SOIL SURVEY

Grand Junction Area, Colorado

Series 1940, No. 19

Issued November, 1955

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with the
COLORADO AGRICULTURAL EXPERIMENT STATION

How to Use THE SOIL SURVEY REPORT

FARMERS who have worked with their soils for a long time know about soil differences on their own farms, and perhaps about differences among soils on farms owned by their immediate neighbors. What they do not know, unless soil surveys have been made, is how nearly their soils are like those on experiment stations or other farms, either in their State or other States, on which new or different farming practices or enterprises are in operation. Farmers of the Grand Junction Area can avoid some of the risk and uncertainty involved in trying new crops and soil management practices by using this soil survey report, for it gives them an opportunity to compare their own soils with soils on which new developments have proved successful.

SOILS OF A PARTICULAR FARM

The soils of the Grand Junction Area are shown on the soil map that accompanies this report. A mile on the ground equals 2.64 inches on this map. To learn what soils are on a particular farm or tract of land, first locate the boundaries of the farm or tract on the map by referring to roads, streams, villages, dwellings, and other landmarks. The next step is to identify the soils on the farm or tract. Each area of each kind of soil is shown on the map with a symbol and distinguishing color. The map legend gives the name of each soil and the symbol and color used on the map to identify that soil. For example, all areas on the map marked with the symbol Fr are Fruita clay loam, 2 to 5 percent slopes, and all areas so marked are the same color, wherever they appear on the map.

If you wish to know what Fruita clay loam, 2 to 5 percent slopes, is like, for what it is used, and to what uses it is suited, turn to the section, Soil Descriptions. Refer also to the section, Salinity and Alkali, and the section, Soils, in which soils requiring about the same management are placed in groups and suitable farming practices are suggested for each group. If you want to know how productive the soil is, consult table 6. You will find the name Fruita clay loam, 2 to 5 percent slopes, in the left-hand column and in columns following you can read the yields of different crops this soil can be expected to produce. You can compare these yields with those given in the table for other soils mapped in the county.

SOIL OF THE AREA AS A WHOLE

A general idea of the soils in the county is given in the introductory part of the section, Soils, which tells about the principal kinds of soils, where they are found, and how they are related to one another. After reading this section study the soil map and notice how the different kinds of soils are grouped according to colors. These groupings correspond with the management groupings given in the section, Soils; that is, all soils that are suited to the same general use and management are shown in one shade or color. These groupings reflect well-recognized differences in types of farming, land use, and land use problems.

A newcomer to the county, especially if he considers purchasing a farm, will want to know about the climate; the types and sizes of farms; the principal farm products and how they are marketed; the kinds and conditions of farm tenure, including tenancy; the kinds of farm equipment; the availability of churches, roads, schools, railroads, telephone and electric services, and water supplies; the industries of the area; and cities, villages, and population characteristics. Information about all these will be found in the section, General Nature of the Area, or in the section, Agriculture.

Those interested in how the soils of the county were formed and how they are related to the great soil groups of the world should read the section, Morphology and Genesis of Soils.

This publication on the soil survey of the Grand Junction Area, Colo., is a cooperative contribution from the—

SOIL CONSERVATION SERVICE

and the

COLORADO AGRICULTURAL EXPERIMENT STATION

Series 1940, No. 19 Issued November 1955

SOIL SURVEY OF THE GRAND JUNCTION AREA, COLORADO[1]

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Area inspected by A. T. STRAHORN, Soil Survey

United States Department of Agriculture in cooperation with the Colorado Agricultural Experiment Station

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[1] Field work for this survey was done under direction of the Division of Soil Survey while it was part of the Bureau of Plant Industry, Soils, and Agricultural Engineering. Soil Survey was transferred to the Soil Conservation Service on November 15, 1952.

THE GRAND JUNCTION AREA is in the Grand Valley of Colorado near the western edge of Mesa County. Grand Junction, the largest city in Colorado west of the Continental Divide, is approximately at the center of the Area. The climate is clear, sunny, and semidesert. The agriculture depends on irrigation. Some 70 years ago the area supported only a sparse cover of desert shrubs. Now it is vitalized by a network of irrigation ditches and produces high-quality orchard fruits, vegetables, and field crops.

At the risk of oversimplification, the critical problem always has been that of applying water at the time and place and in the amount that will obtain the best production without damaging the soils. Farmers must guard against the accumulation of seepage water and salts in the soils; the overirrigating or underirrigating that damages or kills orchard trees; and the planting of crops on a soil that will not tolerate the kind of irrigation those crops must have.

This soil survey, made cooperatively by the United States Department of Agriculture and the Colorado Agricultural Experiment Station, is designed to aid farmers of the Grand Junction Area in determining the suitability of various crops grown in the Area to their particular soils. It describes the soils of the Area and tells something about their use and management in 1940, the date when field work was completed. The survey will serve as a reliable source of information about soils for many years to come. It is not intended as a substitute for the up-to-date, detailed information on management and crop varieties that can be obtained from the county agricultural agent, the local Soil Conservation Service representative, the State experiment stations, or similar sources.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

The Grand Junction Area is located in the western part of Mesa County near the Colorado-Utah State line. Grand Junction, the largest town and county seat, is 195 miles southwest of Denver and 200 miles west of Colorado Springs (fig. 1). The area surveyed covers approximately 121,600 acres, or 190 square miles.

PHYSIOGRAPHY, RELIEF, DRAINAGE, AND GEOLOGY

Physiography.—The area covered by this survey is located in the Canyon Lands section of the Colorado Plateau physiographic province (*3*).[2] It occupies part of the floor of a deep pocket, or valley, known as the Grand Valley of Colorado (pl. 1, *A*). This valley, carved in the Mancos Shale formation by the Colorado and Gunnison Rivers and their tributaries, is surrounded for the most part by steep mountainous terrain (fig. 2). Deep canyons flank the valley to the southwest; a sharp escarpment known as the Book Cliffs rises above it to the north and northeast; foot slopes of the Grand Mesa lie to the east; and rough broken and steep hilly land that borders high terraces or mesas lies to the south.

[2] Italic numbers in parentheses refer to Literature Cited, p. 118.

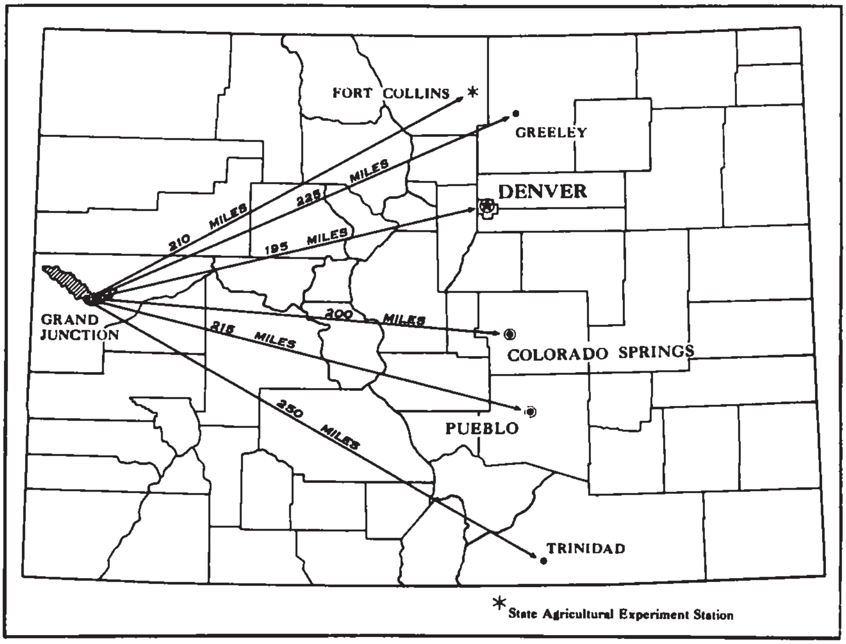


FIGURE 1.—Location of the Grand Junction Area in Colorado.

For convenience the surveyed area can be divided into three general physiographic sections:[3] (1) A recent alluvial plain consisting of broad coalescing alluvial fans and stream flood plains; (2) older and higher-lying alluvial fans, terraces, or mesas; and (3) rolling to steep land occurring as terrace escarpments, high knobs, or remnants of former mesas.

Relief.—Each of the three general physiographic sections in the area has a typical kind of relief. The recent alluvial plain consisting of broad coalescing alluvial fans and stream flood plains is broad and slopes very gently eastward and northwestward from Grand Junction. The older and higher lying alluvial fans, terraces, or mesas have gentle slopes toward the Colorado River, but their otherwise smooth surface is fringed by narrow steep rims that mark the drop from a higher to a lower bench, or by a few steep-sided arroyos running toward the Colorado River. Orchard Mesa, south of the Colorado River, is typical of this pattern of relief.

[3] Various areas within the survey have commonly used local names that are used in this report. That part of the survey lying southeast of Palisade is known as the Vinelands; the long high terrace, or mesa, south of the Colorado River to the southeast of Grand Junction is called Orchard Mesa; and the smooth gently sloping area southwest of the Colorado River and west of Grand Junction is named the Redlands.

Some of the more distinctive soils and soil areas also have local names. The gray, moderately fine textured to fine textured alluvial soils on the young alluvial plain north of the Colorado River are called adobe. Soils on the higher benches or mesas northwest of Grand Junction are referred to as red sandy land or red heavy land, depending on their texture. The rather sharply uneven soils formed in place over shale are known as shale land.

The rolling to steep land occurring as terrace escarpments, high-knobs, or remnants of former mesas has steep irregular slopes and includes uneven, choppy areas occupied by exposed Mancos shale.

From Palisade westward elevations range as follows: Palisade, 4,729 feet; Grand Junction, 4,573 feet; Fruita, 4,500 feet; and Loma, 4,515 feet. Mack Mesa, north of Mack, has an elevation of 4,796 feet at its highest point, or an only slightly lower elevation than the eastern extremity of Orchard Mesa (fig. 2).

Drainage.—Most of the Grand Junction Area is drained by the Colorado River, which rises along the western slope of the Continental Divide and flows in a generally westerly direction. Southwest of Grand Junction, the Colorado is joined by the Gunnison River. The northern part of the Grand Valley is drained by a number of washes or arroyos that flow southwestward into the Colorado. The largest of these are Big Salt Wash, Little Salt Wash, West Salt Creek, Mack Wash, Sleepy Hollow, Adobe Wash, Persego Wash, and Indian Wash. West Salt Creek enters the area in the extreme northwestern part and drains southeastward along the western border of the Area and thence southward into the Colorado River.

Geology.—The geologic formations of the Grand Junction Area are shown in figure 3. The terrain is extraordinarily varied and complex. Most of the valley is influenced by the Mancos shale formation, which is extensive in western Colorado and ranges from 3,908 to 4,150 feet in thickness (*2*). To the north and northeast, the Mancos shale is capped by the Book Cliffs, which stand out in bold relief above the valley. The base of these cliffs is at an elevation of about 5,500 feet, and the crest, at 6,500 to 7,000 feet. The total relief from the crest of the cliffs to the lower base level of the Grand Valley is about 3,000 feet (*2*).

Though the Book Cliffs belong to the Mesaverde group in Colorado and Utah, the name is used to designate a lithologic group that contains buff to yellowish-brown sandstone bedded with soft gray shale that has one or more beds of bituminous coal, and, underlying, thick beds of sandstone that rest upon the marine Mancos shale (*2*).

The soils of the Persayo and Chipeta series have developed in place on the Mancos shale, and the gray alluvium washed from this shale has contributed to the Billings soils. The soils on the sloping and higher benches north of the Colorado River have developed from brown sandy alluvial materials largely derived from formations of the Mesaverde group in the Book Cliffs.

Overlying the Mesaverde group are the Plateau Valley, Wasatch, and Green River formations, which successively rise to the lava-capped deposits on Grand Mesa. The western escarpment of Grand Mesa (pl. 1, *B*), elevation 10,000 feet, overlooks the Grand Valley from the east. This lava-capped formation and others farther up the Colorado River consist of igneous, sandstone, and shale formations and are the source of the older alluvial deposits on Orchard Mesa and of the younger alluvium on the Colorado River flood plain.

The mountainous terrain with deep canyons that flanks Grand Valley to the southwest and west of Grand Junction is more complex geologically than other parts adjoining the Grand Junction Area. This complexity results from the Uncompahgre uplift, as is evidenced by the sharply tilted landscape and varicolored rocks to the west of

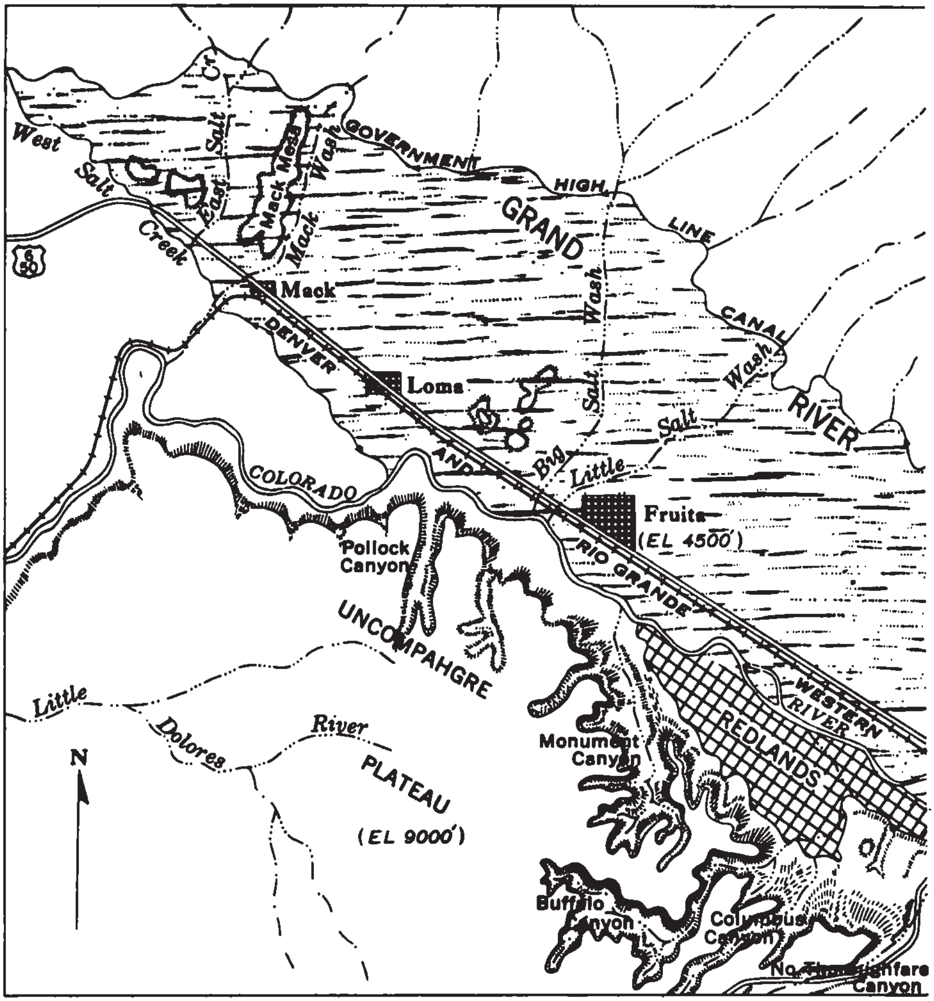
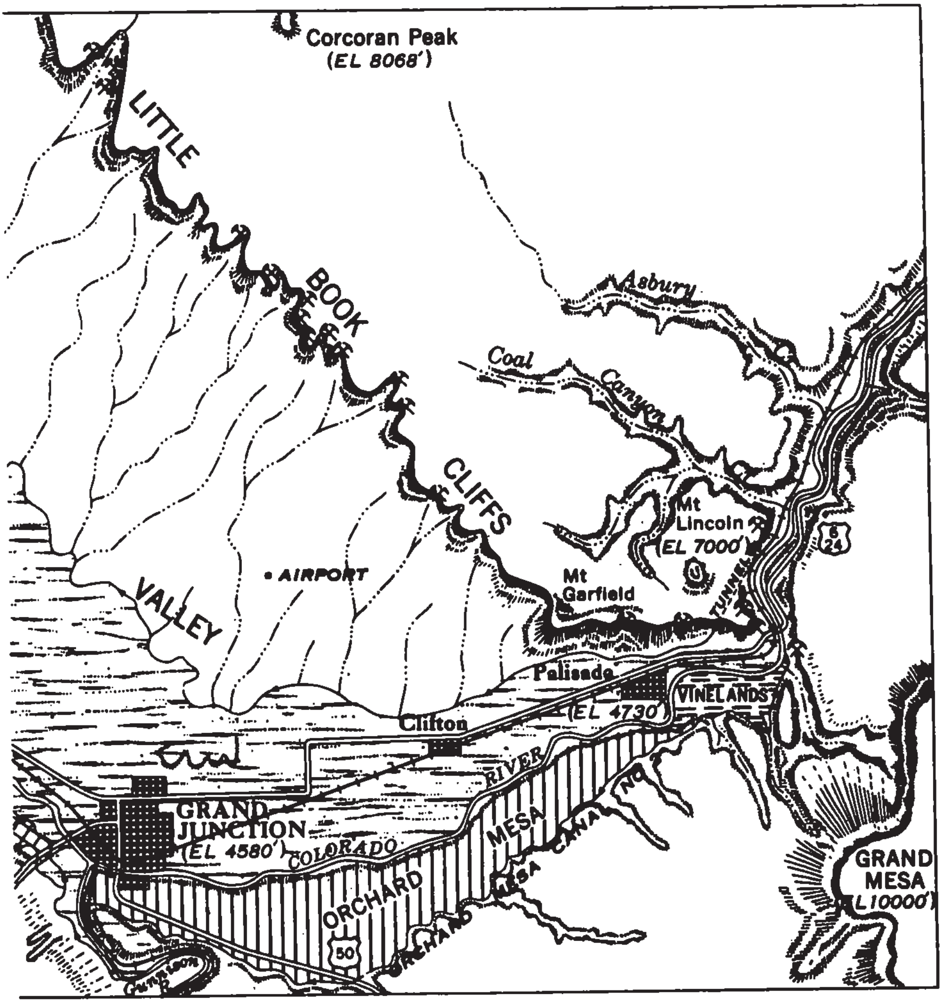


FIGURE 2.—Geographic, physiographic, and cultural

the Redlands. This uplift, after ages of severe geologic erosion, has caused the exposure of several of the upheaved geological formations that before the uplift normally were situated far below the thick, 4,000-foot, Mancos shale bed. From the top downward, in respect to their former position below the Mancos shale, these formations include Dakota, Morrison, Summerville, Entrado, Kayenta, Chinle, and the lower pre-Cambrian. These give rise to the sandy soils of the Redlands.

CLIMATE

The climate of the Grand Junction Area is similar to that of most of the intermountain areas west of the Continental Divide in its aridity, wide range of daily temperatures, high percentage of bright sunny days, and high evaporation rate. Where the climate differs, the differences apparently are caused by protective mountain barriers.



features of the Grand II Junction Area, Colorado.

In the extreme eastern part of the Area, the Colorado River enters the Grand Valley through a steep narrow canyon that tends to stabilize air currents in the valley. During the day, the air tends to move up the slopes that confine the valley at its eastern end. Then, at night, the air moves down again. This peculiar movement, spoken of as air drainage, affords a more limited daily range in temperature and less danger from frost in the proximity of Palisade than elsewhere in the valley. Hence, the eastern section of the valley, to a distance of about 3 or 4 miles west of Palisade, has a climate particularly suitable for orchard fruits.

Aside from the difference already mentioned, climatic conditions at Grand Junction are representative for the area. Normal monthly, seasonal, and annual temperatures and precipitation compiled from records of the United States Weather Bureau station at Grand Junction are given in table 1.

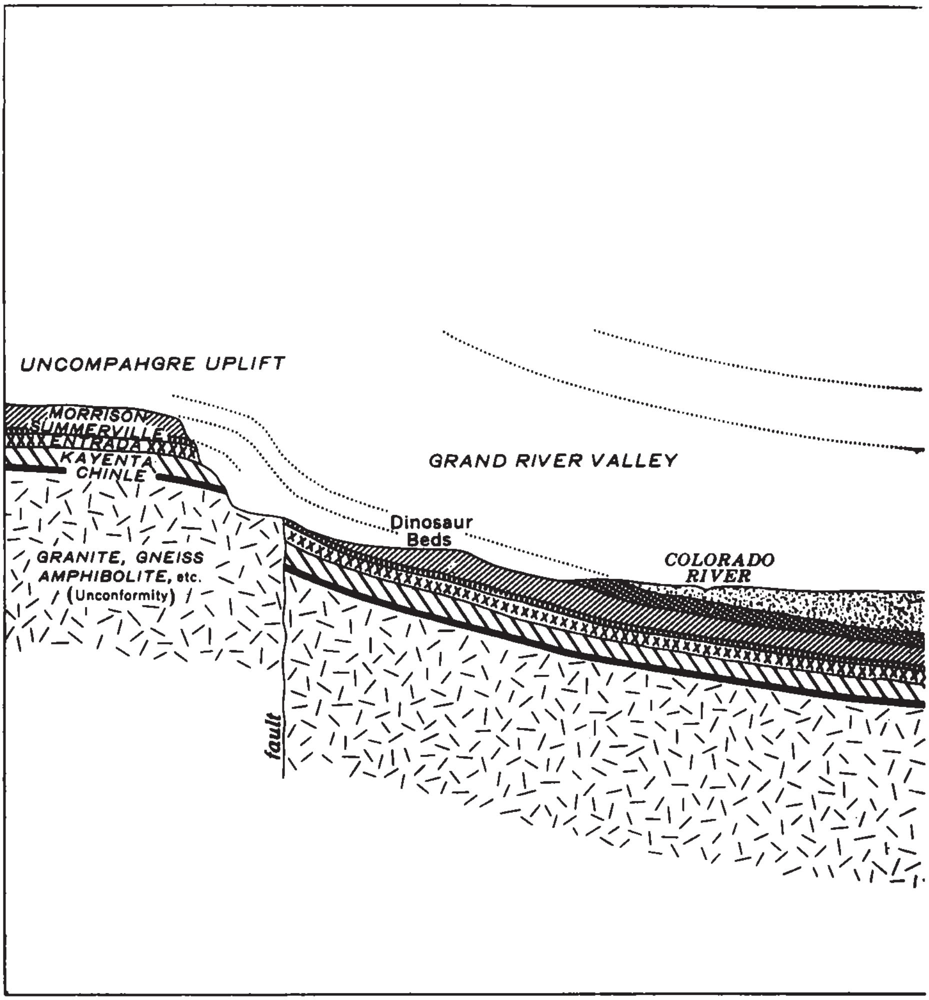
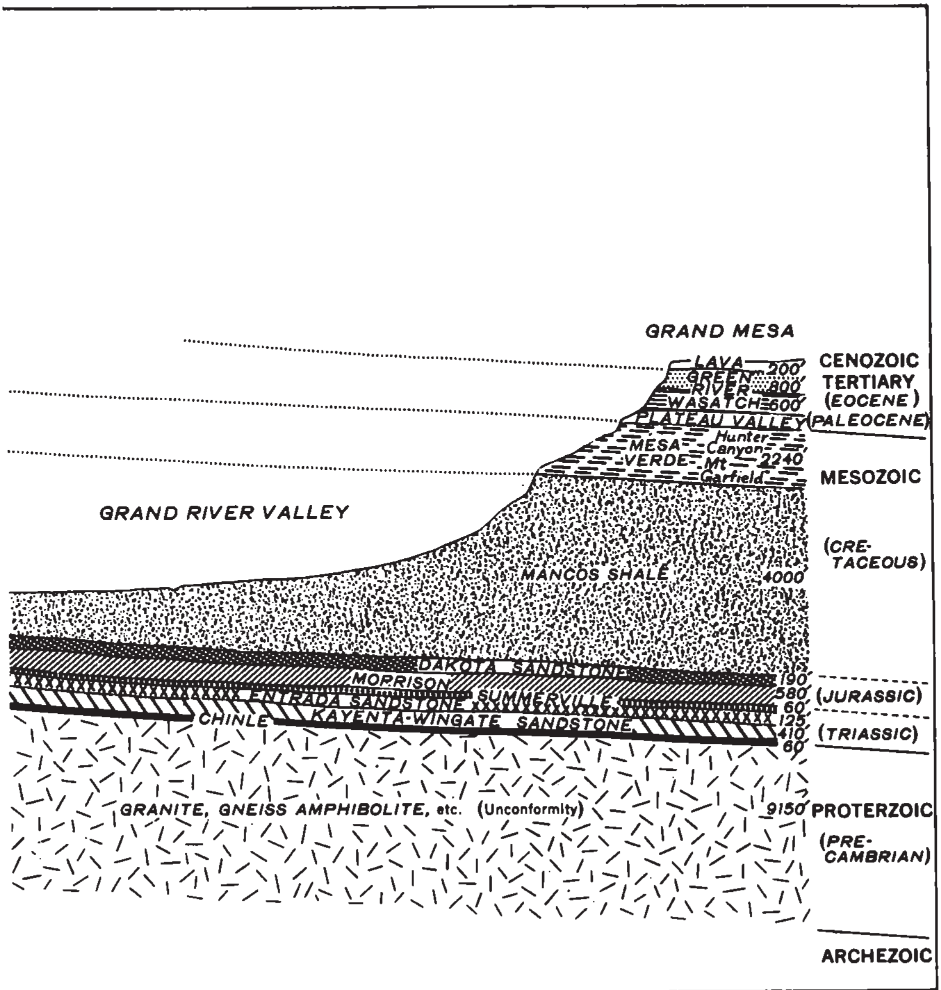


FIGURE 3.—Northwest-southeast cross section of the Uncompahgre uplift and the principal

As shown in table 1, summer temperatures rise to a maximum of about 105° F. Several days in summer may have temperatures above 100°. The nights are cool, however. The winters are mild. Temperatures are usually above zero, though an absolute minimum of −21° has been recorded. The average humidity is low, so zero weather does not seem so cold nor the summers so hot as in States where the humidity is higher.

The average date of the last killing frost in spring is April 14, and the first in fall is October 21. The average frost-free, or growing season is 190 days. Occasionally, late spring or early fall frosts do some damage to fruits and vegetables on the bottom lands and recent flood plains. On the mesas or higher terraces, frost damage is slight. Frost is especially rare in the climatically protected areas around Palisade and along the bluffs bordering the Redlands.



Grand Junction Area showing the tilt caused by the formations giving rise to the soils.

High winds are unusual, and cyclones are unknown. Light thundershowers are common during summer. Hail damage is localized and usually slight. Summer showers are frequently more detrimental than beneficial, especially those that come during the harvesting season for alfalfa, cantaloups, pinto beans, and peaches. In some seasons a few days of damp drizzly weather during peach harvest stop work and may allow part of the crop to become overripe and unfit to be shipped by rail.

The average annual precipitation at Grand Junction is 9.06 inches per year. This precipitation is well distributed throughout the year but is not sufficient to permit successful dry farming. The soils support only a scant growth of native grasses and shrubs if they are not irrigated. The average snowfall is 22.0 inches. The snow usually melts within a few days after it falls. The ground is free of snow most of the winter.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Grand Junction, Mesa County, Colo.*

[Elevation, 4,849 feet]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Total for the driest year	Total for the wettest year	Average snowfall
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	28. 5	66	−21	0. 68	([3])	0. 49	5. 4
January	24. 0	62	−19	. 60	0. 14	. 77	5. 8
February	32. 0	70	−15	. 63	. 14	. 93	4. 8
Winter	28. 1	70	−21	1. 91	. 28	2. 19	16. 0
March	41. 2	81	7	. 87	. 13	1. 70	2. 6
April	51. 8	85	14	. 75	1. 26	1. 31	. 7
May	62. 1	94	29	. 68	. 06	1. 03	. 1
Spring	51. 7	94	7	2. 30	1. 45	4. 04	3. 4
June	71. 2	104	35	. 45	. 04	. 78	0
July	78. 2	105	47	. 79	. 09	. 35	0
August	75. 6	103	47	1. 20	. 19	1. 51	0
Summer	75. 0	105	35	2. 44	. 32	2. 64	0
September	67. 3	98	28	1. 02	1. 18	2. 90	0
October	54. 4	86	16	. 84	. 14	2. 73	. 3
November	38. 6	74	4	. 55	. 27	. 26	2. 3
Fall	53. 4	98	4	2. 41	1. 59	5. 89	2. 6
Year	52. 1	105	−21	9. 06	[4] 3. 64	[5] 14. 76	22. 0

[1] Average temperature based on a 64-year record, 1890 to 1953; highest and lowest temperatures from a 39-year record, 1892 to 1930.
[2] Average precipitation based on a 65-year record, 1889 to 1953; wettest and driest years based on a 62-year record, 1892 to 1953; snowfall on a 39-year record, 1892 to 1930.
[3] Trace. [4] In 1900. [5] In 1941.

WATER SUPPLY

Water for the city of Grand Junction is obtained mainly through a 25-mile gravity pipeline that brings snow water into the area from near Granby Lakes on Grand Mesa. Part of the water supply, mainly that used to fill cisterns outside Grand Junction, comes from several artesian wells south and southwest of the city. Ordinarily, artesian water is obtained at depths ranging from 800 to 1,200 feet.

In most parts of the valley, water from comparatively shallow wells is unfit to drink. This is especially true north of the Colorado River, where the water has a high content of salts derived from the underlying Mancos shale formation. A few springs exist in this part of the valley but they are unfit for drinking purposes. Farmers have their domestic water supply trucked from artesian wells to the farm and stored in cisterns. Water for livestock may be obtained directly from the Colorado or Gunnison River, irrigation canals leading therefrom, small ponds, and in some cases from the artesian wells.

Irrigation water, essential to agriculture in this area, is obtained from both the Colorado and Gunnison Rivers. The main diversion canal from the Colorado River, which supplies water for the Government High Line Canal and Orchard Mesa Canals Nos. 1 and 2, has a capacity of 1,525 cubic feet a second.

The largest irrigation canal, the Government High Line Canal, takes water out of the main diversion canal about 8 miles northeast of Palisade and carries it through a canal, flume, and approximately a mile of concrete tunnel to the valley. This irrigation system, completed in 1914, furnishes water for the greater part of the irrigated land north of the Colorado River. The Kiefer Extension, Grand Valley Canal, and Independent Ranchmens Ditch are supplementary systems operating on the north side of the Colorado River.

Orchard Mesa, in the southeastern part of the area, is irrigated by Orchard Mesa Canals No. 1 and No. 2, which are independent of the Government High Line Canal. The Orchard Mesa pumping plant lifts water 195 feet from the main diversion canal to the upper Orchard Mesa canal (Canal No. 2).

The Redlands are irrigated by a canal that originates at the Redlands Dam on the Gunnison River about 2½ miles south of Grand Junction. The Redlands pumping plant, located approximately a mile west of Grand Junction, lifts water about 300 feet to the main canal. Two other pumps, 4 and 5 miles west of Grand Junction, respectively, complete the lifts required for flow in the higher canals.

Ample irrigation water for all the canals is normally available. Occasionally, during the latter part of summer, the supply of water for the Redlands becomes low.

VEGETATION

The Grand Junction Area, before settlement and irrigation, had a cover of desert brush. A few scattered trees grew along the larger rivers and drainageways. A large part of the area consists of gently sloping alluvial fans and flood plains along streams that originate in the Grand Valley proper. The native cover was chiefly greasewood, rabbitbrush, saltgrass, and bordering the larger intermittent creeks and washes, scattered cottonwoods. Greasewood dominated on most of the alluvial flats that were derived largely from redeposited Mancos shale. Greasewood, a salt-tolerant shrub, is a fairly accurate indicator of Ravola and Billings soils, which developed mainly from Mancos shale material and frequently contain quantities of salts injurious to crops.

At levels directly above the greasewood flats are the gently undulating to sharply rolling uplands, which are derived from Mancos shale and are subject to continual erosion. These support a moderate to scant cover consisting chiefly of saltbush, rabbitbrush, shadscale, and galletagrass.

The older higher terraces or mesas support a cover consisting dominantly of shadscale, but some sagebrush and pricklypear cactus are common.

A high percentage of the native vegetation on the sandy Redlands soils consists of sagebrush, but a more general mixture of native grasses is found here than on most soils of the area, and some greasewood grows on the lower slopes.

The lowest alluvial belt, or the first bottom of the Colorado River, supports a variable plant cover consisting of greasewood, saltgrass, various shrubs, and a conspicuous growth of cottonwood trees along with a few willows and boxelders.

The principal noncultivated plants in the Grand Junction Area are listed in table 2.

TABLE 2.—*Principal noncultivated plants in the Grand Junction Area, Colo., and their principal habitat*

Scientific name	Common name	Habitat
Shrubs, grasses, and other plants:		
Agropyron repens	Quackgrass	
Artemisia tridentata	Sagebrush, big sagebrush.	Higher benches (Mesa and Fruita).
Asclepias galioides	Poison milkweed	Mainly on banks of irrigation canals.
Atriplex canescens	Fourwing saltbush	Generally deep soils, medium to coarse textured.
Atriplex confertifolia	Shadscale	Almost all soils in areas of low precipitation and soils containing alkali and salts.
Atripex decumbens	Matscale	Fine-textured soils having high content of salts.
Atriplex nuttallii	Saltsage	Fine-textured soils (chiefly Persayo and Chipeta).
Avena fatua	Wild oats	Fine-textured soils (Persayo, Chipeta, Billings).
Bassia hyssopifolia	Bassia	Almost all soils in areas of low precipitation and on soils containing alkali and salts.
Bouteloua gracilis	Blue grama	High mesas.
Bromus tectorum	Cheatgrass (annual), downy cheat.	Irrigated soils.
Chrysothamnus spp	Rabbitbrush	Soil along drainageways.
Cicuta occidentalis	Waterhemlock (western).	Generally along canal banks.
Convolvulus sepium	Wild morningglory	
Convolvulus arvensis	Bindweed	Widely scattered; generally on deep soils (Billings).
Cuscuta spp	Dodder	
Distichlis stricta	Saltgrass	Saline and seeped areas (Billings).
Dondia spp	Sea blite	Strongly saline areas.
Elymus triticoides	Ryegrass, beardless wildrye.	Rough rocky hillsides and rough broken land affected by seepage.
Erodium cicutarium	Alfileria	Higher benches (Mesa and Fruita).
Festuca octoflora	Annual, fescue, six-weeks fescue.	Irrigated soils.

TABLE 2.—*Principal noncultivated plants in the Grand Junction Area, Colo., and their principal habitat*—Continued

Scientific name	Common name	Habitat
Shrubs, grasses, and other plants—Continued		
Grayia spinosa	Hopsage (spiny)	Higher benches (Mesa and Fruita).
Gutierrezia spp	Snakeweed	Highly calcareous soils.
Hilaria jamesii	Galleta grass	Open ridges (Fruita and Mesa).
	Sandgrass	High benchland.
Lepidum spp	Peppergrass, pepperweed.	
Opuntia spp	Pricklypear cactus	Bottoms and uplands (Billings, Fruita, and Mesa soils).
Oryzopsis hymenoides	Indian ricegrass	Deep sandy soils.
Plantago spp	Indianwheat (annual)	Irrigated soils.
Sarcobatus vermiculatus	Greasewood, black greasewood.	Saline and alkali areas (Billings soils).
Sitanion hystrix	Squirreltail	Do.
Sorghum halepense	Johnsongrass	Billings soils.
Yucca glauca	Yucca	High sandy benchland.
Trees:		
Populus sargentii	Cottonwood	Soils on riverwash (Green River).
Rhus trilobata		Soils along gullies and larger canals; riverwash.
Salix spp	Willow	Do.
Tamarix spp	Tamarisk	Soils along gullies, in seeped spots.

Weeds.—The valley has many kinds of weeds found from the Dakotas south to southern Texas. Many of the weeds have been transported to and scattered over the valley since it was opened for settlement. The weed seeds are commonly scattered by use of uncleaned farm seed, by the wind, and by water. Birds, livestock, farm implements, packing materials, nursery stock, manure, trucks, and railroads contribute to the spreading of weed seeds (*8*). Probably the spreading of weed seeds in irrigation water is the greatest source of infestation and the hardest to control.

Eradication of the more noxious weeds in this area, even at considerable expense, should pay good returns in the long run, as many of the farmers are operating on high-priced land.

The principal noxious weeds are the field bindweed, poison milkweed, wild morningglory, dodder, wild oats, quackgrass, tumbling mustard, and water hemlock. Other common weeds and plants are pigweed, cocklebur, smartweed, plantain, gumweed, sunflower, horseweed, Mexican fireweed, Spanish-needles, snakeweed, beggartick, burdock, bullthistle, tumbleweed, dandelion, cattail, peppergrass, purslaine, lambsquarter, skeletonweed, wild barley, downy bromegrass, sandspur, crabgrass, pigeongrass or foxtail, witchgrass, asparagus, watercress, and several sedges.

FORESTS AND WILDLIFE

The Grand Mesa National Forest, though not in the Grand Junction Area, is close enough to be of economic and recreational value. This forest is on Grand Mesa, a high plateau about 5,000 feet above the Grand Valley. The National forest contains 679,804 acres and includes 225 reservoirs and natural lakes that supply Grand Junction, Fruita, Palisade, and other towns with excellent drinking water and some water for irrigation.

Ranchers may get permits from the Government to graze livestock in the National forest. Fishermen, trappers, and hunters have access to 166 miles of streams and 60 lakes. The last game census showed that there were 5,750 deer and 750 elk in the forest, as well as bear, coyotes, mountain lions, bobcats, lynx, the usual small fur bearers, and pheasants, mountain quail, and grouse.

ORGANIZATION AND POPULATION

The Grand Junction Area was Ute Indian territory until 1881. In that year the Indians were removed, and on September 4 immigrants were permitted to enter the Grand Valley. The townsite for Grand Junction was established on September 26, 1881. On February 14, 1883 the area now in Mesa County was taken from the western part of Gunnison County and organized as a political unit.

The agricultural development of the Grand Valley began with the completion of the first system of irrigation canals in 1885. By 1890, the population had increased to 4,260, and by 1900 to 9,267. The settlers came largely from Kansas, Nebraska, Missouri, other central States, and Texas.

Grand Junction (pop. 14,504 in 1950), is the county seat and largest town. Fruita (pop. 1,463 in 1940) is the second largest town. It lies about 10 miles northwest of Grand Junction and is surrounded by a district where diversified farming dominates. Palisade (pop. 861 in 1950), is the third largest town. It is located near the eastern extremity of the Grand Junction Area and is the heart of the peach-growing district.

The rural population is densest near Palisade in the eastern part of the valley, decreases to the west, and is least in the northwestern part of the area. Mesa County had a total population of 38,974 in 1950, of which 14,504 was classed as urban and 24,470 as rural.

INDUSTRIES

A fair to good grade of bituminous coal is mined in the Book Cliffs coal field, which borders Grand Valley to the north and extends around the bluffs at Palisade. This entire field, including the part extending into Utah, has an area of about 500 square miles, and the total deposits are estimated at 5,103,000,000 short tons *(2)*. The mines provide employment for approximately 200 men, especially during the colder months. Many of the mines do not operate the year round.

The shops and yards of the Denver and Rio Grande Western Railroad at Grand Junction employed about 800 people at the time of survey.

Among other industries in the valley are several canneries, a packing plant, a brick kiln, chicken hatchery, power plants, and a plant south of Loma for processing uranium and vanadium. Recently, other industries have come in increasing numbers, especially to Grand Junction.

The industries of the valley provide some income for farm families when they are not busy on the farm. The increase of population since the end of World War II has increased the local demand for farm products, especially fruits and vegetables.

TRANSPORTATION AND MARKETS

The Denver and Rio Grande Western Railroad runs through the valley and makes direct connections with Denver to the east, Salt Lake City to the west, and by branch lines with a number of towns to the southeast. Intercity bus lines connect with these same towns and cities. Air transportation is available to Salt Lake City, Las Vegas, and Los Angeles to the west; Denver to the east; and Albuquerque to the south.

Most of the farm products are shipped to Denver. The peach crop, however, is largely shipped by rail to a number of eastern and northern markets outside the State. Less important marketing centers for general farm produce are Salt Lake City, San Francisco, Los Angeles, Kansas City, and Omaha. Many truckers operate between Grand Junction and towns in Kansas, Oklahoma, and Texas.

Public roads in the valley permit rapid movement of perishable crops. A few of the farmers in the northwestern part live 10 to 12 miles from a shipping point, but most of them are within 4 to 6 miles.

FARM AND HOME IMPROVEMENTS AND SOCIAL FACILITIES

Telephones, radios, trucks, tractors, and automobiles are in general use in the area. Farmers that specialize in any particular type of agriculture normally have enough equipment to do their own work. Most of the people in rural districts have access to electric power lines. In the western part of the valley, however, many of the homes do not yet have electricity.

The diversified farms, especially those on which livestock are raised, are fenced. Many of the other farms are only partly enclosed. The majority of the general farms have necessary barns and outbuildings, but some need additional buildings.

