
Soil Survey

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The Price Area Utah

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In cooperation with the
Utah Agricultural Experiment Station

CONTENTS

	Page
Area surveyed.....	1
Climate.....	3
Agriculture.....	4
Soil-survey methods and definitions.....	6
Soils and crops.....	7
Soils developed on recent alluvial materials.....	8
Billings loam.....	9
Billings loam, shallow phase.....	10
Billings loam, gravelly phase.....	10
Billings silty clay loam.....	10
Billings silty clay loam, poorly drained phase.....	11
Billings silty clay loam, shallow phase.....	11
Billings clay loam.....	11
Billings clay.....	12
Green River loamy fine sand.....	12
Green River fine sand.....	12
Soils developed on old valley-filling materials.....	12
Mesa loam.....	13
Mesa gravelly loam.....	13
Soils developed in place on shales and sandstones.....	13
Chipeta clay.....	14
Chipeta clay, deep phase.....	14
Chipeta clay loam.....	14
Miscellaneous land types.....	15
Rough broken land (Billings soil material).....	15
Rough broken land (Mesa soil material).....	15
Rough broken land (Chipeta soil material).....	15
Rough stony land (Chipeta soil material).....	15
Riverwash.....	16
Morphology and genesis of soils.....	16
Erosion.....	18
Irrigation, drainage, and alkali.....	19
Productivity ratings.....	21
Summary.....	23
Map.....	

SOIL SURVEY OF THE PRICE AREA, UTAH

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AREA SURVEYED

The Price area is in the east-central part of Utah, east of the Wasatch Plateau in the Colorado River Basin (fig. 1). It comprises a total area of 113 square miles, or 72,320 acres. A large proportion of the area lies within Carbon County, of which it forms, however, but a small part, and a smaller proportion—about 18 square miles—is in the north-central part of Emery County. Price, the most important town and county seat of Carbon County, is situated 125 miles southeast of Salt Lake City. The boundaries of the survey were drawn to include the major part of the lands which are, or can be, irrigated from Price River.¹ This river traverses the area from northwest to southeast.

The principal purposes of the survey were to determine the area of arable land irrigable from Price River and the character and relative value of the individual soils which occupy the area.

This part of the western intermountain region is a titanic example of geologic erosion. The sandstone and shale have been cut to depths of thousands of feet in places, and cliffs, canyons, and

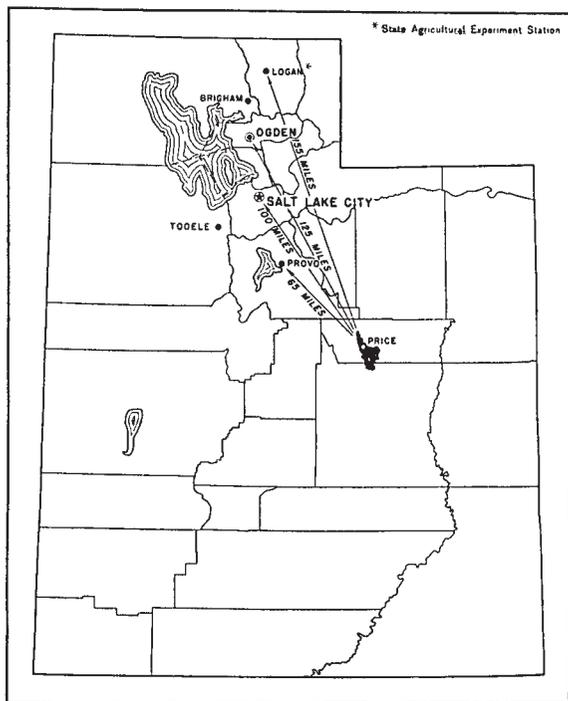


FIGURE 1.—Sketch map showing location of the Price area, Utah.

¹ A few small isolated areas of lands irrigated from Price River, south and southeast of Farnham, were not covered by the survey.

dissected plateaus and ridges abound. The area lying within the boundaries of the survey consists largely of a more or less rolling or dissected plain, called Castle Valley, which lies at the eastern base of the Wasatch Plateau and is walled in on the north and northeast by the Book Cliffs (pl. 1, A). Probably more than one-half of Castle Valley consists of rolling uplands or steep-sided buttes. Surrounding these uplands and sloping down from them are extensive comparatively smooth gently sloping alluvial fans. Price River and a number of small tributaries have cut channels, along which lie narrow alluvial flats or bottom lands.

Erosion is still extremely active, and, in many places, the smooth alluvial-fan and stream-bottom lands are being cut deeply by gullies. Although surface drainage is good, subdrainage is poor in many small areas, owing largely to the impervious character of the subsoil or substrata.

The elevation ranges from about 5,250 feet above sea level in the southeastern part of the area in Emery County to more than 7,000 feet in the Book Cliffs in the extreme northwestern part. At Farnham the elevation is 5,320 feet, at Price 5,547 feet, and at Helper 5,840 feet.²

The population of Carbon County, as reported by the United States census for 1930, is 17,798, of which 61.9 percent is rural and 38.1 percent urban. Over 25 percent of the inhabitants of this county are foreign born, among whom Greeks and Italians predominate. Price has a population of 4,048, according to the same census. It is an important supply center for the surrounding mining, farming, and livestock-raising country. It is a shipping point to the Uinta Basin country to the north. Helper, a coal-mining town and railroad division point, has a population of 2,707. Wellington and Spring Glen are small settlements in the farming districts. A number of coal-mining camps adjoin the area surveyed. Among them are Castlegate, Hiawatha, Kenilworth, Rolapp, and Sunnyside.

The area is served by the main line of the Denver & Rio Grande Western Railroad which connects Denver and Salt Lake City. A number of short branch lines extend to the coal mines in the Helper district.

United States Highway No. 50 parallels the railroad, and a surfaced State highway connects Price with Huntington and Castle Dale in Emery County. Other improved roads connect Price and Helper with Duchesne, Vernal, and other Uinta Basin towns. Graded roads, some of which are graveled, render the farming districts easily accessible.

The area has good grade and high schools under a centralized system. Electric lights, power, and telephone service are available in the towns and in parts of the farming districts. In many of the agricultural districts water is hauled for domestic use.

The inhabitants of the farms, towns, and mining camps, within or adjacent to the area, consume the dairy and poultry products, potatoes, vegetables, and fruits produced here. The small amount of wheat grown is milled locally. Much produce and grain are shipped into the district. Hay and grain are fed to range cattle and sheep and to dairy and work animals on the farms. Cattle and sheep are

² GANNETT, H. A DICTIONARY OF ALTITUDES IN THE UNITED STATES. U. S. Geol. Survey Bull. 274, ed. 4, 1072 pp. 1906.

shipped to Salt Lake City, Ogden, or Denver, many of them as feeder animals. Sugar beets are shipped to Grand Junction and Delta, Colo., for manufacture into sugar.

The most important industry of the section is coal mining. Most of the mines are just outside the area surveyed, in the Book Cliffs and Wasatch Plateau near Helper, Kenilworth, Castlegate, Spring Canyon, Hiawatha, Sunnyside, and elsewhere. At present (1934), 26 mines are in operation. Coal is shipped or trucked to points throughout Utah and other western intermountain States. Coal mined here is used in the manufacture of steel near Provo.

Three general types of native vegetation are dominant in the area. On the high mesas, or benchlands, juniper and piñon dominate. On the well-drained valley lands, shadscale (*Atriplex confertifolia*) is dominant, and on some of the salty flats, greasewood (*Sarcobatus vermiculatus*) is common. There is but little grass growing in the area. Cottonwood, willow, and boxelder trees grow along Price River.

CLIMATE

The climate of this section is marked by its aridity, large proportion of sunshiny days, and extreme daily and annual range of temperature. The wind movement is pronounced in spring and early summer, and the rate of evaporation is high.

