertile; pasture.
5	Pentz loam	Shallow, rolling, low organic content.
5	Pentz loam, light-colored phase	Shallow, infertile, low organic content.
5	Gould clay	Shallow, in many places stony; pasture.
5	Surprise gravelly sandy loam, coarse-textured phase.	Coarse gravelly sand.
5	Antelope stony clay	Heavy and intractable; pasture.
5	Gould clay loam, gravelly phase	Shallow, gravelly, and infertile; pasture.
5	Surprise gravelly sandy loam, calcareous-subsoil phase (alkali).	Strong alkali.
5	Gleason stony clay loam, steep phase	Steep and rough; nonarable.
5	Bieber stony clay loam	Shallow and stony.
5	Canby silty clay loam	Alkali; nonarable.
5	Canby silty clay loam, noncalcareous phase	Nonarable.
6	Scab land	Very stony and shallow.
6	Lassen stony clay	Shallow, intractable stony clay.
6	Lahontan fine sandy loam (alkali)	Strong alkali.
6	Canby silty clay loam, heavy-textured phase	Shallow, strong alkali.
6	Lahontan fine sandy loam, heavy-textured phase (alkali).	Strong alkali.
6	Rough stony land	Nonagricultural.
6	Playa lakes	Alkali lake beds; nonagricultural.

SOILS AND THEIR INTERPRETATION

The Alturas area is located in the extreme northeastern part of California, in a region characterized by the Pacific coast type of climate dominated by hot dry summers and cool wet winters.

The area lies just east of the crest of the Cascade Mountain Range and on the western edge of the Nevada Desert. It is in what is known as the basin-and-range geographic division—a region characterized by broad gently sloping or flat lava plateaus and numerous short parallel mountain ranges with intervening enclosed drainage basins, the central or lower parts of which are generally occupied by intermittent or dry playa lakes. Drainage from the area surveyed empties into these playa lakes, except in the southern and western parts lying west of Warner Mountains. Drainage from this section flows westward, by way of Pit River, and empties into Sacramento River in the upper part of Sacramento Valley. The playa lakes in the Surprise Valley section are normally covered with turbid water during the winter and are dry during the summer. Goose Lake, however, in the north-central part of the area, is under water the year round in seasons of normal rainfall, although it was dry at the time the field work was in progress and had been dry during the summer for several years previous.

The dry beds of these playas, or lakes, consist of dark dull-gray calcareous material of deflocculated structure. When moist this material is loose and granular, but on drying it generally develops an alkali crust-and-mulch structure, but some areas have a hard baked surface. The deeper material, to a depth of more than 72 inches, consists of light-gray or light yellowish-gray stratified and highly calcareous sediments of firm dense consistence, which in many places contain appreciable quantities of gypsum.

The surface of most of this land is bare of vegetation, except along the margins of the lakes where the soil contains little alkali. Some areas that are moist throughout the year support a good growth of alkali-resistant shrubs and grasses. The texture of the sediments differs, some areas along the margins of the lakes being of sandy loam, fine sandy loam, or clay loam texture. As the sediments contain considerable alkali, the soils are of no value as agricultural soils, aside from the small amount of grazing they afford.

In the Surprise Valley section, streams issuing from Warner Mountains have built up a series of coalescing alluvial fans that are well drained in their upper parts, but where the lower parts spread out and encroach on the playalike flats, drainage becomes increasingly restricted. Pit River, for the most part, has cut rather deeply into the lava plateau and now follows a sluggish meandering course through a comparatively narrow poorly drained strip of alluvium. Most of the small streams tributary to this river are swift-flowing and are bordered by well-drained soils.

The climate differs widely in different parts of the area, and these differences are reflected in the vegetation. In the valleys and lower plateau sections, the annual rainfall ranges from about 10 to 19 inches, and the native vegetation consists of sagebrush and bunch grass, with sedges, needlegrass, and other water-loving grasses occupying the poorly drained areas. The higher lying areas are comparatively well watered, being blanketed with snow throughout the greater part of the winter and, in protected areas, until midsummer

or later. Here the native vegetation consists of fir and pine, with aspen and birch along the stream courses. Points of intermediate elevation reflect a climate intermediate in character between the humid mountain slopes and the semiarid valleys, and the soils are covered with juniper or juniper and sage.

The soil series mapped fall naturally into three main groups, one of dark-brown or dark dull brownish-gray well-drained soils, a second of dark-colored poorly drained soils, and the third of gray alkali soils. Enumeration of the soil series represented in each of these groups, with the characteristic vegetation of each group, which reflects the climatic zone in which it is developed, is given in table 4 (p. 13). Each of these groups includes soils in various stages of development, as reflected in their profiles. Owing to the prevailingly granular structure and somewhat gritty texture they are characteristically of friable physical character and apparently of lighter texture than is indicated by mechanical analyses.

The dark-brown or dark dull brownish-gray soils are developing under normal processes of soil development, although the presence of an impervious layer, such as bedrock, inhibits the formation of the complete, normal profile in many soils of this group. The darker colored soils are those that owe their color largely to accumulation of organic matter under restricted drainage, and until such time as these conditions are changed the soils will not reflect normal processes of development. The gray alkali soils reflect their environment, but, under existing conditions, they are developing into normal soils for this region.

The dark-brown forested soils, embracing soils in the Gleason series, are developing under a rainfall ranging from 25 to 40 or more inches. The soils of this group occupy high mountainous areas, and only the lower lying, less well watered areas are included in the present surveyed area. The higher annual rainfall and the occurrence of occasional summer thunderstorms tend to keep the soils comparatively moist throughout the year, and they are leached of lime and other readily soluble minerals. These soils occur on rather steep slopes where erosion and soil creep are active, and they show very little evidence of mature development. Under virgin conditions the surface soils are covered with an inch or two of leaf mold or partly decayed organic matter.