Most of the rural schools have been consolidated. Many rural pupils, especially those more advanced, are transported by bus to schools in the larger towns. In Grand Junction students may attend high school, two parochial schools, and Mesa Junior College.

Most of the rural population lives within 5 to 8 miles of the larger towns, where there are churches of the leading denominations. Mesa Memorial, St. Mary's, Lincoln Park, and Veterans Administration hospitals are located in Grand Junction. Recreational facilities in Grand Junction include parks, indoor gymnasiums, golf courses, swimming pools, and lighted ball fields.

AGRICULTURE

The first train reached Grand Junction a year after the first settlers arrived. The completion of the Denver and Rio Grande Western Railroad in 1883 greatly facilitated early settlement of the valley.

The early settlers recognized the need for irrigation shortly after they arrived. They began diverting river water for four irrigation districts: The Pacific Slope, a 9-mile ditch supplying Grand Junction; the Pioneer or Mesa County, a 12-mile canal supplying water to some 9,000 acres east of Grand Junction; the Independent Ranchmens, a 10-mile canal supplying about 5,000 acres between Grand Junction and Fruita; and the Grand Valley, intended for coverage of about 50,000 acres lying above and beyond the other canals.

Digging irrigation systems, clearing away greasewood brush, leveling and breaking the land, and ascertaining the adaptability of the soils and climate to many field, garden, and orchard crops was a task that required 5 or more years.

The early agriculture, once established, was much like that of today. A wide diversity of field, orchard, garden, and truck crops were grown. Livestock—particularly dairy cattle, poultry, and bees—were kept. Today, peach-growing is the most important agricultural enterprise, but diversified farming and truck farming are also important.

TYPE AND SIZE OF FARMS

In the 1950 census, the farms in Mesa County were classified by type as follows:

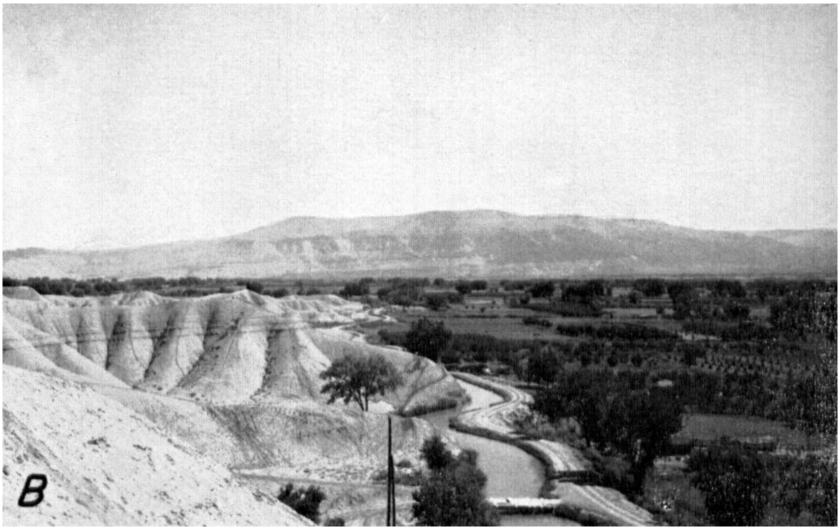
Classified farms:	*Number*
Fruit	468
Livestock	416
General	255
Field crop	188
Dairy	166
Vegetable	52
Poultry	21
Miscellaneous and unclassified farms	959

The 1950 census groups the farms of Mesa County by size as follows:

Size of farm in acres:	*Number*
Less than 10	431
10 to 29	806
30 to 49	319
50 to 69	156
70 to 99	209
100 to 139	143
140 to 179	119
180 to 219	66
220 to 259	37
260 to 499	82
500 to 999	46
1,000 and more	111

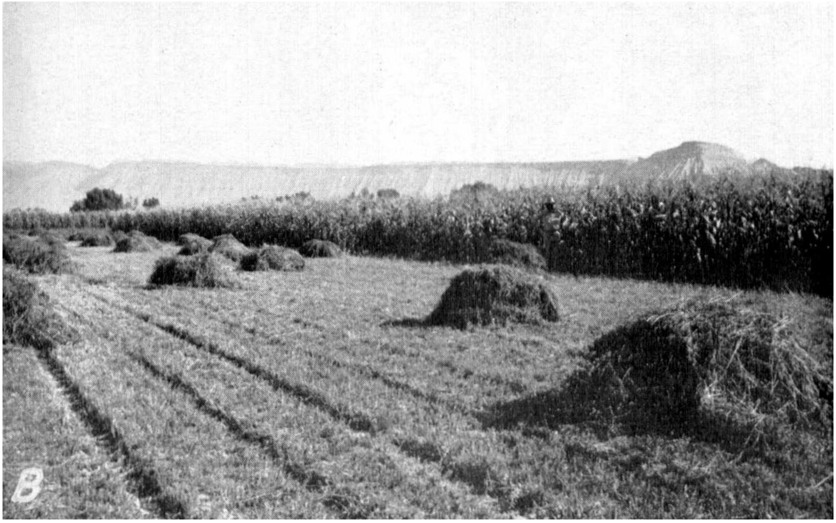
The foregoing tabulations on type and size of farm are representative, but are not entirely satisfactory because they are for Mesa County, which covers some land not within the Grand Junction Area.

The number of farms in Mesa County increased from 2,207 in 1920 to 2,525 in 1950. The increase in number of farms has been accompanied by an increase in acreage per farm. In 1920 the average farm was 105.2 acres in size, but in 1950 it was 216.3 acres. The increase in size of farms in Mesa County can be accounted for by inclusion of more rangeland in the farms.

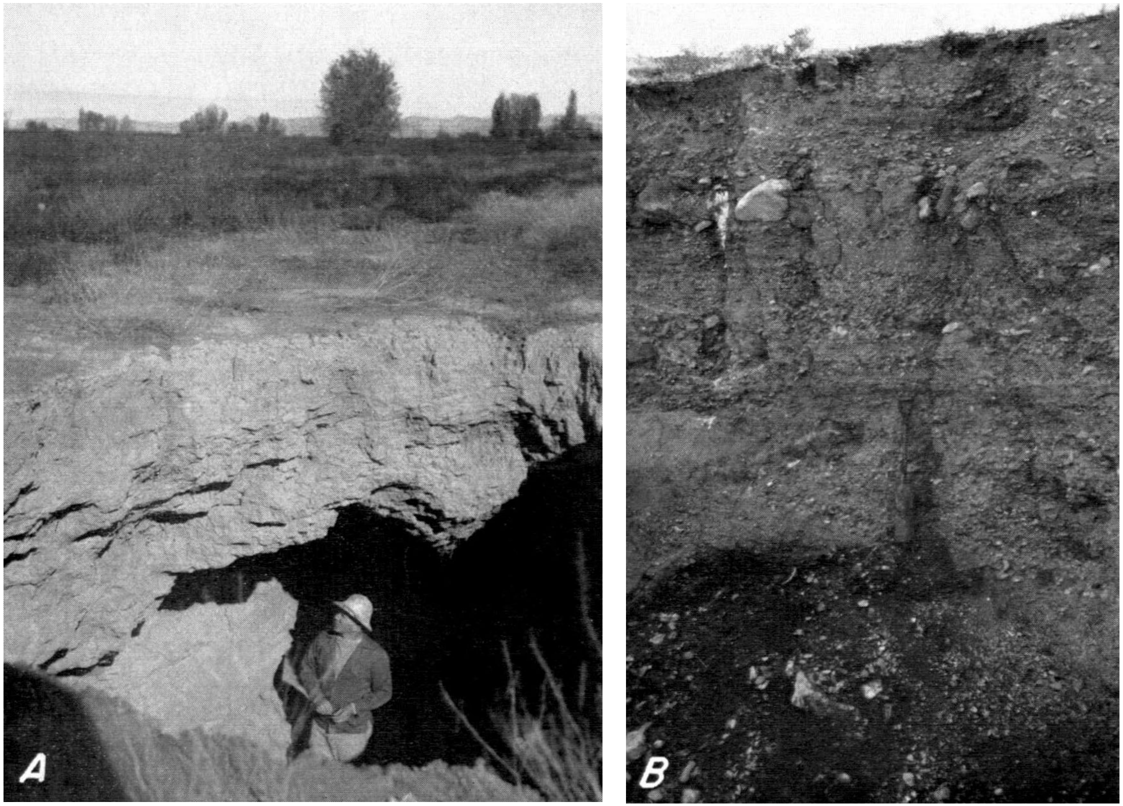


A, Looking out over the Grand Valley of the Colorado River from the shale heights 2 miles northeast of Grand Junction.

B, Looking east toward Grand Mesa from 2 miles northeast of Grand Junction; irrigation canal skirts bluffs of Rough broken land, Chipeta and Persayo soil materials, in left foreground.

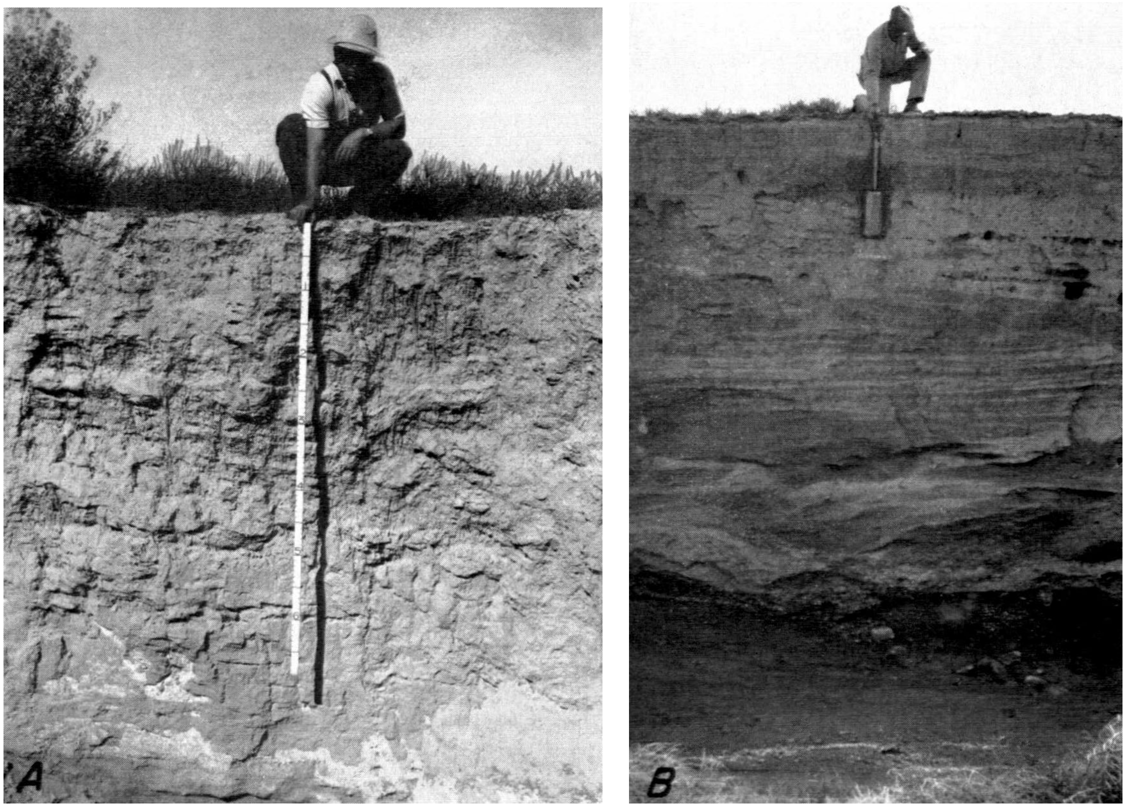


A, Alfalfa after second cutting on Ravola loam, 0 to 2 percent slopes.
B, Third cutting of alfalfa (foreground) and yellow dent corn (background) on area of Ravola loam, 0 to 2 percent slopes, 1 mile south and 1 mile west of Clifton.



A, Cave-in, or tunnel, caused by irrigation water and consequent internal erosion.
B, Profile of Mack clay loam, 0 to 2 percent slopes, on north end of Mack Mesa.

PLATE 4



A, Exposure of a Billings soil on the cutbank of an intermittent stream, showing horizontal stratification caused by successive deposits of alluvium, but no segregation of lime nor any definite soil layers.
B, Profile of a Ravola very fine sandy loam.

FARM TENURE

In 1950, 85 percent of the farms in Mesa County were operated by owners or part owners, and nearly 15 percent by tenants. Managers operated only 6 farms in the county. Of the tenants in Mesa County, 29 were cash tenants, 15 were share-cash tenants, and 83 were share tenants and croppers. Within the Grand Junction Area, the share-tenant and cropper systems are by far the most common.

Ordinarily, the share tenant furnishes labor and necessary farm equipment. In return, he receives half of the hay crop, whether it is cut for hay or seed; two-thirds of the corn, small-grain, potato, or pinto-bean crop; half of the peach or other orchard crop; and four-fifths of the sugar beets and of crops such as onions, cucumbers, cantaloups, melons, and tomatoes. Various arrangements regarding fertilizers and general expenses are made. Tenure arrangements in 1945 and 1946 provided that the landlord pay one-third of the threshing expense and sack bill. Changes in tenure agreements come with changing economic conditions.

FARM POWER AND MECHANICAL EQUIPMENT

In 1950, there were 1,623 tractors, 1,854 motortrucks, and 3,347 automobiles on the 1,525 farms in Mesa County. The tractors used for plowing, disking, cultivating, haying, and other work on the general farms are rubbertired types having about 24 horsepower. Most of the orchardists have been using 20- to 24-horsepower crawler tractors, but the recent trend is toward a slightly heavier crawler type of about 30 horsepower that has power enough to pull heavy cultivating equipment.

Most of the trucks are of small or medium size. A few farmers have heavy trucks.

The tillage implements in common use are cultivators, disks, turning and disk plows, harrows, and drags or levels. Other mechanical equipment includes binders, mowers, hayrakes, peach-grading machinery, threshing machines, cream separators, feed grinders, hay balers, and hay stackers. About 94 percent of the farms in the county have electric power.

Horses are used on some of the farms. They are of the draft type, mainly Percherons.

ROTATIONS AND FERTILIZERS

Crop rotations commonly used elsewhere normally are not followed in this area. The few rotations used in this valley vary considerably and may not follow each other in a regular sequence. Some farmers who practice diversification of crops grow corn 1 or 2 years, follow with oats, wheat or barley sown with alfalfa or clover, and then use the clover or alfalfa for hay or pasture. The stand of clover or alfalfa is left 4 or 5 years, or until wilt, weevil infestation, or noxious weeds makes it necessary to plow out the field. After plowing, the field is returned to a row crop such as corn, sugar beets, pinto beans, or potatoes. Some farmers grow alfalfa 3 or 4 years, then potatoes or sugar beets 1 or 2 years, and finally corn. Others rotate corn and legumes almost exclusively.

Use of commercial fertilizer has increased, largely because many of the truck, vegetable, and fruit growers do not have an adequate sup-

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ply of manure, or possibly none at all. Some fruit growers use a mixed fertilizer. Many others apply 10 to 15 tons of barnyard manure an acre for peach orchards where the trees are large, and, in addition, grow a legume cover crop.

Some potato growers near Fruita use mixed fertilizer. If it is available, most of the farmers producing truck and garden crops use heavy applications of manure. If manure is not available they use commercial fertilizer similar to that applied for potatoes.

CROPS

The main crops now grown in the Grand Junction Area are peaches, alfalfa, corn, dry beans, oats, wheat, barley, sugar beets, clover, and potatoes, in approximately that order of importance. The acreage in Mesa County of these and other leading crops is given in table 3 for stated census years. These acreages are representative, but it is to be considered that they include some land in Mesa County that is outside the Grand Junction Area.

TABLE 3.—*Acreage of principal crops and number of fruit trees and grapevines of bearing age in Mesa County, Colo.*

[Figures in this table are not entirely representative for the Grand Junction Area, because Mesa County includes large acreages outside the irrigated valley. Nevertheless, these figures indicate in a general way the relative proportion of the various crops in the Grand Junction Area and the shifts in acreage that have taken place in the past 30 years]

Crop	1919	1929	1939	1949
	Acres	*Acres*	*Acres*	*Acres*
Corn for grain	4, 449	7, 282	6, 322	6, 856
Small grains threshed:				
Oats	3, 116	2, 976	2, 228	5, 281
Wheat	5, 406	6, 069	3, 059	3, 793
Rye	105	37	171	161
Barley	667	1, 431	2, 202	3, 734
Dry beans	219	5, 752	18, 486	6, 469
Irish potatoes	1, 619	1, 363	1, 197	[1] 706
Sugar beets	2, 632	1, 343	812	1, 251
All hay	39, 726	39, 734	33, 116	36, 234
Alfalfa	35, 868	36, 274	30, 893	32, 118
Timothy and clover	773	1, 170	574	1, 236
Grains cut green	1, 814	1, 899	978	769
Wild grasses	149	187	492	1, 275
Other hay cut	1, 122	204	179	836
Coarse forage	3, 864	796	634	774
All vegetables, except potatoes, for sale	[2]	1, 174	1, 359	1, 305
Strawberries	20	53	36	31
	Number [3]	*Number* [3]	*Number* [3]	*Number* [3]
Peach trees	242, 200	285, 754	445, 462	636, 354
Pear trees	115, 525	139, 114	71, 504	59, 654
Apple trees	477, 800	108, 950	20, 269	13, 885
Apricot trees	[2]	3, 725	12, 248	24, 338
Cherry trees	9, 639	3, 763	8, 514	14, 996
Plum and prune trees	4, 565	3, 356	5, 638	7, 231
Grapevines	18, 390	38, 375	19, 104	33, 937

[1] Does not include acres for farms with less than 10 bags harvested.
[2] Not reported.
[3] Number in the census year, which is 1 year later than the crop year given at the head of the column.

The acreage in sugar beets, small grains, and tree fruits has fluctuated considerably over a period of years. Some areas formerly used for growing such crops have become too saline and have been shifted to irrigated pasture. In contrast, some saline areas have been drained and improved to the point where irrigated pasture has been plowed under and intertilled crops planted.

ORCHARD FRUITS

Tree fruits require a deep and permeable soil, but it need not be high in organic-matter content. So far as suitability of the soils is concerned, the acreage of tree fruits in this valley could be doubled, or brought to a total of about 28 square miles. Danger of frost damage keeps the acreage of tree fruits to about its present extent. Tree fruits in unprotected parts of the valley might be satisfactory or partly satisfactory for a number of years, but the low recorded temperature of −21° F. at Grand Junction indicates the risk involved in planting orchards in areas that have not been proved climatically suitable.

The acreage of tree fruits reached a maximum before 1910, when they were grown mainly near Fruita and east of Grand Junction. Risk of loss through winterkilling, difficulty in controlling the coddling moth, prevalence of blight and other disease, high fixed costs, and increasing acreages affected by poor underdrainage and salinity forced abandonment of most of the orchard fruits. The land was planted to alfalfa, corn, pinto beans, small grains, potatoes, and other field crops. Fruit growing in the Fruita section has been almost completely discontinued.

Today, tree fruits, especially peaches, are grown mainly on the Redlands, Orchard Mesa, the Vinelands, and from Palisade west to Clifton. These areas have proven dependable for tree fruits. Good net returns from peaches have greatly increased the acreage in that crop in the last 10 to 15 years. The same is true for plums, cherries, and apricots. The acreage in pears and apples declined until about 1943 but has increased recently.

The acreage in grapes was highest during the period between 1900 and 1910. Long distance to markets and low net income have discouraged grape growing. Most of the grapes are now grown in small home vineyards.

Peaches.—Growing of peaches is the most important farming speciality in the Grand Junction Area. Yields fluctuate, but a fair annual average is 350 bushels an acre. This would total 6,300 bushels an acre for the average life of a peach orchard, which is about 20 years (*4*). Some of the older peach orchards near Palisade are more than 50 years old, however, and are still producing high yields. Commercial production of peaches is confined mainly to the climatically better situated parts of the valley—the Redlands, the western part of Orchard Mesa, the Vinelands, and from Palisade west to Clifton. The probable average life of a peach orchard in these areas considerably exceeds 20 years. The number of bearing peach trees in Mesa County increased about 40 percent between 1939 and 1949.

The chief varieties of peaches grown are Elberta, J. H. Hale, Salway, Carman, Halehaven, Orange Cling, Sungold, and Rochester. Approximately 93 percent of the trees are Elberta; 4 percent, J. H. Hale; 2 percent, Salway; and other varieties, 1 or 2 percent.

Cultural practices.—Peach trees for new orchards are normally set out in spring between March 1 and April 15, preferably on well-drained soils that have a medium to coarse texture and a deep, friable, and permeable subsoil. The Mesa, Genola, Ravola, Naples, and Thoroughfare soils are among the better ones for growing peaches and other tree fruits. Well-drained areas of the Green River very fine sandy loam also have proven satisfactory.

Nursery stock a year old and $\frac{7}{16}$ to $\frac{11}{16}$ inch in diameter is preferable for planting (7). Ordinarily, the trees are now spaced 20 to 25 feet apart in the rows. Trees in some older orchards are spaced 18 feet apart, which is too crowded. The square system of planting is most used. Some growers use the hexagonal system, which permits about 15 percent more trees but is more difficult to manage.

A site with good air drainage should be selected for planting. If the site for the orchard has slopes of less than 1 percent, it may be difficult to provide adequate underdrainage. If underdrainage is not satisfactory, the trees will not do so well, especially when they get older. Soils with less than 4 or 5 feet of depth to shale cannot be depended upon to produce sturdy long-lived trees or yields comparable with those obtained on deeper soils.

Peaches are grown entirely under irrigation. The orchards are irrigated by the furrow method. From 3 to 6, but generally 4 or 5, furrows are made between each row after disking or cultivating early in spring or in fall. The furrows are 5 to 8 inches deep.

Several irrigations are applied, the number depending upon the texture and permeability of the subsoil. It is necessary that the soil be moist below a depth of 4 or 5 feet. After the water has soaked down this far, which can be determined by use of a soil auger, the water should be turned off. By testing with the auger during several irrigations, the length of time necessary to irrigate a particular orchard can be determined. The time needed may vary within an orchard because of differences in slope and types of soil it may contain.

Many orchardists literally drown their trees without knowing it. They continue to apply water after the subsoil and substratum have become saturated. Salts may accumulate and rise toward the surface in overirrigated orchards, and in some instances it may be necessary to dig drainage ditches or install extensive tile systems that will lower the water table enough to allow the tree roots a good feeding range. Chlorosis, or yellowing, of fruit trees is nearly always related to inadequate underdrainage.

The danger of overirrigation has been one of the most difficult problems orchardists have encountered, and the same applies for the farmers growing general crops. Some drainage problems, however, have resulted from seepage coming from canals. Such seepage can form a high water table a considerable distance from the canal.

Near harvest, heavy irrigation can impair the quality of the fruit and reduce its storage life. The last irrigation is usually applied not later than 10 days to 2 weeks before harvest. The trees need moisture during winter, so irrigation the latter part of October or early in November is essential. If water is applied too liberally to young trees at this late irrigation, it may cause winter injury. It is well to test the soil to a depth of 3 or 4 feet with a soil auger to determine how much irrigation is needed. A moderate or rather small head of water in each furrow is more desirable than a large head, because the water penetrates the soil more evenly and minimizes soil erosion, especially on sloping land.

When the peach trees are young, corn, red clover, vetch, soybeans, or other crops are grown between the rows. Then the trees have grown fairly large, cover crops of oats, red clover, vetch, sweetclover, and alfalfa are frequently planted between the rows and plowed under late in fall. When the trees are large, some growers practice clean cultivation.

Harvesting and marketing.—The peach harvest normally begins about August 15 and continues to September 10. The fruit is carefully picked by hand and placed temporarily in boxes or baskets for grading at the local grading shed or at shipping points. Many people come to the valley each season to pick the fruit. Occasional wet, misty weather lasting several days during harvest may prevent packing all the fruit before it is overripe. Total crop failures, however, are almost unknown.

Palisade, Grand Junction, and Clifton are the chief marketing centers for peaches. At these places they are graded, pooled, and shipped under the direction of three main shipping organizations. Thousands of refrigerator cars are needed to transport the crop to markets in the central, eastern, and northern States and Canada.

About 60 percent of the peaches for shipment grade as U. S. No. 1. Such peaches must be firm, fairly well colored, and measure 2 inches or more in diameter. Larger peaches—some of them 4 to nearly 5 inches in diameter—grade as "fancy" or "extra fancy." About half of the peaches for shipment are packed in 20-pound boxes. The rest are shipped mainly in either half bushel or bushel baskets.

Truckers help dispose of the peach crop. They prefer to buy fruit that is more nearly ripened than that shipped by rail. Local canneries are an important outlet for part of the crop. More and more peaches are being canned in the Grand Junction Area. The tree-ripened fruit is of exceptionally good quality, so the amount canned likely will increase.

Pears.—This fruit crop ranks second to peaches in the Grand Junction Area. In 1949, there were 59,654 trees of bearing age in Mesa County (table 3). The quality of the fruit is excellent. The methods of planting, irrigating and harvesting are almost identical to those used for peaches. Wider spacing of the trees—25 to 30 feet—is desirable, however. Most of the pear-orchards are now located southeast and east of Clifton. They were formerly grown near Fruita, but low returns caused abandonment of the orchards there.

Most of the pears are graded, packed, and shipped to outside markets. Some are canned locally. The principal varieties are Bartlett, Kieffer, Anjou, and Gorhan.

Cherries.—The number of cherry trees has fluctuated considerably since 1919. There were only 8,514 bearing trees in Mesa County in 1939, but in 1949 the total had increased to 14,996. The plantings of cherries are scattered more widely over the Grand Junction Area than those of other fruits. Most of the areas in cherries are small and adjoin or are near larger acreages in peaches. Many farms have less than a dozen trees.

The principal varieties of sweet or semisweet cherries grown are Mavillo, Royal Anne, Bing, Lambert, Napoleon, Oxhart, Republican, Black Tartarian, and Windsor. The last two varieties are good pollenizers, especially for the Bing and Lambert, if bees are scarce. The Royal Anne is a large white cherry; the others are of the red variety.

Comparatively few sour cherries are grown. The main varieties are the Montmorency, English Morello, and Royal Duke.

The proper spacing for sweet red cherries is about 30 feet, but 20 feet is satisfactory for sour cherries.

The cherries produced in this area are of exceptional quality. A considerable part of the crop is canned for commercial and home use. The largest part, however, is packed in 15-pound boxes and sold through local shipping organizations.

Apples.—The number of apple trees has decreased steadily since 1919 because of low returns. Most of the acreage now in apples is confined to the same general areas as those where peaches are grown. Formerly, large acreages near Fruita and Clifton were in apple orchards, as well as areas between Grand Junction and Clifton. Apple growing has been almost entirely abandoned in the Fruita district, and for the most part in the areas between Grand Junction and Clifton.

The tillage and irrigation methods used for apple trees are much the same as those for peach orchards. Young trees are normally set out between March 1 and April 15. The trees are spaced about 30 feet apart, though some growers prefer 40 feet. Frequent cultivation is not so essential for apple as for peach trees, especially when the trees become large. Consequently, some growers cut the cover crop in apple orchards and let it lie as mulch.

Part of the apple crop is sold, canned, or dried locally. Most of the better quality fruit is graded and shipped. Local marketing organizations do most of the shipping, but some of the crop is trucked to outside markets. The principal varieties are Jonathan, Delicious, Winesap, Rome Beauty, and Starking, a red sport of the Delicious (7).

Apricots and plums.—The number of apricot and plum trees has increased rapidly since 1939 (table 3), but neither crop is extensively grown in the Grand Junction Area. The orchards, not large and widely scattered, are in the same areas as the peach orchards and on the same kinds of soils.

The trees are usually planted in spring. Spacing, tillage, and irrigation methods are almost identical to those used for peach trees. The commonly grown varieties of apricots are Smiths, Tiltons, Moorpark, Mount Ganot, Wenatchee Moorpark, Chinese or Colorado, and Riland. The plum varieties are Santa Rosa, Duarte, Japanese, and Japanese hybrid. In addition there is a small acreage of plums that bloom later and are classed as prunes.

A comparatively large part of the apricot and plum crops is sold or canned locally. The quantity shipped to outside markets probably will increase as many of the younger trees come into production.

Grapes.—There is a considerable acreage of grapes in Mesa County, but most of it lies outside the Grand Junction Area northeast of Palisade. Within the surveyed area, grapes are grown in small plots of 1 or 2 acres or less. The vines do well, however, and the fruit is of high quality.

Grapes are adapted to the medium textured to sandy Fruita, Genola, Ravola, Mesa, Thoroughfare, and Mack soils, especially where these soils are in areas climatically adapted to peaches.

A large part of the grape crop is sold locally. The most important varieties are Concord, Van Buren, Fredonia, Golden Muscat, Caco, and Portland.

Strawberries, raspberries, and blackberries.—The acreage in berries is small. The berries are of good quality, and most of the crop is sold locally. Berries grow best on the Mesa, Ravola, Thoroughfare, and Fruita soils or other deep, well-drained, salt-free soils in the valley that do not have a fine texture.

The common strawberry varieties are Marshall and Utah Centennial; the red raspberries, Latham, Indian Summer, and Newburgh; and the black or purple raspberries, Bristol, Potomac, and Sodus.

FIELD CROPS

The principal field crops, in order of importance, are alfalfa, corn, dry beans, oats, wheat, barley, and sugar beets. Potatoes, clover, and rye are also grown. All of these crops are irrigated. Wet, misty weather lasting several days may seriously affect yields of dry beans, potatoes, clover, and alfalfa, but complete crop failures are almost unknown.

Alfalfa.—This always has been and still is the most important hay crop in the valley. It is grown on almost all the tillable soils throughout the valley. Alfalfa is rarely planted on soils of the Chipeta and Persayo series and occupies only a small acreage on the Billings silty clays. It is a deep-rooted crop that requires good underdrainage. On well-suited soils, such as the Fruita, Mesa, Ravola, and Thoroughfare, yields of 4 or 5 tons an acre are common.

Alfalfa is normally seeded in spring with a companion crop of oats or barley. The seed is ordinarily drilled ½ to 1 inch deep at the rate of 8 to 10 pounds an acre. The varieties most commonly used are Meeker Baltic, Nebraska Common, Colorado Common, Hardistan, Grimm, Cossack, Ladak, and Utah Common (*6*). In recent years the tendency has been toward more frequent seeding, or about every 4 years. More frequent seeding suppresses weeds, decreases wilt and weevil infestation, and improves the quality of the hay.

The small-furrow method of irrigation is used. The furrows range from 1 to 3 feet apart. Water is normally applied before and immediately after each cutting. The soil is given ample time to dry out before the alfalfa is cut. Three, and frequently four, cuttings are obtained each year (pl. 2).

The hay is normally stacked or baled directly from the windrow. Much of it stands unprotected from the weather in piles of bales or haystacks until sold or fed. Some farmers have barns or alfalfa sheds. The common practice is to bale the hay during the daytime, when the dryness of the air causes some loss of the fine leaves. Some alfalfa hay is trucked outside the valley but most of it is fed on the farm or sold locally.

Corn.—This crop is second to alfalfa among the field crops grown in the valley. The acreage fluctuates from year to year. The annual average acreage cannot increase materially without displacing other crops. The acreage of new land that could be irrigated under the present systems and that would be suitable for corn is insignificant.

Corn is as widely distributed as alfalfa in the valley and has about the same soil suitability range. It does best on well-drained, permeable, moderately coarse textured soils. On Fruita, Thoroughfare, Ravola, Green River, Mesa, and Mack soils, corn yields 65 to 80 bushels an acre if properly managed. Yields in excess of 100 bushels an acre have been reported for small areas. Most farmers are now planting hybrid varieties, which under good management yield 10 to 15 percent more than the open-pollinated varieties. Large applications of stable manure or 100 to 150 pounds an acre of triple superphosphate are needed to get best yields.

Corn is normally planted between May 1 and May 15 with a corn drill. Water is applied between the rows by the furrow method. The spacing of furrows between the rows so as to obtain proper penetration will vary from soil to soil. The crop is sensitive to overirrigation, so water must be applied carefully on slowly permeable soils. The most critical irrigation is that just before or after the time the tassels appear. The time for irrigation and the amount of water to apply are best determined by sampling the soil with a 3- or 4-foot auger. Many fields will have abundant moisture in the subsoil, so an irrigation that will obtain 2 feet of penetration is sufficient to bring the entire root zone up to full moisture capacity.

The corn crop may be cut and shocked, cut for silage, hogged down in the field, or shucked late in fall and stored on the farm for feed. Some farmers market all or part of their crop for cash. Poultrymen and dairy farmers buy a considerable part of the corn crop.

Beans.—Practically all of the dry beans grown are of the Pinto variety. They are grown as a cash crop, and the acreage fluctuates widely. During periods of high prices, large acreages are planted; otherwise the acreage is comparatively small. Almost all the bean acreage in Mesa County is in the Grand Junction Area.

Because beans are a relatively shallow rooted crop, they do better than deep-rooted crops on poorer soils such as the Chipeta and Persayo. The better soils, such as the Mack, Ravola, Fruita, and Thoroughfare, generally yield 1,500 to 1,800 pounds an acre. Lately, a serious root blight has decreased the yield 50 percent or more. Before the blight, good soils fertilized with 100 to 125 pounds an acre of triple superphosphate yielded as much as 2,000 pounds an acre.

Beans are planted with a lister planter in rows 20 inches apart at the rate of 40 to 60 pounds an acre. The normal planting time is between May 10 and July 1. Beans are sensitive to an oversupply of water. Light irrigations give best results. After the first irrigation, no further irrigation is advisable until buds or blooms appear.

The crop is harvested about the time of the first fall frost, or when most of the pods have turned yellow but have not dried out. The crop is harvested mainly with a bean harvester that cuts the vines just below the ground. The machine cuts two rows at a time and piles them in one windrow. For rapid curing and drying in case of rains, it is considered good practice to gather the windrows into small flat bunches with a pitchfork. If a thresher is not immediately available, the bunches are gathered and stacked. Some growers thresh their beans directly from the field with a pickup attachment.

After threshing, the beans are graded at regular marketing centers or by the farmer himself. They are marketed in 100-pound bags or held in dry storage for possible higher prices.

Wheat.—This is a dependable crop in the surveyed area. For the most part, the wheat grown within the surveyed area is north of the Colorado River on the Chipeta, Persayo, Billings, Fruita, and Ravola soils.

Spring wheat normally is planted between March 25 and April 15, and winter wheat between September 1 and September 15. Some spring wheat planted late in the season may not ripen until about the time for fall frost. The crop is planted with a drill and irrigated by the corrugation method. Most farmers harvest with a combine, but some still use the binder. The wheat fields are small. The principal wheat varieties are Denmark and Thatcher.

With fertilization and other good management, yields may reach 40 to 50 bushels an acre on the Fruita, Ravola, Mack, Mesa, and Thoroughfare soils. The greater part of the crop is marketed locally, but on many of the smaller farms the wheat is used for feed.

Oats and barley.—These crops have about the same importance as wheat in Mesa County. Both crops fit well in the agricultural economy of the valley, for they produce fairly high acre yields of grain suitable for livestock, and, in addition, grow better than alfalfa, red clover, and similar hay crops on soils such as the Chipeta, Persayo, and finer textured Billings. Moreover, both crops will produce more successfully than alfalfa or red clover on soils moderately affected by salts.

If planted on the better soil types of the Fruita, Mack, Mesa, and Thoroughfare series, oats may yield as much as 60 or 80 bushels an acre, and barley, 40 to 60 bushels.

Oats and barley usually are seeded between March 15 and April 15. Barley is seeded at the rate of 80 or 90 pounds an acre. Many farmers seed oats or barley as a companion crop for new seedings of alfalfa. A few farmers cut their oat crop green for hay. The commonly grown varieties of barley are Improved Club, Trebi, and Velvon. The oat varieties are Swedish Select and Lico.

A few farmers are beginning to grow proso, or hog millet. This crop is desirable for late planting and serves as an emergency crop. Proso is valuable for feed, either as grain or as hay.

Sugar beets.—Most of this crop is grown on the Billings, Ravola, Fruita, and Hinman soils. Beets stand relatively high concentrations of salts better than many crops; therefore a considerable acreage on Billings soils that is slightly or moderately affected by salts is used for beets.

The beets normally are planted between March 10 and April 15 in rows 15 or 18 inches apart. For best results, they are fertilized with as much as 150 pounds an acre of triple superphosphate. They are irrigated by the corrugation method, between each row or between each two rows.

Thinning, cultivating, irrigating, and harvesting of the beets have required considerable hand labor, but machinery is now replacing hand labor.

Potatoes.—This crop is not extensively grown in Mesa County. In recent years most of the crop has been grown in the Fruita district. The crop does best on coarser textured soils—mainly loams, fine sandy loams, and very fine sandy loams of the Fruita, Ravola, Genola, Thoroughfare, and Green River series. On well-drained, salt-free soils, the yield may be 200 to 300 bushels an acre. Yields exceeding 320 bushels an acre have been obtained by applying commercial fertilizer.

Commercial growers usually plant their crop between March 15 and April 15 and harvest for early market in June or July. The season is long enough for two crops, but a second one is seldom planted. Except for a small local sale, the potatoes are sacked in 100-pound bags and shipped or trucked to Denver or other cities. The principal varieties are Irish Cobbler, Red Russet, Bliss Triumph, and Burbank.

Clover.—Though not grown extensively in the past, clover will no doubt occupy an increasing acreage in the valley. It is valuable as a cover crop or green-manure crop; provides good hay or pasture; and is a source of honey for the bees kept on some fruit farms to aid in pollination of fruit trees. Clover is especially popular with fruit growers as a cover crop for orchards.

Clover is seeded in fall or spring at the rate of 15 pounds an acre. Frequently the seeding is made with a companion crop of oats, barley, or alfalfa. The crop is irrigated and harvested like alfalfa and is suited to the same soils. Clover cut for hay makes two crops a year. The stockmen and dairy farmers prefer red clover to most of the other kinds.

Strawberry and alsike clovers are preferable for soils inclined to be damp or wet because they have restricted underdrainage. Strawberry clover, used for pasture, is well suited to the calcareous soils of the Billings, Ravola, and Fruita series. Alsike clover can be sown with timothy, by itself, or with red clover and sweetclover. It does not winterkill. The normal rate of seeding is 4 to 6 pounds of strawberry clover an acre, or 5 to 8 pounds of alsike clover.

Sweetclover is especially valuable in reclamation of saline soils of the Billings, Ravola, Persayo, and Chipeta series. The fibrous roots penetrate deep into the subsoil and make it more permeable to air, water, and plant roots. Sweetclover is valuable as a green-manure crop because it grows rapidly and prolifically. It is sown at the rate of 10 to 14 pounds an acre. Both the white- and yellow-blossomed varieties are grown.

Hubam clover, a very rich honey-producing variety, is valuable as pasture or hay or as a green-manure crop.

White clover is common in most pastures. When sown in mixtures with grass, it increases the carrying capacity and palatability of the pasture.

Field peas, soybeans, and vetch.—Only small acreages of these cover crops have been grown in recent years, but it is likely that their acreage will increase. Canadian field peas enrich the soil and make splendid stock feed. They can be cut for hay or hogged down.

Soybeans, as those of the Manchu variety, can be used for hay or feed, hogged down, or planted with corn to be cut for silage. Yields of 20 to 30 bushels are common when the crop is threshed. Soybeans are cut with either a corn or a grain binder.

Common vetch is grown for hay, silage, pasture, or as a seed crop. It is especially valuable as a cover crop for orchards. Vetch is sown in spring at the rate of 60 to 80 pounds an acre.

TRUCK CROPS

Tomatoes.—Good prices and high yields have caused a steady increase in tomato acreage since 1929. The tomatoes grown in the valley have an exceptionally red color and are of good quality. The six canneries now operating in the area process large quantities of whole canned tomatoes, juice, sauce, and catsup. Nearly three-fourths of the crop is taken by the canneries; the rest is shipped to outside markets when moderately ripe or in green-pack condition.

Tomatoes do well on practically all the soils that are well drained and not affected by salts. Exceptions are the Chipeta and Persayo soils and the fine-textured members of the Billings and Hinman series. Medium- to coarse-textured soils are preferable as they are seldom affected by salts.

The plants are set out in rows as soon as danger of frost is past. They are irrigated by the furrow method, or in much the same way as corn and other row crops. At harvest, they are picked, placed in baskets or boxes, and trucked to the local canneries. The leading varieties are Early Canner, Cardinal, Stokesdale, Earliana Special, and Stone.

Tomato yields are more variable than for any other crop in the valley. Weather has the greatest effect on yields, but type of soil and the cultural methods used also have a direct bearing. Ordinarily, yields range from 10 to 15 tons an acre. Under highly favorable conditions, yields frequently exceed 20 tons, and sometimes 25 tons.

Fall frost can reduce yields drastically. In some places growers keep oat straw near their tomato fields and scatter it over the vines when the first frost is predicted. Normally, the straw can be removed about the third day after the frost, when the weather is warmer. A heavier coating of straw may be needed when the next cold snap is forecast. The straw cover may save 25 to 40 percent of the potential crop in some seasons. When prices are good, straw can be used to good advantage for melons, cantaloups, and similar truck crops.

