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SOIL SURVEY
OF
THE GRANDE RONDE VALLEY AREA OREGON

BY

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SOIL SURVEY OF THE GRANDE RONDE VALLEY AREA, OREGON

By A. E. KOCHER, U. S. Department of Agriculture, in Charge, and W. L. POWERS and A. O. ALBEN, Oregon Agricultural Experiment Station

AREA SURVEYED

The Grande Ronde Valley area is in the central part of Union County, near the northeast corner of Oregon. La Grande, the principal town, is 216 miles east of Portland. The area surveyed lies within the Blue Mountains, a rugged range of irregular outline extending southwest from the northeast part of the State. The area, which is about 24 miles long from north to south and 18 miles wide from east to west, comprises principally the Grande Ronde Valley, a high basin within the mountains. As its name implies, it is nearly round. In addition to the valley, a marginal strip of hill land is mapped, the boundaries being so drawn as to include practically all the tillable land immediately adjacent to the valley. The total area comprises 289 square miles, or 184,960 acres.

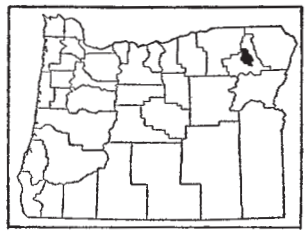

FIGURE 1.—Sketch map showing location of the Grande Ronde Valley area, Oreg.

Evidence is that Grande Ronde Valley was formerly occupied by a lake. Since it was drained a quantity of soil-forming material has been brought into the valley by streams and wind and subsequently reworked by the same agencies. The surface therefore is not so flat as most recently drained lake beds but is marked by comparatively smooth lowlands and ridgelike areas with a typical windblown relief. The principal physiographic features are the valley floor, the sand ridge, the terraces and alluvial fans, the bordering mountain slopes, and Pumpkin Ridge.

The area is crossed by Grande Ronde River, which, rising in the mountains about 25 miles to the southwest, enters the valley at La Grande.

A number of sand ridges, low terraces, and the border fringe of alluvial fans with a few isolated higher hills standing on the valley floor constitute the details of surface relief within the valley.

East of Cove and within 1 mile of the east boundary of the area is Mount Fanny, with an elevation of 7,132 feet, and about the same distance from the east boundary southeast of Imbler is Mount Harris, with an elevation of 5,372 feet. On the west side of the valley and within one-half mile of the west boundary, Mount Emily rises to an elevation of about 6,130 feet.

Pumpkin Ridge is the name given to the cultivated hills at the north end of the valley. This ridge rises rather abruptly to a height

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of 500 or more feet from the valley floor, but with the exception of several deep steep-sided canyons the land is smooth enough for cultivation.

The sand ridge, terraces, alluvial fans, and lower mountain slopes along the south and east sides of the area are treeless and were originally covered with grasses, together with some sagebrush and scattered low bushes along the draws and streams. A few of the wetter areas support tules and marsh grasses, and where alkali is prevalent salt grasses and greasewood (*Sarcobatus vermiculatus*) abound. The fans and mountain slopes along the west side of the area and the higher slopes south of La Grande, east of Cove, and on Pumpkin Ridge are timbered with pine, fir, and tamarack. The rains coming from the west appear to give more water to these localities than to the valley floor or the mountains toward the east.

The entire area is drained by Grande Ronde River and its tributaries. For about 8 miles, from the point where it enters the area to near the center of the valley, the river affords fair natural drainage. Throughout most of the remainder of its course it is extremely sluggish. In the days of early settlement backwater frequently covered extensive low areas, keeping the soil water-logged until summer. During this time pools or small lakes were numerous and a number of areas now cultivated were marshy. The drainage of the southern part of the area has been greatly improved by the construction of the State Ditch (pl. 1, A) which extends about 5 miles northward from the center of the county. There is still need of considerable drainage work in this part of the valley in order to lower the water table. Drainage is also needed in the lowest part of the area west of the sand ridge, as Willow Creek, which crosses it, is sluggish and unable to maintain the water table at a favorable depth. Practically all other sections of the area surveyed are well drained, and, where the relief is favorable, are suitable for irrigation.

The first permanent settler arrived in the Grande Ronde Valley area in 1861, and in the following year a number of families established homes there. Two years later Union County was organized. Located on the Old Oregon Trail, this beautiful valley attracted the attention of many home seekers on their way to western Oregon. Some went no farther; others returned from the West to make their home here. However, settlement was slow, only the better-drained parts of the valley being occupied. In 1884 the railroad was built and gave an added impetus to settlement. The boundaries of the county have been changed from time to time. In 1887 a part was taken to form Wallowa County; a part was annexed to Wallowa County between 1890 and 1900; a part was annexed to Baker County in 1902; parts were annexed to Umatilla County in 1913 and to Wallowa County in 1915; and parts of Umatilla and Wallowa Counties were annexed to Union County in 1913 and 1915, respectively. United States census data are available only for Union County as a whole. In 1920 the population of the county was 16,636. Most of the inhabitants are native-born whites. Most of the original settlers came from the Central States. La Grande, the county seat and largest town, is a railroad division and junction point and is noted for its manufacture of lumber. It has shown a consistent growth from 2,991 in 1900 to 6,913 in 1920. Its present (1926) population, as reported by the La Grande Chamber of Commerce, is 9,000.

Union, the next largest town, is a prosperous agricultural center. Island City, 2 miles east of La Grande on the Elgin branch of the Union Pacific Railroad, is a small town noted for its milling industry. The population in the area is dense only in the vicinity of the larger towns and in a few localities on the sand ridge. Most of the farms are large, and extensive areas in the poorly drained sections of the valley are occupied.

Transportation facilities are good. The transcontinental line of the Oregon-Washington Railroad & Navigation Co. of the Union Pacific system, connecting Chicago and Portland, crosses the south end of the area from east to west. From La Grande the Elgin branch of this line extends north through the central part of the valley, leading to Joseph, 84 miles northeast. A branch line connects Union Station with Union. No point in the Grande Ronde Valley is more than 7 miles from a shipping point, and most farms are within 5 miles. The Old Oregon Trail, which is hard surfaced and is one of the more extensively traveled automobile routes across the continent, traverses the area, and another hard-surfaced highway runs north and south. Earth roads are well distributed over the area and are usually in good condition.