The rainfall is insufficient normally for the growing of crops without irrigation. It is somewhat heavier during two periods, one in winter and the other in late summer. Cloudbursts are not infrequent in summer. Table 1 gives the more important climatic data, as recorded at the United States Weather Bureau station at Price.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Price, Carbon County, Utah

[Elevation, 5,507 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1934)	Total amount for the wettest year (1921)
	°F.	°F.	°F.	Inches	Inches	Inches
December.....	24.2	56	-12	0.77	1.15	1.95
January.....	20.5	57	-11	.82	.63	1.66
February.....	30.6	58	-18	.76	.60	.48
Winter.....	25.1	58	-18	2.35	2.38	4.09
March.....	38.4	69	-1	.62	.00	.22
April.....	47.2	79	18	.80	18	.46
May.....	56.3	85	25	.62	.49	1.91
Spring.....	47.3	85	-1	2.04	.67	2.59
June.....	66.0	99	34	.74	.38	1.16
July.....	72.0	97	43	.96	.34	.81
August.....	69.7	94	43	1.23	.87	4.32
Summer.....	69.2	99	34	2.93	1.59	6.29
September.....	61.0	91	28	1.22	.00	.22
October.....	50.3	82	12	.80	.35	.47
November.....	37.2	70	4	.83	1.50	.08
Fall.....	49.5	91	4	2.85	1.85	.77
Year.....	47.8	99	-18	10.17	6.49	13.74

The precipitation records of the United States Weather Bureau station at Wellington, kept for 4 years, give a mean annual precipitation of 6.39 inches, which is much lower than that at Price.

Greater extremes of temperature occurred at Wellington during the 8 years in which record was made, compared with those reported at Price. The absolute minimum at Wellington was -30° F.; the absolute maximum, 102° ; and the mean, 45.3° . The average frost-free season at Wellington extends from June 2 to September 11, a period of 101 days. The average frost-free season at Price extends from May 17 to September 29, a period of 135 days. Frost has occurred at Price, however, as late as July 3 and as early as September 9.

Where sufficient irrigation water is available, the climate is well adapted to the growth of the common temperate climate crops, such as alfalfa, small grains, sugar beets, corn, potatoes, beans, and garden vegetables. The low humidity and strong wind movement cause a high rate of evaporation, and this, no doubt, has a detrimental effect on the growth of crops. It causes drying and baking of the surface soil and renders seed germination and emergence difficult. According to records kept by Zobell,³ the average evaporation is 7.69 inches in June and 40.08 inches in the growing season, April to October, inclusive.

In a few rather sheltered locations with good air drainage, notably near Spring Glen and Helper, apples, peaches, pears, plums, apricots, and cherries are grown.

AGRICULTURE

Agriculture in this area dates from the settlement of Price in 1879 by Mormon pioneers⁴ who established a number of irrigation ditches and canals during the eighties. Since then, all the minor irrigation projects have been included in the Price River Water Conservation District. The Horsley, or Scofield, Dam on the headwaters of Price River was completed in 1926. Water from this reservoir flows through an extensive system of canals to irrigate nearly 18,000 acres of land in Carbon and Emery Counties. The development of the coal mines furnished some impetus to the expansion of agriculture.

Although the area surveyed forms but a small part of Carbon County, it includes most of the cultivated land, and the United States agricultural census for the county indicates the trend of agriculture within the area. Improved land in farms in Carbon County increased from 8,784 acres in 1900 to 15,590 acres in 1930, but this was reduced to 14,291 acres in 1935. The slight reduction in acreage represents land abandoned, owing to low productivity or damage by erosion or by seepage and concentration of salts. The 14,291 acres of improved land constitutes a small proportion—less than 15 percent—of the land in farms, and the area of farm land is but 10.1 percent of the total area of the county. The limited possibilities for expansion of farming in the southern part of the area surveyed are offset by the probability of abandonment of some land now under cultivation.

³ ZOBELL, I. D. SOIL-MANAGEMENT AND CROP-PRODUCTION STUDIES, CARBON COUNTY AREA. Utah Agr. Expt. Sta. Bull. 270, 22 pp., illus. 1936.

⁴ CARBON DISTRICT TEACHERS, PUPILS, AND PATRONS. (A BRIEF HISTORY OF CARBON COUNTY.) 33 pp. 1930. [Mimeographed.]

A large number of the farmers within the area are employed in the coal mines during the slack agricultural season in winter. This practice of farming during the summer and working in the mines in winter is recommended and may be considered a type of subsistence homesteading, although the size of the farms generally is much larger than that of ordinary subsistence homesteads. The 1935 census reports 408 farms in Carbon County with an average size of 235.9 acres.

The census data reveal the fact that hay, mostly alfalfa, has been the most important crop since 1900. Small grains—wheat and oats—rank next in acreage. The production of potatoes is of some importance. The acreage devoted to sugar beets is being increased. Corn for grain, beans, and barley, crops which do well in this area, occupy small acreages, as do garden vegetables. There are a few thousand fruit trees including apples, peaches, pears, plums, cherries, and apricots. Their number is much smaller than it was in 1920.

Alfalfa occupied 5,109 acres in Carbon County in 1929, out of a total of 5,583 acres devoted to hay crops, and yielded 11,485 tons of hay. Although this is an average of but $2\frac{1}{4}$ tons of hay to the acre, experiments carried on at the Carbon County Experimental Farm show that 4 tons or more per acre may be produced on the better soils where properly fertilized and irrigated. Superphosphate fertilizer has caused large increases in yield and higher quality in alfalfa hay.⁵ In 1934, alfalfa was grown on 4,037 acres and produced 4,848 tons of hay. A serious shortage of water in the 1934 season is largely responsible for the sharp reduction in yields.

Wheat occupied 838 acres in Carbon County in 1929 and produced a total of 21,528 bushels, or an average of 25.7 bushels to the acre. The production from 930 acres in 1934 was 20,017 bushels. Between 50 and 60 bushels to the acre have been obtained on highly fertilized land.

The 828 acres devoted to oats in 1929 yielded 27,751 bushels, or an average of 33.5 bushels to the acre, and the 402 acres used for the same purpose in 1934 yielded 10,136 bushels. Barley occupied only 180 acres and produced 6,417 bushels in 1929, which is an average of $35\frac{1}{2}$ bushels to the acre. It was grown on only 72 acres in 1934, and only 1,805 bushels were obtained. Barley is recommended as preferable to oats as a feed crop.

Potatoes were grown on 340 acres, with a production of 41,138 bushels, or 122 bushels to the acre, in 1929, and on 266 acres, with a production of 13,262 bushels, in 1934. On well-fertilized land, yields of more than 300 bushels to the acre have been obtained. The quality of the potatoes is high.

Sugar beets occupied 278 acres, producing 3,086 tons, or 11.1 tons to the acre, in 1929. Although the acreage was expanded to 407 acres in 1934, only 1,933 tons of beets were produced, owing to the shortage of water. With proper cultural methods and fertilization, acre yields of 20 tons or more are obtained. The use of superphosphate fertilizer gives large increases in yields of beets and a higher sugar content.

Corn and beans occupy only small acreages, although tests at the Carbon County Experimental Farm demonstrate that they produce well where properly cultivated.

⁵ ZOBELL, I. D. See footnote 3, p. 4.

Truck and home gardens occupy a small acreage, but the acre value of the produce they return is large.

Fertilizer tests made by Zobell show the great benefit to be obtained by the application of barnyard manure and superphosphate fertilizers and that there is little or no response from potash or nitrogen fertilizers. Alfalfa, sweetclover, and other legumes, in rotation with other crops, are recommended as a means of maintaining soil productivity. Careful irrigation is recommended as a means of helping in the control of both seepage and erosion. It is also necessary in order to obtain good penetration of moisture, as the soils absorb water slowly.

There is little doubt that the nitrogen content of most of the soils in this section is low, but, because of the comparatively large quantities of salts in the soil and irrigation water, fertilization with either sodium nitrate or ammonium sulphate is a rather dangerous procedure, especially before seeding or during the seedling stage, as these fertilizers have a tendency to burn or destroy the seedlings.

Application of these fertilizers to well-established crops in places where the salt content of the soil is not high doubtless would cause marked stimulation of growth in most instances, as has been observed on similar soils elsewhere. Probably it generally is best to depend on barnyard manure or the growing of alfalfa or other legumes to supply the nitrogen which is naturally lacking in these soils. The organic matter added in this way has a very beneficial effect on the tilth of the soil and probably increases its power to absorb water readily.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil⁶ and its content of lime and salts are determined by simple tests.⁷ Drainage, both internal and external, and other external features, such as relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. Areas of land, such as coastal beach or bare rocky mountain sides that have no true soil, are called (4) miscellaneous land types.

⁶ The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity.

⁷ The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction.

The most important group is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first recognized. Thus, Billings and Mesa are names of important soil series in this area.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Billings loam and Billings clay are soil types within the Billings series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it generally is the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within a type, which differs from the type in some minor soil characteristic that may have practical significance. Difference in relief, stoniness, and the degree of accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type, there may be areas that are adapted to the use of machinery and the growth of cultivated crops and others that are not. Even though there may be no important differences in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance the more sloping parts of the soil type may be segregated on the map as a sloping or a hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

In its natural state, this area was a desert, and lack of moisture is the factor preventing the growth of crops in most places. The soils differ greatly in their productive capacity. Some areas are unfit for the production of crops owing to poor drainage and the accumulation of salts, and large areas are untillable owing to erosion and rough relief.