Cantaloups, muskmelons, and honeydews.—These crops produce good yields of excellent quality but are not extensively grown. Normally, a few outside commercial growers rent small tracts and ship the crop to distant markets. A number of local growers sell their crop in nearby towns or to motorists along the principal highways. Recently, some of the growers have been producing their crop under contract for seed. Yields range from 250 to 400 pounds of seed an acre. The best suited soils are those of sandy texture, preferably Ravola, Genola, Fruita, Mesa, and Thoroughfare fine sandy loams.

Watermelons.—This crop is grown on a small acreage, mainly for sale in nearby towns or to tourists who stop at the roadside stands. Recently, some farmers have been growing watermelons under contract for seed. The yield of seed ranges from 250 to 400 pounds an acre.

Cucumbers.—Recently, practically all the cucumber crop has been grown under contract for seed. Reported yields range from 250 to 400 pounds an acre, depending on the amount of fertilizer used.

Cucumbers are best suited to the sandy soils, preferably Ravola, Genola, Fruita, Mesa, and Thoroughfare fine sandy loams.

Onions.—About 140 acres was planted to dry onions in Mesa County in 1949. Onions are best suited to medium- or coarse-textured soils of the Ravola, Naples, Fruita, Mack, and Mesa series. The onions grown in this area are of excellent quality, and fall weather is usually favorable for harvesting. Most of the crop is sacked and transported to outside markets. The onions grown are chiefly the yellow varieties. Early Yellow Globe and Sweet Spanish are the leading varieties.

Miscellaneous garden and truck crops.—Other garden and truck crops grown in the valley are sweet corn; asparagus; green snap, string, wax, and lima beans; table beets; cabbage; carrots; celery; lettuce; spinach; peppers; squash; parsnips; cauliflower; green onions; sweetpotatoes; peas; turnips; and other vegetables. If properly grown, these vegetables are of high quality. They are grown mainly for local consumption, but some are trucked to outside markets.

Most of these vegetable crops are confined to small acreages on well-drained, heavily fertilized soils. The sandy and medium-textured soils of the Green River, Naples, Fruita, Genola, Ravola, Mesa, and Mack series are best suited to these and other truck crops.

PERMANENT PASTURES

For the most part, the pastures in this valley are small areas of 1 to 5 acres that provide grazing for 1 or 2 cows. The stand is made up of legume-grass mixtures that contain some of the following: Kentucky bluegrass, meadow fescue, bromegrass, orchardgrass, common or Italian ryegrass, reed canarygrass, crested wheatgrass, alfalfa, and various clovers, including strawberry, white, sweet alsike, Ladino, and red clovers.

A good seeding mixture for well-drained soils is 1 pound of alfalfa, 6 pounds of orchardgrass, 6 pounds of bromegrass, 4 pounds of meadow fescue, and 3 to 4 pounds of sweetclover. A seeding rate of 16 to 20 pounds an acre is ample for most mixtures if the seed is of high quality.

For small pastures, many farmers use one or two legumes—alfalfa or white, sweet, or red clover—to make up 30 to 40 percent of the stand. Bluegrass and one or two of the other grasses mentioned in the preceding paragraph make up the rest of the stand.

On imperfectly drained land, Bermudagrass, creasted wheatgrass, white clover, strawberry clover, and sweetclover are more suitable because they are more tolerant of alkali than other pasture plants.

Irrigated pastures commonly have a grazing capacity of at least 1 cow per acre for the grazing season. Well-fertilized and otherwise well-managed pastures will carry 2 or 3 animals.

The terrace or Mesa soils that lie below irrigation canals are generally kept in permanent irrigated pasture, providing they are not too steep or shaly.

Rough, uneven, erodible soils and miscellaneous land types within the irrigated valley cover a considerable acreage unfit for cropping that probably will not be used for permanent irrigated pasture. These areas are grazed for the sparse cover of native vegetation they produce. Possibly the native cover could be improved by sowing Italian ryegrass, bromegrass, or other grasses, but it is not likely that any substantial increase in carrying capacity could be achieved without irrigation. Contouring grooves that would hold more of the rainfall on the land might increase the carrying capacity in some places, but in most places the soils are so irregular and steep that this work would be too expensive.

LIVESTOCK AND LIVESTOCK PRODUCTS

Livestock raising is secondary to crop growing in the Grand Junction Area but is still an important source of income. Table 4 gives the number of livestock on farms of Mesa County and the amount of livestock products sold. Figures in this table are only partly representative for the Grand Junction Area. Some of the livestock—particularly the beef cattle and sheep—is kept on ranches outside the valley.

About 20 percent of the cattle in Mesa County are dairy breeds, mainly Holstein-Freisian, Jersey, and Guernsey. Dairying is concentrated in the valley, or surveyed area. Raw and pasteurized milk is sold in the local towns. Most of the cream is sold and processed locally.

TABLE 4. *Number of livestock of all ages on farms of Mesa County, and quantity of livestock products produced*

[Figures for Mesa County are not entirely representative for the Grand Junction Area, as the county includes large acreages outside the irrigated valley]

Item	1920	1930	1940	1950
	Number	*Number*	*Number*	*Number*
Livestock on farms:				
Horses	9, 434	7, 426	[1] 6, 597	4, 383
Mules	434	484	[1] 447	217
Cattle	56, 596	43, 071	[1] 33, 541	50, 304
Cows milked	9, 307	6, 543	5, 331	4, 702
Hogs	9, 907	8, 946	[2] 6, 568	9, 121
Sheep	41, 027	71, 621	[3] 56, 485	53, 445
Goats	2, 340	802	[2] 177	(4)
Chickens	83, 023	[1] 111, 261	[2] 92, 107	82, 372
Other poultry	3, 620	(4)	[2] 1, 505	680
Livestock products:[5]				
Eggs produced ... dozens	460, 015	888, 865	719, 993	(4)
Eggs sold ... do	244, 101	543, 915	(4)	347, 200
Milk produced ... gallons	2, 566, 081	3, 919, 882	3, 144, 297	(6)
Whole milk sold ... do	155, 958	379, 067	556, 110	1, 463, 724
Cream sold ... do	30, 841	4, 391	(4)	(4)
Butterfat sold ... pounds	308, 327	774, 371	436, 983	374, 893
Butter churned ... do	234, 301	148, 391	153, 544	(7)
Butter, sold ... do	89, 785	27, 343	20, 328	(4)
Wool produced ... do	268, 068	435, 767	385, 868	371, 370
Honey produced ... do	294, 178	299, 620	263, 944	189, 014

[1] Over 3 months old.
[2] Over 4 months old.
[3] Over 6 months old.
[4] Not reported.
[5] Production items are for year preceding census, 1919, 1929, 1939, and 1949, respectively.
[6] Not reported on yearly basis; 13,255 gallons produced on day preceding enumeration.
[7] Not reported on yearly basis; 1,292 pounds churned in week preceding enumeration.

During summer, some farmers living in the surveyed area graze their beef cattle on Grand Mesa or other mountainous areas outside the irrigated valley. The favorable climate and palatable grasses produce sturdy cattle that bring top market prices. Most of the cattle are marketed in Denver.

Poultry provides considerable income. Many of the farmers in the Grand Junction Area raise and sell poultry and eggs. Poultry raising is especially important in the central and western parts of the valley. Some farmers own flocks of 200 to 2,000 or more birds. The favored breeds are Rhode Island Red, Plymouth Rock, and White Leghorn. Several of the farmers, especially in the western part of the Area, specialize in turkey raising.

Hogs are raised mainly for home or local consumption, but some are shipped to Denver and Los Angeles. The most common breeds are Poland China, Duroc-Jersey, and Chester White.

Sheep farmers living in the Grand Junction Area frequently pasture their bands in the adjoining mountains through the summer, and on their own farms or on the winter grazing lands of eastern Utah during winter. Most of the rough land within the surveyed area is used as fall pasture for sheep until the cover becomes thin or inadequate.

Many farmers and fruit growers keep bees. The tree fruits, berries, clover, and alfalfa are a good source of honey. The bees aid in pollenizing the fruit and the crops grown for seed.

Many of the farmers raise their own livestock feed. Those engaged in dairying, poultry raising, or growing of fruit or truck crops usually have to buy part or all of their livestock feed. The farmers who pasture their sheep or cattle in the mountains during summer may need to buy part of the feed required to carry their stock through the winter.

SOILS

The soils of the Grand Junction Area, in their virgin state, are very similar to those in arid valleys in southwestern Colorado and eastern Utah. The desert climate allows only sparse growth of desert shrubs and grasses, so only a small amount of organic matter has accumulated in the soils. The older soils, which occur on the mesas, generally contain less than 1 percent organic matter. In contrast, many of the prairie soils of the Central States have accumulated 5 or 6 percent of organic matter, largely through the continual decay of prairie grasses, especially the roots.

The soils have a very low content of nitrogen, which is to be expected, considering their low content of organic matter. They have a high content of lime carbonate, gypsum, and salts of sodium, potassium, magnesium, and calcium. In many places irrigation has brought about a concentration of salts toxic to plants. Application of acid-treated phosphate fertilizer brings increase in crop yields. This indicates that the phosphorus these calcareous soils contain becomes available too slowly to permit rapid growth of cultivated crops. Probably iron and some of the other elements plants use in small quantities may be relatively unavailable in areas that do not have adequate drainage.

The soils are all light colored. Many of them, especially the older ones, have a reddish tinge that becomes more pronounced in the upper subsoil. This reddish hue is caused by dehydrated iron oxides in the soil.

The soils range widely in age, or stage of development. The soils on the lower lying alluvial fans and stream flood plains are recent; that is, they have had only a short period of time for development. They have no definite concentration of lime or clay in the subsoil. On the higher terraces and benches or mesas, the soils have weathered a long time without being subjected to severe geologic erosion or to deposition, and, as a result, have high concentrations of lime, and in places, a subsoil somewhat finer textured than the surface soil.

The agriculture of this area depends on irrigation. Successful irrigation, in turn, depends on favorable physical characteristics of the soils. In fact, the physical characteristics of the soils influence not only the kinds of crops grown and types of agriculture practiced but also the density of population and general welfare of the inhabitants. Among the most important favorable characteristics are a medium to moderately coarse textured, thick, friable surface soil; a moderately permeable subsoil; and good surface and internal drainage. Most of the older soils of this area and some of the more recent alluvial soils meet these requirements.

Many of the soils having favorable physical characteristics have become more productive through the years of cultivation. This results from incorporation of organic matter by the growing of legumes and the application of moderate to large amounts of barnyard manure. Some of the soils, though otherwise favorable, require careful control of irrigation water to prevent erosion or to safeguard against the building up of a high water table.

Some soils of the area have limited agricultural suitability, or are entirely unsuited to irrigation farming. Large areas of alluvial soils have limited agricultural use because restricted internal drainage causes waterlogging and the accumulation of strong concentrations of salts. This condition is especially evident in the larger areas of Billings silty clay soils located between Fruita and Grand Junction and east of Grand Junction. Unsatisfactory for most crops are the soils with fine-textured very slowly permeable subsoils consisting of raw shale that weathered in place. Also unsuitable are the soils with irregular 10- to 20-percent slopes that consist mainly of raw shale or excessively cobbly or gravelly soil material.

The soils of the Grand Junction Area have been placed in five major groups that indicate their general suitability for irrigated agriculture. Two of the groups have been subdivided into subgroups according to differences in physical characteristics of the soils that affect their suitability, productivity, and management when farmed. All the soils in one subgroup have similar characteristics and, consequently, similar crop suitability, productivity, and management requirements. Each of the groups and subgroups listed below is described in the pages following.

SOIL GROUPS IN THE GRAND JUNCTION AREA, COLO.

1. SOILS OF THE RIVER FLOOD PLAINS:
   - Green River clay loam, deep over gravel, 0 to 2 percent slopes
   - Green River fine sandy loam, deep over gravel, 0 to 2 percent slopes
   - Green River silty clay loam, deep over gravel, 0 to 2 percent slopes
   - Green River very fine sandy loam, deep over gravel, 0 to 2 percent slopes

2. SOILS OF RECENT ALLUVIAL FANS AND LOCAL STREAM FLOOD PLAINS:
   - 2a. Moderately coarse to medium-textured soils with moderately permeable subsoils:
     - Genola fine sandy loam, deep over gravel, 0 to 2 percent slopes
     - Genola loam, 2 to 5 percent slopes
     - Genola very fine sandy loam, deep over gravel, 0 to 2 percent slopes
     - Naples fine sandy loam, 0 to 2 percent slopes
     - Ravola fine sandy loam, 0 to 2 percent slopes
     - Ravola fine sandy loam, 2 to 5 percent slopes
     - Ravola loam, 0 to 2 percent slopes
     - Ravola very fine sandy loam, 0 to 2 percent slopes
     - Ravola very fine sandy loam, 2 to 5 percent slopes
     - Thoroughfare fine sandy loam, 0 to 2 percent slopes
     - Thoroughfare fine sandy loam, 2 to 5 percent slopes
     - Thoroughfare fine sandy loam, 5 to 10 percent slopes
   - 2b. Moderately fine textured soils with moderately permeable subsoils:
     - Genola clay loam, 0 to 2 percent slopes
     - Genola clay loam, 2 to 5 percent slopes
     - Genola clay loam, deep over Hinman clay, 0 to 2 percent slopes
     - Mayfield shaly clay loam, 2 to 5 percent slopes
     - Naples clay loam, 0 to 2 percent slopes
     - Ravola clay loam, 0 to 2 percent slopes
     - Ravola clay loam, 2 to 5 percent slopes
   - 2c. Moderately fine textured soils with slowly permeable subsoils:
     - Billings silty loam, 0 to 2 percent slopes
     - Billings silty clay loam, 2 to 5 percent slopes
   - 2d. Fine-textured soils with slowly permeable subsoils:
     - Billings silty clay, 0 to 2 percent slopes
     - Billings silty clay, 2 to 5 percent slopes
     - Billings silty clay, moderately deep over Green River soil material, 0 to 2 percent slopes
     - Navajo silty clay, 0 to 2 percent slopes

3. SOILS OF THE MESAS:
   - 3a. Slightly to moderately developed, moderately coarse textured to medium textured soils with moderately permeable subsoils:
     - Fruita very fine sandy loam, 0 to 2 percent slopes
     - Fruita very fine sandy loam, 2 to 5 percent slopes
     - Fruita very fine sandy loam, moderately deep, 0 to 2 percent slopes
     - Fruita very fine sandy loam, moderately deep, 2 to 5 percent slopes
     - Fruita very fine sandy loam, moderately deep, 5 to 10 percent slopes
     - Fruita and Ravola loams, 2 to 5 percent slopes
     - Fruita and Ravola loams, moderately deep, 2 to 5 percent slopes
     - Redlands loam, 2 to 5 percent slopes
     - Redlands loam, 0 to 2 percent slopes
     - Redlands loam, 5 to 10 percent slopes
   - 3b. Slightly to moderately developed, moderately fine textured soils with moderately permeable subsoils:
     - Fruita clay loam, 0 to 2 percent slopes
     - Fruita clay loam, 2 to 5 percent slopes
     - Fruita clay loam, moderately deep, 0 to 2 percent slopes
     - Fruita clay loam, moderately deep, 2 to 5 percent slopes
   - 3c. Moderately to strongly developed, moderately fine textured soils with moderately permeable subsoils:
     - Mack clay loam, 0 to 2 percent slopes
     - Mesa clay loam, 0 to 2 percent slopes
     - Mesa clay loam, 2 to 5 percent slopes
   - 3d. Moderately developed, moderately fine textured and fine textured soils with slowly permeable subsoils:
     - Hinman clay, 0 to 1 percent slopes
     - Hinman clay loam, 0 to 2 percent slopes
     - Hinman clay loam, 2 to 5 percent slopes

3e. Moderately developed, gravelly soils with gravelly or cobbly subsoils:
- Fruita gravelly clay loam, 0 to 2 percent slopes
- Fruita gravelly clay loam, 2 to 5 percent slopes
- Fruita gravelly clay loam, 5 to 10 percent slopes
- Fruita gravelly clay loam, moderately deep, 2 to 5 percent slopes
- Fruita gravelly clay loam, moderately deep, 5 to 10 percent slopes
- Fruita and Ravola gravelly loams, 5 to 10 percent slopes

3f. Moderately to strongly developed, gravelly soils with gravelly or cobbly subsoils:
- Mesa gravelly clay loam, 2 to 5 percent slopes
- Mesa gravelly clay loam, 5 to 10 percent slopes
- Mesa gravelly clay loam, moderately deep, 2 to 5 percent slopes
- Mesa gravelly clay loam, moderately deep, 5 to 10 percent slopes

4. SOILS OF THE SHALE UPLANDS:
- Chipeta silty clay loam, 0 to 2 percent slopes
- Chipeta silty clay loam, 2 to 5 percent slopes
- Chipeta-Persayo shaly loams, 2 to 5 percent slopes
- Persayo-Chipeta silty clay loams, 0 to 2 percent slopes
- Persayo-Chipeta silty clay loams, 2 to 5 percent slopes

5. MISCELLANEOUS SOILS AND LAND TYPES:
- Chipeta-Persayo shaly loams, 5 to 10 percent slopes
- Chipeta-Persayo silty clay loams, 5 to 10 percent slopes
- Fruita and Ravola gravelly loams, 20 to 40 percent slopes
- Redlands and Thoroughfare soils, shallow over bedrock, 5 to 10 percent slopes
- Redlands and Thoroughfare soils, shallow over bedrock, 2 to 5 percent slopes
- Riverwash, 0 to 2 percent slopes
- Rough broken land, Mesa, Chipeta, and Persayo soil materials
- Rough broken land, Chipeta and Persayo soil materials
- Rough gullied land

GROUP 1—SOILS OF THE RIVER FLOOD PLAINS

The soils of group 1—four members of the Green River series—occur on flood plains of the Colorado and Gunnison Rivers. Their parent materials are derived from igneous and sedimentary rock formations. The texture of the surface soils ranges from silty clay loam to very fine sandy loam. The subsoils become increasingly coarse-textured with depth, and at depths beginning at less than 2, but normally at about 6 to 8 feet, they are underlain by thick beds of porous gravelly and cobbly sand.

Complete overflow of these soils has not occurred since the valley was opened for irrigation. Nevertheless, some of the lower lying areas are occasionally covered by backwaters during the spring rise of the rivers. Most areas of these soils have a rather high water table, and practically all the lower lying areas must be ditched before they can be irrigated. Considerable salt has accumulated in the soils because the water table is high and because some seepage water coming from the substratum of the Billings soils to the north brings in additional salts.

Poorly drained areas of these soils are used for pasture. The adequately drained acreage is well suited to truck crops and general field crops.

GROUP 2—SOILS OF THE RECENT ALLUVIAL FANS AND LOCAL STREAM FLOOD PLAINS

The soils of group 2 occupy gentle slopes just above and extending back from the recent flood plain of the Colorado River. They have formed on alluvium that was derived largely from Mancos shale but to lesser extent from fine-grained sandstone rocks of the Mesaverde formation. The soils are in a somewhat intermediate position; they are below the higher lying soils of group 3 and above the lowest lying alluvial soils on the flood plains of the Colorado and Gunnison Rivers (group 1).

The soils of group 2 are on a deep broad mantle of alluvial sediments that overlies Mancos shale. They have gentle slopes, especially in positions well toward or bordering the flood plain of the Colorado River. They are dominantly light gray to light brownish gray, in contrast to the light-brown or pale-brown color of the dominant soils in group 3. They are calcareous, but the lime is not visible as it is in the subsoils of the older soils in group 3. A relatively high percentage of the acreage is made up of moderately fine textured to fine textured soils.

Irrigation has caused accumulation of underground water that cannot flow away fast enough to prevent the development of poorly drained places on the broader lower lying areas. The water is held in layers of sediment or in pockets above the underlying Mancos shale. Numerous drainage ditches have been dug in the many broader flats having a thicker alluvial mantle over shale, but these have not successfully drained the areas. Hence, many of the problems of improving drainage and removing harmful concentrations of salts remain unsolved.

Many areas of these soils farther northward, as well as some bordering the washes, have a coarser texture and more rapid underdrainage; consequently, they are only slightly affected by salts, even though their mantle is thinner over shale.

The soils of this group have been placed in four subgroups, each of which is discussed separately.

Subgroup 2a.—The soils of this subgroup are among the best agricultural soils in group 2. They lie on slightly elevated areas, on natural levees, and have developed from materials deposited along the larger washes. They have moderately coarse to moderately fine textured surface soils and moderately permeable subsoils. Their favorable surface texture, friable subsoil, and permeability to air, water, and plant roots make them especially suitable for potatoes, tomatoes, onions, melons, cantaloups, cucumbers, sugar beets, pinto beans, alfalfa, and clover. In places where danger of frost is only slight, they are desirable for berries, grapes, and orchard fruits. The Ravola and Naples soils of this subgroup have about the same crop-suitability range as the soils of subgroup 3a.

The porous substratum affords adequate underdrainage in most places. Only a few places have required drainage ditches to relieve the pressure of underground water and to lower the water table.

A few small areas bordering the slightly lower lying fine-textured soils of subgroup 2c are more or less saline, but the concentration of salts normally is not harmful to crops.

Subgroup 2b.—The soils of this subgroup have a moderately fine textured surface soil and a moderately permeable subsoil. Except for their moderately fine texture, they are very similar to the soils of subgroup 2a in soil characteristics, crop suitabilities, management requirements, and productivity.

Subgroup 2c.—The soils of this subgroup are the two mapping units of Billings silty clay loam. They are derived from an alluvial mantle that is 35 to 45 feet deep over shale in some places. They have a moderately fine textured surface soil and a slowly permeable subsoil. They have slower internal drainage than the soils of subgroups 2a and 2b because their subsoil layers are slowly permeable, and because their porous substratum is at a great depth, is not so thick, and is not continuous. Problems of restricted drainage and salinity are therefore more common, especially in areas beginning west of Clifton and stretching onward to the western part of the valley.

Soils of this subgroup have about the same crop adaptabilities as those in subgroup 3c. Alfalfa, corn, clover, pinto beans, sugar beets, and small grains are well suited if the soils are adequately drained. Orchard fruits do well in the better protected positions east of Clifton.

Subgroup 2d.—Three soils of the Billings series and the Navajo soil are in this subgroup. They have fine-textured surface soils and permeable subsoils. Owing to their fine texture, restricted underdrainage, susceptibility to saline conditions, slow permeability, and slopes of only about 1 percent, these soils have the least favorable characteristics of any in group 2. The common crops are sugar beets, small grains, alfalfa, corn, and irrigated pasture. Approximately one-fourth of the acreage still is not cultivated, mainly because of restricted underdrainage and consequent salinity.

GROUP 3—SOILS OF THE MESAS

Soils of the mesas (group 3) occupy relatively high positions and have weathered a longer time than other soils within the Grand Valley. The surface soils and subsoils range from very pale brown to light reddish brown, the light brown being dominant. When moist, the soils are redder.

All the soils of this group are highly calcareous; they have moderate to strong accumulations of lime in the subsoil. For the most part, their surfaces are smooth. Most of these soils are sufficiently permeable to allow free expansion of the roots of deep-rooted crops, including orchard fruits. Salinity problems generally are of small concern.

The cobbly substratum of the Mack and Mesa soils insures excellent underdrainage. The substratum in soils of the Fruita and Redlands series is cobbly in some places, but elsewhere it normally is sufficiently porous and deep to afford adequate internal drainage. In the few places where subdrainage is not adequate, it can be made satisfactory by ditching.

Practically all of the irrigable land lying below the irrigation canals is cultivated. A few small areas located above the canals are still not cultivated, but they could be irrigated by using pumping equipment. The soils of this group lend themselves well to irrigation and are among those most highly prized in the valley. They occur on Orchard Mesa, in the Redlands, and on a number of narrow mesas and higher alluvial fans north of the Colorado River.

Subgroup 3a.—The soils of this subgroup have medium-textured surface soils and friable and moderately permeable subsoils. They are especially well suited to potatoes, tomatoes, onions, cantaloups, cucumbers, pinto beans, corn, alfalfa, clover, and, in protected positions, orchard fruits. The soils are only moderately deep over shale and therefore not so desirable for crops as deeper soils. The shale limits the root systems of deep-rooted plants such as alfalfa and tree fruits. Moreover, the erosion becomes increasingly harmful as the mantle over the shale becomes thinner.

Subgroup 3b.—The soils of this subgroup, like those of subgroup 3a, are among the best in the Grand Valley for agriculture. They differ from the soils of subgroup 3a in having moderately fine textured instead of medium textured surface soils. Because they have a clay loam texture, they are better for pinto beans, alfalfa, clover, corn, sugar beets, other field crops, and orchard fruits than the soils of subgroup 3a. They are, however, not so well suited to onions, cantaloups, cucumbers, and potatoes as the soils of subgroup 3a.

In climatically suitable locations, soils of this subgroup, like those of subgroup 3a, are well suited to orchard fruits. The friable and permeable subsoils assure free root expansion of deep-rooted plants. The thick soil mantle and thick substratum of smooth water-worn stones, cobbles, gravel and sandy material permit sufficient internal drainage and virtually eliminate the danger that the soils may become waterlogged and saline.

Subgroup 3c.—The soils of this subgroup differ from those in subgroup 3b mainly in stage of profile development. They are very similar in crop suitabilities, management requirements, and productivity.

Subgroup 3d.—In this subgroup are three soils of the Hinman series. They have moderately fine textured or fine textured surface soils and slowly permeable subsoils. They do not have so wide a suitability range for crops as the soils of subgroups 3a, 3b, and 3c. Their surface soils and subsoils are slowly permeable to deep-rooted plants, so that sugar beets, sweetclover, small grains, and irrigated pasture are among the better suited crops. Corn produces fair to good yields when planted after clover or alfalfa.

Several drainage ditches have been dug to improve the drainage of the more nearly level areas where a water table has developed above the underlying shale beds. A small acreage of these soils remains strongly saline.

Although these soils are somewhat like those in subgroup 2d, they have a thicker and more cobbly substratum that facilitates subdrainage. The substratum begins at depths ranging from 6 to 12 feet and, in turn, overlies Mancos shale.

Subgroups 3e and 3f.—The soils of these two subgroups differ principally in degree of profile development. They are similar in crop suitabilities, management requirements, and productivity. About 62 percent of their total acreage is under cultivation.

Soils of these subgroups have gravelly surface soils and gravelly or cobbly subsoils. The gravel, cobbles, and water-worn stones adversely affect tilth and workability. Most crops yield less than on soils of subgroups 3a, 3b, or 3c. In spite of the cobbles, gravel, and reduced water-retaining capacity, these soils are permeable enough to allow successful growing of deep-rooted crops. A comparatively large acreage of these soils is in tree fruits.

GROUP 4—SOILS OF THE SHALE UPLANDS

The soils of group 4 are members of the Chipeta and Persayo series. They have developed over thick beds of Mancos shale and are the only residual soils in the valley that can be cultivated. They are so thin over laminated, slightly weathered clay shale that they are very slowly permeable to air, water, and plant roots. Shallow-rooted crops such as small grains, pinto beans, and mixed pasture grasses are best suited, but yields average less than on any of the other irrigated soils except possibly those that are poorly drained and affected by salts. The soils of group 4 are not important agriculturally and fortunately they do not occupy a large acreage.

GROUP 5—MISCELLANEOUS SOILS AND LAND TYPES

In group 5 are miscellaneous soils and land types that do not belong in any of the other four groups because they are not suitable for irrigated crops, and, for the most part, are not suitable even for pasture. Most areas are too steep or irregular for irrigation. Those that could be irrigated are too shallow to shale or contain such excessive quantities of stone, cobbles, or gravel that they are not suitable for cultivation. They are used mainly for grazing but provide scant forage. Some of the land types provide material for road surfacing, for building, or for manufacture of tile and brick. The miscellaneous land types of this group cover a large acreage but have little potential agricultural value.

SOIL DESCRIPTIONS

In the following pages the soil types, phases, and miscellaneous land types mapped in the Grand Junction Area are described in detail and their agricultural relations are discussed. Their location and distribution are shown on the accompanying map; their approximate acreage and proportionate extent in table 5; and the yields of principal crops [4] under prevailing management in table 6.

[4] Yields of orchard fruits were not estimated because of differences in frost hazard from place to place. Aside from frost hazard, soils having a high estimated yield for alfalfa are normally well suited to tree fruits.

TABLE 5.—*Approximate acreage and proportionate extent of the soils mapped in the Grand Junction Area, Colorado*

Soil	Acres	Percent
Billings silty clay loam, 0 to 2 percent slopes	30, 944	25. 4
Billings silty clay loam, 2 to 5 percent slopes	744	. 6
Billings silty clay, 0 to 2 percent slopes	3, 344	2. 7
Billings silty clay, 2 to 5 percent slopes	76	. 1
Billings silty clay, moderately deep over Green River soil material, 0 to 2 percent slopes	873	. 7
Chipeta silty clay loam, 0 to 2 percent slopes	2, 961	2. 4
Chipeta silty clay loam, 2 to 5 percent slopes	3, 432	2. 8
Chipeta-Persayo shaly loams, 2 to 5 percent slopes	1, 025	. 8
Chipeta-Persayo shaly loams, 5 to 10 percent slopes	2, 331	1. 9
Chipeta-Persayo silty clay loams, 5 to 10 percent slopes	1, 872	1. 5
Fruita clay loam, 0 to 2 percent slopes	2, 619	2. 2
Fruita clay loam, 2 to 5 percent slopes	458	. 4
Fruita clay loam, moderately deep, 0 to 2 percent slopes	693	. 6
Fruita clay loam, moderately deep, 2 to 5 percent slopes	1, 390	1. 1
Fruita gravelly clay loam, 2 to 5 percent slopes	790	. 6
Fruita gravelly clay loam, 0 to 2 percent slopes	74	. 1
Fruita gravelly clay loam, 5 to 10 percent slopes	92	. 1
Fruita gravelly clay loam, moderately deep, 2 to 5 percent slopes	661	. 5
Fruita gravelly clay loam, moderately deep, 5 to 10 percent slopes	118	. 1
Fruita very fine sandy loam, 0 to 2 percent slopes	1, 380	1. 1
Fruita very fine sandy loam, 2 to 5 percent slopes	573	. 5
Fruita very fine sandy loam, moderately deep, 0 to 2 percent slopes	636	. 5
Fruita very fine sandy loam, moderately deep, 2 to 5 percent slopes	1, 237	1. 0
Fruita very fine sandy loam, moderately deep, 5 to 10 percent slopes	64	. 1
Fruita and Ravola loams, 2 to 5 percent slopes	1, 414	1. 2
Fruita and Ravola loams, moderately deep, 2 to 5 percent slopes	392	. 3
Fruita and Ravola gravelly loams, 5 to 10 percent slopes	800	. 7
Fruita and Ravola gravelly loams, 20 to 40 percent slopes	157	. 1
Genola clay loam, 0 to 2 percent slopes	200	. 2
Genola clay loam, 2 to 5 percent slopes	53	(1)
Genola clay loam, deep over Hinman clay, 0 to 2 percent slopes	606	. 5
Genola fine sandy loam, deep over gravel, 0 to 2 percent slopes	44	(1)
Genola loam, 2 to 5 percent slopes	264	. 2
Genola very fine sandy loam, deep over gravel, 0 to 2 percent slopes	142	. 1
Gravel pits	38	(1)
Green River clay loam, deep over gravel, 0 to 2 percent slopes	82	. 1
Green River fine sandy loam, deep over gravel, 0 to 2 percent slopes	440	. 4
Green River silty clay loam, deep over gravel, 0 to 2 percent slopes	277	. 2
Green River very fine sandy loam, deep over gravel, 0 to 2 percent slopes	2, 084	1. 7
Hinman clay, 0 to 1 percent slopes	578	. 5
Hinman clay loam, 0 to 2 percent slopes	2, 099	1. 7
Hinman clay loam, 2 to 5 percent slopes	392	. 3
Mack clay loam, 0 to 2 percent slopes	639	. 5
Mayfield shaly clay loam, 2 to 5 percent slopes	570	. 5
Mesa clay loam, 0 to 2 percent slopes	2, 032	1. 7

1 Less than 0.1 percent.

TABLE 5.—*Approximate acreage and proportionate extent of the soils mapped in the Grand Junction Area, Colorado*—Continued

Soil	Acres	Percent
Mesa clay loam, 2 to 5 percent slopes	2, 713	1. 8
Mesa gravelly clay loam, 2 to 5 percent slopes	1, 590	1. 3
Mesa gravelly clay loam, 5 to 10 percent slopes	841	. 7
Mesa gravelly clay loam, moderately deep, 2 to 5 percent slopes	133	. 1
Mesa gravelly clay loam, moderately deep, 5 to 10 percent slopes	430	. 4
Naples clay loam, 0 to 2 percent slopes	89	. 1
Naples fine sandy loam, 0 to 2 percent slopes	79	. 1
Navajo silty clay, 0 to 2 percent slopes	127	. 1
Persayo-Chipeta silty clay loams, 0 to 2 percent slopes	4, 169	3. 4
Persayo-Chipeta silty clay loams, 2 to 5 percent slopes	3, 062	2. 5
Ravola clay loam, 0 to 2 percent slopes	7, 407	6. 1
Ravola clay loam, 2 to 5 percent slopes	501	. 4
Ravola very fine sandy loam, 0 to 2 percent slopes	5, 726	4. 7
Ravola very fine sandy loam, 2 to 5 percent slopes	96	. 1
Ravola fine sandy loam, 0 to 2 percent slopes	2, 519	2. 1
Ravola fine sandy loam, 2 to 5 percent slopes	111	. 1
Ravola loam, 0 to 2 percent slopes	2, 518	2. 1
Redlands loam, 2 to 5 percent slopes	999	. 8
Redlands loam, 0 to 2 percent slopes	8	(1)
Redlands loam, 5 to 10 percent slopes	173	. 1
Redlands and Thoroughfare soils, shallow over bedrock, 5 to 10 percent slopes	442	. 4
Redlands and Thoroughfare soils, shallow over bedrock, 2 to 5 percent slopes	28	(1)
Riverwash, 0 to 2 percent slopes	3, 460	2. 9
Rough broken land, Mesa, Chipeta, and Persayo soil materials	4, 353	3. 6
Rough broken land, Chipeta and Persayo soil materials	3, 539	2. 9
Rough gullied land	3, 502	2. 9
Thoroughfare fine sandy loam, 2 to 5 percent slopes	1, 651	1. 4
Thoroughfare fine sandy loam, 0 to 2 percent slopes	117	. 1
Thoroughfare fine sandy loam, 5 to 10 percent slopes	67	. 1
Total	121, 600	100. 0

[1] Less than 0.1 percent.

TABLE 6.—*Estimated average acre yields to be expected over a period of years from irrigated crops on soils of the Grand Junction Area, Colo.*

[All estimates are based on common management, which is that used by most farmers in the area at the time the survey was made. Blank spaces indicate soil is not suited to the crop specified. Because of variation in frost hazard from place to place, yields are not given for orchard fruits. Aside from frost hazard, a soil that produces good yields of alfalfa is normally well suited to tree fruits]

Map symbol	Soil	Corn	Alfalfa	Oats	Wheat	Barley	Beans (dry)	Sugar beets	Potatoes [1]	Tomatoes	Vegetables	Irrigated pasture
		Bu.	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Lbs.*	*Tons*	*Bu.*	*Tons*		*Cow-acre days* [2]
Bc	Billings silty clay loam, 0 to 2 percent slopes.	50	3. 5	52	35	45	1, 500	12. 5	140	9. 5	Fair to good	200
Bd	Billings silty clay loam, 2 to 5 percent slopes.	50	3. 5	50	30	45	1, 500	12. 5	140	9. 5	do	200
Ba	Billings silty clay, 0 to 2 percent slopes.	38	3. 0	42	30	35	1, 200	11. 0	125	8. 0	Poor to fair	170
Bb	Billings silty clay, 2 to 5 percent slopes.	45	3. 2	45	32	40	1, 300	11. 5	130	8. 5	Fair	185
Be	Billings silty clay, moderately deep over Green River soil material, 0 to 2 percent slopes.	48	3. 5	50	35	40	1, 300	13. 0	130	9. 0	Fair	185
Cd	Chipeta silty clay loam, 0 to 2 percent slopes.	22	1. 7	27	18	22	850	9. 0		6. 0	Poor	135
Ce	Chipeta silty clay loam, 2 to 5 percent slopes.	22	1. 5	27	17	22	850	9. 0		6. 0	do	135
Ca	Chipeta-Persayo shaly loams, 2 to 5 percent slopes.	27	2. 0	25	20	22	850	9. 7		6. 7	do	150
Cb	Chipeta-Persayo shaly loams, 5 to 10 percent slopes.										do	

Cc	Chipeta-Persayo silty clay loams, 5 to 10 percent slopes.	------	------	------	------	------	--------	------	------	------	----------------	-----
Fe	Fruita clay loam, 0 to 2 percent slopes.	52	3. 8	58	40	45	1, 600	13. 0	160	12. 0	Very good	200
Ff	Fruita clay loam, 2 to 5 percent slopes.	52	3. 8	58	40	45	1, 600	13. 0	160	12. 0	do	200
Fg	Fruita clay loam, moderately deep, 0 to 2 percent slopes.	45	3. 0	58	35	40	1, 500	12. 5	160	11. 0	Good to very good	170
Fh	Fruita clay loam, moderately deep, 2 to 5 percent slopes.	45	3. 0	58	35	40	1, 500	12. 5	160	11. 0	do	170
Fl	Fruita gravelly clay loam, 2 to 5 percent slopes.	32	3. 0	38	25	30	1, 200	10. 0	130	8. 5	Moderately good	170
Fk	Fruita gravelly clay loam, 0 to 2 percent slopes.	32	3. 0	38	25	30	1, 200	10. 0	130	8. 5	do	170
Fm	Fruita gravelly clay loam, 5 to 10 percent slopes.	30	3. 0	36	22	27	1, 100	9. 5	125	8. 0	do	170
Fn	Fruita gravelly clay loam, moderately deep, 2 to 5 percent slopes.	30	2. 8	38	25	27	1, 100	9. 5	130	8. 0	Fair to moderately good.	170
Fo	Fruita gravelly clay loam, moderately deep, 5 to 10 percent slopes.	28	2. 5	35	22	25	1, 000	9. 2	120	7. 5	Moderately good	170
Fp	Fruita very fine sandy loam, 0 to 2 percent slopes.	55	3. 8	55	35	45	1, 600	13. 0	175	12. 0	Very good	200
Fr	Fruita very fine sandy loam, 2 to 5 percent slopes.	55	3. 8	55	35	45	1, 600	13. 0	175	12. 0	do	200
Fs	Fruita very fine sandy loam, moderately deep, 0 to 2 per-slopes.	50	3. 2	50	30	45	1, 500	12. 0	160	11. 0	Good to very good	185
Ft	Fruita very fine sandy loam, moderately deep, 2 to 5 percent slopes.	50	3. 2	50	30	45	1, 500	12. 5	160	11. 0	do	185
Fu	Fruita very fine sandy loam, moderately deep, 5 to 10 percent slopes.	45	3. 0	45	30	40	1, 400	11. 5	160	10. 5	do	170
Fc	Fruita and Ravola loams, 2 to 5 percent slopes.	45	3. 3	50	35	45	1, 500	13. 0	165	11. 0	Good	185

See footnotes at end of table.