Portland is the principal near-by market for agricultural products, especially grain and livestock. A large quantity of wheat is milled within the area, and the flour is shipped to various parts of the United States. Cherries and apples are disposed of in eastern cities.

CLIMATE

Grande Ronde Valley lies some distance east of the Cascade Range, which effectively shuts off the moisture-laden winds sweeping inland from the Pacific Ocean, causing the rainfall of the greater part of central and eastern Oregon to be scant. It is sheltered by the Rockies and outlying ranges on the east and north, so the cold waves that sweep down over the central plains from Canada are less severe here. It is further protected by the local mountain ranges which closely encircle it on all sides. The climate is continental in character, being intermediate between that of the coast and that of the central part of the United States. The elevation, ranging from 2,700 feet on the floor of the valley to about 8,000 feet in the mountains, influences both temperature and rainfall, especially rainfall, as the cooling of the winds passing over the mountains reduces their moisture-holding capacity and causes the precipitation to be greater than in most of central and eastern Oregon.

The climate is marked by a range in temperature of 140° F. The relative humidity is low, evaporation rapid, and sunshine abundant. July and August are nearly always dry, having a combined mean rainfall of only 1.31 inches. With the exception of these two months the rainfall is evenly distributed throughout the year. The distribution is favorable to the growing of winter grain.

The average annual precipitation is 19.37 inches. This amount is insufficient for maximum crop returns, although fair yields of grain are obtained by summer fallowing, taking two years to produce a crop. However, as the total rainfall is so nearly sufficient, conditions are favorable for supplemental irrigation since only small additional quantities of water are required. The annual snowfall at La

Grande is 45.3 inches, but on the surrounding mountains it reaches many feet. The heavy snowfall in the mountains provides an ample supply of water, if properly conserved, to irrigate a large acreage. Snow rarely remains on the ground in the valley longer than a week or 10 days at a time. This lack of protection to fall-sown grain causes more or less loss.

The mean annual temperature at La Grande is 48.7° F. The average date of the last killing frost is April 24 and that of the first is October 2, giving an average frost-free season of 160 days. Killing frost, however, has occurred at La Grande as late as May 28 and as early as August 30. In most years considerable pasturage is obtained on the drier soils after the first killing frost.

The prevailing winds in winter are from the southeast and during the rest of the year are from the west. In winter and in the spring, wind causes more or less damage to young grain. However, tornadoes or very destructive winds are unknown. The climate as a whole is stimulating and healthful, and although high temperatures are common in summer the heat is not oppressive.

Table 1, compiled from records of the Weather Bureau, gives the normal monthly, seasonal, and annual temperature and precipitation at La Grande.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at La Grande*

[Elevation, 2,784 feet]

Month	Temperature			Precipitation			
	Mean	Absolute minimum	Absolute maximum	Mean	Total amount for the driest year (1895)	Total amount for the wettest year (1912)	Snow, average depth
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	32.5	59	−22	2.08	1.52	2.28	9.6
January	30.1	62	−34	2.14	.94	4.25	14.6
February	33.1	65	−19	1.86	.50	3.88	12.4
Winter	31.9	65	−34	6.08	2.96	10.41	36.6
March	40.0	76	−2	1.90	.85	1.04	4.2
April	47.5	89	16	1.69	1.70	3.03	1.0
May	54.2	100	25	2.19	2.17	3.98	Trace.
Spring	47.2	100	−2	5.78	4.72	8.05	5.2
June	61.1	100	29	1.45	.05	2.06	Trace.
July	69.4	106	36	.62	.50	1.36	.0
August	68.5	103	27	.69	.22	2.03	.0
Summer	66.3	106	27	2.76	.77	5.45	Trace.
September	59.1	99	22	1.13	2.31	1.01	.0
October	49.7	87	16	1.52	Trace.	1.85	.1
November	40.1	83	1	2.10	1.33	1.64	3.4
Fall	49.6	99	1	4.75	3.64	4.50	3.5
Year	48.7	106	−34	19.37	12.09	28.41	45.3

AGRICULTURE

Agriculture in the Grande Ronde Valley area is an established industry which began about 1862. The first settlers found an open valley covered with a luxuriant growth of grass, with here and there

a fringe of brush along the streams. The first agricultural interests were centered in the grazing of livestock. The animals found a ready sale in the numerous mining camps which already flourished in the mountains to the east. Under the stimulus of this demand, as well as the need for food products, small grains, potatoes, and many vegetables and fruits were early introduced, and a considerable acreage of wild grass was cut for hay for winter feeding.

Production figures for the Grande Ronde Valley area are not available, but data covering Union County indicate fairly well the type of agriculture in the area surveyed, together with the history of its development. It should be borne in mind that the figures representing the percentages of improved land are less for the county as a whole than they are for Grande Ronde Valley.

Table 2 gives the acreage and production of the principal crops in Union County, as reported by the census.

TABLE 2.—*Acreage and production of principal crops in Union County, Oreg., as reported by the census*

Year	Wheat		Oats		Barley		Corn		Rye		Potatoes		Hay and forage	
	Acres	*Bush.*	*Acres*	*Bush.*	*Acres*	*Bush.*	*Acres*	*Bush.*	*Acres*	*Bush.*	*Acres*	*Bush.*	*Acres*	*Tons*
1879	11,422	284,463	6,724	251,344	3,044	116,393	56	1,110	201	3,925	------	29,932	[1] 17,201	25,427
1889	30,226	614,677	9,455	273,053	6,226	188,098	37	1,015	200	2,815	399	52,053	[1] 40,928	59,929
1899	38,025	767,000	10,490	299,350	8,858	215,640	166	3,880	808	10,830	1,443	197,704	44,817	75,592
1909	41,487	1,177,808	16,087	684,556	9,802	300,656	124	4,429	1,041	13,079	1,989	238,272	33,147	53,589
1919	55,749	962,054	8,943	199,026	4,361	73,133	288	5,733	952	8,099	1,017	59,710	43,544	79,873
1924	43,738	831,716	7,798	214,967	5,387	123,858	118	2,304	813	8,797	450	47,561	[1] 37,100	50,672

[1] Hay only.