Certain distinctive characteristics of the soils of this area are the result of the climate under which the soils are developed and the character of the parent materials (mostly shales and sandstones) from which they are formed. They are, for the most part, light

gray, dull gray, brownish gray, or drab in color, very low in nitrogen and organic matter, and rich in lime carbonate, gypsum, and various calcium, magnesium, sodium, and potassium salts. Phosphorus, although present in comparatively large quantities, is largely unavailable for plants, as is demonstrated by marked increases in yields produced by the application of superphosphate. The texture of most of the soils is fine. They absorb moisture rather slowly but retain it well. Generally, they are highly erodible and tend to puddle or bake. The latter condition can be relieved to some extent by the plowing under of barnyard manure, alfalfa, sweetclover, or other organic materials.

The soils are included in three broad groups which differ in their productive capacity under irrigation: (1) Soils developed on recent alluvial materials, which are deep fine-textured soils generally well suited to the production of crops; (2) soils developed on old valley-filling materials, which have tough gray limy subsoils and fair or rather low productivity; (3) soils developed in place on shales and sandstones, which are shallow soils with a low water-holding capacity and low productivity; and (4) miscellaneous land types which include little or no arable land.

In many places the soils are intermediate in character between those of the first and third groups. Such areas consist of comparatively shallow alluvial deposits over the shales. Their agricultural value, also, is intermediate between the deeper and the shallower soils. Soils of the second group occupy high tablelands, or mesas, which, for the most part, are inaccessible and difficult to supply with water. Only a small area, therefore, is cultivated.

In the following pages the soils are described in detail, and their adaptations and limitations in the production of crops are discussed. The accompanying map shows the location and distribution of these soils, and table 2 gives their acreage and proportionate extent.

TABLE 2.—*Acreage and proportionate extent of the soils mapped in the Price area, Utah*

Soil type	Acres	Percent	Soil type	Acres	Percent
Billings loam.....	9,408	13.0	Chipeta clay.....	9,600	13.2
Billings loam, shallow phase.....	256	.4	Chipeta clay, deep phase.....	1,408	1.9
Billings loam, gravelly phase.....	256	.4	Chipeta clay loam.....	2,048	2.8
Billings silty clay loam.....	9,344	12.9	Rough broken land (Billings soil material).....	4,544	6.3
Billings silty clay loam, poorly drained phase.....	832	1.2	Rough broken land (Mesa soil material).....	2,688	3.7
Billings silty clay loam, shallow phase.....	3,008	4.2	Rough broken land (Chipeta soil material).....	13,632	18.9
Billings clay loam.....	2,496	3.4	Rough stony land (Chipeta soil material).....	5,824	8.1
Billings clay.....	1,920	2.7	Riverwash.....	1,024	1.4
Green River loamy fine sand.....	320	.4			
Green River fine sand.....	320	.4			
Mesa loam.....	1,280	1.8			
Mesa gravelly loam.....	2,112	2.9	Total.....	72,320	-----

SOILS DEVELOPED ON RECENT ALLUVIAL MATERIALS

Soils developed on recent alluvial materials include the Billings and the Green River soils. These are the most important agricultural soils in the Price area. The relief is nearly level, and, if the soils are supplied with sufficient water and managed properly, they produce from fair to good yields of the crops commonly grown in

this section, such as alfalfa, wheat, potatoes, sugar beets, oats, and corn. As a general rule, the heavier textured members of the typical Billings soils contain more harmful quantities of salts, are more difficult to farm, and are less productive than the lighter textured Billings soils. The shallow phases are less productive than the typical soils. The poorly drained phase of Billings silty clay loam contains considerable salt and is very difficult to farm.

The Green River soils are much less productive than the typical Billings soils and they are comparable, in desirability for farming, with the poorer areas of Billings loam, gravelly phase. Green River loamy fine sand is more productive than Green River fine sand. Both soils, however, are incoherent, loose, and subject to shifting by the wind in areas unprotected by vegetation.

Without irrigation, the soils of this group are used only as range land.

The Billings soils are the most extensive and important soils in this area and, for the most part, are well adapted to the growth of crops. These soils consist of or are developed from dull-gray, brownish-gray, or drab alluvial materials which are more or less stratified but consist mostly of rather fine textured deposits. A definite development of surface soil and subsoil horizons is lacking. Moisture is absorbed rather slowly but is retained well. The surface soil of irrigated areas tends to become slick when wet and to bake when dry. In some places, the texture of the subsoil is very heavy clay which hinders the downward movement of moisture and roots. In other places, the underlying substratum of shale lies at a comparatively slight depth and tends to obstruct the movement of water and the penetration of roots. Waterlogged areas are numerous, although fairly small. These soils are highly erodible.

The Green River soils consist of light grayish-brown or light brownish-gray rather light- or sandy-textured recent alluvial deposits that are friable and calcareous throughout and stratified in many places. The low-lying areas are subject to overflow. The color is lighter and the profile is even less well developed in these than in the Billings soils. The Green River soils are not extensive in this area, and they occur only along Price River.

Billings loam.—Billings loam is one of the more extensive and important soils in the Price area. It is widely distributed on alluvial fans and stream bottoms.

The surface soil is dull-gray, brownish-gray, or drab material, ranging in texture from fine sandy loam to heavy loam. The subsoil is similar to the surface soil, although in places it contains white flecks of lime carbonate, gypsum, or other salts. The soil material, in many places, is irregularly stratified, but tough, impervious layers or very loose sandy horizons are not common. Billings loam consists of alluvial outwash from shales, sandstones, and older valley-filling materials. It is normally highly calcareous and more or less strongly impregnated with salts, although the salt concentration is not sufficient, in most places, to damage crops seriously. Surface drainage generally is good, and underdrainage is good in most places. The land should be carefully irrigated in order to minimize erosion or waterlogging. The soil tends to become slick, or seal over, when water runs over it, and it absorbs moisture rather slowly. The addition of organic matter in the form of barnyard manure and the plow-

ing under of alfalfa and clover improves the physical condition, tilth, and ability to absorb water, and also supplies nitrogen and phosphorus in available form.

This soil, where well drained, comparatively free from salts, and supplied with sufficient irrigation water is probably the best all-round farming soil in the Price area. About 60 percent of the land is under cultivation. Most of the remainder is uncultivated because of lack of irrigation water or owing to its situation in the southern part of the area, which is somewhat isolated and lacks a convenient supply of water for domestic purposes. Only small areas are waterlogged or strongly affected by mineral salts.

The most important crop is alfalfa hay, with the small grains, potatoes, and sugar beets following in acreage in the order named. Corn and vegetables, especially beans, are well adapted to this soil but are not grown extensively. Small areas are in orchards which apparently thrive better on this soil than on the heavier, less pervious, and more poorly drained soils. In some areas, where the frost-free season is longer than the average, good crops of apples, peaches, apricots, plums, and cherries are produced.

Unirrigated areas and those irrigated areas that have become waterlogged and strongly affected with salts have little value except for the scant grazing or browse they afford. The native vegetation is largely greasewood and shadscale.

Billings loam, shallow phase.—The shallow phase of Billings loam occupies only a few small scattered areas. It consists of light brownish-gray alluvial material similar to typical Billings loam, but it is underlain, in most places within a depth of 4 feet, by the slate-gray Mancos shale. This soil occupies undulating or gently rolling areas. It is slightly more difficult to irrigate than is typical Billings loam and has a lower moisture-holding capacity. The crop adaptations are similar to those of the typical soil, but yields are probably slightly lower. Owing to its lower moisture-holding capacity, this soil needs more frequent but lighter irrigation than does the typical soil.

Billings loam, gravelly phase.—The gravelly phase of Billings loam occurs only in a few small areas on the higher parts of alluvial fans. It is similar to typical Billings loam but is somewhat lighter or sandier in texture and contains, in most places, a rather high proportion of gravel, and, in places, some stone, throughout the surface soil and subsoil.

Most of this soil is on a higher level than the irrigation canals and ditches. Owing to its coarseness and open leachy characteristics, it would require frequent irrigation and a rather large total amount of water. For these reasons it is not likely to be developed for agricultural crops, although with sufficient irrigation it would be fairly productive for alfalfa and tree fruits.