The material in the topmost inch or two of soils in the Gleason series is loose and granular and of decidedly darker color than the subsurface soils which consist of dark dull-brown friable material to a depth ranging from 9 to 12 inches. The subsoils consist of dark dull reddish-brown slightly compact material that, where disturbed, breaks up readily to a medium-granular or small-cloddy structure. The material is permeated by innumerable root cavities and animal or insect burrows. At an average depth of about 30 inches the subsoil grades into decaying bedrock of basic igneous material. As mapped in this area, Gleason stony loam represents somewhat lighter colored material which is developed on comparatively steep slopes and which includes much colluvial material. It is derived largely from weathered basic tuffaceous rocks including some quartzite and other materials.

The group of dark-brown or dark brownish-gray soils, on which juniper, or juniper and sage, are the predominant vegetation, in-

cludes soils of the Pentz and Lassen series and the calcareous-subsoil phase of Bieber sandy loam. These soils occur on flatter relief and, as a rule, show better evidence of weathering than do the soils of the Gleason series. They also, for the most part, lack the dull or dark surface horizon resulting from the decomposition of organic matter. The surface soils are less granular and friable than the Gleason soils, and these soils, in general, are shallow over bedrock.

The surface soils of members of the Pentz series are dull dark brownish-gray or dull grayish-brown rather firm material that breaks up readily to a granular and friable structure. The subsoils are slightly compact material, of about the same texture as the surface soils, that show little clay or colloidal deposition. The subsoils rest on parent tuffaceous and andesitic bedrock at a depth ranging from 12 to 18 inches.

The surface soils of members of the Lassen series consist of dull-brown or dull reddish-brown material low in organic matter. The subsoils are dull reddish brown and very compact. When dry the material has a coarse-cubical or medium-nut structure. Rocks in the lower part of the subsoil are generally coated on the under side with gray lime carbonate, but the weathered soil material, in most places, does not effervesce. At a depth ranging from 12 to 18 inches the soil material rests on basic igneous bedrock from which the soils have developed through weathering. The Lassen soils of this area differ from those of the earlier survey of the Shasta Valley area (*6*), which have been subjected to less leaching and in which the subsoil material is, in most places, decidedly mottled with lime carbonate and effervesces vigorously.

The dark-brown or brownish-gray soils which, under virgin conditions, support a native vegetation consisting largely of sage, are grouped in the Modoc, Standish, Surprise, Gould, and Bieber series, in addition to the miscellaneous classification of rough stony land. The soils of this group also are prevailingly of dark dull-brown, dark brownish-gray, or grayish-brown color. They show appreciable colloidal deposition in the subsoils of the older soils of the group and have a well-developed coarse-granular, small-cloddy, or nut structure in the zone of illuviation. In structural characteristics the soils of this group do not differ so much from the soils characterized by juniper, or juniper and sage vegetation, as do the soils of this last-mentioned group differ from those under a fir and pine vegetation.

Modoc loam is typical of the soils of this group, which are developing under normal conditions. It shows the following profile:

A_1. 0 to 1½ inches, dark brownish-gray granular loam without organic decomposition.

A_2. 1½ to 7 inches, dull dark grayish-brown or dull brownish-gray loam or sandy clay loam, that is firm until disturbed, when it breaks up under slight pressure to a fine-granular structure. The material is comparatively dense and is without pronounced development of root cavities or insect or animal burrows.

B. 7 to 36 inches, brown, dull-brown, or dark rich-brown moderately compact loam or sandy clay loam. The material is comparatively dense but breaks up to a medium cloddy structure. The structural particles and the insides of the cavities are slightly stained with a dull-brown colloidal coating.

C. 36 to 72 inches, pale-brown or light grayish-brown sandy clay loam of slight compaction, that shows no colloidal deposition or clay accumulation.

Although this soil is immature, it represents one of the more mature soils of the area, that is developing under normal conditions.

The surface soils of members of the Standish series are brown or dull brown. The upper part of the subsoil is compact light brownish-gray or grayish-brown calcareous material containing some lime-cemented seams or lenses. The lower part of the subsoil consists of brownish-gray calcareous material also somewhat cemented with lime, and in most places it consists of coarse-textured sediments and gravel or cobbles. The soils of this series occur as elevated terraces that were deposited at the mouths of streams emptying into ancient lakes.

The soils of the Surprise series are similar to those of the Modoc series but are, in general, somewhat browner or richer brown. They are also less mature, representing a youthful development of the soils of the Modoc series. Typically they are without lime, but they include a calcareous-subsoil phase of some types.

The surface soils of members of the Gould series are dark reddish-brown or dark chocolate-brown material that is friable when disturbed but generally very firm and dense in place. The surface soils grade rather abruptly into dull reddish-brown or dark rich-brown compact clay or clay loam, that rests on a firmly cemented substratum at a depth ranging from 15 to 36 inches. The material in the B horizon is of columnar structure when wet, but it breaks up readily to a small-cloddy or medium-nut structure when disturbed. When dry the material crumbles easily to a coarse-granular structure.

The soils of the Bieber series are similar to those of the Gould series in profile development and occurrence of a cemented substratum at a slight depth, but they differ from the Gould soils in that they are duller brownish gray or dull grayish brown (pl. 1, *A*).

The dark brownish-gray or black soils that support a vegetation consisting largely of native grasses are grouped in the Pit, Carson, Hovey, and Antelope series or in the miscellaneous classification, muck and peat. The soils of this group are developing under poor drainage, and the vegetation reflects this condition. Some of these soils occupy gently sloping alluvial fans that are subject to seepage or have been irrigated for an appreciable period of time under continuous flooding practices, but more generally they occupy flat poorly drained drainage courses or lake margins.