Table 3 gives farm acreages and values in census years.

TABLE 3.—*Farm acreages and values, Union County, Oreg., in census years*

Year	Farms	Total land in farms	Average size of farms	Improved land in farms	Average value all farm property
	Number	*Acres*	*Acres*	*Per cent*	*Dollars*
1880	659	164,002	249.0	57.4	3,958
1890	1,104	320,678	290.0	57.0	5,987
1900	1,481	391,299	264.2	41.5	5,731
1910	1,309	395,769	302.3	41.8	12,986
1920	1,279	441,735	345.4	40.3	22,024
1925	1,218	420,029	344.9	----------	18,039

The value of all farm products in 1919 was $7,854,444, more than double that in 1909. The type of farming is shown by the fact that of this amount $6,587,050, or nearly 84 per cent, was in cereals, hay and forage, and domestic animals. Dairy products, excluding those for home use, were valued at $353,733, poultry and eggs at $185,825, wool, mohair, and goat hair at $61,981, vegetables at $191,567, and fruits and nuts at $467,570.

At the present time the agriculture of the Grande Ronde Valley area consists of the production of wheat and fruit for sale, the growing of alfalfa and other forage crops for sale and for home use, dairy farming in a small way, hog raising, winter grazing of

beef cattle and sheep, and the production of potatoes and vegetables for local markets and for home use. The principal crops are wheat, alfalfa, and apples. Other crops which are grown for sale and shipped in carload lots are cherries, prunes, potatoes, pears, oats, and barley.

Wheat is the most important crop, both from the viewpoint of acreage and financial returns. A part of it is shipped to outside points for milling, but a large quantity is manufactured into flour within the valley. In 1925, 387 carloads of wheat, 90 carloads of flour, and 34 carloads of mill products were shipped from Grande Ronde Valley points. Wheat is grown under dry-farming methods, usually on summer-fallowed land. On the better-drained soils from 60 to 70 per cent of the wheat is sown in the fall and the rest in the spring. On the valley soils these proportions are reversed. Most of the fall seeding is done between September 15 and October 1 and spring seeding from March 1 to May 1, the earlier dates applying to the sand-ridge and hill sections of the area. The leading variety grown in the valley is Hard Federation, which is sown in the spring. About 55 per cent of the fall-sown wheat is the Goldcoin (Forty-fold), and most of the remainder is Hybrid 128. The Federation variety is becoming important, especially on the deeper soils with good moisture conditions, as it returns better yields than the Hard Federation. Fall wheat, when not damaged by winterkilling, yields better than spring wheat, as it ripens before the summer drought. On the better-drained soils of the sand ridge winter wheat yields from 25 to 45 bushels, with an average of about 35 bushels to the acre, and spring wheat from 17 to 35 bushels, averaging about 25 bushels. On the valley soils yields of spring varieties of wheat range from 17 to 28 bushels to the acre, with an average of 20 bushels, and of winter varieties from 25 to 35 bushels, with an average of about 27 bushels. In some years, when dry weather or spring freezes prevent the grain from maturing, the crop is cut green for hay. In 1919, 13,905 acres of small grains in Union County were utilized in this way.

Hay, always an important crop in the county, became especially so in 1899 as a large acreage of alfalfa and tame grasses was added to the acreage already in wild grasses. By 1909 a marked change in the proportions of the various hay crops grown was noticeable. The acreage of alfalfa, timothy, and other tame or cultivated grasses increased greatly, whereas only a little more than one-half of the former acreage of wild grasses was cut for hay. In 1919 there was a further considerable increase in the acreage of tame or cultivated grasses. The acreage of alfalfa nearly doubled, and timothy sown alone occupied only about one-half its 1909 acreage.

Alfalfa is the most important hay crop in the valley. It is fed to work animals, dairy cattle, beef cattle, and sheep, used for fall pasture, and grown for seed. The seed is a cash crop and is usually taken from the second cutting, when the supply of moisture is too small to produce a profitable crop of hay. According to information obtained from the county agricultural agent, 25,000 pounds of seed were produced in the valley in 1925. Yields of seed range from 60 to 150 pounds to the acre. When alfalfa is harvested for hay either two or three cuttings are obtained, depending on the season

and on whether or not the crop is irrigated. Yields range from 2 to 5 tons to the acre, depending on the character of the soil and the moisture supply.

According to the 1920 census report, 22,196 acres in the county were devoted to cultivated grasses in 1919. Of this acreage timothy alone occupied 4,661 acres and timothy and clover mixed 2,380 acres. These crops are most common on the subirrigated soils around Union and Summerville and on some of the well-watered soils along the river from Phys Point north. Yields range from 2 to 2½ tons to the acre. There is a large acreage of wild grass in the south end of the valley, some of which is cut for hay, yielding about 1 ton to the acre. However, most of the wild grass is pastured.

Fruit growing is of some importance in the vicinity of Imbler, La Grande, Union, and Cove. Apples occupy the largest acreage, cherries, prunes, and pears following in the order named. Apples are grown most extensively near Imbler, from which point 181 carloads were shipped in 1925. The total shipment from the valley was 237 cars. The leading varieties of apples, in order of their importance, are Rome Beauty, Delicious, Gano, Jonathan, and Winter Banana. The apple crop is grown mainly without irrigation, and the orchards are given a little clean cultivation during the spring and summer. During the summer of 1926 some orchards received no cultivation whatever. Insufficient cultivation is reflected in low yields of only moderate-sized fruit. The better-cared-for orchards return from 100 to 500 packed boxes to the acre, with an average of about 200 boxes. Frequently the trees appear less thrifty than they should, indicating not only a shortage of moisture but a lack of nitrogen and organic matter in the soil. For the control of pests, it is said about 70 per cent of the growers give a dormant lime-sulphur spray in March. About 80 per cent give two arsenate-of-lead sprays in spring and summer for codling moth, and the remaining 20 per cent give three sprays for codling moth.