One small area of this soil northeast of Spring Glen contains a large quantity of boulders and cobbles. It lies largely above the level of the sources of irrigation water and is practically valueless for agriculture. It might be used for orchards if provided with sufficient water.

Billings silty clay loam.—Billings silty clay loam is widely distributed throughout the area, and its extent is nearly equal to that of Billings loam. It is an important agricultural soil but is some-

what less valuable than Billings loam because it has a finer texture, is more difficult to till, and tends to be somewhat less pervious and more poorly drained than that soil. The surface soil is light brownish-gray or dull grayish-brown silty clay loam, with included variations of clay loam and clay texture. The subsoil is similar to the surface soil, consists of stratified but predominantly fine textured material, and in many places is relatively impervious. There is no marked development of a profile, although the subsoil contains faint white mottlings of lime carbonate, gypsum, and other salts. Surface drainage is good, but subdrainage is retarded. The salt content of the soil varies from rather low to high, depending largely on present or past drainage conditions.

Where fairly well drained, comparatively low in salt content, and provided with sufficient irrigation water, this soil is productive of the crops commonly grown. Probably about two-thirds of the total area is under cultivation. Alfalfa is the principal crop and generally yields from 2 to 4 tons to the acre. Small grains, especially wheat and oats, do well, and sugar beets, potatoes, corn, beans, and garden vegetables yield fairly well. Where strongly affected with salts, this soil has little productive capacity. The salt content may be lowered by adequate drainage and the practice of flooding to wash out the salts, although this may not be economically feasible in many places. The tilth and productivity of this soil may be improved through the use of barnyard and green manures. Superphosphate produces large increases in yields of alfalfa and sugar beets.

Uncultivated areas have only very low browse value (pl. 1, *B*). Greasewood and shadscale comprise the greater part of the native vegetation.

Billings silty clay loam, poorly drained phase.—The more poorly drained areas of Billings silty clay loam are mapped as a poorly drained phase. In most places the water table is within 3 feet of the surface, and in many places the land is wet or marshy. The salt content of the soil is strong or moderate. This soil has little value in its present condition. Drainage and the washing out of salts would prove difficult in most places.

Billings silty clay loam, shallow phase.—The shallow phase of Billings silty clay loam is rather widely scattered throughout the southern part of the area. Much of it occupies transitional strips between the shallow Chipeta soils and the deeper soils of the Billings series. It consists of a shallow mantle of alluvial material, varying in thickness from about 1½ to 4 feet, over gray Mancos shale. This soil is similar to typical Billings silty clay loam, but, because of its shallowness, it holds less moisture and is not so favorable to such deep-rooted plants as alfalfa. Its crop adaptations are similar to those of the deeper soil, but yields average somewhat lower, and more frequent irrigation is desirable than on that soil.

Some areas of this soil are poorly drained and are affected with salts. The value of this soil varies with the seriousness of this condition. Areas strongly affected with salts are practically valueless, whereas areas of moderate salt content are intermediate in their crop-producing ability.

Billings clay loam.—Billings clay loam is similar to Billings silty clay loam, but it has a slightly lighter or coarser texture than that soil, especially in the subsoil. It occupies bottom lands and

alluvial fans, scattered throughout the area surveyed. The largest single body is in the southern part of the area. In general, this soil is somewhat better drained and less affected by salts than is Billings silty clay loam. The surface soil, in most places, consists of clay loam, but it contains a fairly large proportion of fine sand, and the subsoil, in many places, is somewhat lighter in texture, ranging from fine sandy loam to clay loam. In some places where this soil occupies alluvial fans, a few gravel are present in the surface soil and subsoil.

Billings clay loam is a desirable agricultural soil. Its crop adaptations are similar to those of Billings loam and Billings silty clay loam. It is, however, less extensive than either of those soils. Alfalfa, small grains, and sugar beets are the important crops. Probably about two-thirds of the land is cultivated.

Billings clay.—Billings clay is dull brownish-gray or slate-gray clay similar to Billings silty clay loam, but it is heavier, tougher, and slightly darker than that soil. It appears to be an almost unmodified deposit of outwash material from shale. The 2- to 4-inch surface layer is, in most places, somewhat granular. The subsoil is tough, has a massive structure, and contains indistinct mottles or flecks of lime, gypsum, or salts.

This is not an extensive soil. It occurs in small bodies on alluvial fans throughout the central part of the area. Very little of the land is under cultivation. It appears to have rather low productivity, is comparatively intractable, and is not readily pervious to moisture. It has slight value as browse land.

In a few areas of this soil, gravel are numerous on the surface, and, in places, are scattered throughout the surface soil and subsoil. Such areas are of little value except for the scant browse they afford.

Green River loamy fine sand.—Green River loamy fine sand occupies narrow strips along Price River, from the vicinity of Price northwest to Helper. Its total extent is small. The surface soil is light grayish-brown or brownish-gray loamy fine sand. The subsoil is similar to the surface soil but, as typically developed, is stratified, rather incoherent, and porous.

This soil is worked easily but is so light textured and loose that it has a tendency to blow when unprotected by vegetation. Frequent irrigations are required, as the water-holding capacity is low. It is best adapted to the production of alfalfa (pl. 1, A), potatoes, and truck crops.

Green River fine sand.—Green River fine sand occupies a number of small areas adjacent to the channel of Price River. It is excessively light in texture, porous, and leachy, and parts of it are subject to overflow during periods of high water. Small patches of the higher areas are devoted to alfalfa and truck crops, which produce fairly well but require frequent irrigation. Some of the lower areas are wet and contain large quantities of harmful salts.

SOILS DEVELOPED ON OLD VALLEY-FILLING MATERIALS

The soils developed from old alluvium or valley-filling materials include only two types of the Mesa series. The physical characteristics and relief of those soils are more or less favorable for the growing of crops, but their high position deprives most of the land

of irrigation water. Only a very small proportion of them, therefore, is cultivated. Yields of crops are less than on the Billings soils. The principal use of the Mesa soils is for grazing.

The Mesa soils have light-brown or grayish-brown surface soils slightly tinged with red in places. The upper subsoil or subsurface layers are somewhat redder, heavier in texture, and tougher than the surface soils. The lower subsoil layers are light-gray or white, highly calcareous, and more or less cemented with lime. In many places a large quantity of gravel or stone is present in the surface soils and subsoils. These soils occupy high terraces, or mesas, most of which are too high to be irrigated from any existing water supply.

Mesa loam.—Mesa loam occupies a number of narrow ridges or mesas in the southern part of the area. Two bodies are on the terraces in the vicinity of Wellington, and small bodies are south of Price and east of Spring Glen. The surface layer typically is a friable light-brown or pale reddish-brown loam, although it ranges in texture from fine sandy loam to clay loam. The subsurface layer consists of light reddish-brown loam or clay loam, which is more compact than the surface layer, and the subsoil is light-gray or white tough or slightly cemented clay loam. The content of organic matter is low. Both surface soil and subsoil are highly calcareous, and the subsoil doubtless offers much resistance to the penetration of moisture and roots, owing to the lime cementation. External drainage is good.

Only a small acreage of this soil, probably less than one-third of its total area, is under cultivation. Most of the remainder is too high to be watered from present irrigation systems. The cultivated land is producing fairly good crops of alfalfa hay, small grains, corn, and garden vegetables, but yields are not equal to those obtained on the better Billings soils. Alfalfa seems to be the crop best adapted to this soil. Virgin areas are covered largely by shadscale, with scattered bunch grass, and, in places, pricklypear cactus. This vegetation has a low carrying capacity for livestock.

Mesa gravelly loam.—Mesa gravelly loam is developed on high benches or mesas along the border of the area, east or northeast of Price River, from Spring Glen to Farnham. A few small bodies are in the southern part of the area south of Wellington. This soil is similar to Mesa loam, but it contains a rather large quantity of gravel scattered through the surface soil and subsoil. In some places the subsoil is cemented into a hardpan by lime carbonate. This soil lies too high to be irrigated from the existing ditches, and it is so coarse and shallow that it would be of low agricultural value even if it were irrigated. The land has some value for grazing or browse.

In a few places, large quantities of boulders are strewn over the surface. The vegetation on these stony areas consists of shadscale and, in places, juniper and bunch grass. These areas are used for grazing and for the production of juniper fence posts.