TABLE 6.—*Estimated average acre yields to be expected over a period of years from irrigated crops on soils of the Grand Junction Area, Colo.*—Continued

[All estimates are based on common management, which is that used by most farmers in the area at the time the survey was made. Blank spaces indicate soil is not suited to the crop specified. Because of variation in frost hazard from place to place, yields are not given for orchard fruits. Aside from frost hazard, a soil that produces good yields of alfalfa is normally well suited to tree fruits]

Map symbol	Soil	Corn	Alfalfa	Oats	Wheat	Barley	Beans (dry)	Sugar beets	Potatoes [1]	Tomatoes	Vegetables	Irrigated pasture
		Bu.	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Lbs.*	*Tons*	*Bu.*	*Tons*		*Cow-acre days* [2]
FD	Fruita and Ravola loams, moderately deep, 2 to 5 percent slopes.	25	2.0	30	22	24	900	9.5	120	7.0	Fair to good	150
FA	Fruita and Ravola gravelly loams, 5 to 10 percent slopes.	42	3.0	45	30	40	1,400	11.5	150	10.0	do	170
FB	Fruita and Ravola gravelly loams, 20 to 40 percent slopes.											
GA	Genola clay loam, 0 to 2 percent slopes.	55	3.8	58	40	45	1,600	13.2	175	12.5	Very good	200
GB	Genola clay loam, 2 to 5 percent slopes.	55	3.8	58	40	45	1,600	13.2	175	12.5	do	200
GC	Genola clay loam, deep over Hinman clay, 0 to 2 percent slopes.	55	4.0	58	35	45	1,600	13.0	170	12.0	Good to very good	200
GD	Genola fine sandy loam, deep over gravel, 0 to 2 percent slopes.	53	3.8	55	40	45	1,500	12.2	165	11.5	do	200
GF	Genola loam, 2 to 5 percent slopes.	55	3.8	58	40	45	1,600	13.2	175	12.5	Very good	200
GG	Genola very fine sandy loam, deep over gravel, 0 to 2 percent slopes.	55	4.0	55	35	45	1,600	13.0	175	12.5	do	200

GH	Green River clay loam, deep over gravel, 0 to 2 percent slopes.	50	3. 5	50	35	40	1, 400	12. 5	155	10. 0	Moderately good	185
GK	Green River fine sandy loam, deep over gravel, 0 to 2 percent slopes.	53	3. 8	55	40	45	1, 500	12. 2	165	11. 5	Good to very good	200
GL	Green River silty clay loam, deep over gravel, 0 to 2 percent slopes.	45	3. 7	50	35	40	1, 400	12. 2	155	11. 0	Fair to good	200
GM	Green River very fine sandy loam, deep over gravel, 0 to 2 percent slopes.	55	4. 0	55	35	45	1, 600	13. 0	175	12. 5	Very good	200
HA	Hinman clay, 0 to 1 percent slopes.	40	2. 8	45	30	35	1, 200	11. 5	125	8. 5	Poor to fair	170
HB	Hinman clay loam, 0 to 2 percent slopes.	48	3. 0	40	33	40	1, 500	12. 0	135	10. 0	Fair to good	170
HC	Hinman clay loam, 2 to 5 percent slopes.	48	3. 0	47	33	40	1, 500	12. 0	135	10. 5	do	170
MA	Mack clay loam, 0 to 2 percent slopes.	52	3. 8	58	35	45	1, 600	13. 0	160	12. 0	Very good	200
MB	Mayfield shaly clay loam, 2 to 5 percent slopes.	45	3. 5	50	30	40	1, 500	12. 0	150	10. 0	Good	185
MC	Mesa clay loam, 0 to 2 percent slopes.	52	3. 8	58	40	45	1, 600	13. 0	160	12. 0	Very good	200
MD	Mesa clay loam, 2 to 5 percent slopes.	52	3. 8	58	40	45	1, 600	13. 0	160	12. 0	do	200
ME	Mesa gravelly clay loam, 2 to 5 percent slopes.	33	3. 5	38	25	30	1, 200	10. 0	130	8. 5	Fair	185
MF	Mesa gravelly clay loam, 5 to 10 percent slopes.	30	2. 8	35	23	25	1, 000	9. 2	130	8. 2	do	170
MG	Mesa gravelly clay loam, moderately deep, 2 to 5 percent slopes.	28	2. 8	38	25	27	1, 100	9. 5	135	7. 5	do	170
MH	Mesa gravelly clay loam, moderately deep, 5 to 10 percent slopes.	27	2. 5	33	22	25	1, 000	9. 2	130	7. 0	do	170
NA	Naples clay loam, 0 to 2 percent slopes.	52	3. 5	55	35	45	1, 500	12. 5	165	------	Good to very good	200

See footnotes at end of table.

TABLE 6.—*Estimated average acre yields to be expected over a period of years from irrigated crops on soils of the Grand Junction Area, Colo.*—Continued

[All estimates are based on common management, which is that used by most farmers in the area at the time the survey was made. Blank spaces indicate soil is not suited to the corp specified. Because of variation in frost hazard from place to place, yields are not given for orchard fruits. Aside from frost hazard, a soil that produces good yields of alfalfa is normally well suited to tree fruits]

Map symbol	Soil	Corn	Alfalfa	Oats	Wheat	Barley	Beans (dry)	Sugar beets	Potatoes [1]	Tomatoes	Vegetables	Irrigated pasture
		Bu.	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Lbs.*	*Tons*	*Bu.*	*Tons*		*Cow-acre days* [2]
NB	Naples fine sandy loam, 0 to 2 percent slopes.	55	4.0	60	35	50	1,500	12.0	155	11.0	Good to very good	220
NC	Navajo silty clay, 0 to 2 percent slopes.	40	3.0	45	30	35	1,200	11.0	------	8.2	Poor	170
PA	Persayo-Chipeta silty clay loams, 0 to 2 percent slopes.	23	2.0	25	20	22	900	9.0	------	6.5	do	150
PB	Persayo-Chipeta silty clay loams, 2 to 5 percent slopes.	23	2.0	25	20	22	850	9.0	------	6.5	do	150
RA	Ravola clay loam, 0 to 2 percent slopes.	52	3.8	58	35	45	1,600	13.0	165	11.5	Good to very good	200
RB	Ravola clay loam, 2 to 5 percent slopes.	52	3.8	58	35	45	1,600	13.0	165	11.5	do	200
RF	Ravola very fine sandy loam, 0 to 2 percent slopes.	52	3.8	55	35	45	1,600	13.5	170	12.2	do	200
RG	Ravola very fine sandy loam, 2 to 5 percent slopes.	52	3.8	55	35	45	1,600	13.5	170	12.2	do	200
RC	Ravola fine sandy loam, 0 to 2 percent slopes.	55	4.0	55	35	45	1,600	13.0	175	12.0	do	200
RD	Ravola fine sandy loam, 2 to 5 percent slopes.	55	4.0	55	35	45	1,600	13.0	175	12.0	do	200
RE	Ravola loam, 0 to 2 percent slopes.	45	3.5	55	35	45	1,500	13.0	165	11.5	Good	200

Rn	Redlands and Thoroughfare soils, shallow over bedrock, 5 to 10 percent slopes.											
Rm	Redlands and Thoroughfare soils, shallow over bedrock, 2 to 5 percent slopes.											
Rk	Redlands loam, 2 to 5 percent slopes.	52	3. 8	58	38	45	1, 500	13. 0	175	12. 2	Very good	200
Rh	Redlands loam, 0 to 2 percent slopes.	52	3. 8	58	38	45	1, 500	13. 0	175	12. 2	do	200
Rl	Redlands loam, 5 to 10 percent slopes.	48	3. 5	55	38	40	1, 400	12. 0	165	10. 5	Good	185
Ro	Riverwash, 0 to 2 percent slopes											
Rr	Rough broken land, Mesa, Chipeta, and Persayo soil materials.											
Rp	Rough broken land, Chipeta and Persayo soil materials.											
Rs	Rough gullied land											
Tb	Thoroughfare fine sandy loam, 2 to 5 percent slopes.	52	3. 5	60	35	45	1, 500	12. 0	165	11. 0	Good to very good	200
Ta	Thoroughfare fine sandy loam, 0 to 2 percent slopes.	50	3. 5	55	35	45	1, 500	12. 5	165	11. 0	do	200
Tc	Thoroughfare fine sandy loam, 5 to 10 percent slopes.											

[1] Most of the potatoes are grown for early marketing. Because of immaturity, the average acre yields are considerably lower than for potatoes harvested later in the season when fully matured.

[2] Cow-acre-days is an expression of the animal units per acre times the number of days without injury to pasture; e. g. 1 animal unit per acre × 360 days=360; 1 animal unit equals 1 mature cow, steer, or horse, 5 hogs, or 7 sheep or goats.

Billings silty clay loam, 0 to 2 percent slopes (Bc).—This soil, locally called adobe, is one of the most important and extensive in the Grand Valley. It covers nearly one-fifth of the Grand Junction Area. The areas occur on the broad flood plains and very gently sloping coalescing alluvial fans along streams. Many large areas are north of the Colorado River.

The soil is derived from deep alluvial deposits that came mainly from Mancos shale but in a few places from fine-grained sandstone materials. The deposits ordinarily range from 4 to 40 feet deep but in places exceed 40 feet. The deposits have been built up from thin sediments brought in by the streams that have formed the coalescing alluvial fans or have been dropped by the broad washes that have no drainage channel. The thickest deposit, near Grand Junction, was built up by Indian Wash.

The color and texture of the soil profile vary from place to place. The 8- to 10-inch surface soil normally consists of gray, light-gray, light olive-gray, or light brownish-gray silty clay loam. This layer grades into material of similar color and texture that extends to depths of 3 or 4 feet. Below this depth the successive depositional layers show more variation. Although the dominant texture is silty clay loam, the profile may have a loam, clay loam, fine sandy loam, or a very fine sandy loam texture.

Where there are fairly uniform beds of Mancos shale and where the soil is not influenced by materials deposited by adjoining drainage courses, the profile varies only slightly within the upper 3 or 4 feet. In areas bordering drainage courses, however, the soil varies more in texture and color from the surface downward.

One small area about 1½ miles southeast of Loma consists of light grayish-brown or pale-brown heavy silty clay loam that shows only slight variation in texture to depths of 4 to 6 feet. The underlying soil material is more variable. Below depths of 6 to 10 feet the layers generally are somewhat thicker and have a higher percentage of coarse soil material.

Also included with this soil are several small areas totaling about 3 square miles that are dominantly pale yellow. These are located 2½ to 3½ miles northeast of Fruita, 5 miles north of Fruita, 2½ miles northeast of Loma, 3 to 5 miles north of Loma, 1½ miles northwest of Loma, and 4 miles northwest of Mack. In these areas the 8- or 10-inch surface soil is pale-yellow silty clay loam, and the subsoil is a relatively uniform pale-yellow silty clay loam to depths of 4 to 8 feet. The accumulated alluvial layers are difficult to distinguish, but in a few places transitional to Fruita soils there are small areas having a pale-brown to light-yellowish brown color. These transitional areas are included with Billings silty clay loam because they have a finer textured subsoil than is characteristic of the Ravola soils.

Although moderately fine textured, this Billings soil permits successful growth of deep-rooted crops such as alfalfa and tree fruits. Its permeability is normally not so favorable as that of the Mesa, Fruita, and Ravola soils. Its tilth and workability are fair, but it puddles so quickly when wet and bakes so hard when dry that good tilth can be maintained only by proper irrigation and special cultural practices. Runoff is slow and internal drainage is very slow.

Like all other soils in the area, this one has a low organic-matter content. Under natural conditions it contains a moderate concentration of salts derived from the parent rock (Mancos shale). In places, however, it contains so much salt that good yields cannot be obtained. Some large areas are so strongly saline they cannot be used for crops. Generally, this soil is without visible lime, but it is calcareous. In many places small white flecks or indistinct light-colored streaks or seams indicate that lime, gypsum, or salts are present.

Use and management.—About 80 percent of this soil is cultivated. The chief irrigated crops are alfalfa, corn, dry beans, sugar beets, small grains, and tomatoes and other truck crops. Where the soil is located so as to avoid frost damage, tree fruits are grown.

Most of the field crops are grown in the central and western parts of the valley, or from Grand Junction westward. The entire acreage in tree fruits—approximately 3 square miles—lies between Grand Junction and Palisade. Because the climate is more favorable near Palisade, the acreage in orchard fruits is greater there. A few small orchards are located northeast of Grand Junction in the direction of Clifton. The main fruit acreage is between Clifton and Palisade. Peach orchards predominate, but a considerable acreage is in pears, especially near Clifton. Yields depend on the age of the trees and other factors, including management, but the estimated potential yield is somewhat less on this soil than on Mesa soils. This takes into account the slower internal drainage of this soil and its susceptibility to salinity if overirrigated. Yields of other crops vary according to the length of time the land has been irrigated, internal drainage or subdrainage, salt content of the soil, management practices, and local climate.

The uncultivated areas of this soil are mostly inaccessible places adjoining the larger washes, which occur mainly in the western part of the area, and those places that cannot be cropped profitably because they have inadequate drainage and a harmful concentration of salts. The uncultivated land supports a sparse growth of greasewood, saltbush, shadscale, rabbitbrush, ryegrass, peppergrass, and saltgrass. From 70 to 90 acres are required to pasture one animal during a season.

A number of places shown on the map by small marsh symbols are low and seepy. They could be ditched, but their acreage is likely too small to justify the expense. Left as they are, their salt content makes them worthless for any use except pasture.

Sizeable acreages of this soil apparently were overirrigated in the past. Irrigation water applied at higher levels to the north seeps upward in this soil where it occurs in low areas toward the river. Even now, new saline areas are appearing, and existing areas are getting larger. The total acreage affected by salts has remained more or less the same for the last two decades, but affected areas will continue to change in size and shape because of seepage.

Most fields are ditched where necessary. Some uncultivated areas require both leveling and ditching. In places subdrainage is inadequate because irregularities in the underlying shale tend to create pockets and prevent underground water from flowing into the drainage ditches. Also, in some areas where the alluvial mantle is 30 to 40 feet thick, the ditches are not always deep enough to drain the soil. Some areas are seepy because there are no ditches running in an east-west direction to intercept lateral flow of ground water from the overirrigated, permeable, medium-textured, stratified soils on the upper parts of the fan to the north. After being leveled, uncultivated areas would have to be cropped for 3 years before their salt content would be reduced enough to permit good yields.

Farmers can increase the organic-matter content of this soil by applying manure liberally and by growing alfalfa or clovers at least part of the time. A combination field crop and livestock type of farming favors improvement of this soil. Many of the small imperfectly drained areas may be kept in pasture. Strawberry clover and sweetclover are well suited, and mixtures of pasture grasses grow well.

Billings silty clay loam, 2 to 5 percent slopes (Bd).—This soil covers a relatively small acreage in the Grand Valley. The areas are widely scattered. Except for its stronger slope, the soil is almost the same as Billings silty clay loam, 0 to 2 percent slopes. In a few places, notably north of Loma, there are areas having a pale-yellow color rather than the gray typical of the Billings soils.

Use and management.—Only about 15 percent of this soil is cultivated. Many of the areas lie along large drainageways or washes where they are difficult to reach. Even a larger number have such an uneven surface that considerable leveling would have to be done before they could be cropped. The cost of leveling, together with the expense of controlling erosion and gullying, discourages farmers from using them.

Many of the uncultivated areas have moderate concentrations of salts, but they are not particularly difficult to reclaim because they border natural ditches or washes which afford free disposal of irrigation water. Furthermore, for the most part, they have a porous substratum.

About the same crops are grown on this soil as on Billings silty clay loam, 0 to 2 percent slopes. The average yields are approximately the same.

Billings silty clay, 0 to 2 percent slopes (Ba).—This soil, locally called heavy adobe, occurs well toward the Colorado River. It is on alluvial materials—4 to about 40 feet thick—that largely came from Mancos shale. Most of this soil lies east and southeast of Grand Junction and along the railroad between Grand Junction and Fruita.

The 8- or 10-inch surface soil consists of light brownish-gray, gray, or olive-gray silty clay. The layer is similar to the surface layer of Billings silty clay loam soils but it is harder and, in many places, darker. The subsoil consists of similarly colored layers of silty clay loam, silt loam, and silty clay. In places the soil is silty clay to depths exceeding 4 feet.

The entire profile is firm when moist and has a massive structure. The subsoil has many small irregularly shaped light-gray specks or indistinct mottles. Poorly defined light-colored streaks indicate the presence of lime, gypsum, or salts. The surface soil and subsoil are calcareous, the lime being well distributed. The fine texture of the soil greatly retards penetration of roots, moisture, and air.

Surface runoff is very slow to slow where the slope is less than 1 percent. Internal drainage is very slow because the subsoil is massive and very slowly permeable. Even with ample drainage ditches, the discharge of irrigation water is slow.

Tilth and workability are not good, because the soil has a fine texture and a low content of organic matter. Moreover, some fields contain areas 20 to 60 feet across that have excessive amounts of salts. Slick spots also occur. These salty areas and slick spots produce low or negligible yields of most crops and are extremely difficult to eliminate.

Use and management.—About 75 percent of this soil is cultivated. Most of the rest is affected by salts. Small grains, beans, sugar beets, and alfalfa are the chief crops. They yield less than on Billings silty clay loam, 0 to 2 percent slopes. Ordinarily, newly broken fields are cropped to oats or other small grains the first few seasons so that excess salts can be removed. Afterwards, if drainage is adequate, they may be planted to pinto beans, sugar beets, corn, or alfalfa. The very slow permeability of this soil makes it unsuitable for orchard crops. Also, it is located mainly in areas where the frost hazard is great. Probably the greater part of the irrigable acreage is used for sugar beets. Small grains, alfalfa, and pinto beans usually follow in the order named.

Billings silty clay, 2 to 5 percent slopes (BB).—This soil is similar to Billings silty clay, 0 to 2 percent slopes. It differs mainly in having greater slopes and a slightly finer textured and darker gray surface soil. In places, below depths of 3 or 4 feet, the silty clay or clay material is light olive gray.

The tilth and workability are poor. Surface runoff is medium, and internal drainage is very slow. The soil is better suited to irrigation than most of the larger nearly level areas of Billings silty clay, 0 to 2 percent slopes, many of which are affected by salts. Approximately 12 acres of this soil is in peach orchards. All the rest is normally used for cultivated crops, principally corn, pinto beans, and alfalfa. This soil is suited to about the same crops as Billings silty clay, 0 to 2 percent slopes, but it generally produces better yields.

Billings silty clay, moderately deep over Green River soil material, 0 to 2 percent slopes (BE).—This soil occurs on the outer margin of coalescing alluvial fans where 1 to 4½ feet of fine-textured deposits derived from shale overlies Green River soil materials.

Except for a few strips only a few rods wide that adjoin low-lying areas of Green River soils, this soil has not been altered by high overflows from the Colorado River. It is not likely that the main part of the soil will be covered by floodwaters from the Colorado River, as it lies well above the level of normal overflow.

Use and management.—About 85 percent of this soil is cultivated. The principal crops are alfalfa, corn, sugar beets, and pinto beans. A few peach orchards are on this soil near Clifton. Because the underlying strata are coarser, crops produce better on this soil than on most areas of the other Billings silty clay soils. Drainage and saline conditions have to be corrected before the soil will produce well.

Uncultivated acreages of this soil northwest of Grand Junction are saline, imperfectly drained, or both. Their tilth and workability are poor because they have a fine texture and a low content of organic matter.

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Chipeta silty clay loam, 0 to 2 percent slopes (CD).—The scattered areas of this soil normally border areas of Billings silty clay loams. It is a shallow soil developed in place from Mancos shale.

In areas not disturbed, the surface 2½ to 3 inches consists of gray or light-gray silty clay loam that has a slight crust but is otherwise moderately granular. Below 3 inches the material becomes increasingly hard and compact, and it is soon replaced by thin hard plates of dark-gray or gray shale that show little weathering below depths of 12 to 18 inches. Clusters of gypsum crystals are noticeable on the surface, and seams of gypsum occur throughout the unweathered shale. The entire soil profile is calcareous; the lime is well dispersed through the soil material.

Surface drainage is slow but adequate. Internal drainage and subdrainage are very slow; the hard parent shale obstructs the penetration of roots, air, and water.

The salt content is slight from the surface downward. Nevertheless, because water moves laterally over the shale, seepy or waterlogged areas with a high salt concentration frequently develop. In places, water from the upper irrigation canals seeps through crevices and produces waterlogged and saline areas at lower elevations.

Included with this soil are areas of Chipeta clay that together total about 120 acres. These occur ½ mile north, ½ mile south, and 1 mile west of Loma, and about 2½ miles northwest of Fruita. These included finer textured areas do not have so good tilth, workability, and internal drainage, but the difference is not enough to lower yields or to justify separate mapping.

Use and management.—About 25 percent of this soil is cultivated. Pinto beans, small grains, and sugar beets are grown but they produce low average yields. Some of the soil is in irrigated pasture. The grasses do not produce heavy stands, because the soil has low natural fertility. Generally this soil has to be irrigated more often than the deeper soils of groups 1 and 2. Probably those places underlain by hard shale would be benefited by subsoiling. Breaking up the shale should increase the available water-holding capacity, the spread of roots, and the average yields. The growing of sweetclover or other legumes, or the application of stable manure, is recommended to increase the content of organic matter.

Chipeta silty clay loam, 2 to 5 percent slopes (CE).—This soil has developed in place from Mancos shale. Before leveling, it has a somewhat irregular surface and includes a few small sharp rises and dips that have slopes in excess of 5 percent.

The 8- to 10-inch surface soil consists of a gray crumbly mass of thin slaty shale fragments. The subsoil and underlying layers of shale are hard, compact, and very slowly permeable to water and plant roots. The platy shale fragments in this soil become harder and more compact below depths of 12 to 15 inches and are eventually replaced by the shale rock.

This soil is calcareous from the surface downward. It is harder to till than most irrigated soils in the Grand Valley because it contains little or no organic matter and has been only slightly affected by weathering.

Use and management.—Most of this soil is grazed. Only about 25 percent is cultivated. The scant natural cover is largely saltsage and a small admixture of bunchgrass, pricklypear cactus, and other plants of low grazing value. Some farmers in the western part of the area graze sheep on this soil late in fall.

The areas now cultivated are planted mainly to small grains, sugar beets, and irrigated pasture. Because the soil has low fertility, crop yields are poor, or about the same as on Chipeta silty clay loam, 0 to 2 percent.

Erodibility, limited crop suitability, low productivity, and frequent out-of-the-way location, plus the cost of leveling, have discouraged farmers from trying to irrigate this soil. Most of the acreage now cultivated was moderately smooth to start with, so it required little expense for leveling.

Chipeta-Persayo shaly loams, 2 to 5 percent slopes (CA).—In this complex of Chipeta and Persayo shaly loams, the Chipeta soil is dominant. The Chipeta surface soil in uncultivated areas is a very pale-brown, pale-yellow, or light yellowish-brown, slightly hard, calcareous shaly loam or shaly fine sandy loam. This layer contains fragments of shale and sandstone that are about the size of fine gravel and mostly angular. The fragments from the fine sandy shale and silty shale are very hard. At depths of 10 inches or less, the surface soil is replaced by a light-gray to dark-gray calcareous silty clay loam that ranges from weak coarse platy to granular structure. Calcareous shale normally begins at depths of less than 20 inches.

The Persayo soil has a pale-yellow surface layer of calcareous silty clay loam. This layer grades into pale-yellow, hard shale of coarse platy structure.

Both soils of this complex have a surface soil derived from material left after weathering of the sandier layers in the Mancos shale formation. Where soils of this complex are associated with soils of the Fruita series, they have surface soils that contain semirounded and rounded sandstone pebbles. Here, the very shallow surface soils have developed in the remnant of an alluvial mantle.

Included with this complex are areas with slopes of 0 to 2 percent that together cover about 45 acres. Several of these occur 2½ miles north, 3½ miles north, and ½ mile south of Mack. Another area lies 3½ miles northwest of Grand Junction.

Use and management.—About 60 percent of this complex is cultivated. Tillage has mixed the surface layers with the underlying silty clay loams and formed a clay loam surface texture. This complex is not well suited to crops but it produces higher yields of shallow-rooted crops than either Chipeta silty clay loam, 2 to 5 percent slopes, or Persayo-Chipeta silty clay loams, 2 to 5 percent slopes.

Pinto beans, wheat, oats, barley, sugar beets, and sorghums are grown with better success on this complex than are other crops. Management that aids in increasing the content of organic matter is necessary if the present low productivity is to be increased. If barnyard manure is not available, the soils can be improved a great deal by growing sweetclover and turning it under as a green-manure crop. Subsoiling increases the water-holding capacity and permits deeper penetration of plant roots. Unless prices of farm crops are fairly high, it probably would be best to use this complex for irrigated pasture.

Chipeta-Persayo shaly loams, 5 to 10 percent slopes (CB).—The more strongly sloping areas of Chipeta-Persayo shaly loams have the same soil characteristics that were described for Chipeta-Persayo shaly loams, 2 to 5 percent slopes. None of the complex is cultivated; it occurs in association with the complex having 2 to 5 percent slopes. The native cover consists of shadscale, a scattered growth of grasses, and some saltsage, rabbitbrush, and pricklypear cactus. The browse is better than on the associated undulating and sloping areas of Chipeta-Persayo silty clay loams.

Chipeta-Persayo silty clay loams, 5 to 10 percent slopes (Cc).—This complex occupies a considerable acreage, mainly north of the Colorado River in the western half of the area. The soils are derived from material weathered from the thick Mancos shale formation. Except for their silty clay loam texture in the surface layer, the soils are very similar to those of the Chipeta-Persayo shaly loam complex on 5 to 10 percent slopes.

The Persayo soil in this complex contains somewhat more silt and fine sand and is slightly more permeable than the Persayo soil in the complex of Chipeta and Persayo shaly loams, but it is nonetheless highly erodible if cropped. In fact, the platy, compact, impervious shale under both soils of this complex permits so much erosion that only a sharp or choppy surface remains.

Use and management.—Because the surface of this complex is choppy and uneven, leveling for irrigation generally is not practical. Almost all of the complex therefore is used for periodic grazing. Even if the complex were leveled to permit growing of ordinary field crops, the soils would be so low in inherent fertility and so slowly permeable to plant roots that they would produce low yields.

Probably this complex is best used for periodic grazing. Some areas could be irrigated for pasture, but the difficulty of establishing a stand of grasses and the high erodibility of the soils keep the average stockraiser from attempting this. Moreover, a number of the larger areas and several of the smaller ones are on knobs scattered, for the most part, in the lower half of the valley and lie well above the level of the present irrigation system.

Fruita clay loam, 0 to 2 percent slopes (FE).—This fairly extensive soil occurs on old alluvial fans and in relatively low mesalike positions. The alluvial deposits are 4 to 10 feet thick and overlie Mancos shale. The alluvium is derived mainly from fine-grained sandstone but contains small quantities of material from shale and igneous rock.

The 8- to 10-inch surface soil is a slightly hard, calcareous clay loam, light brown to light reddish brown when dry and brown to reddish brown when moist. The upper subsoil is light-brown to light reddish-brown clay loam. At depths of 15 to 22 inches it grades into the lower subsoil, a very pale-brown, very strongly calcareous loam or clay loam that is mottled with soft, white accumulations of lime. Small fragments of sandstone and other rock occur in places.

The very gentle slopes favor irrigated crops. The position of the soil on comparatively narrow mesas facilitates underdrainage, and practically all the soil is free of harmful concentrations of salts. Like other soils of the area, this one has a low organic-matter content. When moist, the soil is friable throughout the profile. Internal drainage is medium. The moderate permeability favors successful growth of deep-rooted crops.

Use and management.—Nearly all of this soil is cultivated. The chief crops are pinto beans, alfalfa, corn, cantaloups, small grains, and truck crops. Yields generally are good. This would be a good soil for fruit growing, but it is subject to occasional low temperatures and frosts.

Ordinarily, alfalfa is left on the soil 4 or 5 years and then followed by corn, a small grain, and pinto beans. No set crop rotation is practiced. For alfalfa or beans, most farmers apply manure when available, or use superphosphate at the rate of 100 to 125 pounds an acre.

Fruita clay loam, 2 to 5 percent slopes (Ff).—This soil has a profile almost identical to that of Fruita clay loam, 0 to 2 percent slopes, but its greater slope and more undulating surface make it less favorable for irrigation. Shale ordinarily occurs at depths of 3½ to 5 feet or more.

Use and management.—Although all of this soil could be cultivated, the areas now cropped represent about 88 percent of the total acreage. The chief crops are alfalfa, beans, small grains, and corn, which yield about the same as on Fruita clay loam, 0 to 2 percent slopes. Soil management is about the same, but more care is necessary to control erosion and to prevent the thinning of the soil mantle over the underlying shale. Farmers should be particularly careful to construct their small irrigation furrows at gradients that will assure the least amount of erosion.

Fruita clay loam, moderately deep, 0 to 2 percent slopes (Fg).—This soil occurs in the more level parts of the area. It is located on mesalike tracts that have been more affected by geologic erosion than the larger mesas on which Fruita clay loam soils occur. Consequently, it has somewhat less depth to shale. The soil occurs as scattered narrow areas in association with Fruita clay loam, 0 to 2 percent slopes.

The surface soil and subsoil, similar to corresponding layers in Fruita clay loam, 0 to 2 percent slopes, rest on Mancos shale at depths ranging from 1½ to 4 feet. The soil is calcareous. In places it is somewhat mottled with white accumulations of lime or contains soft segregations of lime. The soil is moderately permeable but its moderate depth to shale limits the growth of deep-rooted crops and, in places, retards subsoil drainage. A few areas located about a quarter of a mile north of Loma are exceptionally shallow; the shale occurs at depths of 1 to 1½ feet.

Use and management.—About 80 percent of this soil is cultivated. Beans, alfalfa, corn, and small grains, listed in the approximate order of their importance, are the chief crops. The soil would not be well suited to orchard fruits, even if the climate were suitable. The very slow underdrainage and the very slow permeability of the shale beds are unfavorable. This soil is less productive than Fruita clay loam, 0 to 2 percent slopes, especially for deep-rooted crops. Also, more care is necessary to prevent erosion if the productivity of this soil is to be maintained.

Fruita clay loam, moderately deep, 2 to 5 percent slopes (Fh).—Like the deeper Fruita soils, this soil is derived from alluvial material somewhat older than that for the associated Billings and Ravola soils, which occur at lower levels. It is practically the same as Fruita clay loam, 2 to 5 percent slopes, but splotchings and segregations of lime are normally less conspicuous. The soil ranges from about 1½ to 3½ feet in thickness over Mancos shale. The profile is moderately permeable, but the underlying shale beds are very slowly permeable and restrict root development and internal drainage. Runoff is medium. Salinity is negligible. The principal areas occur within 2 miles of Loma and from 1 to 4 miles northeast of Fruita.

Use and management.—About 75 percent of this soil is cultivated. Except for the largest single area, about 260 areas located 1½ miles northwest of Loma, all of the soil could be cultivated by leveling it and extending irrigation ditches. The large area northwest of Loma would require pumping equipment and pipelines to raise the water 15 or 20 feet to the ridge crest. The uncultivated areas of this soil have a relatively thin growth of desert shrubs, chiefly rabbitbrush, hop sage, saltbush, and shadscale.

Crop yields are about the same as on Fruita clay loam, moderately deep, 0 to 2 percent slopes. Productivity is limited by the shallow depth to shale. With good management, current yields can be maintained. Erosion needs to be prevented, so far as possible, if the soil is to maintain its present productivity.

Fruita gravelly clay loam, 2 to 5 percent slopes (FL).—This soil occurs along the border of alluvial fans or mesas north of the Colorado River. It is at a higher elevation and more isolated than the Fruita very fine sandy loam soils. The areas are narrow and irregular, and the soil mantle over Mancos shale is not so thick as that of the Fruita clay loam or Mack clay loam soils situated farther back on the fans and mesas. Geologic erosion since deposition has removed a considerable part of the original clay loam surface soil, so there is more gravel in the present surface soil. The gravel content diminishes rapidly 150 to 300 feet back from the irregular borders of the mesas. This old alluvium is approximately 3½ to 7 feet deep.

The 8- or 10-inch surface soil consists of very pale-brown to light-brown gravelly light clay loam. The upper subsoil, a light-brown calcareous gravelly clay loam to gravelly loam, grades at depths of 14 to 18 inches into very pale-brown similarly textured material. The lower subsoil may be light gray, very pale-brown, or pale yellow. A fairly large number of angular to semirounded pieces of gravel and fragments of sandstone are intermixed with the clay loam material in the subsoil. The parent material is derived mainly from sandstone but to minor extent from shale.

The amount of visible lime is greater than in the Fruita very fine sandy loams. The subsoil is faintly to moderately splotched with lime, and segregations of lime are common throughout the profile. The soil is friable when moist. Internal drainage is medium and underdrainage is good. Despite the moderate to somewhat excessive quantities of gravel in the lower subsoil, the permeability to plant roots is not seriously restricted.

Use and management.—About 60 percent of this soil is cultivated. Most of the uncultivated acreage occurs along the northern rim of the mesa about 4 miles north of Mack. This tract and a few isolated areas northwest of Mack will require pumping equipment if they are irrigated.

Like other soils of the Fruita series, this one is suitable for a wide variety of crops. Alfalfa, beans, corn and small grains are most commonly grown. Crop yields are not consistently so high as on the Fruita clay loam soils. Likewise, the workability of this soil is not so favorable, because of the gravel and the irregular field borders.

Fruita gravelly clay loam, 0 to 2 percent slopes (Fk).—This nearly level soil has approximately the same physical characteristics, crop suitabilities, and crop yields as Fruita gravelly clay loam, 2 to 5 percent slopes. About half of its acreage is above present water diversions and therefore is not irrigated.

Fruita gravelly clay loam, 5 to 10 percent slopes (Fm).—Aside from its greater slope, this soil is much like Fruita gravelly clay loam, 2 to 5 percent slopes. Ordinarily its soil mantle is 3 to 6 feet deep over the shale. The areas occur along slopes bordering the Mack mesa. A few cultivated areas have been damaged by sheet erosion, and in time probably will become similar to Fruita gravelly clay loam, moderately deep, 5 to 10 percent slopes.

Use and management.—Practically all of this soil except a few areas near the northern extremity of Mack mesa could be cultivated. At the time of survey, however, less than 20 percent was cultivated. Most of the acreage probably will remain uncultivated because the soil is erodible, has poor workability, and is difficult to level. Moreover, most of the areas along the northern part of the Mack mesa lie above the irrigation canals and would require pumping equipment if they were irrigated.

Cultivated areas are normally cropped to alfalfa, pinto beans, and corn. Crop yields probably average a little lower than on Fruita gravelly clay loam, 2 to 5 percent. The soil requires frequent irrigation because its gravelly and stony subsoil lowers the water-holding capacity.

Fruita gravelly clay loam, moderately deep, 2 to 5 percent slopes (Fn).—This soil differs from Fruita gravelly clay loam, 2 to 5 percent slopes, in having a mantle 2 to 3½ feet thick instead of 3½ to 7 feet thick. Even though the soils have the same slope, this one has developed from an alluvial mantle that was thinner over shale. Such variation in depth of the soil mantle is normal on the old alluvial fans and lower lying benches or mesas. The soil profile does not contain so much gravel and stony material as Fruita gravelly clay loam, 2 to 5 percent slopes. It also shows less compaction because it has been less influenced by lime.

The 10- or 12-inch surface soil, a very pale-brown to light-brown gravelly clay loam, grades into the very pale-brown to light-brown gravelly loam to clay loam upper subsoil. Lower down in the profile, splotches and some pinkish-white segregations of lime are common. Encrustations of lime occur on the lower sides of the pieces of gravel and the small stones. Ordinarily, gray silty clay loam shale material similar to that under the Chipeta soils lies at depths of 2 to 3½ feet.

Use and management.—About 80 percent of the soil is cultivated. Except for several isolated places northward from Mack and one slightly southeast of Loma, all the soil could be irrigated without pumping equipment.

The soil is used largely for alfalfa, pinto beans, corn, and small grains. It has a relatively wide suitability range for crops, but average yields, especially those of alfalfa, are somewhat lower than on the deeper Fruita gravelly clay loam soils. Good soil management is needed to conserve this soil and maintain its fertility. Growing of alfalfa, clovers, or other hay crops is recommended to promote gradual accumulation of organic matter and to check erosion.

Fruita gravelly clay loam, moderately deep, 5 to 10 percent slopes (Fo).—Except for its greater slope, this soil is similar to Fruita gravelly clay loam, moderately deep, 2 to 5 percent slopes. Raw Mancos shale is 1 to 3 feet from the surface and is getting nearer to the surface as erosion gradually removes the soil material.

Use and management.—About 60 percent of this soil is cultivated. The pieces of sandstone and gravel affect workability, but not to the extent they do on Mesa gravelly clay loam, moderately deep, 5 to 10 percent slopes.

The soil has relatively wide suitability range for crops. It is not good for deep-rooted crops such as alfalfa, corn, and tree fruits, because the underlying shale material makes it very slowly permeable to plant roots. Whenever the soil material overlying the shale becomes too thin for advantageous cropping, the soil probably would be best used as irrigated pasture.

Fruita very fine sandy loam, 0 to 2 percent slopes (Fp).—This inextensive soil occurs on alluvial fans north of the Colorado River. It is derived from alluvial deposits 4 to 8 feet thick that overlie shale. Generally the soil occurs on mesas or alluvial fans that are at lower levels than those occupied by the Fruita clay loam soils. It has a less conspicuous accumulation of lime, which suggests that it developed in alluvial deposits somewhat more recent than those under the Fruita clay loam soils found on the higher mesa positions north of Loma.

The 8- or 10-inch surface soil is a very pale-brown, light-brown, or light reddish-brown calcareous very fine sandy loam. This layer is slightly hard when dry but very friable when moist. The subsoil is slightly lighter brown but is otherwise nearly the same as the surface soil. At depths of 18 to 22 inches it grades into very pale-brown, heavy, very fine sandy loam. This highly calcareous material has a fine subangular structure and is friable when moist. Below a depth of 50 inches the texture is dominantly sandy, but the texture is variable and there is some admixture of sandstone gravel.

This soil has good tilth in spite of a low content of organic matter. It is friable throughout, which assures medium internal drainage and easy penetration of deep-rooted plants.

Included with this soil are a few areas of fine sandy loam that were too small to map separately. These areas, covering about 45 acres in all, are in the southeastern quarter of section 34, range 2 west, township 2 north, or about 2½ miles northeast of Fruita.

Use and management.—The physical properties of this soil make it especially suitable for field, orchard, truck, and garden crops. Nearly 97 percent of the acreage is cultivated. The chief crops, in order of importance, are potatoes, alfalfa, corn, pinto beans, small grains, and tomatoes, onions, and other truck crops. Most of the cultivated acreage is cropped to potatoes, alfalfa, and corn. Small patches are in grapes, berries, and orchard fruits. The soil is not well situated for orchard fruits; it lies where there is danger of frost.

This soil should remain productive indefinitely if irrigation water is carefully used so as to prevent erosion; manure is applied if available; and alfalfa, red clover, or sweetclover is grown in the crop rotation. Some farmers apply commercial fertilizer to special crops to obtain maximum yields.

Fruita very fine sandy loam, 2 to 5 percent slopes (Fr).—This inextensive soil is derived from alluvial deposits 3½ to 8 feet deep over shale. It is located in positions somewhat lower than those occupied by Fruita very fine sandy loam, 0 to 2 percent slopes, but higher than those occupied by the Billings soils.

The surface soil is relatively smooth. Where it is uneven, the undulations are slight. Although the organic-matter content is low, the tilth is good. Surface runoff and internal drainage are medium.

Use and management.—About 87 percent of this soil is cultivated. The smooth, gentle slopes are easily prepared for irrigation. The same crops are grown on this soil as on Fruita very fine sandy loam, 0 to 2 percent slopes, and they produce practically the same yields. If management practices that control erosion and increase the content of organic matter are followed, this soil should remain productive indefinitely.

Fruita very fine sandy loam, moderately deep, 0 to 2 percent slopes (Fs).—Aside from its thinner mantle, 2 to 4 feet of alluvium over the Mancos shale, this soil is little different from Fruita very fine sandy loam, 0 to 2 percent slopes. It has the same easy workability, and only a few small scattered areas are adversely affected by salts. Because it is only moderately deep to shale, it has slower subdrainage and does not permit so deep penetration of roots as similar soils that have more depth.

Use and management.—More than 99 percent of this soil is cultivated. The chief crops are alfalfa, pinto beans, corn, small grains, and truck crops. Yields from most crops compare favorably with those from Fruita very fine sandy loam, 0 to 2 percent slopes. Alfalfa and other deep-rooted crops yield slightly less; the reduction in yield is proportional to the shallowness of the soil mantle over the shale.

Fruita very fine sandy loam, moderately deep, 2 to 5 percent slopes (Ft).—This inextensive soil differs from Fruita very fine sandy loam, moderately deep, 0 to 2 percent slopes, chiefly in having greater slope. It is 1 to 4 feet deep to the underlying Mancos shale.

Use and management.—About 85 percent of this soil is cultivated. Most of the rest could be cultivated, but a few small scattered areas are a few feet higher than the present irrigation canals. Irrigation of these would require readjustment of the present canals or installation of pumping equipment.

The soil has a fairly wide crop adaptability but is not well suited to deep-rooted crops. It is used for the same crops as Fruita very fine sandy loam, moderately deep, 0 to 2 percent slopes. Shallow-rooted crops such as beans, onions, potatoes, and small grains yield about the same as on that soil.

The potentialities of this soil are limited by its moderate depth to shale and its susceptibility to erosion. Good soil management is necessary to control erosion as much as possible.

Fruita very fine sandy loam, moderately deep, 5 to 10 percent slopes (Fu).—Except for its greater slope, this soil is almost the same as Fruita very fine sandy loam, moderately deep, 0 to 2 percent slopes. It is 1 to 3½ feet deep to Mancos shale.

About half of the acreage is cultivated to the same crops as are grown on Fruita very fine sandy loam, moderately deep, 0 to 2 percent slopes. Yields are less, especially for deep-rooted crops such as corn and alfalfa. Careful management of this soil is necessary if erosion is to be controlled. Nevertheless, some erosion will take place if this soil is used for row crops.

Fruita and Ravola loams, 2 to 5 percent slopes (Fc).—This unit consists of areas of Fruita and Ravola soils so small and closely associated that it was not practical to map them separately. It occupies either gently undulating or ridged topography along the several alluvial fans. Most of it is north of Grand Junction.