Cherries are grown principally on the high alluvial fans in the vicinity of Cove. In 1925, 3 carloads were shipped by freight from Union Station, which is the shipping point for the Cove district, and 5 from La Grande. The previous year 60 carloads were shipped from the Cove neighborhood. In addition to freight shipments small quantities go out by express. About 40 per cent of the cherries grown are of the Lambert variety, 30 per cent are Napoleon (Royal Anne), 20 per cent are Bing, and perhaps 10 per cent are Republican (Black Republican). Yields vary greatly, owing to a number of causes, chief among which are late spring frosts which severely damage the crop about one year in five. The cherry crop is grown principally under irrigation or on land which is naturally subirrigated. The Bing and Lambert varieties are graded and packed and marketed in eastern cities, and the Royal Anne are sold locally or shipped to the cannery at The Dalles, Oreg.

Prunes are assuming some importance in the vicinity of Union and Cove, 49 carloads being shipped from Union Station in 1925. The trees are grown principally under irrigation or where the land is naturally rather wet. The trees differ in degree of thriftiness and yields, depending on the moisture supply and drainage conditions.

Pears are of minor importance, only 2 carloads being reported from Imbler in 1925. In addition to the fruits enumerated, several

kinds of berries are produced for home use and for sale in the local markets.

Potatoes are grown on nearly every farm for home use and to supply local markets. A few farmers grow potatoes as one of their principal cash crops. Forty carloads, of which thirty-five left from La Grande, were shipped from the valley in 1925. Potatoes are grown mainly without irrigation, perhaps 15 per cent of the crop near Union being watered. Yields range from 100 to 350 bushels to the acre. The Russet Burbank (Netted Gem) is the leading variety.

Very little oats and barley are grown. The acreage of barley fluctuates considerably with market conditions. Nearly all the crop is used locally for feeding work animals. Oats and barley are grown principally on the moist valley soils, oats especially giving poor yields on the higher lands. The Union Pacific Railroad reported 20 carloads of oats and 9 carloads of barley shipped from the valley in 1925. The leading varieties of oats are the Markton, Swedish Select, and Iowa Silvermine. The first-named variety is increasing in popularity since it is early and smut proof, requiring no treatment before seeding.

During the last year (1925) 154 carloads of sheep, 95 carloads of cattle, 18 carloads of horses, and 13 carloads of hogs were shipped from Grande Ronde Valley. Dairying is practiced on a small scale in the vicinity of La Grande and Union, the milk being delivered from house to house and the cream manufactured into butter at local creameries. There is a monthly express shipment of about 5,000 pounds of butter from La Grande, and 48 carloads have left the valley by express during the first nine months of the present year and probably the same number by freight.

Vegetables are grown on practically every farm for home consumption and for sale locally. Some lettuce is grown for outside markets, 3 carloads being shipped from Union in October, 1925. During that year 2,252 carloads of lumber and 66 carloads of wood were shipped from La Grande.

The farmers of the Grande Ronde Valley area recognize that the Catherine soils and Conley silt loam are well suited to the production of alfalfa and small grains (pl. 1, B), including oats, but that the Alicel and Palouse soils and the soils of the hills are not well suited to oats. They recognize that the upland soils, including those of the sand ridge, are better suited to fall-sown wheat than to spring wheat, since the former ripens before there is an acute shortage of moisture, whereas on the valley soils where conditions are reversed and there is frequently an excess of moisture, spring wheat does best since here the fall-sown variety is frequently injured by winterkilling. The alluvial-fan phase of La Grande gravelly clay loam near Cove is considered best suited to cherries and prunes because of its good water supply and greater immunity from frost. Also because of freedom from frost, Waha clay loam on Pumpkin Ridge is considered well suited to the production of fruits and vegetables. Poorly drained areas of Gooch and Klamath soils and shallow areas of the latter, where the underlying white deposits are near the surface, are considered undesirable for the production of any of the crops of the valley and are thought best suited to the production of wild hay or for use as pasture.

The soils and surface relief in the Grande Ronde Valley area have had a marked influence on the distribution of crops. The slightly elevated, gently rolling, well-drained soils of the sand ridge are devoted largely to winter wheat, with a smaller acreage in apples and alfalfa. On the valley soils, where moisture is plentiful and winterkilling is common, spring wheat predominates, with small acreages of oats and alfalfa. Considerable areas of poorly drained soils of the Gooch and Klamath series, which are more or less affected by alkali, are uncultivated and are used only for pasture. (Pl. 1, C.) High alluvial fans and mountain foot slopes near Cove, being more immune from frost, are planted to cherries and prunes. Most of the slopes in other parts of the area are too steep or stony for cultivation and are used only for pasture or timber.

During the fall a few sheep are driven into the valley from the summer ranges in the Wallowa National Forest for fall and winter feeding. A few beef cattle are grazed all summer on the more poorly drained land in the southern part of the valley. Sometimes sheep are grazed on summer-fallowed fields to help rid the land of horsetail and other weeds. Following harvest, hogs and other livestock are turned into the stubble fields to eat shattered and fallen grain.

No systematic crop rotation is followed. Wheat, broken only by summer fallow, has occupied most of the valley for many years. Alfalfa is usually left as long as the stand is satisfactory.

The farm buildings throughout the Grande Ronde Valley area are adequate and are kept in good repair. The fences are especially good. Most of the plowing and all the summer-fallow work is done with horses, six or eight usually forming a team. In harvesting, some of the combines used for cutting and threshing the grain are hauled with tractors and some with teams. The work animals consist of medium-weight horses, the supply of which is abundant. Most of the dairy cows are grades, but there are some excellent Holsteins and Jerseys in the valley. Farming is generally on a large scale, and improved machinery is in evidence everywhere.