SOILS DEVELOPED IN PLACE ON SHALES AND SANDSTONES

The soils developed in place on shales and sandstones include only three members of the Chipeta series. Their color ranges from dull dark gray or slate gray to brownish gray or drab. In many areas a rather large quantity of gypsum is present in the subsoil, and mod-

erate quantities of salts are present in many places in the surface soil, subsoil, and substratum.

These soils occur throughout the central and southern parts of the area on the undulating or rolling uplands and the mesas. Owing to their high position above most of the irrigation canals, shallowness, low productivity, and unfavorable relief, these soils are used to a very small extent for the growing of agricultural crops. The clay soils are more difficult to farm and are more subject to waterlogging than the clay loams. Most areas of these soils are used only as range land for sheep and cattle.

Chipeta clay.—Chipeta clay occurs throughout the central and southern parts of the area on undulating or rolling plains. It is a shallow soil, ranging in depth from a few inches to about $1\frac{1}{2}$ feet, and is underlain by slate-gray Mancos shale. In typical areas, the surface soil is dull dark-gray granular clay, but in places it is drab, brownish gray, or rusty brown. At an average depth of about 3 inches, the material becomes tougher and more compact than it is in the surface soil and gradually changes to the soft and more or less weathered shale that contains a large quantity of white or pale-yellow soft granular material, most of which probably is gypsum. The shale is harder and shows but little weathering below a depth ranging from $1\frac{1}{2}$ to 3 feet.

Surface drainage is good in most areas of this soil, but in a few places water rises to the surface under pressure, apparently having been conducted long distances through the porous or crevassed shale. The salt content of the soil and underlying shale is generally rather low or moderate, but in the waterlogged areas a high concentration of salts is common at or near the surface.

Most of this soil is still in a virgin desert condition. Probably less than 5 percent of it is now cultivated, although fairly large areas have been cultivated and abandoned. The soil has very low natural productivity and low moisture-holding capacity. For these reasons it is not recommended for agricultural use. In its natural state, it is covered with shadscale, together with a small admixture of bunch grass and pricklypear. It has some value as grazing or browse land.

Chipeta clay, deep phase.—Chipeta clay, deep phase, differs from the typical soil in that the underlying parent shale lies at a greater depth, generally from $1\frac{1}{2}$ to 2 feet. The shale is capped by clay or heavy clay loam. Gray splotches or mottles of lime and gypsum are common in the subsoil.

This is an inextensive soil occurring in small bodies in the southern part of the area. The surface soil, in some places, is outwash from Chipeta clay, but, in other places, it is residual. Only a small portion of the land is used for the growing of crops, mainly small grains and alfalfa. Apparently the productivity is rather low. The soil is not deep enough to hold moisture well, and the land should be cultivated only under the most favorable agricultural and economic conditions. Small areas have become waterlogged and affected with salts since irrigation has been practiced in the vicinity.

Chipeta clay loam.—Chipeta clay loam occupies rolling uplands and mesa tops, principally in the southeastern part of the area. Smaller bodies are in the northern part near Maxwell, Spring Glen,

and Helper. This soil is developed from sandy shales and sandstones. It is a thin soil similar to Chipeta clay, but it has a lighter or sandier texture than that soil. The surface soil consists of clay loam in most places, but there are some areas of heavy loam and in a few small areas, near Spring Glen and Helper, of fine sandy loam. At a depth of a few inches, the surface soil grades into soft disintegrating sandstone or shale which, in places, is interspersed with much gypsum. The slightly weathered bedrock lies at a depth of about 12 inches.

This soil has little agricultural value at present and little prospect of future development, owing to its extreme shallowness and low productivity, as well as to its position which generally is higher than the irrigation ditches. It supports a growth of shadscale, and, in places, a few juniper trees. It has some value as range land.

MISCELLANEOUS LAND TYPES

The miscellaneous land types include land that is so rough, stony, or so frequently overflowed as to be nonagricultural. Many areas are seriously eroded and devoid of vegetation. The land types included are: Rough broken land (Billings soil material), rough broken land (Mesa soil material), rough broken land (Chipeta soil material), rough stony land (Chipeta soil material), and riverwash.

Rough broken land (Billings soil material).—Narrow, rough, and gullied areas of Billings loam, Billings silty clay loam, and Billings clay, adjacent to drainage channels, are classified as rough broken land (Billings soil material). This type of land is widely distributed throughout the area but in its present condition has little or no value either for the growing of crops or for use as grazing land.

A few small areas might be made fit for farming by leveling, but in most places the relief is too rough to make leveling practical. If dams were constructed in the gullies, erosion would be retarded, and the gullies would gradually fill, thereby tending to make the land more level. In some places, however, the construction of dams would impair the drainage of adjoining more productive lands.

Rough broken land (Mesa soil material).—Rough broken land (Mesa soil material) comprises rough broken areas on bluffs surrounding ridges or mesas, occupied by Mesa loam and Mesa gravelly loam. Its rough relief and gravelly or stony character render it valueless for the production of crops, and it has a low value even for grazing.

Rough broken land (Chipeta soil material).—Rough eroded areas, badlands, and bluffs surrounding ridges or mesas occupied by Chipeta and Mesa soils are differentiated on the soil map as rough broken land (Chipeta soil material). This land is distributed widely throughout the area surveyed. It consists largely of bare exposed shale. In some places, a covering of shallow soil persists, and, in other places, only gravel or stone remain from the original soil, all the fine materials of which have been washed away. The vegetation is sparse or entirely lacking, and the land has no value for crops and only very little value for grazing.

Rough stony land (Chipeta soil material).—Rough stony land (Chipeta soil material) consists of steep eroded and broken areas, many of which contain cliffs of sandstone and shale or are covered

with loose rock. The texture of the soil material is variable. The covering of vegetation is thin in most places. Shadscale is common in the southern part of the area, and juniper trees are fairly numerous in the northern part. Grass grows sparsely in places. The grazing or browse value is in general low.

Riverwash.—Low-lying sandy or gravelly flats along Price River, which are overflowed at every period of high water, are designated on the soil map as riverwash. Many of these areas are permanently wet and contain harmful salts; and others consist of unassorted coarse leachy material. A few willow trees and very little grass grow in these areas which have little or no value for agricultural crops or for grazing but are valuable as watering places for cattle and sheep on the range.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of the environment acting on the soil materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent soil material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the relief, or lay of the land, which determines the local or internal climate of the soil, its drainage, moisture content, aeration, and susceptibility to erosion; (4) the biologic forces acting on the soil material—the plants and animals living on and in it; and (5) the length of time the climatic and biologic forces have acted on the soil material.

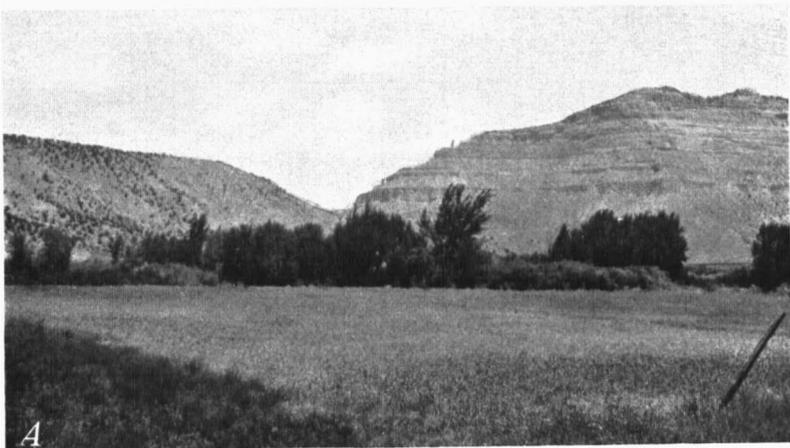
When the parent soil materials have not been in place long enough to develop definite profile characteristics, they may be considered simply as soil materials and are so designated in this discussion.

The soils of the Price area have many characteristics in common with soils of other northern sections of the arid western intermountain region. They are light colored, low in organic matter, only slightly leached, highly calcareous, and rich in salts of the alkali and alkaline earth groups. The color is predominantly gray, drab, or dull grayish brown.

Erosion, deposition, and character of parent materials have had decisive effect in determining the character of most of the soils in this arid region. Both erosion and deposition have been very active, but the soil-forming processes are expressed rather feebly, owing to the small amount of rainfall, shallow penetration of moisture, and sparse vegetation.

Most of the soils of this area are very immature. The soil materials have come mostly from sandstones and shales and are either alluvial deposits or shallow residual layers. The soils of the Mesa series are the only ones having a distinct mature profile, and these cover only a small percentage of the area.