The soils of this unit have formed in old alluvial deposits derived mainly from the Mesaverde sandstone and Mancos shale formations that lie to the north. The alluvial mantle is 3½ to 7 feet deep and is underlain by Mancos shale. Either this unit is associated with soils of the Fruita series or it occurs in positions between Fruita soils and Ravola soils.

On the gently sloping rounded crests and upper slopes of the narrow ridges, or on the brows of the mesas or the alluvial fans, the soil is similar to the Fruita very fine sandy loams. In contrast, on the lower slopes and in the bottoms of shallow troughs, the soil is similar to the Ravola loams in that it has no distinct profile layers. Instead, there is very pale-brown, calcareous, medium-textured surface soil and a subsoil that shows no definite stratification.

The soils of this unit are calcareous throughout. The soil on the ridge crests is noticeably splotched or spotted with lime, but the lime is not visible in the soil on the lower slopes. Angular and semirounded pieces of sandstone rock and gravel are common in some places but they do not seriously impair cultivation. This unit has a textural range from fine sandy loam to light clay loam.

Use and management.—About 85 percent of this undifferentiated unit is cultivated. Alfalfa, beans, corn, small grains, orchard fruits, grapes, berries, and truck crops can be grown successfully. Grand Junction, about 5 miles to the south, provides a nearby market that encourages farmers to diversify their crops. Practically all of this unit could be cultivated. Only a few small areas contain harmful quantities of salts. Crop yields are probably only slightly lower than on the Fruita very fine sandy loams. Great care to prevent erosion needs to be taken.

Fruita and Ravola loams, moderately deep, 2 to 5 percent slopes (Fd).—This mapping unit occupies the same type of gently undulating or ridged alluvial fans as Fruita and Ravola loams, 2 to 5 percent slopes. In some places it is associated with that mapping unit and in others it is associated with other soils of the Fruita series. Where it occurs at the upper margin of the alluvial fans it lies below the soils of the Persayo and Chipeta series. The friable and moderately permeable alluvial mantle varies from several inches to 3½ feet thick over the Mancos shale. This unit therefore favors better root distribution and has better internal drainage than the complexes of Persayo-Chipeta silty clay loams.

In nature and complexity, the soil profiles of this unit are very similar to those of Fruita and Ravola loams, 2 to 5 percent slopes. In places the soil consists of pale-yellow, calcareous, fine sandy loam, underlain at depths of 20 or 30 inches by thin, platy, shale material. In these locations the soil probably developed in place on platy siltstone or fine sandy shale.

Use and management.—Approximately 45 percent of this unit is cultivated. Barley, oats, wheat, pinto beans, onions, sugar beets, corn, and alfalfa are grown. Alfalfa and other deep-rooted crops are not well suited. Crops yield more than they do on the shallow soils of the Chipeta or Persayo series but less than they do on Fruita and Ravola loams, 2 to 5 percent slopes. As is true for other soils moderately deep over shale, the productivity of this unit can be increased by growing legumes and pasture crops and by applying barnyard manure liberally if it is available. Measures for controlling erosion should be applied if economically possible. Irrigated pasture generally proves fairly successful.

Fruita and Ravola gravelly loams, 5 to 10 percent slopes (FA).—The principal areas of these undifferentiated soils occur on benches or mesas north of Grand Junction. The areas begin at the first ridge north of the city and continue as far as the Government High Line Canal. Small areas occur north of Fruita.

In the virgin state, the soils of this undifferentiated unit are spotted and variable. Ordinarily, the soil at the upper levels—Fruita gravelly loam, 5 to 10 percent slopes—has a very pale-brown loam surface layer and a moderate accumulation of lime in the subsoil. In contrast, the soil at the lower levels—chiefly Ravola gravelly loam, 5 to 10 percent slopes—has a very pale-brown to pale-brown surface layer and only a weak accumulation of lime in the subsoil. In both positions, the lime can be seen in the subsoils. Shale ordinarily occurs at depths of 2½ to 4½ feet, but the alluvial mantle may be 10 to 12 feet thick in some places.

The soils of this unit are friable and permeable enough to permit easy penetration of plant roots down to the underlying shale. Ordinarily, they are very spotty and contain considerable amounts of sandstone gravel and semirounded stones. Gravel for road building has been taken out a mile north of Grand Junction and 2 miles north of Fruita. Most of the stones have been removed from the cultivated fields.

Use and management.—Nearly half of this unit is cultivated. Its suitability for crops is relatively wide. General field crops, truck crops, tree fruits, and irrigated pasture are grown. Because this unit has slopes not particularly favorable for tillage, much of it probably could be used to advantage for berries, grapes, tree fruits, and irrigated pasture. Growing of corn or other row crops on this land encourages erosion. If erosion is not prevented during irrigation, the soil mantle will become thinner, yields will gradually diminish, and eventually the raw shale will appear at the surface. The soils have a low content of organic matter, so farmers need to apply barnyard manure or grow legume crops to maintain or increase the supply.

Fruita and Ravola gravelly loams, 20 to 40 percent slopes (FB).—This undifferentiated unit occurs on the steep escarpments of mesas and alluvial fans. The Fruita gravelly loam soil of the unit occurs on the brow of the mesa escarpments, and the Ravola gravelly loam lies farther down the slope. In both locations the porous soil mantle consists of either gravelly clay loam or of clay, sand, gravel, cobbles, and stones. Except in a few places where there are gravel beds—as for example ¼ mile north of Mack and 2 miles north of Fruita—the mantle varies from 3 to 6 feet deep over the Mancos shale.

The Fruita soil of this unit is light brown and has a moderate accumulation of visible lime in the subsoil. The Ravola soil is pale brown and has practically no visible lime in the subsoil.

Practically all of this unit is now used for grazing. The scant growth of vegetation consists of shadscale, rabbitbrush, pricklypear cactus, scattered bunchgrass, and a few other shrubs that afford a little browse. With considerable leveling, some of the areas now uncultivated could be planted to orchard fruits, berries, and grapes or used for irrigated pasture.

Genola clay loam, 0 to 2 percent slopes (GA).—This inextensive soil occurs southwest of Palisade on Orchard Mesa; it is associated with the Mesa soils. It differs from Genola loam, 2 to 5 percent slopes, in having less slope, a slightly grayer surface soil, and a finer textured and generally shallower alluvial mantle overlying Mesa soil material and cobblestones.

Apparently the soil has developed from comparatively recent alluvium washed down from the small arroyos that extend back to the higher mesas to the south. This alluvium has been more or less modified by local material washed from the more sloping or rolling areas of Mesa soils to the south, where there are few if any exposures of shale.

The 8- or 10-inch surface soil, a light yellowish-brown or very pale-brown heavy loam to clay loam, is underlain by similar subsoil material. In some places the subsoil is relatively loamy but in most places it is a light clay loam. Slight lime segregation occurs in the subsoil in places but is not so distinct as in Mesa clay loams. In some places at depths of about 3½ feet the soil material resembles the subsoil of Mesa clay loam, but in others it is relatively uniform to a depth of about 5 feet.

Surface runoff is slow, but underdrainage is adequate for successful production of all the common irrigated crops. The soil has about the same crop suitability range as Mesa clay loam, 0 to 2 percent slopes. It is easily tilled and irrigated. The moderately permeable profile permits easy penetration of air, water, and plant roots. This allows successful production of all deep-rooted crops climatically suited to the locality. Practically all of the soil is cultivated. Owing to the favorable climate, it is planted chiefly to tree fruits, especially peaches.

Genola clay loam, 2 to 5 percent slopes (GB).—Aside from its greater slope and some scattered cobbles and gravel on the surface, this soil differs very little from Genola clay loam, 0 to 2 percent slopes, the soil with which it is associated. Its good drainage, friability, and moderate permeability give it a wide suitability for crops. Most of the soil is used for growing peaches, a crop that does particularly well under the climate prevailing in the eastern part of this locality.

Genola clay loam, deep over Hinman clay, 0 to 2 percent slopes (Gc).—This soil is derived mainly from old alluvium of igneous rock origin. It occurs on the tops and slopes of higher mesas near to or along the southern border of Orchard Mesa. The alluvium has been deposited in broad nearly level areas; it ranges from 2 to 7 feet deep over Hinman clay.

The soil has a light-gray to very pale-brown color. The upper layers may be relatively heavy loam, fine sandy loam, clay loam, or silt loam. In depth and thickness the layers differ greatly from place to place. Nevertheless, most of the subsoil layers below depths of 10 to 18 inches have medium textures.

The upper part of this soil is friable and moderately permeable and therefore is favorable for deep-rooted crops. The underlying Hinman clay is so slowly permeable that a water table develops above it. In a few of the larger more nearly level areas, open ditches have been dug to provide adequate underdrainage.

Use and management.—All of this soil is under cultivation. Alfalfa normally occupies the largest acreage. Corn, pinto beans, tomatoes, small grains, sugar beets, and other crops follow in about the order named. Only a few acres were in orchard fruits at the time of survey, presumably because of frost hazard and inadequate subdrainage. Average crop yields are very nearly the same as for Mesa clay loam, 0 to 2 percent slopes.

Genola fine sandy loam, deep over gravel, 0 to 2 percent slopes (Gd).—This soil occurs on a river terrace north of the Colorado River near Palisade. It is associated with Genola very fine sandy loam, deep over gravel, 0 to 2 percent slopes. It lies about 50 feet above the river flood plain, which is occupied largely by soils of the Green River series.

The 8- or 10-inch surface layer is a light brownish-gray slightly micaceous fine sandy loam. This material is calcareous and slightly hard but porous. The subsoil, a light yellowish-brown slightly micaceous fine sandy loam, is highly calcareous and has a porous massive structure. At depths of about 2 feet there are light-gray threads and flakes of accumulated lime. Below about 30 inches there is a light-gray highly calcareous fine sandy loam that overlies a thick stratum of igneous cobbles and gravel loosely embedded in sand. This gravelly material rests on Mancos shale.

Use and management.—All of this soil is cropped, mainly to peaches and alfalfa. Although the shale occurs at depths of several feet, this is not enough depth to provide adequate internal drainage for best results from fruit trees.

Genola loam, 2 to 5 percent slopes (Gf).—This inextensive soil is located mainly on the eastern part of Orchard Mesa. It is associated with Mesa soils. The soil is close to drainageways or arroyos, which suggests that much of its material was washed from the higher lying mesas to the southeast. Those mesas consist of Mancos shale mantled with old alluvium derived from igneous rock materials.

The 8- or 10-inch surface soil is pale-yellow to light yellowish-brown heavy loam. In places its texture approaches a silt loam. In most fields, a few cobblestones or pieces of gravel are scattered over the surface layer. In many places, little or no difference in texture or color is noticeable with increase in depth, but in some areas the soil material becomes sandier at depths of 24 to 36 inches and may contain a considerable amount of cobblestones and gravel. Light-gray indistinct specks and spots indicate a very slight concentration of lime or the presence of gypsum. Ordinarily, the lime is well disseminated throughout the profile. At depths of 4 to 5 feet, very pale-brown to pale-yellow very fine sand to loamy fine sand is common. The quantity of cobblestones and gravel increases with depth. The substratum consists largely of acid igneous cobbles, gravel, stones, and sandy material like that underlying the Mesa soils.

Included with this soil is approximately 30 acres of Genola loam having slopes of 5 to 10 percent. This area occurs about 2 miles southeast of Clifton (NE¼ sec. 18, T. 1 S., R. 99 W.).

Use and management.—Because of its good drainage, favorable texture, and moderately permeable subsoil, this soil is easily worked and has a wide range in crop suitability. More than 90 percent of the acreage is in peach orchards. The soil is also well suited to berries, grapes, and melons, tomatoes, potatoes, and other truck crops. It produces yields of corn, alfalfa, and peaches as good as those on the Mesa soils, and where well managed, may outyield the Mesa soils when planted to crops such as grapes, berries, and melons.

Prevention of erosion is probably the most difficult problem in the areas used for orchards. The soil must be irrigated carefully, and a cover crop of red clover, alfalfa, or oats should be growing between the trees during the irrigation season. Many peach growers apply large amounts of stable manure and grow legume crops to maintain organic matter and fertilize the trees. These practices may not give full benefit if the grower fails to apply water carefully. Overirrigation of this soil is common.

Genola very fine sandy loam, deep over gravel, 0 to 2 percent slopes (GG).—Except for its very fine sandy loam surface soil and loam-textured subsoil this soil has about the same characteristics as Genola fine sandy loam, deep over gravel, 0 to 2 percent slopes. It is deeper to the underlying Mancos shale, however, and therefore has better internal drainage and greater suitability for peaches. The soil is used largely for peach orchards.

Green River clay loam, deep over gravel, 0 to 2 percent slopes (GH).—This soil occurs mainly along the Colorado River in the Vinelands southeast of Palisade. The areas slope gently toward the river. The soil has developed chiefly from overflow deposits left by the Colorado River, but in places it is influenced by admixtures of shale and sandstone materials such as those from which the Ravola clay loam soils were formed.

The surface soil is pale-brown to light brownish-gray clay loam. The color is influenced to some extent by admixture of Ravola clay loam soil materials that have been washed from the drainageways to the southeast. The subsoil, in most places, has the pale-brown color and the noticeable mica scales that are characteristic of Green River soils.

Included with this soil are a few areas north of Palisade bridge that developed in gravelly alluvium derived largely from igneous rock.

Use and management.—Underdrainage for this soil is not good but apparently adequate, as practically all the acreage is in peach orchards. Chlorosis of the peach trees occurs more frequently on this soil than on those farther back from the river, which indicates that underdrainage of this soil is not the best. The soil has about the same range of crop suitability as the other Green River soils but produces somewhat lower yields of some crops.

Green River fine sandy loam, deep over gravel, 0 to 2 percent slopes (GK).—Widely separated narrow strips of this soil occur along the channel of the Colorado River in association with Riverwash. The surface layer is light brownish-gray or pale-brown fine sandy loam that extends to depths of 18 to 30 inches in most places. It grades into very pale-brown loamy fine sand or sand.

Because this is an alluvial soil derived from materials deposited by rather rapidly flowing waters, the subsoil normally is more or less incoherent, porous, and stratified, and the different layers below the subsoil are variable from place to place in depth from the surface, thickness, and texture. The soil normally is calcareous below depths of 20 inches and frequently calcareous from the surface downward. The various layers are friable when moist, but the soil has a low water-holding capacity and must be irrigated more often than Green River very fine sandy loam, deep over gravel, 0 to 2 percent slopes.

Use and management.—Because of its porous nature and low position on the bottom land, the greater part of this soil is not cropped. Most of the areas high enough above the river to permit satisfactory irrigation are used for peach orchards and truck crops. The lower areas are used for pasture. About 15 percent of the total acreage is cultivated. This soil gradually should become more satisfactory for crops as its organic-matter content is built up under good management and the natural silting that takes place under continued irrigation.

Green River silty clay loam, deep over gravel, 0 to 2 percent slopes (GL).—This is one of the least extensive of the Green River soils. There are several separate areas of it, the largest of which is less than half a mile northwest of Grand Junction. Normally the soil occurs on slightly lower levels than Green River fine sandy loam, deep over gravel, 0 to 2 percent slopes.

The surface soil, a pale-brown to light brownish-gray silty clay loam, extends to a depth of about 10 or 12 inches and grades into a very pale-brown or light brownish-gray silty clay loam. At depths of 18 to 26 inches small gray specks or faint mottlings are noticeable. Below 24 inches the soil consists of successive alluvial layers that vary in texture, depth, and thickness. The entire profile is friable when moist.

Surface runoff and internal drainage are not adequate. Some areas that are exceptionally low and close to the river are affected by a high water table and by overflow in some years. Seepy places, shown on the map by marsh symbols, are prevalent in some areas. Most of the soil needs ditching or tiling to provide underdrainage, but so far the expense of obtaining proper drainage has been prohibitive. The soil contains considerable quantities of salts. Uncultivated areas, which account for approximately 90 percent of the acreage, are either moderately or severely saline. Soil tests indicate that lime is present in the surface soil and the subsoil.

Included with this soil are a few small strips with a clay loam surface texture. These strips adjoin the higher lying Billings soils and were included with this Green River soil because they were too small to be mapped separately.

Use and management.—If they were properly drained, many areas of this Green River soil could be used for the ordinary field crops, chiefly corn, alfalfa, clover, and sugar beets. Tomatoes, cabbage, onions, and several other truck crops also could be grown successfully. Undrained areas of this soil remain in natural pasture consisting largely of saltgrass.

Green River very fine sandy loam, deep over gravel, 0 to 2 percent slopes (GM).—This soil occurs along the Gunnison and Colorado Rivers, but for the most part at higher levels than the other Green River soils. Its better position makes it less susceptible to flooding or occasional high water tables. It can be cropped successfully, especially after it has been ditched to provide adequate underdrainage.

The surface soil, a pale-brown or light brownish-gray very fine sandy loam, contains numerous small fragments of mica. Below depths of 10 to 12 inches, the very fine sandy loam has a brighter pale-brown or very pale-brown color, and at depths of 24 to 30 inches it grades into similarly textured soil material that shows light-gray and reddish-brown specks or very small spots. Below depths of 3 or 4 feet textural variations are common, but fine sandy loam is dominant.

When moist, this soil is friable. Well-disseminated lime is present from the surface downward, but the organic-matter content is low. Workability and tilth are exceptionally favorable for irrigation and cultivation, but some places need ditches that will lower the water table. A few narrow lower lying seepy places are indicated by small marsh symbols on the map.

Use and management.—Nearly 70 percent of this soil is cultivated. All the climatically suited crops, including truck crops and general field crops, produce high yields. Berries, grapes, and orchard fruits also thrive in the areas east of Clifton, which are better situated climatically.

The highest yields are obtained by making heavy applications of barnyard manure (10 to 15 tons an acre) or by using commercial fertilizer liberally. Farmers often plant this soil to truck crops after plowing out an old stand of alfalfa or alfalfa and clover mixed, or after they have turned under a heavy stand of red clover or some other legume. Some farmers use about 150 pounds of commercial fertilizer to the acre.

Hinman clay, 0 to 1 percent slopes (HA).—This soil occupies nearly level areas mainly on Orchard Mesa. The soil material consists largely of deposits of finer clay particles settled from backwaters during former high flood stages of the Colorado River. The alluvium, 7 to 10 feet or more thick, overlies a cobbly stratum, which, in turn, overlies Mancos shale. The alluvium is derived largely from acid igneous materials.

The 8- or 9-inch surface soil consists of pale-brown or yellowish-brown clay that is low in organic matter. Despite its calcareous nature, this layer is hard and somewhat blocky when dry. Even when systematically cropped, this layer is more cloddy than the corresponding one in Hinman clay loam soils. At a depth of 14 to 16 inches, the very pale-brown to light yellowish-brown clay generally shows a few faint limy specks or a tendency toward splotching, but in some places these specks or splotches are not noticeable within depths of 2 to 2½ feet. The splotching of limy material is less pronounced than in Mesa clay loam soils and generally occurs at greater depths. Below depths of 4 feet, the very pale-brown to yellow clay generally is more friable when moist, even though lime splotching is less conspicuous than in the upper subsoil horizons. Pieces of gravel or cobblestones in the soil profile are rare. At depths below 7 to 10 feet cobblestones are more or less common, but the stratum containing these stones is not so thick as the corresponding one underlying Mesa clay loam soils.

Because this soil is nearly level and fine textured, surface runoff is slow and internal drainage is very slow. A high water table, with accompanying slight to strong salinity, occurs in places. Ditching of the lower lying places has greatly improved drainage. Regardless of ditching, however, this soil tends to puddle or bake after irrigation. This adversely affects tilth and workability.

Use and management.—About 94 percent of this soil is cropped, chiefly to pinto beans, small grains, tame hay, corn, and sugar beets. Less than 1 percent is used for orchard crops, as the soil is not permeable enough to be well suited to orchard fruits. Even alfalfa does not grow so vigorously as on soils of coarser texture. Probably sugar beets do as well or better than other common field crops.

Hinman clay loam, 0 to 2 percent slopes (Hb).—This soil occupies nearly level to very gently sloping areas on Orchard Mesa. It differs from Mesa clay loam, 0 to 2 percent slopes, mainly in having developed on alluvium that is deeper to the layers of gravel and cobblestones and also finer textured. Lime splotching occurs at deeper levels and generally is not so conspicuous. The old alluvium is derived from the same mixture of acid igneous rocks, sandstone, and shale as that for the Mesa soil, but over it there lies a comparatively recent shallow accumulation of wash brought down from higher positions.

In cultivated fields the 8- or 10-inch surface soil consists of a slightly hard pale-brown to light-brown calcareous clay loam. The subsurface layer is nearly the same as the surface soil. The subsoil beginning at depths below 12 to 15 inches, is very pale-brown to reddish-yellow, medium blocky, calcareous, heavy clay loam that is hard when dry. At depths of 2 or 3 feet, the subsoil is friable when moist and exhibits some limy spots, pale streaks, or a very slight tendency toward splotching.

The substratum, to an average depth of 60 inches, is very pale-brown to reddish-yellow or yellow heavy clay loam that contains many limy specks and spots and some light-gray streaks or poorly defined splotches. Below depths of 60 to 90 inches, layers of gravel and cobblestones are common. These may vary from a few feet to 10 to 15 feet in thickness. There are only a few cobblestones and pieces of gravel in the soil profile, however. The limy subsoil is sufficiently permeable for root penetration and adequate underdrainage.

Tilth is moderately good despite the low organic-matter content. Saline areas are few, but one along the highway about 1½ miles southeast of Grand Junction has proved troublesome. Because some areas

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of this soil are nearly level and low, recent alluvial material washed from higher levels has been deposited on them. The low areas occur in assocation with soils of the Genola series.

Included with this soil are a few areas, especially southwest of Palisade, that have been covered with recent alluvial deposits normally less than 1½ feet thick. The areas covered with these deposits of loam, fine sandy loam, or silty clay loam are underlain by the clay loam subsoil typical of the Hinman series. They are included because they cover a small total area and have slight effect on agriculture.

Use and management.—Nearly 95 percent of this soil is cultivated. Of this, less than 17 percent is used for orchard fruits, mainly peaches. About 370 acres of this soil southwest of Palisade is well situated climatically and is almost entirely in peaches. This contrasts with the remaining area (about 2,320 acres), of which only 4.7 percent is in orchard fruits.

Tame hay—alfalfa and red clover—probably ranks first in acreage. Corn, orchard crops, pinto beans, small grains, and truck crops usually follow in the order named. The acreage in field crops fluctuates considerably according to market conditions. Truck crops consist largely of tomatoes for canning, melons, cantaloups, and minor acreages of other vegetables. The soil is well suited to sugar beets, but only a few small areas were in this crop when the survey was in progress.

Growing of clovers and alfalfa, use of methods to control erosion, and practice of other good management should keep this soil productive indefinitely.

Hinman clay loam, 2 to 5 percent slopes (Hc).—This soil differs from Hinman clay loam, 0 to 2 percent slopes, mainly in having greater slopes. It is closely associated with Hinman clay loam, 0 to 2 percent slopes, and Mesa clay loam, 0 to 2 percent slopes, on the high terrace south of the Colorado River. It varies in depth to shale. On the higher positions southeast of Grand Junction the soil probably ranges from 6 to 10 feet deep, instead of the 10 to 15 feet or more for Hinman clay loam, 0 to 2 percent slopes. Little of the soil is affected by salts.

Use and management.—About 80 percent of this soil is cultivated, and of this approximately 17 percent is in orchard fruits. The chief field crops are alfalfa, corn, beans, and small grains. Smaller acreages are used for truck and garden crops. The productivity of this soil differs very little from that of Hinman clay loam, 0 to 2 percent slopes, but good soil management and careful irrigation are necessary to control erosion.

Mack clay loam, 0 to 2 percent slopes (Ma).—Areas of this soil occur on the highest mesa in the Grand Valley. They begin about 1 mile north of Mack and continue in the same direction for approximately 3 miles. The northern extremity of this mesa is about 90 feet above the valley floor, and, according to the United States Geological Survey, has an elevation of 4,796 feet. The general slope of the mesa is southward.

This soil resembles the Mesa soils on Orchard Mesa in most respects except parent material. It has developed on old alluvial sediments derived from fine-grained sandstone and shale, with which semirounded sandstone rocks have been mixed at the levels of the lower subsoil and substratum. The Mesa soils, in contrast, developed on alluvial sediments derived not only from sandstone and shale but also from igneous and mixed igneous rock materials, and, furthermore, are underlain by a thick porous substratum of rounded cobblestones and gravel. This Mack soil differs from Fruita clay loam, 0 to 2 percent slopes, in having a predominantly redder surface soil and a thicker subsoil that contains more lime.

The surface 8 or 10 inches, consisting of a light-brown to light reddish-brown calcareous clay loam, grades into light-brown to light reddish-brown clay loam, which shows some very pale-brown to pinkish-white limy spots at depths of 12 to 16 inches. At depths of 16 to 34 inches the clay loam is splotched and spotted, which indicates a high concentration of lime. The lower subsoil, at depths of 34 to 60 inches, consists of nearly white, friable, very strongly calcareous loam. This layer contains soft, partly disintegrated sandstone fragments, sandstone rocks, and sandstone boulders. The stoniness increases with depth. The underlying Mancos shale lies at depths ranging from 6 to 10 feet.

This soil has a low organic-matter content, but the surface soil is friable when moist, and the subsoil is friable and moderately permeable. This assures good moisture relations, medium internal drainage, and moderate permeability to plant roots. The uncultivated part, about 100 acres, would require pumps to elevate irrigation water. At the highest northern part, water would have to be lifted 80 or 90 feet.

Use and management.—The principal crops are corn, alfalfa, and pinto beans. A few peaches are grown, but tree fruits are not so well protected from frost as on the Redlands, Orchard Mesa, and the Vinelands. The soil is suited to a wide range of crops, or about the same crops as the Mesa and Fruita soils. The various crops yield about the same as on the Fruita soils.

Mayfield shaly clay loam, 2 to 5 percent slopes (MB).—This inextensive soil borders the mountainous land north, northwest, east, and northeast of Palisade. From place to place the soil varies considerably in color, texture, slope, and depth to the underlying shale. The main areas have gentle slopes ranging from 2 to 5 percent.

North and northwest of Palisade the soil largely consists of a 10- or 12-inch surface layer of light yellowish-brown, pale-brown, or light olive-gray shaly clay loam that lies on successive layers of alluvium reaching to depths of 4 to 8 feet. A narrow area of 40 acres that borders the bluffs northwest of Palisade, however, is 2 to 4 feet deep to shale. The underlying alluvial accumulations are similar to the surface layer in color but are extremely variable in thickness and texture. Layers of loam, fine sandy loam, and loamy sand are represented, as well as thin accumulations of silt or silty clay loam. The layers are moderately shaly to very shaly and contain angular fragments of sandstone and shale. Along the upper slopes bordering the Government High Line Canal, the soil material contains moderate to fairly abundant quantities of flat to angular sandstone fragments. These fragments diminish in size and quantity toward the lower boundary of the soil area. The larger stones have been removed.

East and northeast of Palisade this soil commonly has a fine sandy loam texture and does not contain so many small, flat, shalelike fragments of sandstone. Variation in the various alluvial layers is apparent, but not so pronounced as in the areas north of Palisade. Several peach orchards bordering the bluffs east of Palisade contain sandstone boulders 5 to 15 feet in diameter. Most of the smaller rocks and boulders have been removed from these orchards. About 30 acres northeast of Palisade has slopes of 5 to 10 percent.

Considering this soil as a whole, it is moderately permeable to plant roots, air, and moisture but low in water-holding capacity. The successive soil layers are friable and moderately calcareous.

Use and management.—Practically all of this soil lying below the irrigation canals is cultivated. About 99 percent of it is in peaches. In a few places where shale is within 4 or 5 feet of the surface, the trees are not uniform in size, and some have had to be replaced. Although yields generally compare favorably with those from the Ravola soils, the average yield is lower. Considering the favorable climate, peach growing is one of the best uses for this soil.

Mesa clay loam, 0 to 2 percent slopes (Mc).—This soil occupies a former flood plain or high terrace immediately south of the Colorado River. It is largely derived from acid igneous soil-forming materials the streams have brought down from a higher watershed.

In cultivated fields the 8- or 10-inch surface soil consists of very pale-brown, pale-brown, or light-brown calcareous clay loam. It merges with a reddish-yellow to light reddish-brown calcareous clay loam showing white or pinkish-white segregations of lime. Below depths of 12 to 14 inches, the reddish-yellow to light-brown clay loam exhibits numerous white streaks or splotches that have a comparatively vertical or jagged outline along road cuts. A few scattered cobbles and pieces of gravel are common. Beginning at depths of 3 or 4 feet or in places below 6 or 7 feet, about 40 to 50 percent of the soil mass is made up of pieces of gravel, cobbles, and stones derived largely from granite and basalt but to some extent from lava and sandstone. Most of the sandstone is crumbly or partly disintegrated. Mancos shale underlies the gravel-and-cobble substratum in most places at depths below 8 to 12 feet. In some places, however, the shale may be as near the surface as 4 or 5 feet, and in others as far down as 20 feet.

The high lime content of this soil doubtless offers some resistance to penetration of water and plant roots but the entire profile is friable when moist. Judging from many orchards and alfalfa fields, its permeability to deep-rooted crops is sufficient to permit healthy and vigorous plant growth. Underdrainage is adequate; harmful concentrations of salt are negligible.

Because a considerable part of this soil consists of material washed from higher places, the depth to the noticeably lime-splotched zone is variable. Generally, however, the depth ranges from 1½ to 3 feet. Leveling of the soil also accounts for part of the variation in depth to lime splotching. On the whole, the variations in depth to lime have little, if any, agricultural significance.

Use and management.—About 97 percent of this soil is cultivated. It is highly productive and much of it is well-suited to fruit growing. At least 40 percent of the acreage is in orchard fruits, mainly peaches. About 20 percent is in alfalfa, 15 percent in corn, 10 percent in beans, and 8 percent in truck crops, including cantaloups, melons, and tomatoes. The rest is used for small grains and other field crops.

These percentages show the relative importance of the various kinds of crops, though the area used for field crops fluctuates from year to year.

Many of the orchards have been planted in the past 15 years. If well cared for and not severely injured by low temperatures, they should give good yields until the trees reach 30 or 40 years of age. A few orchards more than 50 years old are still producing good yields. The areas having the best climatic location for orchard crops begin south and southeast of Palisade and extend 5 or 6 miles southwestward. Under practices designed to increase the organic-matter content and to control erosion, this soil should remain productive indefinitely.

Mesa clay loam, 2 to 5 percent slopes (Md).—Except for its greater slope and the appearance of lime splotches nearer the surface, this soil is very similar to Mesa clay loam, 0 to 2 percent slopes. The lime splotches normally are 10 or 15 inches from the surface. Small quantities of gravel and cobblestones strewn over the surface in most places indicate that there is a slight continuous removal of the surface soil by sheet erosion. Tilth and workability are good. In most places the soil is underlain by shale at depths of 6 to 20 feet.

Use and management.—The area of this soil occurring below the irrigation canals is about 87 percent under cultivation. It is a productive soil, and practically all field crops of the area can be grown successfully. About 32 percent of the acreage is in orchard fruits, mainly peaches but also some sweet cherries and pears. The fairly large percentage in orchard fruits is accounted for mainly by several rather large areas south and southwest of Palisade that are within a climatic zone well suited to tree fruits. Not including these specialized fruit areas, the proportion of the soil in various crops is about the same as for Mesa clay loam, 0 to 2 percent slopes. Yields are also about the same, but in a few small areas shale occurs at depths of 3½ to 4 feet and yields from deep-rooted crops such as orchard fruits and alfalfa may be slightly lower over a period of years.

If erosion is controlled and the soil is planted to legumes to build up its supply of organic matter, it should be productive indefinitely. In some fields the content of organic matter already has decreased appreciably from that in the virgin soil.

A few small areas (about 12 acres) of this soil located just below Orchard Mesa irrigation canal No. 2 are not suited to deep-rooted field crops or tree fruits. In these areas, Mancos shale is at depths between 2 and 3½ feet and the soil does not have a porous gravelly layer over this shale. Beans, wheat, barley, and oats probably are as suited to these areas as any other crops that could be selected.

Mesa gravelly clay loam, 2 to 5 percent slopes (Me).—This soil is derived from old alluvium deposited on Orchard Mesa. The alluvium consists mainly of materials weathered from acid igneous and mixed igneous rocks, largely granite and basalt, but includes smaller quantities of material from sandstone and shale. The alluvial mantle, for the most part, ranges from 5 to 8 feet deep but it is deeper in places.

The 8- or 10-inch surface soil in cultivated fields is light brown when dry and brown when moist; its organic-matter content is very low. The subsurface layer is light-brown or pale-brown clay loam containing a considerable amount of cobblestones, rounded pieces of gravel, and chert fragments. Beginning at depths below 12 to 14 inches the subsoil is very pale brown to reddish yellow and shows a considerable amount of white lime splotching. Lime encrustations appear on the lower sides of the pieces of gravel, cobblestones, and stones that make up about 50 percent of the soil mass. In some places the cobbly material is more abundant than the gravelly, but in others smaller cobblestones and gravel are more abundant. In a few places the subsoil material is weakly cemented into a semihardpan. Generally, however, it is permeable enough to permit the downward growth of deep-rooted plants.

Surface runoff is medium, and underdrainage is adequate. The excess of gravel, cobblestones, and stones makes workability less favorable than on Mesa clay loam soils. Saline areas occur only in a very few places bordering shale soils.

Included with this soil are areas totaling about 30 acres that have slopes of less than 2 percent but are not appreciably different in tilth, workability, and crop yields. These areas occur 1 to 1½ miles southeast of Grand Junction, in the northeast quarter of section 25, and the northwest quarter of section 30, range 1 west, township 1, south.

Use and management.—Nearly 77 percent of Mesa gravelly clay loam, 2 to 5 percent slopes, is cultivated. Of the cultivated area, 14 percent is used for orchard fruits, mostly peaches but also cherries, apricots, pears, and plums. Alfalfa far surpasses fruit as the principal crop. Lesser crops, in order of their importance, are corn, pinto beans, small grains, and truck crops.

Crop yields on this soil do not average so high as on Mesa clay loam, 2 to 5 percent slopes, probably because of the excess gravel, cobbles, and stones. Orchard fruits and alfalfa produce fairly well. As is true for other soils in the eastern part of Orchard Mesa, this soil is widely used for peach orchards because it is in an area where the climate is favorable.

Mesa gravelly clay loam, 5 to 10 percent slopes (MF).—This soil occurs principally on terrace slopes or escarpments. Several areas of it are on the outliers, or edges, of three benches that front the broader part of the terrace southeast of Grand Junction. Scattered areas begin about 4 miles west of Grand Junction and extend nearly to the eastern limit of Orchard Mesa. A small belt also occurs north of the Colorado River, 1½ miles southwest of Palisade.

Except for its greater slope, this soil closely resembles Mesa gravelly clay loam, 2 to 5 percent slopes. Its workability is somewhat less favorable, however, as it is more gravelly and cobbly. Harmful concentrations of salts are negligible.

Use and management.—About 62 percent of this soil is cultivated. Most of the cultivated acreage is used for orchard fruits, chiefly peaches. The trees, particularly the older ones, are not quite so vigorous or so uniform in size as those on Mesa clay loam soils. The fruit is more highly colored, and this somewhat offsets the lower average yield. Probably, however, the trees may not live so long on this soil as on the deeper Mesa clay loam soils.

Alfalfa, corn, and beans are the chief field crops on areas not climatically well suited to orchard fruits. Smaller acreages are in tomatoes, melons, grapes, and other truck crops.

The soil is not so productive as the Mesa clay loams, because the excess gravel, cobbles, and stones in the surface soil and throughout the profile reduce the moisture-holding capacity. Painstaking application of irrigation water, with special care in regulating rate of flow, is required to prevent unnecessary loss of surface soil. Otherwise, workability becomes increasingly difficult as the finer material washes away and leaves the coarse material behind. Some farmers already have spent considerable time and money in removing cobbles and stones brought up in plowing.

Mesa gravelly clay loam, moderately deep, 2 to 5 percent slopes (MG).—Except for moderate depth to shale, this inextensive soil is essentially the same as Mesa gravelly clay loam, 2 to 5 percent slopes. Its tilth and workability are similar to but less favorable than for the Mesa clay loam soils. The soil is adequate for shallow-rooted plants, but its moderate depth to shale (2 to 4 feet) does not provide the root zone needed for best results in growing alfalfa and orchard fruits. Both crops yield less on this soil, and orchard trees do not live so long. The soil is low in organic matter. About 30 percent of it is under cultivation, and of this approximately 12 percent is used for orchard fruits.

Mesa gravelly clay loam, moderately deep, 5 to 10 percent slopes (MH).—This soil is associated with other Mesa soils but generally lies at higher level where the original alluvial deposits were thinner. Aside from having a thinner mantle overlying Mancos shale, the soil differs little from Mesa gravelly clay loam, 5 to 10 percent slopes. The principal areas are scattered over Orchard Mesa from southwest of Palisade to southwest of Grand Junction.

The soil is gravelly and cobbly; hence, its water-holding capacity is low. Some places, however, are seepy because water from Orchard Mesa Canal No. 2 passes through and over the underlying shale. Erosion continues to remove the soil mantle; the soil is becoming thinner and more cobbly all the time.

Use and management.—Only about 15 percent of the soil area below Orchard Mesa Canal No. 2 is cultivated. Several areas are in the climatic zone south and southwest of Palisade that favors fruit growing. About 10 percent of the soil in this location is in orchards. The underlying shale material restricts growth of deep-rooted plants, so this soil is not well suited to orchard fruits or alfalfa. Other crops respond fairly well, though not so well as on the deeper Mesa gravelly clay loams. Peach trees are apparently healthy when young, but they probably do not live so long as those on the deeper Mesa soils. If it is economically feasible, this soil is best used for irrigated pasture most of the time.

Naples clay loam, 0 to 2 percent slopes (NA).—This soil occurs in association with Naples fine sandy loam, 0 to 2 percent slopes, in low positions on the alluvial fan. The alluvial parent material, derived from sandstone and shale and 6 feet or more deep in most places, has been deposited on soils of the river flood plain.

The surface 10 or 12 inches consists of light-brown, slightly hard, light clay loam. The subsoil consists of layers of light-brown loam, fine sandy loam, and very pale-brown loamy fine sand. The thickness and arrangement of these subsoil layers vary from place to place. The soil is calcareous, though no lime is visible in the profile.

At the outer margin of the alluvial fan, there are areas that have a heavy clay loam surface soil and medium-textured subsoil layers, which together form a profile 2½ to 4 feet deep over Navajo silty clay. Internal drainage in these areas is very slow through the clay substratum. An area of about 10 acres on this more shallow deposit is strongly saline.

Naples clay loam, 0 to 2 percent slopes, is suitable for field and truck crops. It produces high yields.

Naples fine sandy loam, 0 to 2 percent slopes (NB).—This soil occurs on an alluvial fan built up by materials washed down from North Thoroughfare Canyon and deposited upon the flood plain of the Colorado River. This alluvium consists primarily of sandstone material that has been washed from the broken escarpment of the Uncompahgre Plateau.

The surface soil is light-brown, pale-brown, or very pale-brown, soft, calcareous fine sandy loam. The calcareous subsoil layers are of the same color but range from loam to loamy fine sand in texture. The layers below 3 feet are dominantly loamy fine sand. The entire profile is well drained.

Use and management.—This soil is used for alfalfa, beans, corn, and truck crops. Crop yields are high—about the same as on Thoroughfare fine sandy loam, 0 to 2 percent slopes—but can be increased by applying manure, growing green-manure crops, and using legumes in the crop rotation.

Navajo silty clay, 0 to 2 percent slopes (NC).—This soil occupies only a few areas. It has developed from alluvium derived largely from shale, sandstone, and granite materials weathered from the rock formations exposed by the Uncompahgre uplift.

Southwest of Grand Junction, the 10-inch surface soil consists of pale-brown to light reddish-brown silty clay or clay. It is underlain by similar soil material that continues to depths of 3 to nearly 6 feet. This, in turn, is underlain by permeable medium to moderately coarse material deposited by former overflow waters of the Colorado and Gunnison Rivers.

In areas of this soil near the irrigation canal, the surface soil and subsoil, extending to depths of 18 to 24 inches, are gray or grayish-brown heavy silty clay or clay. This material grades into light reddish-brown clay, which overlies medium to moderately coarse Green River soil material at depths varying from about 3 to 6 feet. These areas near the canal are low and have a high water table that makes it difficult to establish adequate subdrainage.

Included with this soil is a narrow strip too small to map separately that has a clay loam texture. This strip borders the lower part of the alluvial fan occupied by Naples fine sandy loam, 0 to 2 percent slopes. Also included is an area northwest of Loma that consists of light reddish-brown silty clay to depths of about 3 or 4 feet. Below this lies Billings silty clay or, in a few places, shale.

Use and management.—All of this soil is cultivated except about 25 acres with imperfect drainage that occurs in the larger area southwest of Grand Junction. The soil is slightly to strongly saline and is not easily worked because of its fine texture. Alfalfa, sugar beets, and small grains are among the crops usually grown. The yields are practically the same as those produced on Billings silty clay, 0 to 2 percent slopes. The inadequately drained parts are used for pasture that consists chiefly of saltgrass.