The surface soils of members of the Pit series are dark gray, dark brownish gray, or black. The subsoils are generally slightly grayer than the surface soils and mottled with rust brown and yellow. These soils are developed from poorly drained alluvial deposits derived largely from basic igneous rocks.

The soils of the Carson series are similar to those of the Pit series, except that lime carbonate is disseminated through the lower part of the subsoil.

The Hovey soils are slightly grayer than the Carson or Pit soils. The surface soils and subsoils are moderately calcareous, although in places the surface soils may show no lime in the upper few inches.

The surface soils of the Antelope soils are very dark dull grayish brown or dark brownish gray. The subsoils are moderately compact

and range in color from dull brown to dark brownish gray. They are of similar or of heavier texture than the surface soils and show some colloidal deposition. At a depth ranging from 30 to 50 inches they rest on a firmly consolidated substratum. These soils are in general well drained under natural conditions, but, in some places, seepage from higher land or irrigation practices have given them their characteristic dark color.

Muck and peat are dominated by a high organic-matter content. The peaty areas consist of undecayed fibrous organic deposits that do not contain appreciable mineral material. In the muck areas, the organic materials are well decomposed and mixed to greater or less extent with mineral soil material. Most of the muck areas are dark, whereas areas composed principally of peat are in general grayish brown.

The gray alkali soils, on which the predominant vegetation is alkali grasses, sage, or greasewood, include the Lahontan and Canby soils. All the soils of this group are affected to greater or less extent with salts and, where developed to any extent, in some places show a typical Solonetz profile. These soils occur under climatic conditions similar to other soils in the sage or grassland group, but, owing to the influence of parent materials or poor drainage, they contain more or less alkali.

The surface soils of members of the Lahontan series are typically light-gray or dull-gray firm calcareous material without many root cavities or other pore space. The upper part of the subsoil is pinkish-gray heavy-textured material that is compact and highly calcareous and that in a few places may contain partly cemented layers or strata. The lower part of the subsoil is light-gray, light yellowish-gray, or light brownish-gray very calcareous material which is very compact but breaks up granular under moderate pressure. These soils are developed from old lake deposits. As mapped in this area they include some darker colored variations.

The surface soils of members of the Canby series are gray or light-gray vesicular or spongelike silty materials with a thin surface crust. At a depth of 4 or 6 inches the loose surface soil grades abruptly into dull grayish-brown dense clay or silty clay, that is of columnar structure in the upper part and, at a depth ranging from 14 to 16 inches, consists of slightly lighter textured more friable material of cubical structure. The tops of the columns are generally rounded and covered with a gray siliceous deposit a fraction of an inch thick. The lower part of the subsoil consists of compact partly cemented highly calcareous light brownish-gray or light-gray material.

LABORATORY STUDIES[4]

Laboratory studies of the soils of the Alturas area cover mechanical analysis, a determination of the stone content of the soil samples, the moisture equivalent, and the reaction, or pH value.

Mechanical analyses of the soils were made by a proximate method, in which the air-dried soil was screened through a 2-millimeter sieve, the lumps being crushed and the coarse particles made comparatively clean. The screened soil was shaken in distilled water

[4] This section of the report was prepared by Chas. F. Shaw, professor of soil technology, University of California.

with sodium oxalate as a dispersant, then washed through a 300-mesh sieve to remove the sands. The silt and clay suspension which passed through the sieve was made up to volume, allowed to stand, and sampled by the pipette at the proper time intervals to give effective maximum diameters of silt at 50 microns, coarse clay at 5 microns, fine clay at 2 microns, and ultra clay at 1 micron. It has been found that this method of analysis gives results comparable to those obtained when the soils are first pretreated with hydrogen peroxide and with hydrochloric acid, and show the mechanical composition when dispersion of the clays is practically complete.

The yield of clay by this method is considerably higher than is obtained when ammonia is used as a dispersant, and if the clay content of these soils is compared with the standards established for the several textural grades by the Bureau of Chemistry and Soils (*1*) it is evident that the textural names are, in many cases at least, one grade lighter than the standard would indicate. Natural structure is another factor which has a direct bearing on this discrepancy between textural grade names and analyses. All the upland soils are distinguished by structure or tilth and break into a granular condition which masks the high clay content, and they give a favorable tilth much quicker than their actual texture would indicate.

The progressive aging of the soils is indicated by the differences in content of the ultra clay in the surface soil and subsoil horizons. The recent alluvial soils show no differences in clay content that can be ascribed to downward migration of the clays. This is also true of the young soils of the Surprise series, although the calcareous-subsoil phase of Surprise gravelly sandy loam shows considerable evidence of the beginning of soil development. This, however, is not typical of the Surprise series. In contrast to these recent and young soils, the well-developed Bieber sandy loam shows a marked accumulation of clay in the subsoil horizon. The total clay content of the three surface soil and subsoil horizons is 19.55, 23.74, and 52.40 percent, respectively, and the ultra clay content of the same horizons is 9.31, 17.14, and 40.63 percent, respectively. The proportion of ultra clay in the deeper horizons (72 and 77 percent) is much higher than it is in the surface soils (47 percent). Some of the profiles of the primary soils from residual materials show distinct evidence of profile development, but other profiles are apparently more youthful. This feature seems to be related to the extent of normal erosion activities on these upland areas.

Many samples of soils from this area contained considerable quantities of small stones and gravel. When the samples were being prepared for mechanical analyses by sieving through a 2-millimeter screen, the content of stone 2 millimeters in diameter was determined, and the percentage reported is calculated on the total weight of the fine soil and stone. It must be pointed out that, in the sampling in the field, large stones and coarse gravel are discarded; it is seldom that any stone fragment larger than 1 inch in diameter is included in the sample sent to the laboratory. Hence, the reported percentages of stone err decidedly on the low side. The quantity of these small stones in some places was as high as 50 percent of the total mass and in many places was more than 20 percent. The effect

of this stone content on tilth and on moisture capacity is so great that it was felt desirable to report the quantities present.