The Mesa soils are developed on old alluvial-terrace or alluvial-fan deposits, which exist on high-lying mesas or benches. The surface soils are light brown or dull brown, tinged in some places with red, have medium or coarse texture, and are distinctly calcareous. Gravel and stone are present in places on the surface. The upper



A, Alfalfa growing on the Green River soils in the upper part of Castle Valley near Helper. In the distance are the Book Cliffs, which form an escarpment gateway at Castlegate; B, Billings silty clay loam on a sloping fan in the foreground and Chipeta soils on flat-topped mesas in the distance. Grazing is the principal agricultural enterprise in this area unless the soils are irrigated.



A, An exposed section of the Billings soils, which shows the slight profile development; *B*, a denuded and eroded area of Billings silty clay loam. Low ridges in the distance are occupied by Chipeta soils.

subsoil layer is brown or slightly reddish brown, is somewhat heavier in texture and more compact than the surface soil, and probably contains a considerable concentration of colloidal clay. The lower subsoil layer is light gray or white, highly calcareous, and more or less cemented by lime carbonate. The substratum, or parent material, is dull gray or drab and is somewhat less compact, in most places, than the horizon above. These soils overlie the dark-gray Mancos shale in many places.

A profile of Mesa loam, as mapped in this area, shows the following layers:

- A₁. 0 to 2 inches, distinctly calcareous light-brown rather loose fine sandy loam, with a slight pink or yellow tinge. A few gravel are scattered over the surface.
- A₂. 2 to 4 inches, light-brown or slightly reddish brown distinctly calcareous firm but friable fine sandy loam or loam.
- B₁. 4 to 9 inches, light reddish-brown heavy gritty loam somewhat mottled or splotted with white lime carbonate and grading into a gray or white layer below. The material is compact and cloddy.
- B₂. 9 to 30 inches, tough compact or slightly cemented very highly calcareous light-gray or white heavy clay loam somewhat mottled with brown.
- C. 30 to 72 inches, light yellowish-brown or drab stratified material ranging from loam to clay loam in texture. It is rather compact and cloddy but is much softer than that above.

The other member of the Mesa series mapped is more gravelly or stony, and, in places, the subsoil is cemented into hardpan by lime carbonate.

The soils of the Chipeta series consist of a shallow mantle of residual material over shale or sandstone. They have little definite profile, probably due partly to limited penetration of moisture and sparse vegetation, and partly to removal of the soil material by erosion before sufficient time has elapsed for the formation of a profile. In many places, the subsurface layer contains a concentration of white or yellowish-gray sugarlike material which is probably largely gypsum.

A description of a profile of Chipeta clay, occurring on a gently rolling upland underlain by Mancos shale, follows:

- 0 to 3 inches, a loose granular mulch of dull-gray, dark-gray, slate-gray, or drab clay.
- 3 to 6 inches, dull-gray firm rather cloddy clay, with a somewhat platy structure.
- 6 to 12 inches, slate-gray shale of soft platy structure. Between the shale fragments is a large quantity of white or yellowish-gray salts, largely gypsum. The fragments range from one-tenth to one-fourth inch in diameter and are thin and flat.
- 12 to 20 inches, slate-gray shale in flat platelike fragments ranging from one-eighth to one-half inch in diameter. These fragments are soft but are harder than those in the layer above. Large quantities of gypsum (or other salts) are interspersed among the shale fragments.
- 20 to 72 inches +, slate-gray shale in rather hard plates which are as much as 2 inches or slightly more in diameter. Small quantities of gypsum are interspersed throughout this layer. The profile is highly calcareous throughout.

The Billings and Green River soils consist of alluvial deposits which have undergone little or no soil development. In some places, especially in the heavier soils, a flecking or mottling is apparent in

the subsoil, owing to the presence of lime carbonate, gypsum, or other salts, but little or no development of a compact or heavy layer has taken place through soil-forming processes. What compaction or toughness exists is due to the fine texture, lack of granulation, and tenacity of the soil material.

The Billings soils are dull brownish gray or drab, consist of alluvial materials, and occupy bottom lands, terraces, or alluvial fans. The subsoils are similar to the surface soils (pl. 2, *A*), although they are stratified in many places and are faintly mottled or flecked with lime, gypsum, or other salts in some places.

Billings loam is the most important and extensive type in the Billings series. It consists of stratified materials which are mainly medium textured and fairly pervious. An exposure in a gully in the Miller Creek bottom land shows the following profile:

0 to 2½ inches, light brownish-gray mellow fine sandy loam.

2½ to 4½ inches, rather firm platelike clods of light brownish-gray fine sandy loam or loam.

4½ to 15 inches, light brownish-gray firm somewhat cloddy loam.

15 to 30 inches, thinly stratified or laminated materials ranging in texture from loam to silty clay loam. The lighter textured materials are light brown or grayish brown, and the heavier textured ones are dull gray. Segregations of nearly white salt are scattered throughout, especially in the heavier textured layers.

30 to 72 inches, stratified materials ranging in texture from loam to clay loam and in color from light brown to dull gray. Salt crystals are present. The heavier layers are rather compact. The soil material is highly calcareous throughout.

Mechanical analyses of several layers of Billings silty clay loam are given in table 3.

TABLE 3.—*Mechanical analyses of Billings silty clay loam*

Sample No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	Percent	Percent	Percent	Percent	Percent	Percent
521306	Surface soil, 0 to 3 inches.....	0.1	0.2	0.3	2.0	15.6	57.3	24.6
521307	Subsurface soil, 3 to 7 inches.....	.1	.1	.2	1.5	12.5	47.7	37.9
521308	Subsoil, 7 to 20 inches.....	.1	.1	.2	1.2	7.7	41.9	48.8
521309	Subsoil, 20 to 42 inches.....	.1	.1	.2	1.2	6.0	44.4	48.0
521310	Subsoil, 42 to 72 inches.....	.0	.2	.4	3.5	11.3	40.1	44.5

The Green River soils are light-brown or grayish-brown sandy recent alluvial deposits occurring along Price River. The material is practically unmodified, and the surface soil and subsoil are similar although variously stratified and very open in structure.

EROSION

Erosion or removal of soil by natural forces is very active in this area. Sparsity of native vegetation, the sloping relief of the land, with the consequent steep gradient of nearly all natural drainage-ways, and the violent thunderstorms or cloudbursts, during which much of the rain falls, all tend to promote erosion (pl. 2, *B*). The soft shales and sandstones and the soils derived from them seem to be

peculiarly susceptible to erosion. The soils are characterized by fine texture, lack of granulation, low organic-matter content, and a tendency to shed water rather than to absorb it quickly. Surface run-off tends to concentrate in swift-running streams which have great erosive effect.

Undoubtedly erosion always has been active under desert conditions, especially during the run-off following heavy rainstorms and quick melting of snows, and this condition probably has been aggravated to some extent by destruction of vegetation through overgrazing and by bedding of range livestock. At any rate, serious gullying has taken place in uncultivated areas in this and other western regions ever since the arrival of the first white settlers.

Irrigation still further complicates the problem of controlling erosion. Excessive quantities of irrigation water running across the land cause washing in places. Waste water from irrigation and from broken irrigation ditches concentrates along shallow natural drainage channels, cuts the soil rapidly, and forms deep gullies. In places, the ditches dug to drain waterlogged areas develop into large gullies. The force of the water continues to deepen and widen the gullies as large masses of soil fall in from the sides. Gopher and prairie-dog burrows, which extend from irrigated fields into the gullies, cave and form branches of the ever-spreading gullies.

Very careful handling of irrigation water is essential in controlling erosion on cultivated lands. Excessive heads of water should not be used, and care should be taken that the water does not run into rodent burrows or flow unchecked into the gullies. Checks should be placed in irrigation or drainage ditches wherever the slope is steep or the soil tends to erode. Checks or dams placed in some of the gullies would do much to relieve the trouble, although in some places this might aggravate the drainage problem which is serious.

The fact should not be overlooked that nearly all of the soil materials in the better agricultural lands of the area are alluvial deposits that have been eroded and washed down from higher lying lands. There is, however, little deposition going on within the area at the present time, as most of the material removed by erosion is carried out by Price River into Colorado River.

IRRIGATION, DRAINAGE, AND "ALKALI"^{*}

Irrigation is essential for the successful production of crops in this region of low rainfall. Water is supplied largely by Price River. Gordon Creek, a small creek entering Price River from the west about 1 mile south of Maxwell, furnishes water for a small area along its lower course. The water is distributed largely under the direction of the Price River Water Conservation District.