Persayo-Chipeta silty clay loams, 0 to 2 percent slopes (PA).—At least 80 percent of this complex consists of Persayo silty clay loam, 0 to 2 percent slopes. The other member of the complex, Chipeta silty clay loam, 0 to 2 percent slopes, occurs as small irregular bodies of light-gray to gray silty clay loam too small to separate on the map. These soils are similar in most respects, but they differ slightly in a few. Aside from their color difference—the Persayo soil is a pale yellow whereas the Chipeta is gray—the Persayo has a somewhat higher silt content, a slightly deeper surface soil, and a somewhat less compact subsoil.

The 8- to 10-inch surface soil of Persayo silty clay, 0 to 2 percent slopes, is a pale-yellow silty clay loam that contains a few scattered, pale yellow, easily crumbled, shale fragments. Below this depth the shale fragments generally are increasingly more abundant, but in places there are not many to depths of 15 to 18 inches. This material is hard and compact when it is dry. When wet, however, it is less plastic than in the Chipeta soil and therefore is slightly more permeable to plant roots. The soil is calcareous from the surface downward, although the lime is not visible. A small percentage of salts is common, but the cultivated acreage adversely affected is small. A slight scattering of pebblelike aggregates of gypsum over the surface is common. Seams of gypsum occur in the underlying shale strata. Both soils have developed in place from materials weathered from Mancos shale.

The organic-matter content in both soils is very low. Tilth and workability are not very favorable, although they are better in the Persayo than in the Chipeta soil. Internal drainage and permeability to plant roots are slow and partly account for the low productivity of these soils.

Use and management.—Nearly 25 percent of the complex is cultivated. Practically all of it could be cultivated, but few farmers are willing to attempt using it for irrigated crops because it occurs in small isolated areas that would require considerable expense for leveling, and would produce low yields. Yields of the principal crops on the complex, however, are usually slightly higher than on the Chipeta silty clay loam soils. Uncultivated areas support a comparatively thin cover consisting mainly of saltsage, plus some shadscale, pricklypear cactus, rabbitbrush, and greasewood. They are used late in fall for grazing sheep.

Erosion control is necessary to maintain even the current low yields. Sweetclover and other legumes are beneficial in building up these soils, but heavy applications of manure usually give the best results. A considerable acreage is used as irrigated pasture, probably its best use, especially on general farms having ample acreage of soils that are deeper and more productive for general field crops. In many localities, shale soils are greatly benefited by subsoiling every few years, but this practice is not general in this locality.

Persayo-Chipeta silty clay loams, 2 to 5 percent slopes (PB).—In most features except slope, the soils of this complex are essentially like those of the complex of Persayo-Chipeta clay loams, 0 to 2 percent slopes. At least 80 percent of the complex is made up of the Persayo soil, and the rest of the Chipeta. The Chipeta soil occurs either on comparatively sharp rises or undulations having slopes of more than 5 percent that extend 4 to 6 feet above the prevailing level or in small irregularly shaped bodies on relatively smooth topography. Wherever the areas of Chipeta soil occur, they are too small and too intricately associated with the Persayo soil to be mapped separately.

Use and management.—About 25 percent of this complex is cultivated, but practically all of it could be. The Chipeta soil is not difficult to level, but the expense of leveling and the isolated location of the areas have not favored development for irrigation and cropping. The kinds of crops grown, the management practiced, and the yields produced are approximately the same as for Persayo-Chipeta silty clay loams, 0 to 2 percent slopes.

Ravola clay loam, 0 to 2 percent slopes (RA).—This soil, the second most extensive in the area, has developed in material that consists largely of reworked Mancos shale but includes an appreciable amount of sandy alluvium from the higher Mesaverde formation. The surface of these deposits is relatively level, but the depth of the deposits ranges from 5 to 30 feet. The soil is associated with the Billings silty clay loams and the Ravola fine sandy loams. The most important areas are east, northeast, and southeast of Fruita, north and northwest of Palisade, and north and northwest of Clifton.

The soil is much like the Billings silty clay loams but more porous because it contains more fine sand, especially in the subsoil. Ordinarily, the 10- or 12-inch surface layer consists of light brownish-gray to very pale-brown light clay loam. The underlying layers vary from place to place in thickness and texture and become more sandy below depths of 4 to 5 feet. The range in the subsoil is from fine sandy loam to clay loam.

Small fragments of shale and sandstone are common from the surface downward and are especially noticeable in areas nearest the source of the soil material. The entire profile is calcareous and friable, so internal drainage is medium and development of plant roots is not restricted. The surface is smooth. Most areas are at slightly higher levels than the associated areas of Billings silty clay loams and therefore have better drainage and a lower content of salts. The soil, however, is slightly saline under native cover, and in places it has strongly saline spots and a high water table.

Use and management.—About 95 percent of this soil is cultivated. The chief crops are alfalfa, corn, pinto beans, small grains, and, where climate is favorable, orchard fruits. Practically all the acreage used for tree fruits is near Clifton and Palisade. The acreage used for field crops varies from year to year, but by rough estimate about 30 percent is cropped to corn, 25 percent to alfalfa, 15 percent to pinto beans, 13 percent to orchard fruits, 10 percent to small grains, and the rest to sugar beets, tame hay, tomatoes, and various vegetable crops.

In general, the tilth and workability of this soil are favorable. The content of organic matter is generally less than 1 percent, but many farmers are improving the supply by growing more alfalfa and by using other improved management.

Ravola clay loam, 2 to 5 percent slopes (RB).—This soil differs from Ravola clay loam, 0 to 2 percent slopes, mainly in having greater slopes. Although the combined areas total only seven-tenths of a square mile, this soil is important because the largest single area—

approximately 300 acres—is located southeast of Palisade in the Vinelands and is used for peach growing. The remaining areas, widely scattered over the valley, total about 150 acres and are of minor importance.

The large area occupies a position intermediate between the Green River soils and the higher Mesa soils. Its underlying gravel and stone strata consist not only of sandstone but also of granite, schist, basalt, and lava. Much of the lava was deposited by drainage from the southeast. This large area was included with the soil unit largely because its color was similar to that of the other soil areas. Not many years ago subdrainage became inadequate for existing tree fruits and it was not until a number of tile drains were laid, as deep as 7 to 8 feet in places, that subdrainage was corrected in parts of this particular area.

Use and management.—All of the large soil area is in peaches. On it peach yields average as high as in any section of the valley, primarily because the danger of frost damage is negligible. Some of the orchards are now more than 50 years old but have produced steadily and still yield more than 400 bushels an acre according to reports from local growers. About half of the small scattered areas are cultivated. They are used largely for field crops because climatic conditions are not so favorable for peach growing. In building up the organic matter content, the growing of legumes, application of manure in large amounts, and use of commercial fertilizer generally are practiced.

Ravola very fine sandy loam, 0 to 2 percent slopes (RF).—This extensive and important soil occurs either along washes or arroyas extending from the north or on broad coalescing alluvial fans. The alluvial material from which the soil has developed was derived from sandstone and shale and ranges from 4 to 20 feet deep. The principal areas of the soil are north and northwest of Grand Junction and north, northwest, and southwest of Fruita.

This soil is much like Ravola fine sandy loam, 0 to 2 percent slopes, but is generally more uniformly level. The texture is prevailingly very fine sandy loam, but the percentage of silt is noticeably higher in some places. A few small areas that have a loam texture are included.

The 10- or 12-inch surface layer consists of light brownish-gray to very pale-brown very fine sandy loam. In some places the underlying thin depositional layers vary only slightly in color or texture. In other places, especially near drainage courses, the layers are more variable and may grade to loam, silt loam, or fine sandy loam. Nevertheless, layers of very fine sandy loam are more numerous. Below depths of 4 to 5 feet, the texture is sandier, and at depths of 8 to 12 feet strata of loamy fine sand, gravel, and scattered sandstone rock are common.

Disseminated lime occurs from the surface downward. Owing to the friable consistence of the successive layers, the tilth, internal drainage, available supply of moisture for plants, permeability to plant roots, and other physical properties are favorable and assure a wide suitability range for crops. The organic-matter content, however, is low. The soil is slightly saline under native cover and has a few strongly saline spots. Occasionally the water table is high.

Use and management.—More than 99 percent of this soil is cultivated. The chief crops are alfalfa, corn, pinto beans, small grains, and truck crops. Corn is planted on an estimated 35 percent of the area, alfalfa on 20 percent, beans on 20 percent, small grains on 10 percent, and potatoes, tomatoes, sugar beets, and irrigated pasture on the rest. The percentage of land planted to the various crops fluctuates considerably. Yields have been increased by using improved soil management, such as application of barnyard manure; the growing of clovers and alfalfa frequently after corn, potatoes, sugar beets, and other crops; and the more liberal use of treble superphosphate and mixed commercial fertilizer.

Ravola very fine sandy loam, 2 to 5 percent slopes (RG).—This soil, of minor importance because of its limited extent, occurs chiefly in the northwestern part of the county. Except for greater slope, it is very similar to Ravola very fine sandy loam, 0 to 2 percent slopes. Most of it is not cultivated. If it were leveled and cultivated, it would need about the same management as Ravola very fine sandy loam, 0 to 2 percent slopes, and should produce approximately the same yields.

Ravola fine sandy loam, 0 to 2 percent slopes (Rc).—This soil, fairly important agriculturally, occurs mostly east, northeast, and north of Fruita. The soil-forming material is derived largely from sandstone but has some admixture of silt or finer sediments of shale origin.

The 10- or 12-inch surface layer consists of light brownish-gray, pale-brown, or very pale-brown fine sandy loam. The underlying depositional layers generally range from 1 to 3 inches thick; they may have a fine sandy loam, fine sandy clay, very fine sandy loam, or loam texture. The gradation in texture from one layer to another is almost impreceptible in some places, but fairly distinct in others. In most places the material below 4 feet is more sandy and slightly lighter grayish brown than that above.

The soil is calcareous from the surface downward, but the lime is not visible. Because the successive layers are friable, deep-rooted crops are well suited. Internal drainage is medium to rapid, and moisture relations are favorable. Though the organic-matter content is low, other physical properties are favorable and allow good tilth, good drainage, and moderate permeability for deep-rooted crops. The soil is slightly saline under native cover and strongly saline in a few spots. It is subject to an occasional high water table.

Use and management.—About 98 percent of this soil is cultivated. The most important field crops are potatoes, corn, alfalfa, and pinto beans. Comparatively smaller acreages are in sugar beets, small grains, and tomatoes, cucumbers, and other truck crops. An estimated 30 percent of the cultivated acreage is cropped to corn, 25 percent to alfalfa, 20 percent to potatoes, 15 percent to pinto beans, 5 percent to small grains, and the rest to truck crops, largely tomatoes.

The trend in recent years has been toward larger acreages of potatoes, tomatoes, and pinto beans. In earlier days, a considerable acreage was used for tree fruits, mainly pears. Severe blight, excessive cost of growing and marketing the fruit, and unsuitable climate have caused gradual conversion to field crops.

With proper management, this soil should remain productive indefinitely. Definite rotations normally are not followed. Frequently, alfalfa is grown 4 or 5 years, corn 1 or 2 years, then oats or wheat, and finally pinto beans. Manure, if available, generally is applied to the corn crop. The most common fertilizer is treble superphosphate, applied at the rate of 100 to 150 pounds an acre for field crops and truck crops. Some potato growers use commercial fertilizer at the rate of about 150 pounds an acre.

Ravola fine sandy loam, 2 to 5 percent slopes (RD).—Except for scattered areas totaling about 25 acres, most of this soil is in the Vinelands section east of Palisade. The soil-forming material is mostly local alluvium derived from shale and sandstone that has been brought down the drainage courses from the southeast. In areas east of Palisade a few scattered, rounded igneous gravel, cobbles, stones, and boulders in the lower subsoil indicate that there has been some admixture of sediments deposited in the past by the Colorado River.

The 10- or 12-inch surface layer is light brownish-gray or very pale-brown loam. The subsoil layers are similarly colored and dominantly of a fine sandy loam texture. Nevertheless, in places fine sandy loam, loam, and clay loam textures are represented in the subsoil. The soil is calcareous throughout. Although the organic-matter content is low, other physical properties insure good tilth, drainage, and permeability to deep-rooted crops. The soil is slightly saline under native cover and includes some strongly saline spots. Occasionally the water table is high.

Use and management.—Practically all of this soil is cultivated; deep-rooted crops are well suited. The two areas east of Palisade are in peach orchards and produce yields comparing favorably with those on Ravola clay loam soils in the same area. These two areas are small but valuable because they are located where the climate is ideal for tree fruits. The productivity of this soil, especially for orchard fruits, is practically the same as that of Mesa clay loam soils.

Ravola loam, 0 to 2 percent slopes (RE).—This soil is not extensive, but it is important agriculturally. It occupies relatively broad alluvial fans and flood plains along streams. It is at a slightly higher elevation than the bordering areas of Billings silty clay loam soils. It has developed in an alluvial deposit derived largely from Mancos shale and to lesser extent from the fine-grained sandstone of the Mesaverde formation. The soil is very similar to Ravola very fine sandy loam, 0 to 2 percent slopes, but it contains less very fine sand and a definitely larger amount of silt. In a number of small areas the texture approaches, or may be, a silt loam. From the Ravola clay loam soils, this soil differs in being coarser textured and not so gritty.

In the larger areas near Clifton, the 10- or 12-inch surface layer consists of light brownish-gray to pale-yellow, calcareous, heavy loam. The subsoil, similar to the surface soil in color, invariably contains a higher percentage of silt than the subsoil of the Ravola very fine sandy loams. Differences among the thin alluvial layers in the subsoil are almost imperceptible to depths of 3 to 4 feet. At depths greater than this, however, 1- to 3-inch layers of either silt or very fine sandy loam commonly occur among the more numerous layers of loam. The thin layers of silt or very fine sandy loam are most noticeable in the larger and broader areas west of Palisade.

Northeast of Fruita, northwest of Mack, and southeast and northeast of Loma, this soil consists of pale-yellow to light-gray surface layers underlain by pale-yellow to light-gray subsoil layers of heavy loam. The texture is fairly uniform from the surface down to depths of 4 to 6 feet, or less variable than in the larger areas described in the preceding paragraph.

All areas of this soil have a friable and moderately permeable profile suitable for production of shallow- and deep-rooted crops. Surface runoff is slow, and internal drainage is medium. Well disseminated lime is present throughout the profile. A few saline areas have developed because of local inadequate drainage and excessive use of irrigation water. The tilth is good in spite of the generally low organic-matter content.

Use and management.—Nearly 95 percent of this soil is cultivated. The chief crops are corn, beans, alfalfa, small grains, and tree fruits. Minor acreages are planted to potatoes, sugar beets, tomatoes, and vegetables. Somewhat more of this soil is in alfalfa and orchard fruits, but the proportionate acreage in the various crops is much the same as for Ravola very fine sandy loam, 0 to 2 percent slopes. Less than 3 percent of the acreage is in tree fruits. Larger areas near Clifton are used to some extent for tree fruits because the climate in that area is better for orchard crops than areas of this soil situated elsewhere.

The management for this soil is practically the same as for Ravola fine and very fine sandy loams. The organic-matter content can be improved by applying manure liberally and by planting legumes such as red clover, sweetclover, and alfalfa. Potatoes, cantaloups, and general truck crops are not so well suited to this soil as corn, clover, alfalfa, pinto beans, and tomatoes.

Redlands loam, 2 to 5 percent slopes (Rk).—This soil is associated with the Thoroughfare fine sandy loams in the Redlands westward from Grand Junction. It has moderately distinct profile layers, in contrast to the very indistinct layers in soils of the Thoroughfare series. It has a more pronounced reddish color than the Mesa soils. The soil material is alluvium derived mainly from sandstone but to lesser extent from shale and granite.

The 8- to 10-inch surface soil consists of light-brown to light reddish brown loam that is slightly hard when dry but very friable when moist. The upper subsoil, a light-brown to light reddish-brown somewhat finer textured loam, contains some white and pink limy spots and some white lime splotches. At depths of 20 to 24 inches, the light-brown to pink subsoil generally contains enough clay to be classed as either a loam or a light clay loam. At this depth, the subsoil is very highly calcareous; the most calcareous material is indicated by pinkish-white or white segregations of lime. Below a depth of 4 feet, the soil has a less reddish hue, becomes more sandy, and shows less visible evidence of lime accumulation.

Small granitic aggregates containing a high proportion of biotite and quartzite particles occur on the surface and throughout the profile. The areas nearest the natural drainageways have moderate quantities of gravel and cobblestones in the deep subsoil and the substratum. The areas in the southernmost parts of the Redlands are underlain at depths of 6 to 10 feet by sandstone but have few or no cobblestones in the lower subsoil and substratum.

In spite of its low content of organic matter, this soil has good tilth and workability. The moderate permeability of the profile insures adequate internal drainage. These characteristics, plus a moderate water-holding capacity, favor good root distribution. Saline areas are small and occur where the substratum holds excess irrigation water and forms a water table close to the surface. Massive sandstone bedrock too near the surface causes the water table in most places.

Use and management.—About 81 percent of this soil is cultivated. Approximately 12 percent of the total acreage under cultivation is in orchard fruits, mainly peaches. The soil is desirable for tree fruits but is more susceptible to late spring frosts than the Thoroughfare fine sandy loam soils. The greater danger of frost can be attributed to location. This soil lies in lower places nearest the Colorado River. The Thoroughfare fine sandy loams are on higher places nearer the bluffs. Alfalfa, corn, beans, sugar beets, and small grains are the chief field crops. The soil is well suited to tomatoes, potatoes, other vegetables, melons, and grapes, but only a small acreage is planted to these crops.

The productivity of this soil can be substantially increased by building up its supply of organic matter through application of barnyard manure or the turning under of legumes as green manure.

Redlands loam, 0 to 2 percent slopes (RH).—Except for its gentler slopes, this soil has the same characteristics and crop suitabilities as Redlands loam, 2 to 5 percent slopes. It ranks with the best soils of the Fruita, Mesa, Mack, and Thoroughfare series. All of the acreage is in the Redlands; that is, south of the Colorado River and westward from Grand Junction.

Surface runoff is slow and internal drainage is medium. Saline areas are small and occur only where the substratum holds excess irrigation water and forms a high water table. Because the subsoil layers are medium-textured, moderately permeable, and friable, this soil has a wide crop suitability range and is easily tilled and irrigated.

Use and management.—Practically all of this soil is cultivated, principally to alfalfa, corn, beans, and truck crops. Melons, tomatoes, potatoes, and other truck crops are well suited. The acreage in truck crops is not large but it is increasing. The danger of frost discourages many farmers from planting this otherwise favorable soil to orchard fruits. Only 15 percent of the area is now in orchards, but the acreage is increasing. Yields from tree fruits compare favorably with those on the Mesa soils. Other crops yield about the same as they do on the Mesa soils located on Orchard Mesa.

Redlands loam, 5 to 10 percent slopes (RL).—This soil occurs in the Redlands. It is associated mainly with the Thoroughfare fine sandy loams but occupies a somewhat lower position. Most of it lies on terrace slopes along the river or a little way back from it. The soil is essentially like the two units of Redlands loam on slopes of less than 5 percent, but its alluvial mantle is not so deep in several areas, especially in those occurring in the western part of the Redlands. The alluvium apparently has been built up by deposits from two sources. Considerable amounts of cobbles and gravel of the kind underlying the Mesa soils indicate that much of the alluvial deposit consists of overflow sediments left by the Colorado and Gunnison Rivers. Above these older deposits lies alluvial material derived largely from the Uncompahgre Plateau.

The surface soil and subsoil consist largely of intermixed material derived from sandstone, shale, and granite. Their reddish color is partly accounted for by the reddish color of the shale material in the alluvial deposit. Sandstone boulders, rocks, and gravelly material are scattered over and through the soil. Nevertheless, the soil can be cultivated if the surface stones are removed.

Use and management.—Slopes and stoniness make management difficult. Only about 65 percent of the soil is irrigated. Alfalfa, pinto beans, corn, and truck crops are most commonly grown. There are a few orchards, but most areas of this soil are not so well suited climatically to tree fruits as other soils in parts of the Redlands farther from the Colorado River. Crops on this soil yield somewhat less than on the more gently sloping Redlands soils, mainly because it is more difficult to spread irrigation water and to prevent erosion on this soil. Careful management is necessary to maintain or to increase the productivity of this soil.

Redlands and Thoroughfare soils, shallow over bedrock, 5 to 10 percent slopes (Rn).—These undifferentiated shallow soils occupy uneven topography along the base of the Uncompahgre uplift escarpment and small isolated areas occurring principally in the valleys of the intermittent streams that cross the alluvial fans and terraces of the Redlands.

Where these soils occur in association with Thoroughfare fine sandy loam, 5 to 10 percent slopes, they have the same profile characteristics as that soil but are shallower (2 feet or less) to bedrock of sandstone or shale. Areas 2 to 5 feet deep to bedrock are included, but these are inextensive and occur principally adjoining deeper soils. Outcroppings of bedrock sandstone and shale occur along the outer margin of the alluvial fans adjacent to areas of Rough broken land, Mesa, Chipeta, and Persayo soils materials.

The Redlands member of this undifferentiated unit occupies older parts of the alluvial fans and is generally associated with adjoining areas of Redlands loams. The profile characteristics are the same as have been described for Redlands loam, 5 to 10 percent slopes, but the soil is shallower (2 feet or less) over bedrock sandstone or shale.

Use and management.—Only a very small percentage of this undifferentiated unit is cultivated. Where it occurs on slopes above the irrigation system, it supports a sparse cover of rabbitbrush, some greasewood, and a few annual grasses and weeds. Where it is on slopes below irrigated areas of the associated Redlands loams and Thoroughfare fine sandy loams, it has become poorly drained and saline. In these places the vegetation is saltgrass, fireweed, and greasewood. Because of the shallow depth of the soil and the uneven topography, farmers have not attempted to drain these seepy areas. These soils afford poor grazing. Probably 50 to 80 acres under native cover would be needed to graze one animal through the season.

Redlands and Thoroughfare soils, shallow over bedrock, 2 to 5 percent slopes (Rm).—Aside from having more gentle slopes, this undifferentiated unit is the same as Redlands and Thoroughfare soils, shallow over bedrock, 5 to 10 percent slopes. It has about the same potential use.

Riverwash, 0 to 2 percent slopes (Ro).—This is a miscellaneous land type consisting of fine sand, gravel, cobblestones, and water-worn stones. It occurs along the Gunnison and Colorado Rivers and is subject to occasional partial overflow because it lies only 4 to 8 feet above the normal water level of the streams. As a rule, the deposits at the higher levels have somewhat hummocky relief and consist mainly of sand, loamy fine sand, and fine sand with a few strips or patches of gravel in places. At lower levels the gravelly and cobbly materials are normally more evident. The sandy layers vary in thickness, and the gravelly and cobbly layers vary both in thickness and in the depth at which they occur.

The cobblestones and gravel evident in this unit are only part of the vast deposit that extends back from the Colorado River, under the Green River soils, and, for indefinite distances, under the Billings soils. The cobbly deposit ranges from 8 to 15 feet or more in thickness. On the north side of the Colorado River the belt of this material ranges from ¼ to ½ mile wide and, except along the sharp bluffs, is found under most of the soils. On the south side of the Colorado River the cobbly material underlies practically all of the soils on Orchard Mesa.

The pale-brown deposit of sandy material lying on the gravel, cobbles, and stones is porous and absorbs water so rapidly that irrigation would not be practical, even if small areas could be found that were smooth enough to be irrigated. Except for a few small patches used as gardens, little of this land is cultivated. Many of the areas have almost no vegetation, but some of the larger ones support a scant growth of grasses, cottonwood trees, willows, and a few shrubs.

At present, this land is used mainly as a source of material used for road building and in concrete mixing. The smooth, rounded, water-worn rocks and cobblestones in attractive shades of green, gray, red, and black, have been used to limited extent for building or veneering residences in the area. The cobblestones consist mainly of basalt and granite but some are from hard sandstone and lava.

Rough broken land, Mesa, Chipeta, and Persayo soil materials (Rr).—Except for small areas northeast and south of Palisade, all of this miscellaneous land type occurs south of the Colorado River. It occupies very steep escarpments—25 to 140 feet high—along the south bank of the Colorado River and rough, rugged terrain along tributary drainageways or arroyos. Slopes generally range from 12 to 30 percent along the drainageways but are much steeper along the escarpment adjoining the Colorado River. The soil materials, 10 to 20 feet deep over the Mancos shale, include a layer of sand gravel, cobbles, and stones 6 to 15 feet thick that immediately overlies the shale.

Use and management.—With few exceptions, this land type is too rough, stony, and steep to be leveled for irrigation. The area adjoining the upper irrigation canal southwest of Palisade is partly cultivated to alfalfa and peaches, but the shale is too near the surface to permit entirely satisfactory production of these deep-rooted crops. Moreover, after a decade or more, continued erosion may necessitate use of these areas only for irrigated pasture. The very steep, or precipitous, areas are of little agricultural value; their sparse cover of saltbush, shadscale, cheatgrass, Indianwheat, hopsage, rabbitbrush, and greasewood provides sparse periodic grazing in places that are accessible to livestock.

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Rough broken land, Chipeta and Persayo soil materials (Rp).—This inextensive land type consists mainly of bare Mancos shale. The rather steep areas northeast of Grand Junction consist mainly of bare Chipeta soil-forming material, whereas those north of Mack have a thin to moderately thick mantle of gravelly clay loam, Fruita soil material, overlying the Mancos shale.

Some areas of this land type that have a mantle of soil material could be used for irrigated pasture. Most of the acreage, however, is steep and consists of raw shale. This land type is periodically grazed by sheep, normally late in the fall. The sparse cover consisting of saltsage, saltbush, some shadscale and ryegrass, and other plants provides browse of low value.

Rough gullied land (Rs).—This land type is the product of erosion, gullying, and gully-bank caving of Billings soil material. The largest areas occur along East and West Salt Creeks, Big Salt Wash, and Mack Wash. The texture of the soil material varies; clay, clay loam, silty clay loam, fine sandy loam, gravel, and stones are represented.

The progress of erosion, gully, and caving is unusual (pl. 3, *A*). Erosion, facilitated by occasional mountain freshets and surface flow of irrigation waste water, continues until a gully has been cut down to the sandy substratum. The small continuous flow of irrigation waste water down the gully keeps the sandy substratum wet during the irrigation season. Some irrigation water applied on the fields adjoining the gully follows animal burrows or seeps down through the soil material until it reaches the sandy substratum. It then trickles out into the gully in small springlike veins and carries the saturated sandy material with it. Eventually, the high bank is undermined and topples down into the gully. The underground erosion and caving continually widen the gully. Some of the gully banks are already 50 to 400 yards apart. Unless waste water from irrigated land is disposed of through corrugated iron outlets, the cropland bordering the gullies gradually caves away. Sometimes it is necessary to abandon good cropland in order to stop this type of erosion.

Use and management.—A few small areas of Rough broken land might be made suitable for cropping if they were properly leveled, but the land is so rough that leveling normally would not be economically practical. The areas between wide gullies are rough, seepy, almost always high in salt content, unfit for irrigation, and consequently unsuitable for general field crops. Reclamation of these areas would require enormous expenditure.

Even if shallow, comparatively wide, straight ditches had been dug when the valley was first opened for irrigation, gully erosion could not have been prevented unless stone or concrete baffles were placed in the ditches approximately ⅛ to ¼ mile apart.

Areas of this land that livestock can reach are used primarily for grazing. The vegetation mainly consists of greasewood, scattered cottonwoods, tamarisk, inkweed, snakeweed, Mexican fireweed, smartweed, cattail, and saltgrass. Saltgrass is the most prevalent plant. The value of this land for browsing is low.

Thoroughfare fine sandy loam, 2 to 5 percent slopes (Tb).—This soil occurs in the Redlands westward from Grand Junction. It has developed on alluvium that was derived largely from sandstone and igneous rocks but that also includes an admixture of material weathered from limestone and shale formations exposed by the Uncompahgre uplift. Ordinarily, the alluvial mantle ranges from 4 to 10 feet or more in thickness over the underlying sandstone or shale. Scattered sandstone and granite boulders are common in uncultivated areas that lie above the highest irrigation canal. The soil differs from those of the Mesa series in having a more reddish color and less distinct profile layers, and, except for a few areas bordering the Colorado River, in lacking gravel, cobbles, and stones in the lower subsoil.

The 10-inch surface soil, a light-brown to light reddish-brown fine sandy loam, contains considerable amounts of coarse irregularly shaped aggregates of granite not commonly found in other soil series of the area. This layer is soft when dry and very friable when moist. It has a low organic-matter content. The upper subsoil consists of light-brown to light reddish-brown fine sandy loam that contains a scattering of gravel-size granite and sandstone fragments. Below 20 to 24 inches, the material is slightly coarser and uniformly light brown. At depths below 50 inches the content of lime is noticeably greater; the lime appears as pink or pinkish-white threads and small spots.

The abundance of sandstone, granite, and quartz fragments varies from place to place, not only in the surface layer but also at different depths in the profile. The soil is calcareous throughout, but the lime can be seen only in the lower subsoil layers.

Use and management.—About 80 percent of this soil lying below the present irrigation canals is cultivated. This amounts to about 60 percent of the total acreage. An estimated 15 percent of the cultivated land is in orchard fruits, mainly peaches. The acreage in orchard crops is gradually increasing. Alfalfa, corn, beans, and small grains are the chief field crops. Potatoes, tomatoes, melons, and other truck crops are grown to some extent. Deep-rooted crops are well suited because drainage is generally good and the subsoil is very friable and permeable to plant roots. Yields compare favorably with those produced on Mesa and Fruita soils.

The water-holding capacity is moderate because of the high percentage of sandy material, especially in the lower subsoil. As for others of the Thoroughfare series, this soil requires more water for successful crop production than other soils in the Redlands.

It would cost too much, at least in most places, to bring water to the areas in the northwestern part of the Redlands and in other places lying above the higher irrigation canals. They afford scant grazing for sheep late in fall but are of little value for any other agricultural use.

Thoroughfare fine sandy loam, 0 to 2 percent slopes (TA).—This soil is easily tilled and irrigated and generally favorable for agriculture. Except for its more gentle slope, it is very similar to Thoroughfare fine sandy loam, 2 to 5 percent slopes. It holds less water available for plants than Mesa clay loams.

Use and management.—Approximately 85 percent of this soil is under cultivation, and, of this, about 30 percent is in orchard fruits, mainly peaches. The rapidly permeable subsoil and favorable climate allow successful production of tree fruits. The chief field crops, in order of importance, are alfalfa, corn, and beans. Crop yields average about the same as on the Mesa clay loams.

This soil can be made considerably more productive by using management that will improve its present low supply of organic matter.

Thoroughfare fine sandy loam, 5 to 10 percent slopes (Tc).—This inextensive soil occupies slopes along arroyos in the Redlands. It lies in an intermediate position, or above the other Thoroughfare fine sandy loams but below the areas of Rough broken land.

Because the soil is located on slopes below the steeper areas of Rough broken land, seepage water tends to accumulate in its lower subsoil. In some places this seepage has led to a harmful concentration of salts. Some granite boulders are on the surface. The boulders, seepage, concentration of salts, and considerable slope have prevented use of this soil for irrigated crops. It is grazed for the scant growth of forage it affords.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field. The soil scientist walks over the area at intervals not more than one-quarter mile apart and bores into the soil with an auger or digs holes with a spade. Each such boring or hole shows the soil to consist of several distinctly different layers, called horizons, which are collectively known as the soil profile. Each of these layers is studied carefully for the things about it that affect plant growth.

The color of each layer is noted. The darkness of the surface layer is usually related to its content of organic matter; streaks and spots of gray, yellow, and brown in lower layers generally indicate poor drainage and poor aeration. Texture, or the content of sand, silt, and clay in each layer, is determined by the way the soil feels when rubbed between the fingers and is later checked by mechanical analysis in the laboratory. Texture has much to do with the quantity of moisture in the soil and its availability to plants, whether plant nutrients or fertilizers will be held by the soil in forms available to plants or will be leached out, and how difficult the soil may be to cultivate.

Structure, or the way the soil granulates, and the amount of pore or open space between particles indicate how easily plant roots can penetrate the soil and how easily water enters it.

Consistence, or the tendency of the soil to crumble or to stick together, indicates how difficult it is to keep the soil open and porous under cultivation.

The kind of rocks and the parent material from which the soil has been developed affect the quantity and kind of plant nutrients the soil may have naturally.

Simple chemical tests show how alkaline or acid the soil may be. The depth to bedrock or to compact layers is determined. The quantity of gravel or rocks that may interfere with cultivation, the steepness and kind of slope, the quantity of soil lost through erosion, and other external features are observed.

On the basis of all these characteristics, soil areas that are much alike in the kind, thickness, and arrangement of their layers are mapped as one soil type. Some soil types are separated into two or more phases. For example, if a soil type has slopes that range from 0 up to 10 percent, the type may be mapped in three phases, a nearly level phase (0 to 2 percent slopes), a gently sloping phase (2 to 5 percent slopes), and a sloping phase (5 to 10 percent slopes). A soil type is divided into phases primarily because of differences in the soil other than those of kind, thickness, and arrangement of layers. The slope of the soil, the frequency of outcropping bedrock, the extent of erosion, or artificial drainage, are examples of characteristics that might cause a soil type to be divided into phases.

Two or more soil types may have similar profiles, that is, the soil layers may be nearly the same except that the texture of the surface layer will differ. As long as the other characteristics of the soil layers are similar, these soils are considered to belong in the same soil series. A soil series therefore consists of all the soil types that, except for texture of the surface layer, have about the same kind, thickness, and arrangement of layers, whether the number of such soil types be only one or several.

The name of a place near where a soil series was first found is chosen as the name of the series. Thus, the Billings is the name of a series first found near Billings, Mont. It represents deep and moderately deep, calcareous, fine-textured, gray alluvial soils that occur extensively on the flood plains and very gently sloping alluvial fans in the Grand Junction Area and elsewhere in the West.

When very small areas of two or more kinds of soil are so intricately mixed that they cannot be shown separately on a map of the scale used, they are mapped together, and the areas of the mixture are called a soil complex. Chipeta-Persayo silty clay loam, 5 to 10 percent slopes, is a complex of Chipeta silty clay loam, 5 to 10 percent slopes, and Persayo silty clay loam, 5 to 10 percent slopes that occurs in this area.

Areas such as rough and steep escarpments, extremely gullied lands, and areas of freshly deposited very sandy gravelly or cobbly alluvium that have little true soil are not designated by series and type names but are called miscellaneous land types and given descriptive names such as Rough gullied land and Riverwash.

The soil type, or where the soil type is subdivided, the soil phase, is the unit of mapping in soil surveys. It is the unit, or the kind of soil, that is most nearly uniform and has the narrowest range of characteristics. For this reason, soil-management practices can be more definitely specified for it than for broader groups of soils that contain more variation. One can say, for example, that soils of the Billings series in their natural state contain varying amounts of harmful salts, and that when these are removed the soils are productive of practically all of the crops generally grown in the area. More specific statements on characteristics affecting management can be made for Billings silty clay loam, 0 to 2 percent slopes. It is a moderately fine textured soil that is slowly permeable and will permit the production of deep-rooted crops such as alfalfa and tree fruits. In contrast, Billings silty clay, 0 to 2 percent slopes, is a soil that has slower permeability because of its fine texture, is not suited to tree fruits, and is less productive of most other crops than Billings silty clay loam, 0 to 2 percent slopes. Both of these phases are members of the Billings series.

SALINITY AND ALKALI [5]

About one-third of the Grand Junction Area is occupied by soils affected by accumulations of salts, alkali, or both. The content of soluble salts, the degree of alkalinity, and the percentage of exchangeable sodium in these soils is of great significance to farmers and others interested in their present and potential values.

This section explains how the saline, saline-alkali, and alkali soils of the Grand Junction Area are classified and designated on the soil map. It gives the source of salts and alkali in the soils; describes how salts and alkali affect soils and plants; discusses the laboratory methods used in study of salinity and alkali; and gives chemical analyses for irrigation and drainage waters.

In a general way this section also points out the problems encountered in management of saline and alkali soils and the means by which they may be overcome. It does not give detailed suggestions on management of individual soils, because each soil, and frequently areas within each soil, present particular problems. It is intended that farmers will use this report and accompanying map to locate salty and alkaline soils on their farms. Then, for technical advice on management, they should consult their county agricultural agent or local Soil Conservation Service representative. Past expensive failures through faulty irrigation methods or attempted reclamation of soils not suitable for irrigation emphasize the need for technical advice.

Effects of saline, saline-alkali and alkali conditions on soils and plants.—The chemical and physical properties of soils are conditioned by the amounts and kinds of salts they contain. In general, the chlorides and sulfates of sodium, calcium, and magnesium predominate in saline soils. Saline soils are differentiated from nonsaline soils by their content of soluble salts, which is sufficient to interfere with the growth of most crop plants.

If the salts of calcium and magnesium are high and the salts of sodium low, the salts do not have a detrimental effect on the physical properties of the soil. Conversely, if sodium is high and calcium plus magnesium is low, the sodium will replace the calcium and magnesium on the clay particles. So long as the salts remain high, the soil is described as saline-alkali and there is but little physical change in the soil. An exception occurs when rain water leaches the easily soluble salts out of the immediate surface soil. In this thin leached layer the exchangeable sodium remains on the exchange complex of the clay and fine silt particles.

An alkali soil has a high percentage of exchangeable sodium, 15 percent or more of its exchange capacity. Leaching a saline-alkali soil with rain water or with irrigation water that has a low ratio of calcium and magnesium to sodium removes the soluble salts. This leaching gives rise to a soil that has more than 15 percent exchangeable sodium. Sodium-saturated soil material has a tendency to swell when wet and to puddle or become dispersed. This swelling and dispersing eliminates pore space, decreases aeration, and slows permeability. The soils become essentially puddled because the particles pack so close together that it is difficult for water, air, or

[5] By W. G. Harper, U. S. Department of Agriculture.

roots to penetrate. These conditions usually result in the formation of the so-called slick spots that are common among alkali soils.

Aside from their effect on the soils, salts have a direct effect on plant growth. Dissolved salts increase osmotic pressure of the soil solution; they make it more difficult for plants to draw water from the soil. To keep the concentration of salt in the soil solution within tolerable limits, saline soils must have more irrigation water than nonsaline soils if they are to produce the same yield of any crop.

If the salt content of a soil becomes too high, the osmotic pressure of the soil moisture exceeds that within the plant root. This means that moisture will be drawn out of the plant, and the plant will wilt and perhaps die.

Although injury to plants caused by salinity is usually in proportion to the kind and quantity of salt in the soil, some plants are much more sensitive than others. Green beans and alsike clover, for example, are very sensitive to salt. In contrast, sugar beets and barley have a relatively good tolerance to salts.

Plants affected by but not killed by excess salts are usually stunted, have burned leaf tips, and produce a crop inferior to that obtained from healthy plants growing in salt-free and alkali-free soils. When sodium is dominant in the soil solution, the plants may also suffer from lack of calcium, a mineral essential to plant growth.

The occurrence, appraisal, and mapping of salinity and alkali.— Salinity of the soils in the Grand Junction Area was first studied as part of a soil survey made in 1905(*5*). Then, in 1937, the salt and alkali conditions of soil samples from this area were studied (*1*). Analyses were made on samples from 12 slick-spot soils; practically all of these samples were taken from the Billings series either in the Grand Junction Area or near Delta, Colo. Chemical studies on a soil sample from the Grand Junction Area were made (*5*, *1*). This sample was studied with samples of 12 soils from various locations in the Western States. The results of this work were published in 1945 (*9*).

In 1946, representatives from the U. S. Salinity Laboratory cooperated with the soil survey field party and with the Colorado Agricultural Experiment Station in making additional field and laboratory studies of saline and alkali soils in the area. Data obtained during these studies are given in tables 7, 8, 9, and 10, which appear at the end of this section.

As stated previously, the salt and alkali in this area are derived mainly from the Mancos shale formation. The accumulation of excess salts in the soils is frequently associated with poor drainage and a high water table. The occurrence of ground water at a high level in the soil may be caused by excessive irrigation, by seepage from streams and water-distributing systems, by the presence of impervious strata in the subsoil, or by impeded drainage resulting from the fine texture and massive structure or relative impermeability of the soil itself.

The effect of the Mancos shale formation on underdrainage is partly responsible for saline and alkali soils in this area. The alluvial mantle of the Grand Valley rests upon the uneven or undulating surface of this formation. The shale creates underground dams or pockets that restrict water movement and may cause the accumulation of underground water. Such conditions not only help bring salts to the surface but also complicate attempts to drain the land and leach out excessive concentrations of salts.

The application of unusually large quantities of irrigation water and the seepage of water from canals have contributed to the salinity problems. The soils of the upper fans, in many places, are of sandy texture. Water seeps from these sandy soils to lower areas. If soils high in salt and clay lie immediately down the slope from the sandy soils, movement of the seepage water may be so greatly retarded that a local area may become waterlogged, and as a consequence salts accumulate. For example, north of Palisade, the main canal has been lined with concrete for several miles to prevent seepage, and as a result the water table in the soils below the canal has been lowered.