The use of fertilizers is increasing, although the total amount used is small. In 1909 only 3 farmers in Union County reported the use of commercial fertilizers, and in 1919 48 farmers reported their use. The total amount expended for this purpose in 1919 was $8,017, or $167.02 for each farm reporting.

The largest single item of expense is labor, which in 1919 cost the farmers of the county $648,194, or an average of $759.01 a farm. The labor supply is usually abundant at all seasons. The laborers, nearly all of whom are white Americans, are efficient. Wages for ordinary help range from $2 a day with board to $3 a day without board. During the harvest season from $2.50 to $3 a day with board and from $3.50 to $5 without board is paid. Apples are usually picked by the box and cherries by the pound, 5 cents a box and 2 cents a pound, respectively, being paid.

Feed is another large item of expense in Union County, 936 out of a total of 1,279 farmers reporting purchases in 1919. The total amount expended for this purpose was $352,122, or an average of $376.20 for the farms reporting. The feed bought consisted principally of hay, with some grains and a little mill feed for use in wintering or finishing range stock and feeding dairy cattle and hogs. Most of the feed bought is produced locally.

As in most sections where wheat raising by summer-fallow methods prevails, farming is done on a rather large scale. Many farms are 160 acres in size, and a number range from several hundred to more than 1,000 acres. According to the census there is a consistent tendency toward larger farms. This is probably even more common in the Grande Rondo Valley area than in the county as a whole. It is being brought about by combining a number of smaller holdings with the larger wheat farms.

In 1920, 80.6 per cent of the farms in the county were operated by owners, 18.5 per cent by tenants, and 0.9 per cent by managers. Rented land is usually worked for a share of the crop, the tenant paying the owner one-third or two-fifths of the grain and usually one-half of the hay. Under most agreements the tenant furnishes teams and equipment.

Land improved for general farming commands from $70 to $125 an acre, the greater part being held at a price between $80 and $100 an acre. Apple and cherry orchards range in price from $150 to $500 an acre, depending on location and condition of the trees. The current price of undeveloped pasture land, poorly drained and more or less affected by alkali, is between $35 and $60 an acre.

SOILS

The Grande Ronde Valley area lies in the northwest intermountain region, where the climate is characterized by low or moderately low rainfall, a wide range in temperature, and a high percentage of sunshine. Although the rainfall here is somewhat greater than in the lower parts of the region, owing to the elevation (from 2,700 to 3,000 feet above sea level) and the proximity of still higher mountains, it has not been sufficient to cause extensive leaching of soluble soil constituents. However, with certain notable exceptions, leaching has progressed somewhat farther than in most of the soils in lower altitudes where the rainfall is less. Although there is characteristically a dry period in summer, the rainless period is generally much shorter than in a large proportion of the State. Moreover, in parts of the valley underdrainage is poor, so that only the surface materials become thoroughly dry and these only for a short time. Consequently the soils in late summer do not become so hard as many of the soils of the Willamette and Rogue River Valleys in the western part of the State and many of the soils in central and eastern Oregon and Washington.

The soil profiles in the valley are typical of regions where the natural vegetation consisted of grass instead of forest. The surface soils are all dark colored, are normally rich in organic matter, and are commonly granular or somewhat platy in structure. In all the nearly mature soils the subsoils are lighter colored and somewhat heavier textured than the surface soils. A number of the soils contain accumulations of lime carbonate which, in the oldest and most nearly mature soils, approaches a hardpan. The parent materials or underlying substrata are light colored, light textured, loose, and pervious. In the more poorly drained soils they are mottled; elsewhere they are usually yellowish or light brown.

On the slopes, especially on the west and north sides of the valley, the amount of rainfall increases, grasses give place to trees, and the

surface soils are lighter colored, more mellow, poorer in organic matter, and structureless, and the subsoils are less compact and more thoroughly leached of soluble constituents. The light-colored timbered alluvial-fan soils with loose gravelly subsoils are members of the Springdale series and the hill soils of the Tolo series. The dark-colored hill soils, which are mostly treeless, are of the Waha series. The soils of all three series are well drained and free from lime carbonate in surface soils and subsoils.

The lake-bed soils are heavy in texture, but in the subsoils near the margin of the basin, especially opposite canyons, coarse material is predominant. Following the disappearance of the lakes more or less erosion apparently took place, especially at the upper end. This is evidenced by the fact that very old gravelly terraces from 20 to 30 feet high, which have the appearance of being only remnants of a former plain, may still be seen both north and south of La Grande.

Volcanic ash deposits rest directly on the lake-laid clays, indicating that they were deposited in water. Their depth below the surface ranges from less than a foot about 1½ miles north of Hot Lake to 6 or 8 feet along Grande Ronde River south of Conley. It is possible that some of the materials immediately above these deposits are of lake-laid origin, but evidence on this point is not so convincing as it is in the underlying clays. It seems more likely that the volcanic disturbance resulting in the deposition of volcanic ash and the opening of the gorge which drained the lake were more or less contemporaneous.

The rocks in the mountains immediately surrounding the valley are of low quartz content, or basic in character, and consist principally of basalt, though in the section between Phys Point and Union lighter-colored fine-grained highly fissile rocks occur. A few miles back in the mountains Catherine Creek flows from areas of granite, and these rocks have impressed certain characteristics on the alluvial-fan deposits near Union. Very commonly the substrata of soils in all parts of the valley are highly micaceous, but the most highly micaceous materials are generally fine grained and have been borne in by winds. The surface soils of all the soils in the valley have been brought in by water or wind, and it seems safe to say that all of them contain materials deposited or modified by wind. They occur alike on the floor of the valley and in the forested hills. Strictly wind-blown soils, however, occur only on the sand ridge in the north-central part of the area and on Pumpkin Ridge or the hills at the north end. In the sand ridge these soils are members of the Alicel and Palouse series. In the timbered hills they are members of the Tolo series. The dark-colored soils on the hills seem to be derived partly from the underlying basalt and partly from material borne in by winds. They are classified in the Waha series.