The corrugation, or furrow, method of irrigation is the one most commonly practiced in this area. It is a better adapted method than flooding in most places, because of the sloping or more or less uneven relief of the land. Another advantage of this method is that it

^{*} The term "alkali" is used in its common or agricultural sense and refers to excessive accumulation of soluble mineral salts, most of which are not chemical alkalies but are saline or neutral in reaction.

minimizes hardening, or baking, of the surface soil, which often follows flooding and is detrimental to the growth of plants. On well-established alfalfa fields, especially on the flatter lands, the flooding method frequently is used.

Irrigation of these lands has brought with it not only erosion as discussed in the previous section but also seepage, waterlogging of many areas of land, and an accumulation of alkali, or saline salts, in the soils.

As shown by analyses carried on by the Utah Agricultural Experiment Station,⁹ the waters of Price River contain a relatively large quantity of soluble salts, compared with waters from other sources within the State. A part of these salts is deposited in the soils, and they tend to accumulate in dangerous quantities in places where drainage is poor.

In most places, owing to the sloping relief and numerous gullies, surface drainage is good; nevertheless, in many areas, most of them small, seepage and waterlogging occur. Movement of water is slow through many of the soils, owing, doubtless, to their fine texture and deflocculated condition. On parts of the bottom land east of Wellington, the tight clay subsoil prevents the penetration of water, and, in many places in the area, an underlying comparatively impervious substratum of shale holds up or dams the underground flow and causes a high water table. It seems probable that crevices or pores in the shale act as conduits which carry water for some distance and bring it to the surface under pressure.

In the course of this survey, many small seepy spots were observed on slopes below the irrigation canals or ditches, which traverse the shale beds. The lining of canals and ditches with concrete doubtless would have a beneficial effect in decreasing losses through seepage. Overirrigation is detrimental to both soils and crops, and it may aggravate the drainage trouble on lower lying areas. Drains to intercept the seepage and waste water would have a beneficial effect in some places. Attempts to carry the ground water away from waterlogged areas seldom are successful and, in many places, lead to destructive gullying.

Accumulation of salts goes hand in hand with poor drainage. The ground water rises to the surface, carrying with it soluble salts which, on evaporation of the water, are deposited on or near the surface, in places forming a white or light-brown crust.

The soils of this area contain naturally a fairly large quantity of soluble salts of the alkali and alkaline earth groups, although, in most places, the quantity present is not sufficient to produce harmful effects on growing plants. Some small areas have an excessively high salt content under natural conditions, but, in most places, the higher salt concentrations have been caused or aggravated by seepage since irrigation.

In making a study of the alkali conditions in the Price area, observations were made, during the progress of the soil survey, on the location of areas of salt accumulation and their relation to the soil

⁹ GREAVES, J. E., and HIRST, C. T. COMPOSITION OF THE IRRIGATION WATERS OF UTAH. Utah Agr. Expt. Sta. Bull. 163, 43 pp., illus. 1918.

type, height of the water table, and vegetation. Samples were taken for determination of total salt content by the electrolytic-bridge method.

Based on the results of these observations and tests, alkali conditions are shown on the soil map. Boundaries of alkali-affected areas are shown in red, and the relative salt content shown by red symbols. The areas which are considered practically free from alkali, if designated at all, are shown by the letter F; the areas that are moderately affected are designated by the letter M; and areas that have a high salt content are indicated by the letter A.

The areas designated by the letter F, which constitute the largest part of the total area, are not actually free from soluble alkali salts, but the quantity of these salts is so low that it does little or no damage to agricultural crops. The percentage of salts in these soils is nearly everywhere less than 0.2 percent. Seepage, poor drainage, or irrigation with salty waters may cause a higher concentration in places in the future.

The areas designated by the letter M contain from 0.15 to 0.5 percent of alkali salts, either in the topmost foot of soil or as an average to a depth of 6 feet. The degree of salt concentration varies greatly from place to place within short distances and causes a spotted or uneven appearance of crops. In most places, the concentration is not sufficient to affect visibly the established plants, although, in places, the growth is stunted or the plants turn yellow. These concentrations doubtless affect seed germination and kill seedlings in places. Proper irrigation and adequate drainage are essential in order to lower the salt content or to prevent it from increasing and becoming harmful.

The soils of areas indicated by the letter A contain 0.5 percent or more of salts either in the topmost foot of soil or as an average to a depth of 6 feet. In these areas, the vegetation shows a marked effect of the presence of salts, and reclamation measures are necessary, in order to make the land productive. In general, drainage and washing are the most practical means of lowering the salt content, but in many places it is extremely doubtful that these practices would be very effective, because of the extremely high salt content or the tough impervious character of the subsoil or substratum.

Plants which indicate the presence of salts in this area are greasewood, saltgrass, several species of *Atriplex*, and the plant locally called alkali weed which probably is *Bassia hyssopifolia*.

PRODUCTIVITY RATINGS

Table 4 gives a rating of the soil types, phases, and miscellaneous land classes in the Price area according to their productivity for the more common crops grown under the prevailing system of irrigation farming. Under natural desert conditions these soils have practically no agricultural value, but under irrigation some of them are fairly productive.

TABLE 4.—Classification of soils in the Price area, Utah, according to productivity under irrigation

Soil type, phase, or miscellaneous land type ¹	Crop productivity index ² for—										Permanent pasture		General productivity (weighted average of indexes)
	Alfalfa hay	Wheat	Oats	Barley	Potatoes	Sugar beets	Corn (grain)	Beans	Vegetables	Tree fruits	Irrigated	Unirrigated	
Billings loam.....	90	100	70	100	80	100	70	90	70	³ 50	80	4 5	80
Billings clay loam.....	80	60	80	---	70	100	60	---	60	---	80	5	75
Billings silty clay loam.....	70	80	80	80	60	90	60	70	50	---	80	5	69
Billings loam, shallow phase.....	70	80	60	---	70	80	---	---	60	---	70	5	65
Billings silty clay loam, shallow phase.....	55	80	70	---	50	80	50	50	40	---	70	5	59
Mesa loam.....	70	60	50	---	60	60	50	50	50	³ 20	60	5	58
Green River loamy fine sand.....	70	50	40	---	60	60	50	50	60	---	50	5	55
Billings loam, gravelly phase.....	---	---	---	---	---	---	---	---	---	---	---	---	---
Chipeta clay, deep phase.....	45	40	40	---	40	30	30	---	30	---	40	5	39
Billings clay.....	---	---	---	---	---	---	---	---	---	---	---	---	---
Green River fine sand.....	45	20	20	---	50	20	---	---	40	---	30	5	34
Chipeta clay.....	---	---	---	---	---	---	---	---	---	---	---	---	---
Chipeta clay loam.....	20	20	---	---	---	---	---	---	---	³ 10	30	5	22
Mesa gravelly loam.....	---	---	---	---	---	---	---	---	---	---	---	---	---
Billings silty clay loam, poorly drained phase.....	---	---	---	---	---	---	---	---	---	---	---	20	20
Riverwash.....	---	---	---	---	---	---	---	---	---	---	---	---	---
Rough broken land (Billings soil material).....	---	---	---	---	---	---	---	---	---	---	---	---	---
Rough broken land (Mesa soil material).....	---	---	---	---	---	---	---	---	---	---	---	2	2
Rough broken land (Chipeta soil material).....	---	---	---	---	---	---	---	---	---	---	---	---	---
Rough stony land (Chipeta soil material).....	---	---	---	---	---	---	---	---	---	---	---	---	---

¹ Soils are listed in the approximate order of their productivity under a system of irrigation agriculture. They have little or no agricultural value without irrigation.

² The soil inherently most productive (without aid of amendments or irrigation) for each specified crop in the United States is given the index 100. Only soils of significant acreage in well-known crop regions have been given this standard index. The indexes in this table express the approximate productivity of the soils of this area in percent of the standard. All indexes are for crops under irrigation, with the exception of those for unirrigated pasture or range.

³ Tree fruits are adapted in only a few localities having unusually good air drainage and comparative freedom from frost.

⁴ The ratings of pasture or range land are rough estimates. The rating of 5 given most of the soil types indicates that it requires 80 acres of land to support 1 animal unit throughout the year. Sheep are the principal class of livestock grazed on the desert range.