Moisture equivalents were determined by the standard method, whereby 30 grams of saturated soil are subjected to a force 1,000 times gravity in a centrifuge. The moisture equivalents are reported in percentage of moisture calculated on the basis of oven-dry soil. They represent approximately the normal field-moisture capacity, or the amount of water that is held in a soil after a heavy rain or an irrigation where drainage downward is free and uninterrupted. In most samples the moisture content at the moisture equivalent shows direct relation to the proportion of ultra clay present in the soil. In the samples containing very large proportions of silt, the moisture content is proportionally higher. The moisture equivalent was determined on the soil finer than 2 millimeters. Many of the samples which contain large quantities of stones will probably have a field capacity lower than that indicated by the moisture equivalent.

The reaction, measured as pH, was determined by the colorimetric method which usually errs toward neutrality, tending to indicate the acid soils as somewhat less acid and the basic soils as somewhat less basic than is found when the direct electrometric measurements are made. Most of the upland soils of this area are neutral or slightly acid in the surface soils, whereas some upland soils and most of those in the bottom lands are distinctly basic. Practically all the subsoils are basic, although a few are neutral or very slightly acid in reaction.

The colors of many of the surface soils have been analyzed by means of the disk colorimeter and are reported in table 7 which shows the proportion of standard white, black, yellow, and red, that, when blended by the revolving disk, match the soil color.

TABLE 7.—*Color analyses of soils in the Alturas area, Calif.*

Sample no.	Soil type	White	Black	Yellow	Red
		Percent	*Percent*	*Percent*	*Percent*
578066	Surprise gravelly sandy loam	5	81	7	7
578072	Surprise clay loam	9	78	7	6
578069	Standish gravelly clay loam	10	66	13	11
578001	Bieber gravelly sandy loam	11	66	12	11
578017	Bieber sandy loam	12	64	12	12
578011	Bieber stony clay loam	11	61	14	14
578047	Gould clay loam	5	80	7	8
578049	Gould clay	6	80	6	8
578053	Antelope clay loam	10	78	6	6
578045	Antelope stony clay	5	85	5	5
578035	Modoc loam	10	67	12	11
578004	Pentz loam, light-colored phase	18	61	12	9
578015	Pentz loam	16	67	8	9
578007	Gleason loam	7	74	9	10
578009	Gleason stony clay loam	3	85	5	7
578056	Gleason stony loam	8	70	11	11
578013	Lassen stony clay	5	78	8	9

The types in the Surprise, Bieber, and Gould series are very uniform in color. The samples of Antelope soils, which are rather poorly drained soils, show some variation in the proportion of white and black. The soils of the Pentz series show less variation in the

white but more in the yellow, and they have been separated, with the lighter colored soil as a phase. The three soil samples of the Gleason series show considerable variation. This is a common characteristic of soils developed from primary residual materials, where erosion continually modifies the profile, including the color characteristics. It also reflects variations in the parent material of these soils. The color of all the soils in this area is darker than would be anticipated from the amount of rainfall, as the region is very dry and the vegetal cover is characteristically that of the western semiarid regions. As a whole, this area includes soils which are prevailingly dark brown.

Table 8 gives the results of mechanical analyses of samples of most of the soils mapped in the Alturas area, the moisture-equivalent determinations, the stone content calculated on the basis of the total weight of the stone and soil as sampled, and the pH values as determined by the colorimetric method.

TABLE 8.—*Mechanical analyses* [1] *of soils in the Alturas area, Calif.*

Soil type and sample no.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay				Organic matter	Moisture equivalent	Stone content [2]	pH [3]
								0.005–0.002 mm	0.002–0.001 mm	0.001 mm	Total				
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
Bieber gravelly sandy loam:															
578001	0–3												22.72	26.00	
578002	3–8												28.42	26.50	
578003	8–14												45.33	14.40	
Pentz loam, light-colored phase:															
578004	0–3	2.882	6.059	7.802	24.784	9.067	23.537	8.446	4.592	11.275	24.313	1.378	26.91	2.71	6.4
578005	3–7			[4] 31.069			16.774	7.405	11.537	32.431	51.373	.574	34.06	5.70	6.5
578006	7–13			[4] 24.860			16.687	10.086	12.546	34.932	57.564	.587	42.55	4.08	6.9
Gleason loam:															
578007	0–10	7.196	8.445	10.886	19.530	10.006	19.572	7.831	3.526	11.767	23.124	1.567	21.64	7.32	7.0
578008	10–30			[4] 51.737			18.942	6.601	5.904	15.908	28.413	1.462	22.18	14.90	7.0
Gleason stony clay loam:															
578009	0–10			[4] 50.350			17.835	5.166	3.444	22.468	31.078	.737	25.82	5.93	
578010	10–24												30.42	2.45	
Bieber stony clay loam:															
578011	0–6			[4] 48.183			23.657	7.872	4.305	14.473	26.650	.847	21.09	11.45	
578012	6–10												41.18	50.02	
Lassen stony clay:															
578013	0–5			[4] 21.176			16.195	6.683	7.544	47.642	61.869	.495	45.48	13.92	6.5
578014	5–12			[4] 12.009			13.243	5.207	8.569	50.840	64.616	10.275	50.61	12.90	7.2
Pentz loam:															
578015	0–6	10.647	10.227	3.172	13.483	8.087	30.493	9.389	3.649	9.266	22.304	1.467	26.16	20.28	6.8
578016	6–14	8.914	7.176	7.514	12.678	8.715	23.895	9.266	5.207	16.728	31.201	.736	27.98	22.40	6.8
Bieber sandy loam:															
578017	0–4	9.623	11.789	7.903	20.043	10.506	20.892	6.314	3.936	9.307	19.557	.880	19.65	16.50	6.3
578018	4–7	5.569	6.205	10.998	20.336	10.752	23.934	3.034	3.567	17.138	23.739	.676	21.62	13.32	6.4
578019	7–15			[4] 37.929			8.897	3.403	8.364	40.631	52.398	.554	44.09	11.25	7.2
Surprise fine sandy loam, calcareous-subsoil phase:															
578020	0–10	.982	1.723	4.260	21.748	19.431	28.521	6.519	3.362	11.849	21.730	1.785	24.44	.70	7.2
578021	10–26	1.010	2.930	3.043	16.719	16.846	31.485	7.954	3.936	11.685	23.575	4.988	27.23	1.79	7.4
578022	26–72	1.722	4.992	5.223	18.883	19.164	23.670	5.617	2.870	15.662	24.149		30.82	2.23	8.1
Pit clay:															
578023	0–12			[4] 13.802			35.670	11.562	8.815	28.290	48.667	1.163			
Pit mucky loam:															
578029	0–10			[4] 17.330			31.652	16.154	8.856	17.384	42.394	7.956	81.60	3.26	
Lahontan fine sandy loam, friable-subsoil phase:															
578031	0–10	.693	1.724	4.083	16.587	17.364	30.039	12.956	6.355	8.200	27.511	1.262	21.64		8.6+
578032	10–72	7.128	6.428	9.954	25.211	15.310	19.053	6.313	2.665	7.626	16.604		24.74	1.51	8.6+