On the basis of differences in topographic position and parent materials, the soils of the area are differentiated into (1) soils of the more elevated hills, derived mainly from weathering in place of consolidated rocks; (2) soils of the sand ridge and the lower slopes of Pumpkin Ridge, derived from weathered wind-laid materials; (3) soils of the terraces and alluvial fans, derived from the coarser-textured old alluvial deposits; and (4) soils of the valley floor, derived from the finer-textured alluvial and lake-laid deposits. The

members of each group are further separated into series and types on the basis of differences in drainage, stage and process of development, texture, and details of profile features. It is realized, however, that such a major grouping is justified by convenience only and is not based at all on soil character.

The first group includes the Waha and Tolo soils; the second group the Alicel and Palouse soils; the third group the Hyrum, La Grande, and the younger or less weathered Springdale soils, and the fourth group the Gooch, Klamath, Conley, and more recent alluvial Catherine soils.

All the soils, except those of the fourth group or those on the comparatively flat valley floor, are well drained and generally free of alkali. Those on the flat valley floor are more or less affected by a high water table, which in places has resulted in the accumulation of alkali.

The unit in soil mapping is the soil type. Materials differing only slightly are recognized as phases of types. Soils that are similar in color, structure, profile, and character of material on which they are developed or accumulated are grouped into series and given a geographical name. The members of a series differ only in texture of the surface horizon or the relative proportion of the various grades of sand, silt, and clay present. In addition to rough stony land, a nonagricultural material occurring on the lower mountain slopes, 11 soil series, including 28 soil types and 9 subordinate phases, are represented.

Soils of the Waha series, as occurring in the Grande Ronde Valley area, consist of very dark dull-brown, friable, granular, platy-structured, heavy-textured material to a depth ranging from 20 to 26 inches. This layer has a comparatively high organic-matter content and the material is nearly black, particularly when moist. In places the lower part of this layer is compact and somewhat adobelike or columnar in structure. The upper part of the subsoil, to a depth of about 48 inches, consists of brown mottled columnar or adobe-structured material of heavy texture, the columns, which are from 3 to 8 inches long and from 1 to 5 inches wide, becoming very hard and brittle when thoroughly dry. In many places this material lies directly on basaltic bedrock, and basaltic bowlders are mixed throughout the soil or scattered over the surface. In places the subsoil material is many feet thick and the soil resembles soils of the Alicel series in many characteristics. These soils are noncalcareous throughout. The typical soils are considered residual from the underlying basalt, but in this area they are undoubtedly mixed with fine-textured material which was deposited by wind. Only the clay loam of the Waha series is mapped.

Associated with the Waha soils on Pumpkin Ridge are the lighter-colored, timbered, noncalcareous soils of the Tolo series. They are characterized by light-brown or light grayish-brown friable structureless surface layers and lighter grayish-brown or slightly pinkish-brown slightly compact subsurface layers which are easily broken down into a flourlike grain. At a depth of about 27 inches the material becomes a little more compact but otherwise is similar to the materials above. Below a depth of about 3½ feet is somewhat richer-brown or more yellowish-brown compact cloddy or coarse

granular clay showing iron mottles when freshly exposed. This material continues downward to a depth of 10 or more feet, the compaction increasing with depth. The Tolo soils apparently are derived from weathering of fine-grained wind-borne or loessial materials with an admixture of residual material from basaltic bedrock. Having developed under a forest cover they are poor in organic matter and lack the dark color (except in the surface 1-inch layer) that characterizes soils of the region developed under grass cover. Tolo loam is mapped.

Soils of the Alicel series are characterized by a surface layer about 4 inches thick of very dark dull-brown fine granular thinly laminated or platy-structured material containing, in the original condition, a large proportion of organic matter. This layer is underlain to an average depth of 15 inches by material of similar color and texture but slightly columnar structure. In the original condition these two layers are friable and mellow, but they become slightly compact and more or less cloddy where the organic matter has been depleted. When wet the surface layer is nearly black. The subsoil is lighter colored, more compact, and in most places heavier textured than the layers above. It consists of brown or tawny yellowish-brown compact columnar material in which the columns range from 1 to 3 inches in width and from 5 to 10 inches in length. When disturbed in banks the dry clods are readily broken down by slight pressure. Ranging in thickness from 2 to 4 feet, this layer grades at a depth between 3 and 5 feet into the parent material consisting of similar colored or slightly lighter-colored looser-structured lighter-textured micaceous material which becomes progressively looser and coarser with depth. (Pl. 2, A.) The soils of this series are well leached of soluble constituents, and no lime carbonate is present. A wind-blown origin is ascribed to the Alicel soils. Redistribution of the material by winds may still be seen in the movement of the coarser particles along the surface. The materials are of mixed composition, although dark-colored grains of igneous origin predominate. Differences in texture have given rise to four members of the Alicel series, the sandy loam with a coarse-textured phase, the fine sandy loam, the loam, and the silt loam.

Associated with soils of the Alicel series and resembling them in all features except lime content are soils of the Palouse series. The 4 or 5 inch surface layers of the Palouse soils consist of very dark dull-brown slightly compact platy-structured material rich in organic matter, overlying similar-colored mellow fine granular material which continues to a depth ranging from 16 to 30 inches. When depleted of organic matter the soils are inclined to clod, but in the virgin condition the aggregates are readily broken down into a single-grained structure. Where maturely developed, the lower part of this layer shows a slight columnar structure. Like soils of the Alicel series, the surface soil when thoroughly dry appears very dark gray but when wet is very dark brown or nearly black. In most places the surface layers are noncalcareous, but in some places they effervesce with dilute hydrochloric acid. Where maturely weathered, the subsoil consists of three layers. The first layer is brown, rich-brown, or tawny-yellow compact columnar-structured material of heavier texture than the surface soil, through which the

lime carbonate has leached into the material below. The columns in this layer range from 3 to 5 inches in width and from 5 to 8 inches in length. The prisms are well developed. In the sandy loam member of the series, this layer, as well as the layer directly below, is calcareous in many places. It ranges in thickness from 10 to 20 inches, grading at a depth between 30 and 42 inches into a little lighter-colored, looser-structured highly calcareous material which contains scattered particles of lime carbonate. The material becomes looser structured, lighter textured, and less calcareous with depth until, at a depth ranging from 5 to 12 feet, the accumulated lime carbonate disappears and there begins the unweathered substratum of tawny-yellow loose micaceous sandy loams of various grades, which continue to become looser and coarser with depth. In places the subsoil between depths of 30 and 40 inches contains sharp-pointed or spiny lime nodules ranging from the size of a pea to an inch in diameter. This layer, although referred to as hardpan, is nowhere sufficiently dense to justify the term. The Palouse soils are of loessial origin. Three members of the Palouse series, the sandy loam, fine sandy loam, and loam, are mapped.