The principal factors influencing productivity are temperature, moisture supply, soil, and lay of the land. As crop yields over a long period of time furnish the best available summation of the factors contributing to productivity, they have been used where possible as a basis for the determination of the productivity indexes in this table. Few specific data on crop yields were available on many of the soils of this area, but estimates based on the natural factors were made as to the relative productivity of these soils as compared with that of the more important soils for which data (farmers' estimates) were obtained. These estimates were checked by census data.

The rating compares the productivity, under irrigation, of each of the soil types, phases, and miscellaneous land types in the area for each crop to a standard—100. This standard, or base index, represents the productivity of the soil type or types in the United States inherently most productive for that crop—that is, most productive without the use of amendments, such as lime, commercial fertilizers, drainage, and irrigation, but under a system of management capable

of maintaining the inherent level of productivity. Unusually productive soils of limited acreage in some instances are given an index of more than 100. Superphosphate nearly always is used in the growing of sugar beets in the Price area, so that the rating for that crop is only with the use of fertilizer; but with this one exception, amendments, such as commercial fertilizers, are seldom used, and no separate rating has been given to indicate the response of the soils to fertilization. The use of manure produced on the land and the growing of legumes, such as alfalfa, are not considered amendments. Irrigation is necessary for the production of crops on these soils; therefore the indexes in the table refer to the productivity of the soils if and when irrigated. A single exception to this is the rating for unirrigated pasture or range.

The soils are listed in the order of their general productivity, but no attempt has been made to place them in groups or classes. The general productivity rating is based on a weighted average of the productivity indexes for the various crops; weight is given to each crop according to its relative acreage, alfalfa, the principal crop, being given a weight of 51 percent.

This rating of soils is not to be interpreted directly into specific land values. It stresses the inherent productivity of the land, which is relatively permanent as compared to transitory economic conditions. In some instances the information on which the ratings are based is not so complete as desired, and further study may suggest changes.

Following are some of the acre yields that have been set up as standards of 100. When applied to the inherently most productive soil types of significant acreage, they represent long-time production averages without the use of amendments to alter the inherent productivity of the soil type for a product of satisfactory quality.

Crop:

Alfalfa.....	tons..	4
Sugar beets.....	do.....	12
Wheat.....	bushels..	25
Oats.....	do.....	50
Barley.....	do.....	40
Corn.....	do.....	50
Potatoes.....	do.....	200
Beans.....	do.....	25
Tree fruits (apples and peaches).....	do.....	200
Pasture.....	cow-acre-days ¹ per year..	100

¹The term "cow-acre-days" is used to express the carrying capacity or grazing value of pasture or range lands. It is the product of the number of animal units supported on an acre of pasture multiplied by the number of days the animals are grazed without injury to the pasture. For example, a soil type able to support 1 animal unit per acre for 360 days of the year rates 360, whereas another soil type able to support 1 animal unit per 2 acres for 180 days of the year rates 90. Again, if 4 acres of pasture support 1 animal unit for 100 days the rating is 25.

SUMMARY

The Price area is situated in the high arid western intermountain region. In its natural condition it was, and much of it still is, a desert, with a sparse covering of brush and very little grass. A small part of the area is now under irrigation, and the climate is such that, given sufficient moisture, general farm crops are well adapted on the deeper well-drained soils.

The farmers find a local market for much of their produce. They provide hay and grain for their livestock; and dairy products, potatoes, vegetables, and fruits for home use and to supply the towns and mining camps. Much farm produce, however, is shipped in. Sugar beets are a cash crop of some importance. Many farmers spend several months during the winter, working in the coal mines.

Farming has undergone but little expansion in recent years; in fact, some reduction in the cultivated acreage has taken place. A small amount of land is still available for agricultural development.

The soils and land types of the area may be considered as belonging to four groups: (1) Soils developed on recent alluvial materials, (2) soils developed on old valley-filling materials, (3) soils developed in place on shale and sandstone, and (4) miscellaneous land types.

The alluvial soils, represented by soils of the Billings and Green River series, are generally productive where well drained and supplied with sufficient irrigation water. They are, however, very erodible and, under irrigation, have a tendency to become waterlogged in places. Shallow phases of the Billings soils have a somewhat lower value than the deeper soils. The Billings soils range from medium to fine in texture, whereas the Green River soils are sandier.

The Mesa soils, developed on the old valley-filling materials, for the most part lie at too high an elevation for irrigation, and only a very small area of them is under cultivation. They are intermediate in value, water-holding capacity, and productivity between the Billings and Chipeta soils.

The soils developed in place from shales and sandstones are shallow, have a low water-holding capacity, and have low productivity. They are members of the Chipeta series.

The land included in the miscellaneous land types is so rough, stony, eroded, or, in the areas of riverwash, so wet, that it has little agricultural value except for the scant pasturage it affords in a few places.

Erosion is a serious problem and is destroying or lowering the value of large areas of land, which are either under irrigation or have potential agricultural value.

Drainage of irrigated lands is another serious problem. The fine texture and comparatively impervious character of many of the soils subjects them to damage from excess irrigation or seepage water, and the underlying shale in places serves to hold the water close to the surface. In other places it apparently conducts water under pressure from higher sources.

This soil survey is a contribution from
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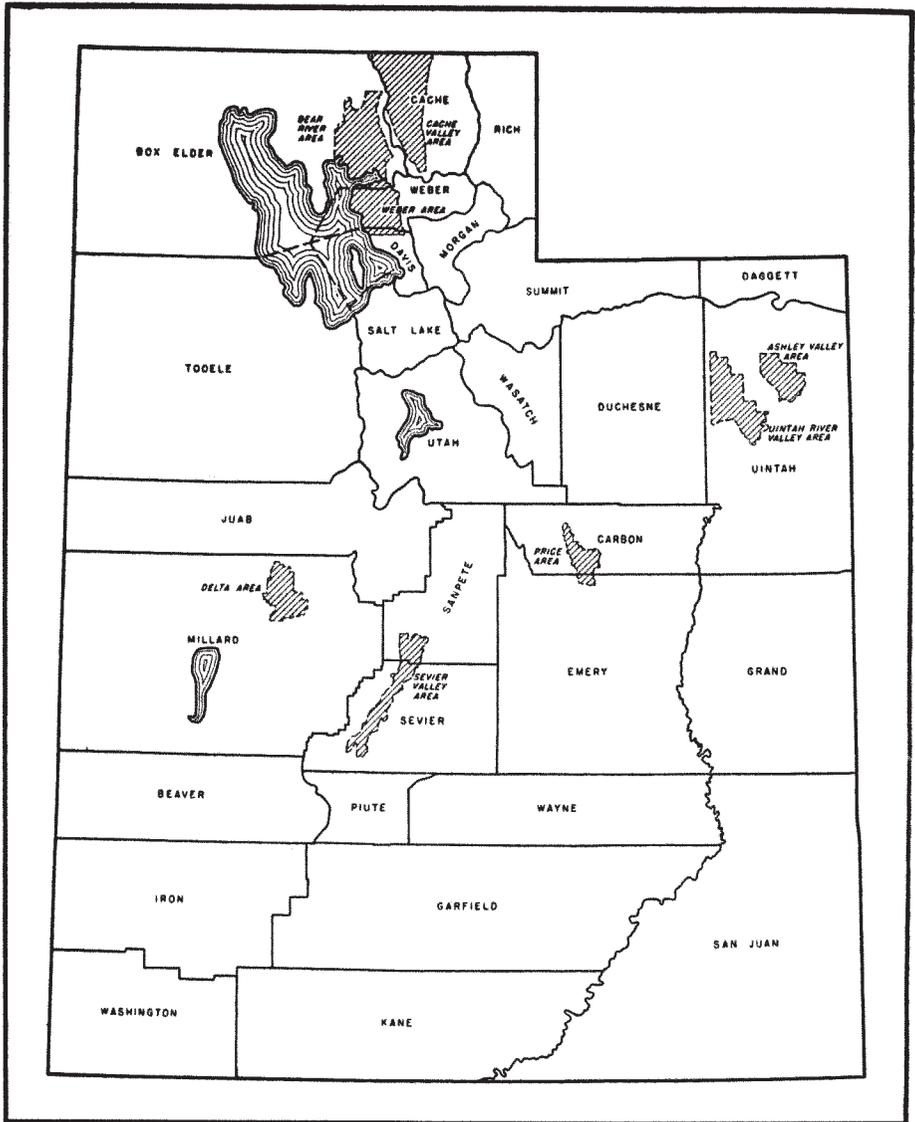
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AREAS SURVEYED IN UTAH SHOWN BY SHADING. DETAILED SURVEYS SHOWN BY NORTHEAST-SOUTHWEST HATCHING.

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