Pit clay, light-textured phase:															
578033	0- 9			[4] 35.260			24.600	6.437	5.822	24.764	37.023	1.116	31.49	6.18	
Modoc loam:															
578035	0- 7	5.849	5.279	7.746	20.364	13.259	23.545	6.232	2.747	12.464	21.443	1.065	22.62	12.31	
578036	7-36			[4] 49.961			23.862	5.535	4.305	14.473	24.313	1.109	23.96	10.72	
578037	36-72			[4] 54.073			22.345	4.305	4.551	13.202	22.058	1.104	24.00	11.32	
Surprise gravelly sandy loam, calcareous-subsoil phase:															
578038	0-14	18.007	16.626	13.261	20.173	6.055	11.720	2.624	2.214	7.708	12.546	1.282	13.18	27.40	
578039	14-40			[4] 74.059			9.430	2.870	2.050	10.168	15.088	1.248	16.40	27.95	
578040	40-72			[4] 72.989			6.970	2.419	1.312	15.047	18.778	1.433	20.73	41.10	
Carson clay loam:															
578041	0-14			[4] 20.039			36.121	13.325	7.216	19.516	40.057	1.366	39.76		
578042	14-72			[4] 38.690			28.495	8.323	6.601	17.835	32.759		33.90		
Pit clay loam:															
578043	0-10			[4] 38.541			27.716	7.093	6.437	18.450	31.980	1.469	36.41	4.69	7.0
Antelope stony clay:															
578045	0- 8			[4] 26.478			24,764	6.970	5.822	34.399	47.191	.660	35.58	10.73	
578046	8-26			[4] 26.506			23.370	8.159	6.191	35.506	49.856		38.76	11.43	
Gould clay loam:															
578074	0- 8			[4] 45.279			25.379	6.314	4.223	15.990	26.527	1.118	23.38	16.70	
578048	8-15			[4] 31.342			18.122	5.822	7.175	37.433	50.430		40.21	11.93	
Gould clay:															
578049	0-10			[4] 19.262			22.427	9.020	6.642	42.476	58.138	.599	37.74	2.42	
578050	10-32			[4] 17.728			23.042	8.651	6.068	43.788	58.507	.441	36.95	4.97	
Antelope clay loam:															
578053	0- 9			[4] 27.114			33.825	15.621	2.460	18.286	36.367	1.560	31.51	18.70	
578054	9-36			[4] 31.169			35.588	5.904	7.134	18.737	31.775	.918	28.93	13.73	
578055	36-44			[4] 34.689			28.577	13.407	8.118	13.243	34.768	1.131	34.17	18.42	
Gleason stony loam:															
578056	0-12	8.242	4.554	5.376	14.090	9.087	27.314	8.979	6.642	13.612	29.233	1.327	22.27	62.50	
578057	12-32			[4] 40.524			26.363	8.979	6.437	16.072	31.488	.951	20.73	40.05	
578058	32-50			[4] 46.422			24.969	8.774	5.412	12.874	27.060	1.000	19.95	59.00	
Pit fine sandy loam:															
578059	0-10	2.090	5.264	6.732	33.614	15.362	17.569	5.002	2.173	10.455	17.630	.993	21.60	2.02	
Lahontan fine sandy loam:															
578061	0- 4	4.473	5.540	9.108	25.710	16.661	28.778	4.264	1.435	2.132	7.831	.918	15.79	.72	
578062	4-14			[4] 32.158			26.117	9.061	9.922	22.345	41.328	.466	64.72	.86	
Hovey clay:															
578064	0-20			[4] 7.091			42.066	17.589	10.045	23.206	50.840	.536	45.12		
578065	20-72			[4] 23.426			40.098	12.177	7.093	15.785	35.055	.709	34.33	.65	
Surprise gravelly sandy loam:															
578066	0-14			[4] 64.578			20.435	4.223	2.829	7.954	15.006		18.00	48.10	7.2
578067	14-44	11.527	10.336	7.004	22.075	16.029	19.517	3.485	2.624	6.273	12.382			37.70	7.2
578068	44-72	15.196	14.830	18.452	24.738	9.665	10.835	1.558	1.103	3.694	6.355			67.60	7.3
Standish gravelly clay loam:															
578069	0- 8	9.926	9.938	11.358	19.189	8.057	16.341	4.640	2.248	17.343	24.231		21.09	39.74	7.5
578070	8-30			[4] 53.305			23.083	5.617	3.444	7.175	16.236	6.223	26.91	16.50	8.6+
578071	30-72			[4] 94.096			2.460	.205	.328	1.025	1.558	1.186		70.70	8.6+

[1] Soil samples shaken with sodium oxalate. Sands separated by washing through 300-mesh sieve; silt and clays by pipette determination.
[2] Percentage on basis of total weight of stone and soil as sampled.
[3] Determined by colorimetric method.
[4] Total sand content.