The Hyrum series includes perhaps the oldest soils in the area surveyed. They are characterized by black adobe-structured surface layers and light-gray or yellowish-gray compact gravelly subsoils with highly calcareous firmly cemented gravelly material in the upper part. The material is gravelly from the surface to a depth of many feet. A typical profile shows the following layers: (1) To a depth of 7 inches, thick noncalcareous dark dull-brown or black heavy granular material containing fine waterworn gravel and a large content of organic matter; (2) a similar-colored or lighter-brown compact noncalcareous adobe-structured clay layer showing faint rust stains to a depth ranging from 18 to 24 inches; (3) a layer consisting of yellowish-gray highly calcareous more or less cemented gravelly material, approaching hardpan (pl. 2, B), which varies greatly in thickness as well as in degree of cementation, rarely being more than 2 feet and more frequently 1 foot thick, characteristically occurring in lenses, and in places thinning out or disappearing entirely; and (4) the underlying yellowish-gray unassorted well-rounded gravelly deposits which continue to a depth of many feet and are in most places noncalcareous, only moderately compact, and loose and pervious to a depth of 10 or 12 feet. These soils are derived from old weathered stream-laid or old alluvial-fan deposits which now occupy terraces near La Grande and the lower hill slopes east of Cove. Hyrum gravelly clay loam and Hyrum stony clay are mapped.

The soils of the La Grande series differ from those of the Hyrum in being younger or less thoroughly weathered. They have gravelly subsoils which are uncemented and usually either leached of lime or of much lower lime content. The surface layer is very dull dark-brown, dark-gray, or black fine granular friable or platy-structured material about 4 inches thick overlying material of similar color and texture which is moderately compact but still platy in structure. This layer continues to a depth ranging from 12 to 20 inches. The upper subsoil layer, which is from 12 to 18 inches thick, is lighter dull grayish-brown moderately compact columnar-structured ma-

terial of a little lighter texture extending to a depth ranging from 30 to 36 inches and in many places containing a slight accumulation of lime. At this depth a layer, from 6 to 12 inches thick, of dull grayish-brown slightly compact soft cloddy loam mottled with rust yellow occurs. At a depth between 30 and 42 inches, these soils are underlain by unassorted gravel and cobbles loosely embedded in light rich-brown or light reddish-brown loam which becomes looser and coarser with depth, until between depths of 10 and 25 feet it consists largely of well-rounded cobbles and bowlders from 8 inches to a foot in diameter. The La Grande soils are derived from weathered stream-laid deposits of mixed origin but consisting principally of basaltic material. The gravelly loam, loam, silt loam, silty clay loam, and gravelly clay loam with an alluvial-fan phase are the members of the La Grande series mapped.

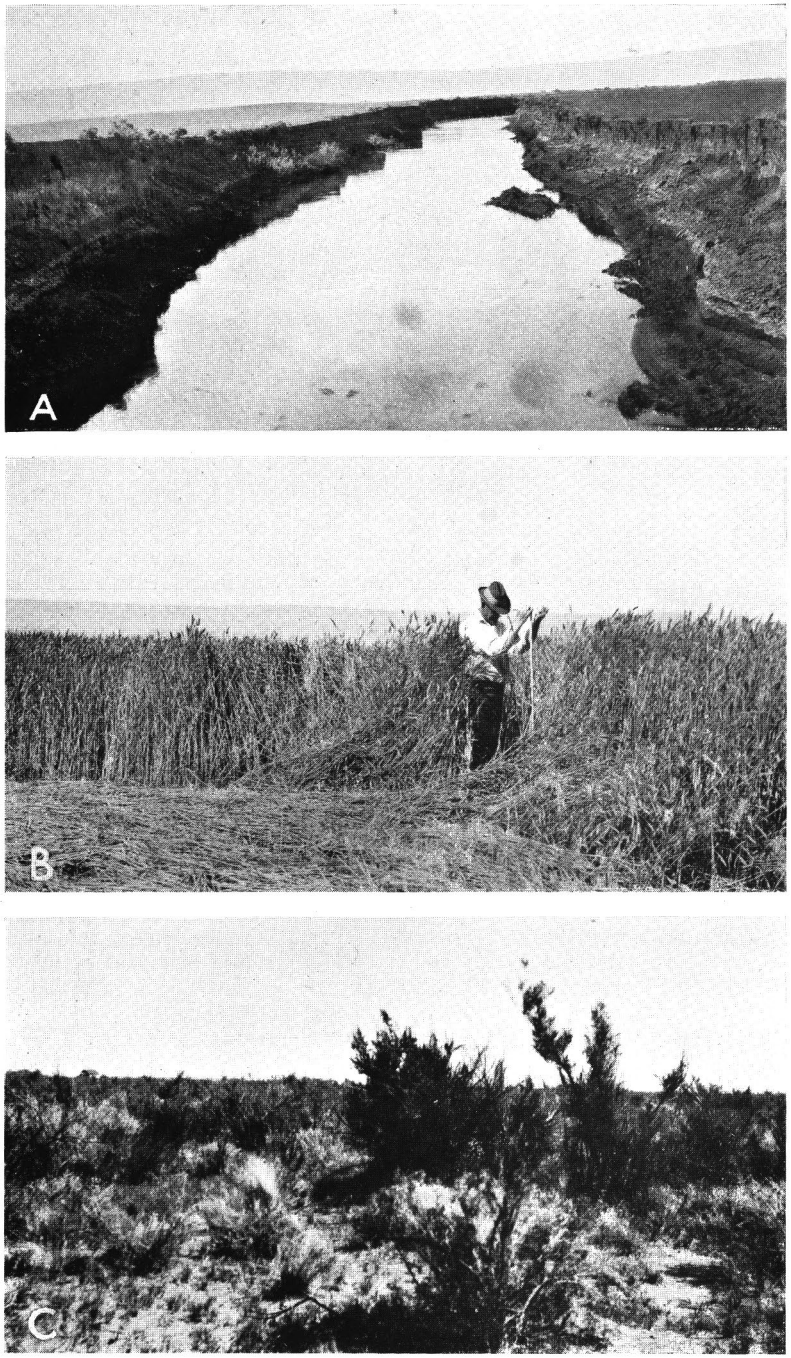
Soils of the Springdale series are characterized by medium-brown, light-brown, or yellowish-brown friable surface layers and light rich-brown, yellowish-brown, or reddish-brown gravelly subsoils which in some places are moderately compact but are generally loose and porous. With the exception of a darker-brown surface mulch, from 1 to 3 inches thick, which contains a quantity of organic matter, the soils are poor in this constituent. The coarser material is chiefly basaltic and ranges from gravel and cobbles to bowlders a foot in diameter. A large proportion of the subsoil and substratum, to a depth of 20 or more feet, is composed of this coarse material. In most places the material shows little weathering, and no lime carbonate is present in any part of the soil. Two members of the Springdale series, the loam and the gravelly loam with a stony phase, are mapped.