Soil salinity in the Grand Junction Area is correctible to considerable extent. The salt content of the soils may vary as a result of changes in drainage and in the practices of irrigation and other soil management used. Many areas that were wet and saline a few years ago are not now affected by a high water table. Some have been reclaimed so that they are producing crops. On the other hand, some changes for the worse have occurred since 1940. Large areas that once produced crops, and were apparently free of harmful concentrations of salts, are now affected with sufficiently high concentrations to prevent the growth of crops. In areas where drainage is being improved, soils that are now saline probably will become more productive. Where a high water table is continuous or becoming worse, salts will continue to accumulate.

Delineation and definition of salt- and alkali-affected soils.—The delineation of areas on the soil map according to salt content, degree of alkalinity, and percentage of exchangeable sodium was done on the basis of field observations supplemented by laboratory investigations. Field men noted the kind and quantity of natural vegetation; the visible condition of crops; the color, structure, texture, and consistence of the soil; and the occurrence of salt crusts or efflorescence. All of these were considered in establishing the boundaries of the salt- and alkali-affected areas and in assigning symbols to designate degree of salt or alkali concentration. The validity of field observations, as they concerned salt content, was then checked by determining the percentage of total salts in a soil paste by means of the Wheatstone bridge. In addition, pH determinations were made in the field by use of dye indicators or in the laboratory by use of a potentiometer and glass electrode. Exchangeable sodium was determined in the laboratory.

The distribution of salts is shown on the soil map by red boundary lines, and the concentration of salts by red symbols. Three groups are shown as follows: (1) Strongly saline or saline-alkali areas; (2) moderately saline areas and spotted areas in which strongly saline and nonsaline soils are intimately intermingled; and (3) nonsaline areas, or those in which the concentration of salts is not sufficient to injure crops.

The strongly saline areas and saline-alkali areas are designated by the letter symbol *A*. The salt content of these areas is so high that production of commercial crops is practically impossible. The native vegetation on these areas consists of salt-tolerant plants such as greasewood, shadscale, and saltgrass. Areas from which the native vegetation has been removed may be barren or have a growth of saltgrass, fireweed, Bassia, and related plants. The percentage of salt in the strongly saline areas is usually more than 0.50 in one or more layers of the soil profile, and in many areas the salt content is greater than 1.00 percent in the entire soil profile.

The term "saline-alkali," as mentioned above, indicates a soil that is high in both salts and exchangeable sodium. Saline-alkali conditions are common among the strongly saline areas, and slick spots occur in places. Some of these have been reclaimed by leaching after first applying gypsum, barnyard manure, or a combination of manure and sulfur. In all instances, these areas were reclaimed only after the water table had been lowered to a depth of 5 feet or more.

The moderately saline areas or spotted strongly saline and nonsaline areas are indicated on the map by the letter symbol *M*. These areas contain salts in quantities sufficient to injure the growth, production, or quality of all except the most salt-tolerant of crop plants; or the salt occurs in irregular spotty fashion such that plants grow normally in some places and will not grow in others. The salt content therefore is variable. Except for occasional spots of higher salt content, however, the areas marked with *M* generally have less than 0.40 percent salt in most layers of the soil profile.

The nonsaline soils contain some salts, but the concentration is so slight or so far below the surface that all crops except a few exceptionally sensitive to salts will grow well. Soluble salts in these soils are generally less than 0.15 percent of the air-dry weight of the soil, or less than 0.20 percent for the soils that are high in gypsum. The nonsaline soils are designated by the symbol *F*.

As can be seen from the study of the soil map, the soil series in which salinity occur are the Billings, Ravola, Hinman, Green River, Redlands, Thoroughfare, Chipeta, and Persayo. Salinity is most extensive in the Billings soils.

Laboratory studies.—To supplement the salt and alkali tests made by field men, a large number of soil samples were collected from problem areas. Specific chemical and physical studies were made on some of these samples at the Colorado Agricultural Experiment Station laboratories, and additional analyses were made on some of the same samples and of other samples at the U. S. Salinity Laboratory at Riverside, California. Samples of irrigation water, drainage water, and ground water were also analyzed at the U. S. Salinity Laboratory. The samples of soil analyzed were taken from several soil types and from various locations so as to include a wide range in soil characteristics and contents of salts and alkali, and so as to take into account the range in other conditions that relate to land use and management.

The location of each soil sample studied at the Colorado Agricultural Experiment Station is shown on the map by a dot and a number from 1 to 82. Those with a dot and a small letter, for example *3a*, have also been analyzed by the U. S. Salinity Laboratory. The laboratory results from analyses of these samples are given in table 7. At each of the 82 locations, the samples were taken at arbitrary depths as follows: 0 to 8 inches, 8 to 20 inches, 20 to 32 inches, and 32 to 44 inches.

The U. S. Salinity Laboratory analyzed a total of 165 soil samples, but only 48 samples, representing the various layers in 12 soil profiles are included in this report. The site locations for soils studied at the U. S. Salinity Laboratory are shown on the map in blue capital letters (*A*, *B*, *C*, *D*, *E*, *G*, *H*, *I*, *J*, *L*, and *N*) that are enclosed in a circle. Two soil profiles were taken in the vicinity of site *A*, and one at each of the other sites, or a total of 12 soil profiles. These profiles were sampled to various depths according to profile horizons or surface soil and subsoil layers. Field infiltration tests of the surface soil and subsurface soil were made at 8 of the sites. Results of the laboratory analyses of the soils, waters, and field infiltration tests appear in tables 8 and 10. A detailed description of the methods used in making the laboratory tests and infiltration tests appears in Technical Bulletin 902 (*9*).

Soluble salts.—The percentages of soluble salts in the 82 soil samples studied at the Colorado Agricultural Experiment Station are given in table 7. It will be noted that some samples in this table have a letter symbol immediately following the number; for example, *3a*. The letter symbol indicates that the soil sample was analyzed by the U. S. Salinity Laboratory after it had been studied at the Colorado Agricultural Experiment Station. The letter symbol allows reference to analyses of total soluble salts made by the Salinity Laboratory and presented in table 8.

The Colorado Agricultural Experiment Station calculated total of soluble salts by resistance of the saturated soil paste when measured by the Bureau of Soils cup method; the results are expressed as a percentage of the air-dry weight of the soil (see table 7). Most of the soils tested at the experiment station were high or moderately high in soluble salts, though some did not contain more than 0.15 percent.

The U. S. Regional Salinity Laboratory calculated total soluble salts by two methods: (1) resistance of the saturated soil paste, and (2) conductivity of the extract made from the saturated soil paste. In the Grand Junction Area, the two methods agreed closely enough for classification purposes.

As shown in tables 8 and 9, the U. S. Salinity Laboratory also made quantitative and qualitative analyses of the saturation extract. The saturation extracts were analyzed for sodium, potassium, calcium, magnesium, carbonate, bicarbonate, chloride, sulfate, and nitrate (see table 9). No carbonates were found, and bicarbonates, calcium, and potassium were low. All the extracts from saline or saline-alkali soils were high in sulfates, sodium, and magnesium. The high proportion of sulfate ions limited the amount of soluble calcium and thereby made large amounts of sodium available on the exchange complex. After leaching of the salts, gypsum, if present in the profile, would be dissolved in applied water and thereby increase the amount of soluble calcium.

The percentage of soluble sodium in the saline extracts was high; it ranged from 15 to 94 percent and averaged 53 percent for the 48 samples.

The pH of saturated soil paste and of 1:10 and 1:60 suspensions.—The relative acidity or alkalinity of a soil is usually designated in terms of pH. The pH of a soil is affected by slightly soluble carbonates, exchangeable sodium and other cations, exchangeable hydrogen, carbon dioxide, and soluble salts. A pH of 7.0 usually indicates that a soil contains little or no free lime; a pH of 9.0 to 10.0 normally denotes an appreciable amount of exchangeable sodium; and a pH above 10.0 almost invariably indicates a high percentage of exchangeable sodium.

Though pH is an indicator of some diagonostic value, it cannot always be correctly interpreted. In this area, pH is not a reliable measure of exchangeable sodium because many of the soils contain gypsum (calcium sulfate). In the absence of gypsum, leaching or dilution by means of irrigation removes salts from the soils. Removal of the salts reduces the buffer action of the saline solution and increases the hydrolysis of the adsorbed or exchangeable sodium on the clay. In other words, leaching of a salty soil tends to increase its pH, or make it more alkaline in reaction. If the salty soil contains gypsum, however, the percolating water dissolves some of the gypsum and releases calcium. The calcium replaces the sodium on the clay particles, and because of this exchange, there may be no increase in pH because of the leaching.

Gypsum.—Calcium sulfate, or gypsum, has the ability to replace sodium in soils. When reclamation of saline-alkali or alkali soils is planned, it is important to know whether they contain gypsum or not, and if they do have gypsum, how much and where located in the profile. If they do not have gypsum, or it is located in the profile where it cannot replace the sodium, the feasibility of applying gypsum as an amendment should be considered.

All of the saline or saline-alkali soils of the Grand Junction Area except those of the Thoroughfare series are related to the Mancos shale formation. This formation contains gypsum, and therefore gypsum is generally present in all the saline or saline-alkali soils of the area except the Thoroughfare.

Analyses of samples from 12 profiles (table 8) and of other samples from soils of the area indicate that the amount and distribution of gypsum within the profile are quite variable. Some soils have more than enough gypsum to replace the adsorbed sodium; others have gypsum in the subsoil and a large amount of exchangeable sodium in the surface soil; and still others have a negligible amount of gypsum.

Permeability and field infiltration.—The permeability of saline soils and soils high in replaceable sodium is usually related to: (1) amount of replaceable sodium, (2) structure, (3) bulk density, and (4) kind of clay mineral. Most of the problem soils of this area either are massive or have weakly defined structural aggregates and are not compact. There is a close correlation of structure with permeability, content of gypsum, percentage of exchangeable sodium, and texture. The compact soils tend to have poor permeability, a variable content of gypsum, a high content of exchangeable sodium, and a fine texture. The soils that are not compact have better permeability, a higher content of gypsum, a lower content of exchangeable sodium, and a coarser texture.

X-ray diffraction, internal and external surface area, total potassium, and cation-exchange measurements of Billings silt loam and its less than 2-micron fraction have been made by C. A. Bower, and J. G. Cady.[6] The clay in this soil was found to be primarily

[6] Unpublished data of U. S. Salinity Laboratory.

illite with very little of the expanding montmorillonite type of lattice. In these relatively unweathered soils, the nature of the clay mineral should be the same as the clay in the Mancos shale formation. Most of the soils affected by salts are derived entirely or in part from the Mancos formation. The Redlands and Thoroughfare soils occur on parent material derived from other geologic formations. Illite is relatively inert and platy and its clay particles are not so fine-grained as those in montmorillonite. These properties of illite, plus the replaceable sodium and fine texture in the problem soils, are contributing factors in the formation of the massive or weakly defined structural aggregates and also have an important influence on permeability during leaching.

The finest textured soil in the area, Billings silty clay, was the most slowly permeable soil tested. The particular sample of Billings silty clay tested contained more than 50 percent exchangeable sodium and did not contain gypsum. Samples of Billings silty clay and Billings silty clay loam that tested high in gypsum and not high in exchangeable sodium had slow to moderately slow permeability. The generally slow permeability of the Billings soils probably results from their massive structure, exceptionally low content of organic matter, and their high content of silt and clay. Billings soils that have a high content of exchangeable sodium and a low content of gypsum will have a low permeability, and reclamation by leaching alone will be difficult.

Permeability for most of the soils studied except the Billings is moderate to rapid. This indicates that soils other than those of the Billings series can be reclaimed easily if adequate drainage is provided. The data on field infiltration in table 8 check closely with the permeability measurements.

Saturation percentages.—This is the quantity of water, expressed in terms of percentage of the dry soil, that a soil holds when saturated. These saturation values (table 8) are used for calculating percentages of salts, percentage of exchangeable sodium, and amounts of gypsum in soils. Furthermore, they usually furnish a basis for estimating field moisture capacity and the wilting percentage. The saturation percentages for the soils studied correlate fairly well with texture; that is, the finer the texture of the soil the greater the amount of water it holds when saturated.

Base exchange capacity.—The amount of cations a soil will adsorb is its base exchange capacity. The base exchange capacity is closely related to and varies widely with the texture of the soil. As shown in table 8, the exchange capacities are lowest in the fine sandy loam and loam textures and highest in the clay loams and silty clays. The exchange capacities of soils in this area range from 3.85 to 23.9 milliequivalents per 100 grams of dry soil and average about 9. These exchange capacities are lower than those usually obtained for soils of similar texture in the arid regions. Nevertheless, they are high enough that mineral nutrients are not readily lost from the soil. Also, they are low enough that large amounts of gypsum, sulfur, or sulfuric acid are normally not required to replace exchangeable sodium. The calcium and magnesium needed to replace the adsorbed sodium are to be found in gypsum and magnesium, which may be in the soil, in the irrigation water, or in added amendments.

Exchangeable sodium.—The percentage of exchangeable sodium is important in characterization of the soils of this area. If the amount of exchangeable sodium is more than 15 or 20 percent of the base-exchange capacity, it will have a detrimental effect on the physical conditions of the soils and on growth of many crops. Many of the soils tested are high in exchangeable sodium, but for most of them this is offset by a high content of gypsum. The gypsum serves as a source of calcium, which replaces the adsorbed sodium. Gypsum is slightly soluble. When the alkali soils are leached, the dissolving gypsum provides a continuous supply of calcium that replaces the sodium on the exchange complex and thereby improves the soils for the production of crops.

Chemical analyses of irrigation and drainage waters.—Data pertaining to eight irrigation, drainage, and ground waters are presented in table 10. Irrigation water diverted from the Colorado River contains about 720 parts per million of salts, of which approximately 50 percent is sodium salts. Water from this river is considerated permissible for irrigating the crops grown in the area. Sample 3, collected from an open drain, contained 950 parts per million of salts, which indicates that the drain was carrying principally runoff rather than water that had seeped through the soil. The ground waters were high to exceptionally high in salts; the range was from 3,600 to 39,000 parts per million, or from 0.36 to 3.9 percent.

SUMMARY

The saline and saline-alkali soils of the Grand Junction Area cover about 21,600 acres. They are mainly soils that have been developed on the Mancos shale or on parent material that came mainly from the Mancos formation. Poor drainage is responsible for most of the saline soils in the area. There are many causes for the poor drainage that occurs in different parts of the area, and also there is a varied distribution of salts. The salt content varies from field to field and within the soil profile.

Sodium sulfate is by far the most prevalent salt, but calcium and magnesium salts are high in many of the saline soils. Some of the saline soils are low in exchangeable sodium, but many of them are high and therefore are designated as saline-alkali soils. Gypsum is present in most of the soils that occur on materials coming from the Mancos formation. The gypsum, like the more soluble salts, is erratic in distribution, but in most soils it appears to be present in sufficient quantities to replace the adsorbed sodium. Most of the problem soils therefore can be reclaimed simply by leaching and without the addition of amendments if *adequate drainage* is provided.

The ease of reclamation by leaching depends largely upon infiltration and permeability. Although Billings soils generally have slower permeabilities than other soils of the area, they have a range in permeability depending upon texture, exchangeable sodium, and content of gypsum. The Chipeta and Persayo silty clay loam soils are slowly permeable. The other saline or saline-alkali soils of the area are moderately to rapidly permeable and should not be difficult to reclaim, provided they are adequately drained.

If drainage is provided, leaching the excess salts down through the soil and out by means of underdrainage can be accomplished in the more rapidly permeable soils. It is expected, therefore, that the salinity status as shown on the map will change from year to year, depending upon drainage conditions and management.

TABLE 7.—*Soluble salts and pH of soil paste and 1:5 soil-water suspension for soil samples taken in the Grand Junction Area, Colo.*

[Analyses by Colorado Agricultural Experiment Station]

Sample No.	Depth	Total soluble salts [1]	pH	
			Saturated paste	1:5 soil-water suspension
	Inches	*Percent*		
1	0–8	1. 68	8. 5	9. 2
	8–20	1. 68	8. 6	8. 9
	20–32	2. 06	8 6	9. 2
	32–44	1. 89	8. 7	9. 0
2	0–8	2. 26+	8. 6	8. 9
	8–20	1. 99	8. 7	8. 9
	20–32	2. 46	8. 9	8. 9
	32–44	2. 46	8. 9	8. 9
3a [2]	0–8	0. 22	7. 7	7. 7
	8–20	. 20	7. 7	7. 7
	20–32	. 16	7. 7	7. 7
	32–44	. 17	7. 7	7. 7
3c	0–8	2. 26	8. 7	8. 8
	8–20	1. 72	8. 8	8. 9
	20–32	1. 83	8. 9	9. 0
	32–44	2. 08	9. 0	9. 0
4	0–8	. 42	8. 7	7. 9
	8–20	. 87	8. 4	8. 2
	20–32	2. 23	8. 3	8. 3
	32–44	2. 04	7. 9	8. 7
5	0–8	. 13	7. 5	8. 0
	8–20	. 16	7. 6	8. 0
	20–32	. 18	7. 7	7. 9
	32–44	. 18	7. 6	7. 9
6	0–8	1. 22	8. 9	9. 0
	8–20	2. 11	9. 2	9. 2
	20–32	2. 31	9. 2	9. 1
	32–44	1. 97	9. 1	9. 0
7a	0–8	. 52	8. 2	8. 6
	8–20	1. 19	8. 7	8. 7
	20–32	1. 57	8. 8	8. 8
	32–44	2. 21	8. 8	8. 7
7b	0–8	. 07	7. 7	8. 1
	8–20	. 21	7. 8	7. 9
	20–32	. 67	8. 2	8. 5
	32–44	1. 19	8. 6	8. 6
8	0–8	1. 03	8. 5	9. 0
	8–20	1. 72	8. 9	8. 9
	20–32	1. 38	8. 9	9. 0
	32–44	1. 31	9. 2	9. 1
9	0–8	. 16	7. 7	7. 9
	8–20	. 60	8. 4	8. 3
	20–32	1. 30	8. 9	9. 0
	32–44	2. 19	9. 1	9. 1
10	0–8	. 65	8. 4	8. 9
	8–20	1. 30	8. 8	9. 0
	20–32	1. 71	8. 8	8. 8
	32–44	1. 15	8. 8	8. 7
11	0–8	. 14	8. 1	8. 8
	8–20	. 60	8. 2	8. 5
	20–32	1. 18	8. 5	8. 5
	32–44	1. 67	8. 6	8. 6

[1] Percentage total soluble salts, based on air-dry weight of soil, as determined from conductance of soil paste.

[2] Letter symbols indicate that sample was later analyzed by U. S. Salinity Laboratory (see tables 8 and 9).

TABLE 7.—*Soluble salts and pH of soil paste and 1:5 soil-water suspension for soil samples taken in the Grand Junction Area, Colo.*—Con.

Sample No.	Depth	Total soluble salts	pH	
			Saturated paste	1:5 soil-water suspension
	Inches	*Percent*		
12	0–8	0.54	8.3	8.3
	8–20	.26	7.9	7.8
	20–32	2.26+	9.0	9.1
	32–44	.28	8.1	8.0
13	0–8	.84	8.4	9.0
	8–20	1.43	8.6	8.7
	20–32	1.64	8.8	8.8
	32–44	1.47	9.0	9.0
14	0–8	2.50+	9.0	8.9
	8–20	2.50+	9.0	8.9
	20–32	2.50+	9.0	9.0
	32–44	1.50	9.0	8.9
15	0–8	1.15	8.8	8.9
	8–20	2.10	9.0	9.0
	20–32	2.10	9.0	8.9
	32–44	1.75	9.1	8.9
16	0–8	.22	8.1	8.1
	8–20	.32	7.9	7.8
	20–32	.40	8.1	7.8
	32–44	.62	8.3	7.8
17	0–8	.52	8.4	9.0
	8–20	.20	7.8	8.5
	20–32	.18	7.8	8.8
	32–44	.19	7.8	9.0
18	0–8	2.11	9.0	8.9
	8–20	2.58	9.0	8.9
	20–32	2.37	9.1	8.9
	32–44	2.58	9.1	8.9
19	0–8	1.98	9.3	9.2
	8–20	1.98	9.2	9.2
	20–32	1.10	9.2	9.1
	32–44	1.32	9.2	9.1
20	0–8	.63	8.6	8.7
	8–20	1.15	9.1	9.3
	20–32	1.75	9.2	9.4
	32–44	.91	9.2	9.4
21	0–8	1.68	9.3	9.1
	8–20	1.89	9.4	9.2
	20–32	2.10	9.4	9.2
	32–44	2.34	9.4	9.2
22	0–8	.67	8.1	9.0
	8–20	.95	8.2	9.2
	20–32	1.04	8.2	9.3
	32–44			
23	0–8	2.42	9.0	9.2
	8–20	.22	8.0	8.4
	20–32	.17	8.0	8.3
	32–44	.16	8.0	8.5
24	0–8	1.98	9.2	9.3
	8–20	2.42	9.2	9.3
	20–32	1.87	9.2	9.2
	32–44	2.16	9.0	9.1
25	0–8	.50	8.5	8.8
	8–20	1.23	9.1	8.5
	20–32	1.54	9.1	8.4
	32–44	1.54	9.0	8.3

TABLE 7.—*Soluble salts and pH of soil paste and 1:5 soil-water suspension for soil samples taken in the Grand Junction Area, Colo.*—Con.

Sample No.	Depth	Total soluble salts	pH	
			Saturated paste	1:5 soil-water suspension
	Inches	*Percent*		
26	0–8	2. 21	9. 1	9. 0
	8–20	1. 53	9. 2	8. 9
	20–32	. 89	8. 7	8. 6
	32–44	. 49	8. 7	8. 5
27	0–8	1. 30	9. 1	9. 0
	8–20	1. 98	9. 3	9. 1
	20–32	2. 21	9. 4	9. 3
	32–44	2. 50+	9. 1	9. 2
28	0–8	1. 06	8. 7	9. 3
	8–20	1. 14	8. 9	9. 5
	20–32	1. 55	8. 9	9. 3
	32–44	1. 99	8. 8	9. 0
29	0–8	. 21	7. 8	8. 1
	8–20	. 45	8. 0	8. 3
	20–32	. 52	8. 4	8. 5
	32–44	. 51	8. 6	8. 5
30a	0–8	. 16	8. 0	8. 0
	8–20	. 17	8. 0	8. 0
	20–32	. 18	8. 0	8. 0
	32–44	. 17	8. 0	8. 0
30b	0–8	2. 50+	9. 5	9. 4
	8–20	2. 42	9. 4	9. 3
	20–32	2. 16	9. 3	9. 2
	32–44	2. 42	9. 3	9. 1
31	0–8	. 80	9. 0	8. 9
	8–20	1. 07	9. 1	8. 9
	20–32	1. 50	9. 1	8. 9
	32–44	1. 30	9. 2	8. 9
32	0–8	1. 21	9. 1	9. 1
	8–20	1. 06	9. 2	9. 1
	20–32	1. 40	9. 3	9. 2
	32–44	1. 81	9. 3	9. 2
33	0–8	2. 07	8. 9	8. 6
	8–20	1. 81	9. 0	8. 7
	20–32	1. 71	9. 0	8. 7
	32–44	1. 71	9. 0	8. 7
34	0–8	. 43	8. 2	8. 0
	8–20	. 17	8. 2	8. 6
	20–32	. 24	8. 2	8. 3
	32–44	. 23	8. 1	8. 3
35	0–8	. 56	8. 3	8. 6
	8–20	. 53	8. 5	9. 0
	20–32	. 77	8. 6	8. 5
	32–44	. 58	8. 5	8. 4
36	0–8	. 67	8. 5	8. 7
	8–20	. 85	8. 6	8. 7
	20–32	1. 12	8. 7	9. 0
	32–44	1. 94	8. 8	8. 8
37	0–8	. 34	8. 2	8. 2
	8–20	1. 03	8. 7	8. 7
	20–32	1. 07	8. 9	8. 8
	32–44	. 60	8. 9	8. 5
38	0–8	. 88	8. 7	8. 6
	8–20	. 83	8. 8	8. 0
	20–32	. 62	8. 6	8. 1
	32–44	. 54	8. 5	7. 8
39	0–8	1. 19	8. 5	8. 9
	8–20	1. 70	8. 8	8. 8
	20–32	1. 90	8. 9	8. 9
	32–44	2. 31	8. 7	8. 7

TABLE 7.—*Soluble salts and pH of soil paste and 1:5 soil-water suspension for soil samples taken in the Grand Junction Area, Colo.*—Con.

Sample No.	Depth	Total soluble salts	pH	
			Saturated paste	1:5 soil-water suspension
	Inches	*Percent*		
40	0–8	0.48	8.1	8.3
	8–20	.25	8.2	8.0
	20–32	.19	8.1	8.1
	32–44	.36	8.2	8.0
41	0–8	1.64	8.7	8.3
	8–20	1.23	8.6	8.6
	20–32	1.42	8.5	8.4
	32–44	1.32	8.6	8.3
42	0–8	2.10	8.9	8.8
	8–20	1.41	8.9	8.8
	20–32	1.64	9.0	8.9
	32–44	.96	9.0	8.9
43	0–8	1.21	8.5	8.4
	8–20	1.21	8.7	8.9
	20–32	1.03	8.9	8.8
	32–44	.66	8.9	8.7
44	0–8	.07	8.2	8.3
	8–20	.58	8.3	9.0
	20–32	.60	8.3	8.9
	32–44	.61	8.0	8.6
45	0–8	2.50+	7.3	8.0
	8–20	1.72	7.6	8.2
	20–32	1.98	7.8	8.7
	32–44	2.50+	8.3	8.6
46	0–8	.99	8.2	8.6
	8–20	1.07	8.5	9.0
	20–32	2.21	8.6	8.8
	32–44	1.98	8.6	8.8
47	0–8	1.63	7.7	7.9
	8–20	1.07	7.7	8.9
	20–32	1.73	8.0	8.3
	32–44	1.26	8.2	8.8
48	0–8	.19	8.2	8.8
	8–20	.48	8.0	8.4
	20–32	.53	8.0	8.5
	32–44	.49	8.1	8.5
49	0–8	.24	8.1	8.2
	8–20	.13	8.0	8.1
	20–32	.15	8.0	8.1
	32–44	.20	8.1	8.4
50	0–8	.12	7.8	7.8
	8–20	.12	8.0	7.9
	20–32	.09	8.0	7.9
	32–44	.31	8.0	8.0
51	0–8	1.08	8.7	8.4
	8–20	1.54	8.8	8.6
	20–32	2.45	8.7	8.7
	32–44	2.45	8.8	8.6
52	0–8	.09	7.8	8.0
	8–20	.13	8.2	9.1
	20–32	.10	8.5	9.4
	32–44	.25	8.0	8.8
53	0–8	.41	8.1	8.7
	8–20	.56	8.5	8.8
	20–32	.80	8.5	8.9
	32–44	.68	8.4	8.7
54	0–8	.64	8.3	8.4
	8–20	.63	8.5	8.7
	20–32	.61	8.5	8.7
	32–44	.38	7.8	8.2

335914—55——7

TABLE 7.—*Soluble salts and pH of soil paste and 1:5 soil-water suspension for soil samples taken in the Grand Junction Area, Colo.*—Con.

Sample No.	Depth	Total soluble salts	pH	
			Saturated paste	1:5 soil-water suspension
	Inches	*Percent*		
55	0–8	0. 11	7. 8	7. 7
	8–20	. 15	7. 7	7. 9
	20–32	. 14	7. 7	7. 9
	32–44	. 15	7. 7	7. 9
56	0. 8	. 12	7. 8	7. 7
	8–20	. 11	7. 9	8. 1
	20–32	. 11	7. 8	8. 0
	32–44	. 22	7. 7	7. 6
57	0–8	2. 50+	7. 4	7. 6
	8–20	1. 70	7. 6	7. 8
	20–32	2. 07	7. 7	7. 9
	32–44	2. 07	8. 0	8. 3
58	0–8	. 58	8. 1	8. 3
	8–20	1. 11	8. 1	8. 1
	20–32	1. 16	8. 4	8. 4
	32–44	1. 35	8. 5	8. 5
59	0–8	. 28	7. 8	8. 2
	8–20	. 60	7. 9	8. 0
	20–32	. 84	7. 9	8. 0
	32–44	. 98	7. 9	8. 0
60	0–8	2. 50+	7. 6	7. 9
	8–20	1. 80	8. 6	8. 6
	20–32	1. 61	8. 8	8. 9
	32–44	1. 13	8. 9	8. 8
61	0–8	. 35	8. 5	8. 4
	8–20	. 16	8. 5	8. 3
	20–32	. 11	8. 5	8. 2
	32–44	. 09	8. 4	8. 2
62	0–8	. 75	9. 0	8. 9
	8–20	. 35	8. 5	8. 6
	20–32	. 19	8. 5	8. 6
	32–44	. 12	8. 4	8. 6
63	0–8	. 56	8. 5	8. 5
	8–20	. 69	8. 5	8. 5
	20–32	. 99	8. 8	8. 8
	32–44	. 65	8. 5	8. 5
64	0–8	2. 50+	8. 8	9. 0
	8–20	1. 46	8. 8	8. 9
	20–32	1. 36	8 8	8. 9
	32–44	1. 46	8. 8	8. 7
65	0–8	1. 64	8. 5	8. 6
	8–20	. 87	8. 6	8. 6
	20–32	. 84	8. 5	8. 6
	32–44	. 70	8. 5	8. 5
66	0–8	. 16	7. 8	8. 0
	8–20	. 21	7. 8	7. 8
	20–32	. 33	8. 2	8. 1
	32–44	. 40	8. 2	8. 1
67	0–8	1. 73	8. 7	8. 7
	8–20	1. 73	8. 7	8. 9
	20–32	1. 54	8. 8	9. 0
	32–44	------	------	
68	0–8	2. 42	8. 8	8. 9
	8–20	1. 14	8. 8	9. 0
	20–32	1. 19	8. 9	9. 1
	32–44	. 82	8. 7	8. 9

TABLE 7.—*Soluble salts and pH of soil paste and 1:5 soil-water suspension for soil samples taken in the Grand Junction Area, Colo.*—Con.

Sample No.	Depth	Total soluble salts	pH	
			Saturated paste	1:5 soil-water suspension
	Inches	*Percent*		
69	0–8	0.49	8.0	8.8
	8–20	.80	8.2	8.3
	20–32	1.34	8.1	8.2
	32–44	1.25	8.2	8.3
70	0–8	.80	8.6	9.2
	8–20	1.05	8.6	8.3
	20–32	1.45	8.6	8.2
	32–44	2.16	8.3	8.1
71	0–8	.13	8.1	8.1
	8–20	.44	8.1	8.2
	20–32	.46	8.3	8.3
	32–44	.68	8.3	8.6
72	0–8	1.98	8.6	8.6
	8–20	1.26	8.5	8.5
	20–32	1.23	8.5	8.5
	32–44	1.16	8.6	8.7
73	0–8	.29	8.0	8.0
	8–20	.24	8.0	7.9
	20–32	.44	8.2	8.1
	32–44	.70	8.6	8.8
74	0–8	1.05	8.9	8.9
	8–20	1.73	8.9	9.0
	20–32	1.83	8.8	8.8
	32–44	1.00	8.8	8.8
75	0–8	.19	8.0	8.1
	8–20	.29	8.0	8.1
	20–32	.35	8.1	8.1
	32–44	.34	8.1	8.0
76	0–8	2.21	8.5	8.6
	8–20	1.55	8.4	8.6
	20–32	1.83	8.5	8.7
	32–44	1.18	8.5	8.7
77	0–8	2.50+	8.5	9.0
	8–20	1.63	8.7	9.4
	20–32	1.18	8.8	9.6
	32–44	1.18	8.9	9.6
78	0–8	.20	8.1	7.9
	8–20	.23	7.7	8.0
	20–32	.23	7.9	8.2
	32–44	.29	7.8	8.0
79	0–8	2.50+	8.0	8.2
	8–20	1.70	8.3	8.6
	20–32	1.39	8.4	8.6
	32–44	.97	8.2	8.5
80	0–8	2.50+	8.4	8.7
	8–20	1.51	8.6	8.8
	20–32	1.84	8.4	8.6
	32–44	.62	8.4	8.4
81	0–8	2.05	8.7	9.0
	8–20	1.40	8.8	9.0
	20–32	.98	8.8	8.8
	32–44	.69	8.8	8.7
82	0–8	.65	8.5	8.8
	8–20	.30	8.1	8.1
	20–32	.20	8.0	8.0
	32–44	.44	8.2	8.2

TABLE 8.—*Physical and chemical characteristics of soils sampled in the Grand Junction Area, Colo.*

[Determinations by U. S. Salinity Laboratory, Riverside, Calif. Sample sites shown on soil map by letters in blue]

Soil type and location	Depth	SP [1]	Total soluble salts [2]	EC_2 [3]	pH [4]			SSP [5]	BEC [6]	ESP [7]	Gypsum [8]	Permeability		Field infiltration
					Paste	1:10	1:60					Initial	Final	
	Inches	*Percent*	*Percent*	*Mmhos/cm.*							*Tons per acre*	*Cm./hr.* [9]	*Cm./hr.* [9]	*Cm./hr.* [9]
Billings silty clay loam (site A).	0–6	53	3. 00	102. 1	8. 2	8. 9	8. 5	65	9. 0	51. 8	45	0. 12	. 15	0. 04
	6–12	55	2. 36	46. 7	8. 7	9. 1	8. 9	67	9. 1	38. 9	------	. 15	. 20	------
	12–24	50	1. 74	35. 5	8. 7	9. 2	8. 9	68	------	36. 6	------	. 10	. 16	------
	24–36	47	1. 20	25. 1	8. 6	8. 9	8. 5	67	7. 9	31. 6	30	. 13	. 23	------
	36–48	49	1. 13	22. 7	8. 5	8. 9	8. 5	67	------	30. 9	------	. 11	. 16	------
Billings silty clay loam (400 feet south and 50 feet east of site A).	0–6	42	. 34	7. 64	7. 9	8. 8	8. 9	57	11. 9	15. 2	------	2. 03	1. 83	. 13
	6–12	56	. 8	18. 2	7. 7	8. 4	9. 1	52	------	18. 9	4. 5	. 88	. 83	1. 12
	12–24	56	1. 14	23. 2	7. 6	8. 3	8. 9	46	14. 5	18. 0	------	. 37	. 73	------
	24–36	50	1. 09	23. 0	7. 7	8. 2	8. 6	45	6. 9	17. 6	27	. 27	. 31	------
	36–44	50	. 82	18. 8	8. 0	8. 5	8. 7	51	------	19. 8	------	. 44	. 44	------
Hinman clay loam (site B)	0–9	40	. 10	1. 98	7. 7	8. 6	9. 2	27	16. 9	2. 96	------	5. 60	4. 65	9. 7
	9–14	44	1. 07	. 728	7. 8	8. 9	9. 2	39	------	2. 76	------	4. 50	3. 17	6. 6
	14–30	36	. 06	. 778	8. 0	9. 1	9. 3	46	10	3. 53	7	5. 58	4. 81	------
	30–48	30	. 05	. 847	7. 9	9. 2	9. 3	49	------	4. 04	------	9. 64	8. 60	------
Hinman clay loam (site C)	0–3	34	3. 0	106. 2	8. 4	8. 9	8. 6	88	------	71. 2	------	3. 27	3. 54	------
	3–20	38	1. 67	40. 6	8. 3	9. 1	9. 0	66	12	37. 8	19	. 84	. 97	4. 3
	20–30	36	. 67	20. 5	8. 5	9. 2	9. 1	69	------	30. 8	6. 5	3. 81	3. 80	2. 5
	30–48	56	. 69	12. 4	8. 2	9. 0	9. 0	54	23. 9	18. 1	------	. 94	1. 21	------
Thoroughfare fine sandy loam (site D).	0–8	30	. 28	10. 6	8. 6	8. 9	8. 9	50	------	15. 8	------	12. 9	12. 1	8. 4
	8–20	27	. 24	9. 70	8. 7	9. 2	9. 2	52	3. 85	15. 7	0	4. 1	4. 0	13. 5
	20–32	28	. 24	9. 28	8. 9	9. 4	9. 4	56	------	17. 2	0	2. 32	2. 39	------
	32–48	29	. 15	5. 96	8. 6	9. 5	9. 4	63	------	15. 9	------	------	------	------

Thoroughfare fine sandy loam (site E).	0–8	28	.06	1.71	7.9	------	------	23	7.8	2.42	0	14.6	14.3	9.6
	8–20	33	.06	1.37	8.0	9.2	9.3	28	------	2.68	------	7.1	6.85	------
	20–32	28	.03	.988	8.1	9.2	9.4	31	3.3	2.58	0	5.04	5.17	------
	32–48	27	.03	.845	8.3	9.3	9.4	34	------	2.55	------	8.40	8.25	------
Billings silty clay (site G)	0–8	42	.76	19.2	8.9	10.0	------	94	------	58.5	0	.013	.001	.30
	8–20	50	1.31	28.4	8.9	9.6	------	88	10.8	51.9	0	.035	.009	.33
	20–32	66	2.28	29.7	9.0	9.4	9.2	87	------	52.4	0	.14	.33	------
	32–48	58	2.62	35.6	9.0	9.4	9.1	86	------	54.1	------	.16	.30	------
	[10]15–60	55	3.00	69.0	8.9	9.2	9.1	93	7.4	72.8	5	------	------	------
Persayo and Chipeta silty clay loams (site H).	0–8	34	.05	1.45	8.4	9.2	9.2	44	6.1	4.74	0	1.36	1.04	------
	8–16	50	.14	2.68	8.1	9.0	9.1	29	------	3.77	0	1.32	1.11	------
	16–24	64	.22	3.51	8.0	8.8	9.0	15	------	2.45	------	2.88	2.43	------
Mack clay loam (site I)	0–8	32	.10	2.53	7.8	8.8	9.0	28	------	3.57	------	3.48	3.40	------
	8–16	44	.05	.893	8.1	9.1	9.1	43	------	3.57	------	5.68	5.07	------
Billings silty clay loam (site J).	0–8	50	.55	12.2	7.8	8.5	8.9	39	9.7	11.4	0	1.14	.86	------
	8–20	48	.20	4.05	8.0	8.9	9.1	38	------	6.58	------	.81	.62	------
	20–32	44	.21	4.47	7.9	8.5	8.8	27	------	4.96	------	.98	.89	------
	32–48	48	.24	4.98	7.9	8.3	8.5	28	12.8	5.53	------	.60	.54	------
Billings silty clay (site L)	0–8	54	.22	5.15	7.9	------	------	37	15.6	7.04	0	1.98	1.62	------
	8–19	60	.83	16.7	8.2	8.7	8.6	61	------	23.5	70	.88	.85	------
	19–32	50	.90	20.2	8.4	8.9	8.8	62	------	23.7	58	.45	.47	------
	32–48	54	1.02	21.0	8.2	8.7	8.7	67	------	29.4	------	.35	.38	------
Ravola fine sandy loam (site N).	0–8	36	.10	2.57	7.3	------	------	47	------	7.14	------	1.30	.97	------
	8–20	38	.05	1.26	7.4	9.1	9.1	47	------	4.53	------	.98	.80	------
	20–32	46	.05	1.02	7.4	9.0	9.2	53	------	5.07	------	.77	.64	------
	32–48	46	.06	1.01	7.4	9.0	9.2	50	------	4.49	------	.74	.67	------

[1] Percentage of moisture at saturation.
[2] Total soluble salts, expressed as a percentage of the air-dry weight of the soil.
[3] Electrical conductivity of extract from the saturated paste expressed in millimhos per centimeter.
[4] pH of saturated pastes and of 1:10 and 1:60 soil-water suspensions.
[5] Soluble sodium expressed as percentage of saturation extract.
[6] Base exchange capacity expressed in milliequivalents per 100 grams of oven-dry soil.
[7] Percentage of exchangeable sodium.
[8] Gypsum by chemical analyses.
[9] Divide by 2.54 to convert to inches per hour.
[10] In feet.