TABLE 8.—*Mechanical analyses of soils in the Alturas area, Calif.*—Continued

Soil type and sample no.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay				Organic matter	Moisture equivalent	Stone content	pH
								0.005–0.002 mm	0.002–0.001 mm	0.001 mm	Total				
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
Surprise clay loam:															
578072	0– 8			[4] 26.335			35.834	9.553	4.346	21.935	35.834	.936	33.65	1.13	------
578073	8–30			[4] 30.558			36.490	7.790	3.854	20.582	32.226	.555		1.06	------
578074	30–72			[4] 32.250			33.169	8.159	4.264	21.730	34.153	.618		4.21	------
Hovey clay loam:															
578075	0–14			[4] 16.018			32.800	13.325	10.291	18.450	42.066	8.097	53.62		------
578076	14–72			[4] 28.069			34.184	10.045	5.894	19.065	35.004	.880	30.13	2.62	------
Carson clay adobe:															
578077 [5]	0– 8			[4] 6.484			26.240	14.551	13.776	26.978	55.305	1.724	50.18		------
578078	8–20			[4] 8.952			31.939	14.063	16.400	26.691	57.154	.318	52.55		------
578079	20–72			[4] 13.323			43.583	15.826	10.619	14.473	40.918	.787	46.53	.72	------
Bieber sandy loam, calcareous-subsoil phase:															
578080	0– 7	3.114	5.531	6.213	18.298	9.563	27.649	10.619	6.191	10.824	27.634	2.296	35.39	6.52	------
578081	7–20			[4] 30.559			12.997	7.831	9.963	38.417	56.211	.520	46.00	6.66	------
Canby silty clay loam:															
578083	0– 5	.189	.510	.553	1.953	2.896	64.151	15.252	7.298	6.027	28.577	1.128	35.02	.45	6.8
578084	5–20			[4] 1.744			43.460	22.181	14.473	12.573	49.227	.273			7.4
578085	20–72			[4] 8.223			43.009	19.106	12.833	15.457	47.396	1.101			8.6+
Surprise fine sandy loam:															
578086	0–10	8.036	7.889	4.733	14.445	13.918	29.364	6.068	3.854	10.086	20.008			16.80	------
578087	10–40	6.645	5.676	6.876	16.247	12.590	25.319	5.822	4.756	13.407	23.985	1.490		12.51	------
578088	40–72	8.700	6.505	7.839	18.660	13.578	21.980	5.986	4.018	11.972	21.976			11.09	------

[4] Total sand content.
[5] Some appreciable loss in weight due to washing out of soluble salts.

ALKALI

In the normal processes of rock weathering and of soil development, a variety of mineral salts and chemical compounds are liberated and formed. Some of these are readily soluble in water, and under humid or subhumid conditions they are removed about as fast as they are formed. In arid or semiarid regions, however, the rainfall is not sufficient to leach them from the soil, with the result that an accumulation of readily soluble chemical compounds are stored in the soil. These accumulated soluble salts are known agriculturally as " alkali."

In any growing plant the concentration of mineral salts is higher in the plant than in the soil solution from which it feeds, and the tendency is for the weaker soil solution to enter the plant and equalize the density of the solution in the plant with that of the soil outside. If, however, the soil solution should become more dense or concentrated than the solution within the plant, the process is reversed and instead of the plant being able to draw moisture and nutrients from the soil, the soil draws moisture from the plant, with the result that the plant withers and dies. This is, therefore, the process that takes place in soils with a high content of soluble salts, or alkali. These materials in weak concentration are not injurious, but the concentration of any soluble mineral may become too great in the soil to allow plant growth.

The most common soluble mineral salts, or alkali, found in the Alturas area are sodium chloride, sodium sulphate, calcium chloride, and sodium bicarbonate. In some localities there are appreciable quantities of sodium carbonate, or " black alkali." This is chemically a true alkali and has a corrosive action on plant tissues such that a very small quantity of it in the soil will effectively prevent the growth of any cultivated plants. In addition to the readily soluble salts mentioned, certain soils of the area contain variable quantities of calcium carbonate, or lime, and calcium sulphate, or gypsum. These salts are not so readily soluble in water and where present in the soil in reasonable amounts are not harmful to plant growth.

Areas affected by alkali are outlined on the soil map by solid red lines and indicated by the symbols A and S in red. The locations at which samples were taken for alkali determination are shown on the map by red dots. In taking samples, parts of the soil from the surface soil, upper subsoil layer, and lower subsoil layer were taken separately, and a determination of the total salt content of each layer was determined by means of the electrolytic bridge. On the map the results of these determinations are shown in the form of a fraction. The number above the line indicates the percentage of soluble salts in air-dry soil in the surface soil, and the number below the line represents the average percentage of salts in air-dry soil to a depth of 6 feet or to the consolidated substratum, or bedrock. If the samples show the presence of " black alkali " by chemical reaction tests, a letter B in red is shown after the percentage figure.

In judging the degree of injury to crops from alkali concentrations, it is generally considered that a soil having 0.2 percent or less of the neutral or " white alkali " in the 6-foot section is free from injurious salt concentration. When the percentage increases above

this figure, alkali injury will be roughly proportionate to the amount of increase, although it is influenced by other factors. A soil containing as much as 2 percent of alkali is generally of little value for crop production. The extent of alkali injury that may be expected from a given percentage, however, is dependent on a number of other factors. If a soil containing 0.2 percent of alkali in the 6-foot section has most of the alkali concentrated in the surface soil, it is natural to expect the injury to crops will be greater than when the alkali is distributed throughout the soil to a depth of 6 feet or deeper. A strong concentration of salts in the topmost few inches of the soil, even though the percentage for the 6-foot section may be less than 0.2 percent, will in many places injure or even prohibit crop growth. The kind of salts present in the soil also determines the extent of injury that may be expected from a given concentration of salts. With two soils showing the same concentration of salts, one containing black alkali and the other, other salts, the injury will be much greater on the soil with " black alkali " than on the soil containing other salts. Different crops also have different susceptibilities to alkali injury. A crop resistant to alkali injury may be grown on a soil where another crop less resistant would fail under the same conditions of alkali distribution and cultural practices.

In the Alturas area two grades of alkali concentration are shown on the soil map. One, indicated by the letter A, has a concentration of more than 0.2 percent in the 6-foot section, or to bedrock. The other, indicated by the letter S, has a concentration of less than 0.2 percent, but, because of the localization of the salts in the surface soil, alkali injury to the growing crops is apparent. Such areas show a spotted alkali condition, depending largely on cultural and irrigation practices. Locally the extent of injury is very great, owing to the concentration of a small quantity of salt directly on and near the surface, whereas in other places no alkali injury can be seen, owing to the distribution of the salts throughout the soil mass. Such spotted areas can be reclaimed with good drainage and good cultural practices.

More or less injury to crops may be expected on all areas marked A. On some areas of high concentration it is doubtful whether any crops can be grown, especially where " black alkali " is present. The reclamation of such areas would be a long and expensive procedure, and it is considered doubtful that it would be economically feasible.

There are no large areas of strongly affected alkali soils, except the sediments that occupy the intermittent lake bottoms. Determinations in a few places show the salt content in the 6-foot soil section to be more than 1 percent, but such determinations are rare, indicating that in most places the soils might be reclaimed if drainage were provided and the carbonate salts neutralized. Bordering the highway 6 miles south of Paola, a sample of the substratum underlying the soils of the Bieber series was taken for alkali determination. This sample showed 2.46 percent of alkali, including the carbonate, or " black alkali " salts. Although the Bieber soil rarely, if ever, shows alkali, this determination would indicate that the underlying consolidated material is the source of considerable alkali salts found in the lower, deeper soils of the area.

The material of the lake beds, as stated, generally contains high amounts of alkali salts, but some of the bottom material in Goose Lake, along the outer margin, is comparatively alkali-free, owing to the leaching of the soil by fresh water from springs or streams entering the lake. The soils of the Lahontan series are developed on old deposits of lake-laid materials that contain appreciable quantities of salts. The soils of the Canby series also contain more or less salts, especially in the deeper parts of the subsoils (fig. 2). These soils, and many others that are shown for the most part in the spotted alkali areas, border irrigated areas, and constant evaporation of

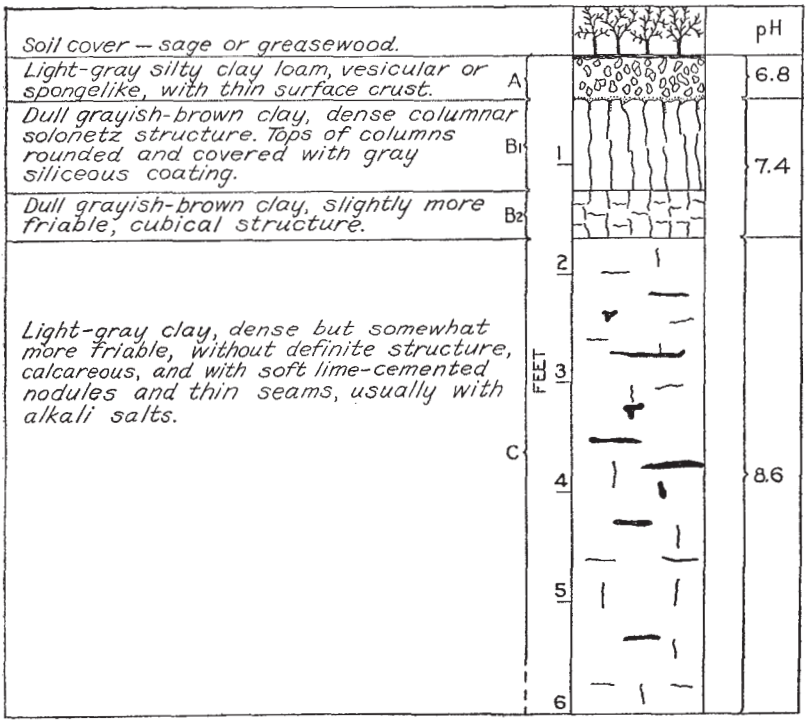


FIGURE 2.—Diagram of a profile of Canby silty clay loam in the Alturas area, Calif.

water seeped from the irrigated soils leaves the soluble minerals deposited in the surface soil where they will do the greatest damage to crops. The soils of the Hovey and Carson series, together with the calcareous-subsoil phase of Surprise gravelly sandy loam, are also in this class and in many places show spotted alkali conditions. In a few places soils of the Pit series and lower lying areas of the Surprise soils contain some alkali as the result of seepage from other alkali-affected soils.