TABLE 9.—*Ionic contents of saturation extracts from soil samples of the Grand Junction Area, Colo.*

[Determinations by U. S. Salinity Laboratory, Riverside, Calif. Sample sites shown on soil map by letters in blue]

Soil type and location	Depth	Ionic content of saturation extract in milliequivalents per liter: Cations				Anions				Sum of cations	Sum of anions	Total [1] soluble salts
		Na^{+}	K^{+}	Ca^{++}	Mg^{++}	HCO_3^{-}	Cl^{-}	SO_4^{--}	NO_3^{-}			
	Inches											*Percent*
Billings silty clay loam (site A).	0–6	1, 356	6. 0	30. 7	688	3. 2	1, 026	1, 030	77	2, 081	2, 136	7. 32
	6–12	450	2	35. 6	189	1. 7	365	292	14	676	673	2. 47
	12–24	346	2	30. 0	132	1. 5	244	268	12	509	525	1. 68
	24–36	232	2	26. 6	87. 1	1. 2	124	225	5. 3	347	355	1. 08
	36–48	218	2	27. 1	82. 2	1. 5	103	233	3. 5	328	341	1. 07
Billings silty clay loam, 400 feet south, 50 feet east of site A.	0–6	51. 7	1. 5	18. 9	18. 8	3. 7	41. 6	42. 1	2. 7	90. 0	90. 1	. 25
	6–12	110	1	56. 1	43. 5	1. 5	153	51. 9	14	210	220	. 78
	12–24	125	1	80. 5	69. 1	. 8	208	48. 6	29	274	286	1. 02
	24–36	124	1	68. 2	84. 7	1. 4	192	58. 8	39	277	291	. 92
	36–44	123	1	38. 2	78. 7	1. 9	116	109	49	240	276	. 80
Hinman clay loam (site B).	0–9	5. 67	1	11. 5	4. 02	2. 0	12. 7	10. 8	6. 2	21. 2	31. 7	. 06
	9–14	2. 83	1	3. 24	1. 24	2. 0	1. 77	3. 95	. 3	7. 31	8. 02	. 02
	14–30	3. 56	1	2. 90	1. 36	2. 2	1. 82	4. 03	. 2	7. 82	8. 25	. 02
	30–48	4. 11	1	2. 86	1. 39	2. 0	1. 82	4. 63	. 2	8. 36	8. 65	. 02
Hinman clay loam (site C).	0–3	2, 741	20. 2	32. 2	328	8. 6	169	2, 780	153	3, 121	3, 110	7. 04
	3–20	416	2	30. 6	180	2. 0	140	419	129	627	689	1. 58
	20–30	193	2	25. 5	59. 0	1. 2	61. 6	207	32	278	302	. 66
	30–48	92. 9	1	25. 1	54. 4	1. 0	30. 0	132	16	172	179	. 64
Thoroughfare fine sandy loam (site D).	0–8	72. 5	5	25. 1	42	2. 8	11	128	8. 9	145	151	. 29
	8–20	63	7. 4	24. 7	26. 7	1. 6	11. 4	114	10. 6	122	137	. 22
	20–32	67. 2	4. 6	11. 6	35. 7	1. 6	10. 1	109	3. 5	119	124	. 22
	32–48	45. 3	1. 4	6. 64	19. 2	2. 6	5. 85	62. 7	1. 6	72. 5	72. 7	. 14

Thoroughfare fine sandy loam (site E).	0–8	4. 45	1	9. 42	5. 10	2. 7	1. 53	12	5. 3	19	21. 5	. 035
	8–20	4. 24	1	7. 06	3. 65	1. 8	1. 43	12. 9	1. 6	14. 9	17. 7	. 033
	20–32	3. 39	1	4. 70	2. 96	1. 8	. 88	8. 95	. 2	10. 8	11. 8	. 020
	32–48	3. 02	1	3. 60	2. 20	1. 9	. 69	7. 58	1. 4	8. 82	11. 6	. 016
Billings silty clay (site G).	0–8	234	2	6. 69	5. 71	3. 3	38. 4	222	4. 4	248	268	. 69
	8–20	341	2	21. 9	23. 2	2. 2	51. 6	336	. 7	388	390	1. 29
	20–32	390	2	22. 3	34. 4	1. 5	43. 2	445	1. 1	445	491	1. 95
	32–48	490	2	23. 1	55. 5	1. 7	21. 6	546	. 4	5. 69	569	2. 19
	15–60	1, 040	2	28. 7	52. 7	2. 5	10. 0	1, 220	[2]	1, 221	1, 232	4. 44
Persayo and Chipeta silty clay loams (site H).	0–8	6. 76	1	5. 02	3. 46	3. 1	2. 66	10. 3	1. 6	15. 2	176	. 034
	8–16	8. 53	1	12. 6	8. 82	1. 5	11. 4	18. 3	1. 1	29. 9	32. 3	. 10
	16–24	7. 67	1	25. 6	16. 5	1. 4	2. 51	48. 2	[2]	49. 8	52. 1	. 21
Mack clay loam (site I)	0–8	7. 87	1	14. 2	6. 20	2. 1	7. 37	16. 6	3. 5	28. 3	29. 6	. 06
	8–16	4. 18	1	3. 24	2. 36	2. 1	3. 68	3. 01	. 3	9. 8	9. 1	. 03
Billings silty clay loam (site J).	0–8	56	1	57. 1	31. 8	1. 5	73. 2	44. 2	48	145	166	. 48
	8–20	17. 8	1	19. 1	9. 7	1. 5	16. 2	26. 7	3. 5	46. 6	47. 9	. 15
	20–32	16. 1	1	29. 3	13. 5	1. 3	11. 6	45. 6	. 9	58. 9	59. 4	. 17
	32–48	19. 2	1	28	20. 5	2. 1	3. 64	55. 9	1. 7	67. 7	63. 3	. 22
Billings silty clay (site L)	0–8	21. 8	2	19. 6	17. 8	3. 3	18. 2	42. 8	[2]	59. 2	64. 3	. 21
	8–19	134	2	26. 4	58. 6	1. 9	71. 5	154	[2]	219	227	. 87
	19–32	135	2	25. 5	59. 4	1. 3	90. 5	186	[2]	220	277	. 91
	32–48	192	2	25. 1	70. 1	1. 8	85. 8	211	[2]	287	298	1. 02
Ravola fine sandy loam (site N).	0–8	14. 6	1	12. 2	3. 98	2	11. 96	11. 5	7. 1	30. 8	32. 5	. 07
	8–20	5. 57	1	4. 52	1. 69	1. 8	5. 31	5. 32	1. 3	11. 8	13. 7	. 03
	20–32	5. 63	1	3. 48	1. 51	1. 8	3. 40	5. 66	1. 6	10. 6	12. 4	. 03
	32–48	5. 05	1	3. 32	1. 88	1. 8	3. 59	5. 20	. 3	10. 2	10. 9	. 03

[1] Percentage of soluble salt, air-dry soil basis, calculated from the saturation percentage and cation concentration of the saturation extract.

[2] Trace.

TABLE 10.—*Chemical analyses of water from the Grand Junction Area, Colo.*

[Determinations by U. S. Regional Salinity Laboratory, Riverside, Calif.]

Kind of water sampled	Sampling site	EC_e	Milliequivalents per liter										Total salt	SSP[1]
			Cations				Anions				Sum cations	Sum anions		
			Na^+	K^+	Ca^{++}	Mg^{++}	HCO_3^-	Cl^-	SO_4^{--}	NO_3^-				
		(Millimhos)											*Percent*	
Irrigation	Lateral near site A.	1. 18	5. 74	([2]) <1	3. 07	2. 14	2. 21	4. 46	4. 23	0. 0	10. 95	10. 90	0. 072	53
Ground	Hole at site A	39. 6	384. 5	<1	24. 2	173. 5	5. 88	189. 8	412. 0	5. 6	582. 2	613. 3	3. 87	66
Drainage	Drain near site A	1. 50	7. 54	<1	4. 71	2. 04	3. 03	5. 79	6. 48	([3])	14. 29	15. 30	. 095	53
Irrigation	Lateral near site B.	1. 20	6. 20	<1	3. 31	2. 29	. 92	5. 33	4. 66	([3])	11. 80	10. 91	. 078	53
Ground	Hole at site B	4. 00	13. 6	<1	26. 3	14. 5	1. 38	7. 82	45. 3	. 5	54. 46	55. 00	. 36	25
Drainage	Drain near site C	4. 28	20. 3	<1	16. 2	19. 2	1. 56	7. 68	46. 7	. 6	55. 73	56. 54	. 37	37
Irrigation	Lateral near site D.	1. 98	7. 80	<1	8. 82	7. 06	1. 84	1. 10	21. 1	. 3	23. 68	24. 34	. 157	33
Irrigation	Lateral near N¼ sec. 9, T. 1 S., R. 9 E.	1. 15	5. 88	<1	3. 13	2. 50	2. 30	4. 78	4. 21	------	11. 51	11. 29	. 076	51

[1] Percentage soluble sodium.
[2] <=less than.
[3] Trace.

MORPHOLOGY AND GENESIS OF SOILS

Soils are formed by the forces of the environment acting upon soil materials deposited or accumulated by geological agencies. The characteristics of a soil at any particular place are determined by (1) the climate under which the soil material has accumulated and has existed since accumulation; (2) the physical and mineralogical composition of the parent material; (3) the relief, or lay of the land, which influences drainage, moisture content, aeration, susceptibility to erosion, and exposure to sun and the elements; (4) the biological forces acting upon the soil material—the plants and animals living in and on the soil; and (5) the length of time the climatic and biological forces have acted upon the soil material.

CLIMATE AND VEGETATION

Climate and vegetation profoundly influence soil formation in more humid areas but have minimum influence in a desert environment such as that of the Grand Junction Area. The area occupies a moderately narrow part of the Grand Valley, which is in the Gray Desert soil zone. The average yearly precipitation, about 9.1 inches, supports sparse semidesert vegetation consisting of desert shrubs, a few flowering plants, scattered grasses, and a few trees on the bottom lands along the Colorado River. Owing to the desert environment, the soils have certain general characteristics in common with most soils of other intermountain valleys of western Colorado and eastern Utah. Some of them classify as zonal, or normal, soils of the region. These are the older soils on the high mesas; they are light colored, low in organic matter, highly calcareous, well drained, and sufficiently permeable to meet the requirements of the climatically suited field and orchard crops.

In contrast, many soils of the Grand Junction Area are azonal, or not typical or normal for the region they occupy. Because of their youth or conditions of parent material or relief, they have not developed profile characteristics normal for the environment in which they occur. These soils, especially those of the Billings and Green River series, generally contain salts, alkali, or both in quantities detrimental to ordinary field crops grown under irrigation, unless both surface drainage and underdrainage are sufficiently free to prevent the rise of harmful quantities of salts. As a rule, if surface drainage and underdrainage are adequate, the salts have little harmful affect after the first 2 or 3 years of cultivation.

RELIEF AND TIME

Relief, or physiographic position, is an important factor in soil development. It may greatly influence erosional activity, as well as surface and internal drainage. Because of differences in relief, some soils have been subjected to soil development a much greater length of time than others. The soil materials on the mesas of this area have been developing a much greater length of time than those on the lower slopes or alluvial flats. Consequently, the soils at these higher levels are older and their horizons are more differentiated. The materials on the lower alluvial fans and flood plains have been in place a shorter time and have been only slightly modified; therefore, the soils in these positions show little horizon differentiation or none at all.

PARENT MATERIAL

The nature of the parent material greatly influences the characteristics of soils in the Grand Junction Area. All the soils of the area except those of the Persayo and Chipeta series have developed from alluvium. Those on the higher mesas have developed from old alluvium deposited in the geologic past, and those on the lower fans and flood plains, from more recent alluvium.

The surface geology of the mountainous country bordering the Grand Valley and of the river canyons that open into the valley ranges from comparatively recent to very old in geologic time (see fig. 3, p. 8). It is obvious that the soils of alluvial origin are derived from many parent rocks belonging to several geologic formations.

The extreme in geologic variation is demonstrated in the terrain that flanks the valley to the southwest. Owing to the Uncompahgre uplift, this terrain consists of numerous exposures of formations that would normally lie well below the 4,000-foot thick Mancos shale formation on which the major part of the Grand Valley is situated. Since this uplift of the far distant past, and the joining of the Colorado and Gunnison Rivers that followed the uplift, the forces of weathering and erosion have removed most of the higher formations, and to the north of the fault have carved out a huge slice of Mancos shale and formed the Grand Valley of the Colorado.

Occasional exposures south and southwest of the Uncompahgre fault line indicate the vastness of the geologic changes. They show formations dating back to the pre-Cambrian era, as well as those less ancient, such as the Mancos shale and formations overlying that shale to the east. These exposures are equivalent to a slice of the earth's crust nearly 2 miles deep. Thus, many geologic formations or four distinct geologic eras have contributed materials to the soils along the southern and southwestern part of the Grand Junction Area. Elsewhere in the valley, the Mancos shale formation is the dominant source of soil material.

The soil series of the Grand Junction Area and the important materials and geological formations that have given rise to them are listed as follows:

Chipeta and Persayo series:
: Residual from Mancos shale, which includes both clayey shale and lenses of silt and very fine sandy shale.

Mack and Fruita series:
: Moderately old to old alluvium on mesas; material derived mainly from the sandy members of the Mesaverde group, which includes the Hunter Canyon and Mount Garfield formations, but also derived partly from Mancos shale.

Billings, Mayfield, and Ravola series:
: Recent alluvium from Mancos shale, but includes some fine sand and clay material from the Mesaverde group.

Mesa, Hinman, Navajo, and Genola series:
: Old alluvium deposited mainly on the high terrace known as Orchard Mesa; derived mainly from mixed igneous, sandstone, and shale alluvial materials washed from local high mountainous terrain or from the upper watershed of the Colorado River, but includes some admixture of fine sand, silt, and clay derived from the Green River, Wasatch, Hunter Canyon, Mount Garfield, and Mancos shale formations.

Thoroughfare and Redlands series:
Alluvium on fans and terraces in the Redlands section; material derived largely from fine-grained sandstone of the Dakota, Morrison, Summerville, Entrada, and Kayenta formations but has considerable admixture of material from gneissoid granites, porphyritic granites, amphibolites, pegmatites, and schist of the pre-Cambrian rocks upheaved by the Uncompahgre uplift.

Soils of these series also contain some material from the Chinle formation, which consists mainly of reddish sandstone, silty sandstone, shale, and argillaceous red limestone. The Chinle formation lies immediately above the pre-Cambrian rocks, and the alluvial material from it accentuates the reddish color of the soils (*2*).

Green River and Naples series:
Recent alluvium derived mainly from sandstone members occurring above the Mancos shale but including some materials from shale and from mica-bearing igneous rock. Bodies of these soils located below the confluence of the Colorado and Gunnison Rivers contain at least slight quantities of sediments from the formations exposed in the Uncompahgre uplift.

As can be seen from the foregoing the geologic formations contributing to the parent alluvium of the soils in the Grand Junction Area are unusually varied. Equally varied are the colors of these formations. The sandstones may be red, purple, buff, yellow, or white; the shales, red, purple, white, gray, green, olive, yellow, and buff; the granites, red, gray, and dark colored; the volcanic lavas, gray and red; the limestones, reddish, purplish, and gray; and the gneiss, schist, and other rocks of the pre-Cambrian era, variably colored. Except for the shale, these different materials and colors are represented in the cobbly substratum of the soils of the Redlands, the Vinelands, Orchard Mesa, and the lowlands bordering the Colorado River.

CLASSIFICATION OF SOILS

The soil series of the Grand Junction Area have been classified by order and great soil group as shown in table 11. The zonal order is represented by one great soil group, the Gray Desert. The azonal order is represented by two great soil groups, the Lithosol and the Alluvial.

ZONAL SOILS

The zonal soils of this area are the Mesa, Hinman, Redlands, Fruita, and Mack. They belong to the Gray Desert great soil group. They occupy the higher terraces or mesa positions, have reached the most conspicuous stage of horizon differentiation in the locality, and may be considered as the normal (or zonal) soils of the area. All of them have developed from old alluvium, as they lie 20 to 150 feet above the more recently formed alluvial soils and have not received deposits of alluvial material for a long time.

It is apparent that the soils on the high mesas have formed from alluvium deposited during different flood periods in the early history of the valley; that is, before the streams of the valley had cut down to the present level. Reliable evidences of older, higher stream levels can be observed: (1) wide ranges in elevation from one mesa to another; (2) successive bench levels on a single mesa, such as the levels on Orchard Mesa; and (3) a substratum under the soils consisting of immense quantities of waterworn stone, caliche, gravel, and sand that has been deposited on an uneven basement indicative of former surface features.

TABLE 11.—*Soil series of the Grand Junction Area, Colo., arranged by soil orders and great soil groups, and some of the important characteristics of each series*

Great soil group and soil series	Topographic position	Parent materials	Natural drainage		Subsoil	
			Surface runoff	Internal	Consistence (dry)	Permeability
ZONAL SOILS						
Gray desert:						
Mesa	Mesas	Old alluvium from mixed igneous, sandstone, and shale materials.	Slow to rapid	Medium	Slightly hard	Moderate.
Hinman	do	do	Slow to medium.	Very slow to slow.	Hard	Very slow to slow.
Redlands	do	Old alluvium from sandstone, granites, shale, basalt, schist, and so on.	Slow to rapid	Medium	Slightly hard	Moderate.
Fruita	do	Old alluvium principally from sandstone, but partly from shale.	do	do	Medium	Do.
Mack	do	do	Slow	do	do	Do.
AZONAL SOILS						
Lithosol:						
Persayo	Uplands	Residuum from silty and clayey shales (Mancos shale).	Slow to medium.	Very slow	(1)	(1).
Chipeta	do	do	Slow to rapid	do	(1)	(1).
Alluvial:						
Billings	Recent alluvial fans	Recent alluvium mainly from Mancos shale; some sandstone.	Slow to very slow.	Very slow to medium.	Hard	Slow to very slow.

Ravola	do	Recent alluvium mainly from sandstone and shale.	Slow to medium.	Medium	Slightly hard	Moderate.
Mayfield	do	do	Medium	do	do	Do.
Green River	Flood plains of Colorado River.	Recent alluvium from mixed igneous sandstone, and some shale rocks.	Slow	Medium to rapid.	do	Moderate to rapid.
Thoroughfare	Recent alluvial fans and local stream flood plains.	Recent alluvium from sandstone, granites, and some shale.	Slow to medium.	Somewhat rapid.	Soft	Rapid.
Genola	do	Recent alluvium from mixed igneous sandstone and shale rocks.	do	Medium	Slightly hard	Moderate.
Navajo	do	Recent alluvium mainly from shale, sandstone, and granitic rocks.	Slow	Very slow	Very hard	Very slow.
Naples	do	Recent alluvium from sandstone and some shale.	do	Medium to rapid.	Slightly hard	Moderate to rapid.

See footnotes at end of table.

TABLE 11.—*Soil series of the Grand Junction Area, Colo., arranged by soil orders and great soil groups, and some of the important characteristics of each series*—Continued

ZONAL SOILS

Great soil group and soil series	Lime distribution		Color (dry)		Associated soils
	Surface soil	Subsoil	Surface soil	Subsoil	
Gray desert:					
Mesa	Well disseminated.	High accumulation; considerable segregation.	Pale brown, very pale brown, or light brown.	Reddish yellow to light brown.	Hinman, Genola.
Hinman	do	Moderately high accumulation.	Light or pale brown	Very pale brown	Mesa, Genola.
Redlands	do	High accumulation; considerable segregation.	Light brown to light reddish brown.	Light brown to pink	Thoroughfare.
Fruita	do	do	Light brown and pale brown to light reddish brown.	Very pale brown, light brown, or light reddish brown.	Mack.
Mack	do	do	Light brown to light reddish brown.	(2)	Fruita.

AZONAL SOILS

Great soil group and soil series	Lime distribution: Surface soil	Lime distribution: Subsoil	Color (dry): Surface soil	Color (dry): Subsoil	Associated soils
Lithosol:					
Persayo	Well disseminated.	(1)	Pale yellow	(1)	Chipeta, Ravola, Billings.
Chipeta	do	(1)	Gray to light gray	(1)	Persayo, Billings, Ravola.
Alluvial:					
Billings	do	Calcareous, but lime well disseminated.	Light brownish gray, gray, or light olive gray.	Gray to olive gray	Ravola, Chipeta, Persayo, Green River.

Ravola	do	do	Very pale brown to light brown.	Very pale brown	Billings, Chipeta, Persayo, Green River.
Mayfield	do	do	Light yellowish brown to light olive gray.	Light yellowish brown to light olive gray.	Billings, Chipeta, Persayo.
Green River	do	do	Pale brown to light brownish gray.	Very pale brown to light brownish gray.	Billings, Ravola, Navajo.
Thoroughfare	do	Calcareous; lime slightly segregated in places.	Light brown to light reddish brown.	Light brown to light reddish brown.	Redlands.
Genola	do	Highly calcareous; some lime segregation in places.	Very pale brown to light yellowish brown.	Very pale brown to light yellowish brown	Mesa, Hinman.
Navajo	do	Calcareous; lime well disseminated.	Light brown to light reddish brown.	Light brown to light reddish brown.	Green River, Naples.
Naples	do	do	Light brown	Light brown	Navajo.

[1] Subsoil absent.
[2] Color similar to that of surface soil.

In their virgin condition the soils developed from old alluvium have a brown, pale-brown, or very pale-brown color that reflects their low content of organic matter and the presence of oxidized, relatively unhydrated, iron compounds. The subsoils have a moderate concentration of clay or of highly colloidal light reddish-brown material, which has been derived through the hydrolytic decomposition and subsequent dehydration of certain minerals in place, principally the feldspars and hornblende. It is likely that the clay concentration in the subsoils has been augmented by the infiltration of at least part of the finer particles from the surface soil. It is to be expected that some infiltration would occur, even under the low precipitation prevailing in this area.

These soils from older alluvium invariably show the maximum lime accumulation. The zone of high lime accumulation begins in the clay horizon, or immediately below it. The lime may occur in different kinds of segregations, such as seams, veins, spots, soft nodules, splotches, or nearly white masses. The lime zone in some of the soils of the high mesas varies considerably in intensity of accumulation from place to place.

Mesa series [7]

The soils of the Mesa series are representative of the group of soils developed from old alluvium on higher mesas. The following profile, which describes Mesa clay loam as it commonly occurs on a large part of Orchard Mesa, was taken 7 miles east of Grand Junction in an open virgin field that had 3 percent slopes (sec 24., T. 1 S., R. 1 E.):

A_{11} 0 to 1½ inches, light-brown when dry, brown when moist, soft calcareous fine sandy loam; a few small waterworn pieces of gravel and round cobblestones thinly scattered on the surface; layer has weak platy vesicular structure in place but crumbles easily into very fine granules.

A_{12} 1½ to 3 inches, light-brown when dry, reddish-brown when moist, calcareous loam containing a few pieces of fine gravel; material nearly loose in place and of moderately fine or very fine granular structure.

B_1 3 to 12 inches, light reddish-brown when dry, reddish-brown when moist, calcareous light clay loam in wavy horizontal layer 6 to 9 inches thick; material exhibits weak prismatic or medium blocky structure in place, but breaks out in weak prismatic or medium subangular blocky structure, and finally into weak to moderately coarse granules; a few fine veins of limy material noticeable in lower part.

B_{2ca} 12 to 27 inches, light brownish-gray to pink clay loam ranging from 12 to 18 inches in thickness and averaging about 15 inches; material has medium subangular blocky structure and is hard when dry but friable when moist; segregated lime occurs as pinkish-white veins, irregular seams, and splotched masses that together account for 50 to 80 percent of the soil material; this is the layer, or zone, of maximum lime accumulation.

B_{3ca} 27 to 30 inches, very pale-brown strongly calcareous clay loam of weak medium subangular blocky structure; friable when moist; lime markings similar to those in layer above but less conspicuous.

C_{cacs} 30 to 42 inches, pale-yellow strongly calcareous and gypsiferous clay loam of massive structure; hard when dry but friable when moist; scattered gravel and cobblestones in lower part; a few rather thick lime seams extend downward through layer.

D 42 to 60 inches +, pale-yellow, soft to nearly loose, strongly calcareous gravelly and cobbly clay loam, the depth of which was not determined at this location.

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[7] Color and consistence terms used in this section are for dry soil unless otherwise stated.

The cobbly or gravelly substratum is important because it facilitates underdrainage and prevents harmful rise of salts. The depth of the substratum is variable from place to place, as it depends upon the surface slope and irregularities in the underlying Mancos shale. The substratum material was deposited by overflow waters from the Colorado River. At the steep escarpment adjacent to the Colorado River, the gravelly or cobbly substratum reaches a maximum thickness of about 20 feet, but along the southern border of Orchard Mesa, below the upper irrigation canal, it is only 8 or 10 feet deep. Probably the average thickness for the substratum is somewhere between 8 and 10 feet.

The gravel and cobblestones in the substratum are smooth, well rounded, and highly colored. In the upper part of the substratum, encrustations of lime are found on the under side or on the entire lower half of the gravel, cobbles, and stones.

The gravel and cobbles in the substratum consist largely of granite, basalt, sandstone, and lava rock, but some jasper, quartzite, and other kinds of rocks occur. The sandstone, which constitutes between 5 and 10 percent of the substratum, shows that some disintegration of the cobbles and gravel is taking place. Approximately 40 to 60 percent of the substratum is made up of the gravel or cherty fragments; these are mixed with accumulated sands, silt, and clay that together approximate a loam or light clay loam. In the eastern part of Orchard Mesa, sandstone cobbles seem to be most abundant, though there are fairly large percentages of lava rocks and cobbles. Farther down the mesa the sandstone and lava rocks give way to higher percentages of basalts and andesites.

The Mesa soils, in addition to variations in the substratum already discussed, show considerable variation in percentages of clay, silt, fine sand, and gravel in the profile. They also vary in intensity of lime accumulation and in total depth of the soil mantle overlying the gravelly and cobbly substratum. The profile here described is therefore only one of several Mesa profiles that could be considered representative of the Mesa series.

Hinman series

Soils of the Hinman series are closely associated with those of the Mesa series, but apparently they are somewhat younger, or less developed. Hinman soils have very gentle surface features and generally occupy lower positions on Orchard Mesa. In the early stages of valley formation, the Hinman soils apparently were more frequently inundated by water from local drainageways or by backwaters of the Colorado River. This past flooding facilitated the deposit of finer sediments. Probably the more frequent flooding accounts for the generally finer surface soils and subsoils of the Hinman series and way in which the lime accumulations occur. In the Hinman soils, the lime is less splotched and spotted, less concentrated, and at a greater depth than in the Mesa soils.

As can be seen along drainage ditches southeast of Grand Junction, the cobbly and gravelly substratum of the Hinman soils has been covered more deeply than that of the Mesa soils. Ordinarily, the gravelly clay loam lies 4 to 8 feet below the surface in all except a few small unmappable areas. The gravelly and cobbly substratum is considerably thinner than that underlying the Mesa soils.

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Redlands series

The Redlands series occurs along the base of the Uncompahgre uplift in the Redlands section of the Grand Junction Area. Like the associated Thoroughfare soils, it is derived mainly from sandstone and granite materials that have been slightly influenced by shale and limestone. The Redlands soils are moderately developed. They are farther from the base of the steep mountainous terrain than the Thoroughfare soils and are therefore more developed than the Thoroughfare soils. Redlands soils occupy smoother and more nearly level positions and have a slight but apparent accumulation of lime in their subsoils. The lime zone is not so pronounced as in the Fruita or Mesa soils but comparable to or greater than the lime zone in the Hinman soils.

Profile description of Redlands loam:

A_1 0 to 8 inches, light reddish-brown loam; weak medium granular structure and slightly hard consistence; lime is well disseminated.

B_1 8 to 20 inches, light reddish-brown loam slightly more reddish than layer above; rather massive structure; soil breaks easily but not in any particular direction; material is of friable consistence and crumbles easily when moist; some uneven or irregular splotchings of lime.

B_{2ca} 20 to 40 inches, light reddish-brown slightly heavy loam; massive, breaks easily, and is friable when moist; lime splotching is common; color varies from light reddish-brown to pink where lime is highly segregated; small granitic pebbles or fragments containing considerable biotite and quartz are common.

C 40 to 60 inches, light-brown fine sandy loam, highly calcareous and faintly splotched with lime; granitic fragments high in quartz and biotite are common; a few scattered irregularly rounded granitic stones occur in lower part.

Fruita series

The Fruita soils occur north of the Colorado River. They are the most important of the group of soils that overlie Mancos shale. They have developed entirely from sandstone and shale materials. So far as development of the lime zone is concerned, there is wide range in profile development. The sandy Fruita types have a moderate zone of lime accumulation. The clay loam Fruita types have a more pronounced and consistently greater lime accumulation, but generally their zone of lime concentration is thinner and less intense than that in Mack clay loam. In the Fruita series, the clay loam types have a more reddish color than the fine sandy loams. This difference in color is especially evident when the soils are viewed from a roadside.

Representative profile of Fruita clay loam:

A_1 0 to 10 inches, light-brown moderately calcareous loam to light clay loam that is slightly hard but crumbles easily to a weak fine granular mass; material is friable when moist; a few small sandstone fragments are scattered on the surface.

B_1 10 to 20 inches, light-brown or brown, moderately calcareous, slightly hard light clay loam containing a few scattered sandstone fragments and pieces of gravel; some segregated lime appears in veins or spots in lower part of layer.

B_{2ca} 20 to 40 inches, very pale-brown loam highly impregnated with lime in rather indistinct spotty pattern; spots or splotches are grayish white or pink when moist; dry soil is slightly hard but breaks easily and becomes friable when moist.

C_{ca} 40 to 68 inches, pink to pinkish-white (light-brown when moist) light clay loam to fine sandy clay; contains a few pieces of fragmental to rounded sandstone gravel; layer is strongly impregnated with disseminated lime and slightly hard when dry but friable when moist.

C 68 to 72 inches, light-brown fine sandy loam; strongly calcareous, the lime being well disseminated but less abundant than in the C_{ca} horizon.

Ordinarily, the lower part of the substratum of the Fruita soils contains a layer of partly rounded sandstone rocks and gravel. The depth to this layer varies, and so does the thickness of the layer. It is several feet thick in some places, but in others, especially where the sandy Fruita soils occur, it is almost absent. The Mancos shale that underlies the Fruita soils may occur at depths of 6 to 10 feet in the Fruita clay loams, but commonly it is at depths of 2 to 7 feet in the Fruita very fine sandy loams.

Mack series

The Mack series, represented by Mack clay loam, is similar to the Mesa series. The soil has the same advanced stage of development and is very similar in color, intensity of lime accumulation, and permeability of the layers within the profile. The outstanding difference in the Mack and Mesa soils is in origin of parent material. The Mack soil has developed on alluvium derived principally from sandstone materials mixed with some shale.

The Mack soil has a substratum of stones, gravel, sand, silt, and clay. This substratum varies in thickness but is sufficiently permeable to afford free underdrainage, in spite of the moderately lime cemented layers or lenses. The stones and gravel in the substratum are not smooth or well rounded (pl. 3, *B*). They consist almost entirely of sandstone.

A few small hard pebbles of jasper, some sandstone gravel, and an occasional small flat piece of scoria are scattered over the surface of the Mack soil. The scoria appears to be baked shale fragments that eroded long ago from burnt beds of coal along the former front of the Book Cliffs to the north.

AZONAL SOILS

The azonal soils of the Grand Junction Area belong to two great soil groups, the Lithosol, and the Alluvial. The Lithosol group is represented by two soil series, the Persayo and Chipeta, which are upland soils that have developed in place from residuum left by weathering of shale rocks.

The Alluvial soils group is represented by seven soil series, the Billings, Ravola, Mayfield, Green River, Thoroughfare, Genola, Navajo, and Naples. All of these soils are on more recent alluvial deposits. They contain calcium carbonate in well-disseminated form. The lime is generally imperceptible or nearly so, in contrast to the conspicuous, definite, light-gray to pinkish-white zone of high lime accumulation existing in the older well-drained soils on the higher mesas. Caliche, or lime-cemented gravel and cobbles, was observed 3 to 6 feet below the surface in places along the border of Mack Mesa and in a few small places on Orchard Mesa, but such conditions are not general. Most of the soils of the valley on recent alluvium, are calcareous from the surface downward. The exceptions are coarse-textured soils, which in some places are neutral in the surface soil, neutral to slightly alkaline in the subsurface layer, and distinctly alkaline in the subsoil. The soils on recent alluvium therefore have not been leached to a shallow depth, considering the depth of leaching common in areas of heavier precipitation.

Persayo and Chipeta series

The Persayo and Chipeta soils are the only residual soils in the Grand Junction Area. They are upland soils and have developed in place on Mancos shale.

The Chipeta soils are dominantly gray and are underlain by predominantly clayey, platy shale fragments which become harder and thicker with increase in depth. At depths of 4 to 5 feet one finds Mancos shale bedrock.

The Persayo soils differ from the Chipeta in having a pale-yellow color, in containing a relatively higher percentage of salts, and in having very few sand particles throughout the profile. The thin laminated shale fragments in the Persayo soil therefore crush more easily and the material is more friable.

The soils of both series contain numerous light-gray particles, lenses, or streaks that indicate the presence of salts. Irregular aggregates of gypsum are common, especially on the surface.

Billings series

The Billings series is the most extensive of several soil series that have developed from more recent alluvial material washed down by intermittent arroyos to the north (pl. 4, A). All the soils on this alluvium may be considered youthful. They belong to the Alluvial great soil group. Most of the parent material has been accumulated because of erosion along the northern rim of the Grand Valley. The soil material was deposited intermittently on a large area because very few natural drainage channels existed before the valley was irrigated. In general, the Billings soils occur on the lower and broader flats north of the alluvium deposited by the Colorado River. In this location the alluvium is deepest and consists of fine sediments derived largely from Mancos shale.

Profile of Billings silty clay loam:

0 to 2½ inches, gray to light-gray slightly hard clay loam; slightly platy structure; moderately calcareous.

2½ to 8 inches, gray to light-gray silty clay loam of thin platy to massive structure; moderately calcareous.

8 to 40 inches, gray to light-gray silty clay loam containing very thin alternate layers of silt loam, loam, and silty clay loam; the layers change in texture with little or no change in color; many irregular, grayish, horizontal seams are traceable in this and succeeding layers, and also a few holes made by angleworms; layer moderately to highly calcareous, but the lime is well disseminated.

40 to 64 inches, light-gray silty clay loam showing thin, faint, horizontal seams that indicate an almost imperceptible gradation of silt loam or loam to silty clay loam; layer is calcareous but the lime is well disseminated; some salt crystals present.

64 to 72 inches +, thin stratified layers ranging from loam to silty clay loam and clay loam in texture and from light brownish-gray to gray and light-gray in color; amount of fine sand grains in the layers increases with depth; salt crystals common; soil material is moderately to rather highly calcareous but the lime is well disseminated.

The foregoing profile description is representative of the Billings soils, but it does not give an idea of the great variation from place to place in the thickness and depth of the thin, stratified layers. Ordinarily, below 72 inches, the soil materials become more sandy as depth increases. An admixture of gravel, cobbles, and water-worn stones is common in the layers directly above the shale. These stones are especially evident where the deposits are thickest, or more than 40 feet thick in some places.

As a rule, the deepest deposits have low gradients (not more than 1 percent); have the finest surface texture; and show consistently finer textures to greater depths. Billings silty clay is mapped on these deepest deposits. It is the most troublesome soil in the Grand Junction Area. Providing adequate subdrainage or removing the salts from such a soil is difficult.

Ravola series

The soils of the Ravola series are young (pl. 4, *B*). They occur on alluvium deposited on somewhat higher rises of the coalescing alluvial fans and stream flood plains. The alluvium comes largely from silty or sandy strata in the Mancos shale formation and from the Mesaverde formation. These materials are more friable and permeable than those of the Billings soils. Consequently, the Ravola soils have better drainage than the Billings. The Ravola soils contain considerable quantities of salts, as do the Billings. Salts are generally easily leached out of Ravola soils, but are extremely difficult to remove from some of the Billings soils.

Mayfield series

The Mayfield series is represented in this area by one mapping unit, Mayfield shaly clay loam, 2 to 5 percent slopes. The soil occurs on recent alluvial fans such as those occupied by Ravola soils. The underlying alluvial accumulations are variable in thickness and texture. Like those of the Ravola series, this is young soil. It is a moderately fine textured soil with a moderately permeable subsoil.

Green River series

The soils of the Green River series differ from those of the Billings and Ravola series in having a more varied mixture of parent materials that have been deposited over porous strata of water-worn river gravel, cobbles, stones, and sand. They have a seasonal high water table because they are on the flood plain of the Colorado River. The Green River soils are pale brown, in contrast to the gray colors of the Billings soils and the light-gray to pale-yellow colors of the Ravola soils.

Thoroughfare series

The Thoroughfare soils occur along the base of the Uncompahgre uplift in association with the Redlands soils. They are derived from sandstone and granite materials that have been little influenced by shale and limestone. They have slight profile development. Evidence of the slight development is a lack of a distinct zone of lime accumulation. Thoroughfare soils are calcareous and permeable in both the surface soil and subsoil. Their color is similar to that of the Redlands soils.

Genola series

The Genola soils occur on recent alluvial fans and local stream flood plains. They are highly calcareous and have some segregation of lime in places. Variations in the alluvial deposit have given rise to clay loam, fine sandy loam, loam, and very fine sandy loam surface textures and different depths to gravel or clay horizons.

Navajo series

The Navajo series is represented in this area by one mapping unit, Navajo silty clay, 0 to 2 percent slopes. The soil lies on recent alluvial fans and local stream flood plains. It has developed on alluvium derived largely from shale, sandstone, and granite materials weathered from the rock formations exposed by the Uncompahgre uplift. The pale-brown to light reddish-brown silty clay or clay alluvial material continues to depths of 3 to nearly 6 feet, where it is underlain by permeable medium to moderately coarse materials deposited by former overflow waters of the Colorado and Gunnison Rivers. The soil is calcareous, but the lime is well disseminated. Because of its fine texture, the soil is not easy to work.

Naples series

The Naples soils occur in low positions on alluvial fans built up by materials washed down from North Thoroughfare Canyon and deposited upon the flood plain of the Colorado River. The alluvium is recent and consists primarily of sandstone material but includes some shale. The soils are calcareous, but the lime is well disseminated.

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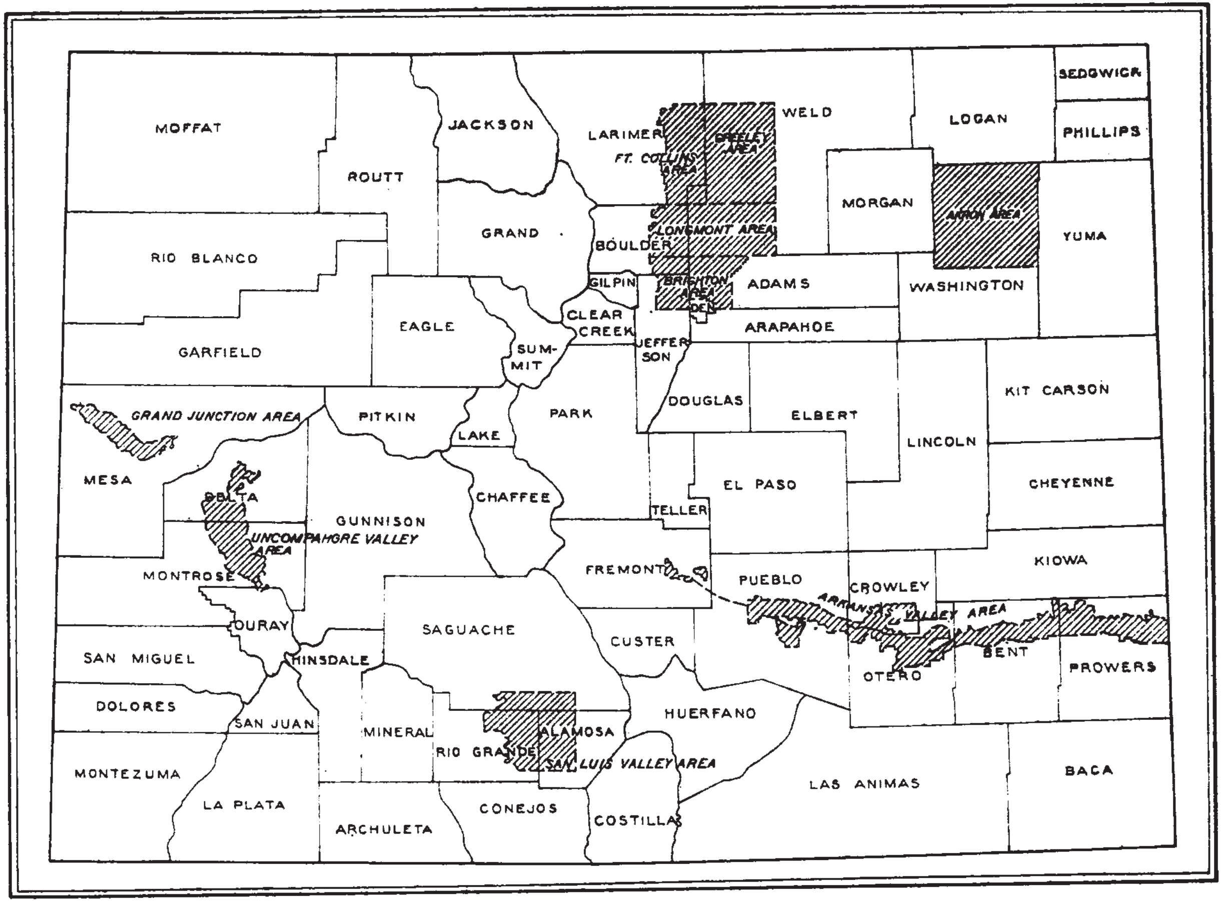

Areas surveyed in Colorado shown by shading.

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