The grasses as a whole are rather resistant to alkali injury, although bluegrass will not grow on soils containing an appreciable quantity of alkali. Giant bluegrass, orchard grass, redtop, and broom grass are good grasses for soils with low or moderate alkali accumulation. Western wheatgrass is also a very good grass on

alkali soil, and saltgrass will grow successfully on soils of high alkali accumulation. Alfalfa will grow successfully on soils containing 0.3 to 0.4 percent of the neutral or white alkali salts, and under good cultural practices it can be grown on soil having even higher concentrations. Alfalfa and most of the other legumes are sensitive to alkali in the seedling stage, but if the salts can be kept below the feeding zone of the roots in this stage the plants, after becoming established, will withstand appreciable concentrations. Sweetclover is one of the most resistant legumes and will grow on soils with 0.6 to 0.8 percent of alkali if the salts are distributed throughout the soil mass and not concentrated in the surface soil.

Barley and rye are the small grains most resistant to alkali injury, rye being slightly more resistant than barley. Sugar beets and milo also are very resistant. Asparagus, onions, celery, and radishes are the vegetables perhaps most resistant to alkali injury and will do fairly well on soils having as much as 0.5 percent of alkali, provided the salts are not concentrated in the surface soil.

In order to reclaim alkali land, it is essential that the soil have good drainage in both surface soil and subsoil and that a plentiful supply of alkali-free water be available to flush the salts out of the soil. Without good drainage no expensive system of alkali reclamation should be attempted, and even with a plentiful supply of water and good drainage outlets, the success of the project will depend somewhat on the porosity of the soil and the character of the salts present. Soils with heavy compact clay subsoils or clay strata will retard the movement of water through the soil to such an extent that reclamation will be a long and expensive process. "Black alkali" salts tend to deflocculate the soil to such an extent that it is practically impossible to get sufficient water through the soil to leach out the salts. The application of gypsum or sulphur to soils containing "black alkali" will neutralize the carbonate salts and usually improve the structure of the soil sufficiently that water will penetrate readily. The turning under of barnyard manure or cover crops is of material benefit in the handling or reclamation of alkali land.

Some of the spotted alkali-affected soils of the area, having the salts concentrated largely on the surface, can be temporarily improved by turning a sufficiently large head of water over the soil so that it will carry the salts over the surface and into a drainage outlet. Drainage outlets for a large part of the alkali-affected soils, that will allow leaching of the soil to a depth ranging from 6 to 8 feet or deeper cannot be had, and most of the areas in which drainage could be established are not large enough to warrant the expense of constructing a drainage system.

A water extract of the surface material of the intermittent lake bed sediments showed 384 parts per million of sodium carbonate, 340 parts per million of sodium bicarbonate, 460 parts per million of sodium or calcium chloride, and 250 parts per million of sodium sulphate.[5]

[5] Determinations made by Esther P. Perry, Division of Soil Technology, University of California.

SUMMARY

The Alturas area is in the extreme northeastern part of California. It occupies most of the central and eastern parts of Modoc County and a small part of Lassen County. It is divided into three units, the nonagricultural lands lying between the units being excluded. The total area is 891 square miles. The Nevada-California State line forms the boundary of a part of the eastern unit, and the Oregon-California State line forms a part of the northern boundary of the central unit.

The drainage of the eastern and northern parts empties into enclosed basins or playa lakes, and drainage from the southern, central, and southwestern parts reaches Sacramento River by way of Pit River which has its source largely within the area.

The general elevation of the area is about 4,500 feet above sea level, although neighboring mountain ranges attain elevations ranging from 6,000 to nearly 10,000 feet.

A few settlers located in this section of the country as early as 1864, but general settlement did not take place until the close of the Modoc Indian wars in 1873. The population of Modoc County in 1930 was 8,038, all classed as rural.

The climate is characterized by cool wet winters and warm dry summers. Frosts are of frequent occurrence throughout the spring and summer, and the average length of the frost-free season is about 120 days. The mean annual rainfall ranges from 12.65 inches at Alturas to 17.69 inches at Fort Bidwell. Snow and below-zero temperatures are common during the winter.

Sheep and cattle are the chief agricultural exports, and some alfalfa seed and grain are grown in excess of local requirements. The production of hay for winter feeding of livestock is one of the major agricultural pursuits.

Slightly more than 70,000 acres were irrigated in Modoc County in 1929. The development of this area by means of irrigation is limited by the water supply rather than by lack of soils capable of irrigation. The unimpounded gravity flow from streams is depended on entirely for irrigation purposes.

The soils fall naturally into three groups as follows: Brown, dark-brown, and dark brownish-gray well-drained soils; dark-gray or black soils of restricted drainage; and gray alkali soils of restricted drainage. The soil series embraced in the first group are the Gleason, Pentz, Lassen, Modoc, Standish, Surprise, Gould, and Bieber, in addition to rough stony land. The darker soils of impeded drainage consist of soils of the Pit, Carson, Hovey, and Antelope series, in addition to muck and peat. The soils in the gray alkali group are the Lahontan and Canby soils. The soils in the first group are well drained and adapted to deep-rooted crops either under irrigation or dry-farming practices, where they are not underlain by an impervious substratum or bedrock. The darker colored soils are largely under irrigation and used in the production of grass hay under continuous flooding practices. They owe their color largely to accumulated organic matter under irrigation practices or impeded drainage conditions. The gray alkali soils are of little value for agriculture, and probably will not be sufficiently

reclaimed of alkali in the future to be of appreciable agricultural value.

For successful reclamation of alkali lands it is essential that the soils have good drainage. "Black alkali" salts must be neutralized by the addition of gypsum or sulphur, and the reclamation of land containing such salts is a slow and expensive process.

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