The soils of the Gooch series resemble somewhat those of the Palouse series but differ in having lighter-colored surface layers, in occupying lower, more poorly drained positions, and in being derived more largely from water-laid rather than wind-laid materials. In general, the Gooch soils are characterized by dark-gray or dark brownish-gray surface layers and similar-colored, light-gray, or dull-brown compact highly calcareous subsoils. The profile of typical Gooch soils shows the following layers: (1) From 0 to 3 inches, dark-gray or dark brownish-gray slightly compact platy-structured or fine granular material containing a good supply of organic matter and in most places being noncalcareous; (2) a layer ranging from 6 to 16 inches in thickness, of similar or lighter-colored granular or platy-structured material of the same general texture as the surface layer, which breaks readily to a single-grained structure; (3) the upper subsoil layer, ranging from 10 to 20 inches in thickness, which is commonly lighter-gray or brownish-gray heavy-textured highly calcareous material, silty in the silt loam soil but platy, compact, or adobelike in the other soils, which when dry offers some resistance to the downward passage of roots but softens and becomes easily penetrable when moist; (4) the lower subsoil layer which varies considerably in thickness in the different members of this series, in the silt loam being 40 inches thick, in the fine sandy loam from 32 to 42 inches, and in the loam from 26 to about 36 inches; and (5) the substratum which in most places consists of light-brown mottled porous sandy material becoming coarser and more porous with depth.

In places, alkali accumulations are prevalent. Gooch fine sandy loam with a light-textured phase, Gooch loam with a gravelly subsoil phase, Gooch silt loam, and Gooch silty clay loam with a gravelly subsoil phase are mapped.

Associated with the Gooch soils and in many places resembling them in surface appearance are the soils of the Klamath series. Their chief distinguishing mark is the presence of a layer of diatomaceous deposits or of light-gray or white fine-textured volcanic ash. This material was apparently laid down either in the waters of the former lake or just after the lake dried, since it rests directly on lake-laid deposits and, wherever examined, was covered by later alluvial deposits. The material is very fine grained, sharp or angular in outline, siliceous, and noncalcareous. When dry it is flourlike or powdery, and when wet it has a cheesy consistence. In some of the thicker deposits there is a central core several inches thick which has become solidified into a soft shalelike mass. When bored into this mass separates into small angular fragments which may be crushed into powder under slight pressure. All this material occupies a like position with reference to the underlying lake-laid deposits but varies considerably in its relation to the overlying deposits. The layers range from very thin to 2 or more feet in thickness and may occur within less than a foot of the surface or at a depth of as much as 8 feet. The surface soils of the Klamath soils include the three following more or less distinct layers: (1) A layer, 4 or 5 inches thick, of dull dark-gray or dark bluish-gray friable material containing a large proportion of organic matter; (2) a 7 or 8 inch layer of similar but thinly laminated or platy material breaking down into a coarse granular or fine nut structure; and (3) a layer of similar color and texture but columnar in structure, the material falling apart naturally into powder or single grains. The upper subsoil layer, between depths of about 24 and 30 inches, is somewhat lighter-gray slightly compact columnar silt loam showing streaks of lime. All the materials above this depth are intermittently calcareous, although the surface layer is commonly free of lime. The lower subsoil layer, lying at a depth ranging from 30 to 40 inches, is dark-gray becoming light gray when dry, slightly compact columnar somewhat honeycombed or vesicular-structured silty clay loam, which is in most places noncalcareous. It is underlain abruptly by the white diatomaceous or volcanic material described, and this in turn overlies the heavy-textured adobe-structured lake-laid clays at a depth ranging from 5 to 6 feet. (Pl. 3, A.) Klamath silt loam and Klamath silty clay loam occur in this area.

The Conley soils resemble the Gooch soils, with which they are associated, in surface appearance and differ from them in the absence of lime. Typically these soils have a surface layer, from 1 to 3 inches thick, of dark-gray, dark brownish-gray, or bluish-gray platy or fine granular material which contains organic matter and is underlain by lighter bluish-gray platy or granular-structured heavy-textured material continuing to a depth ranging from 16 to 19 inches. The upper subsoil layer extending to a depth ranging from 4 to 5 feet is dark dull brownish-gray or drab compact clay of columnar, adobelike, or prismatic structure. This layer contains a large amount of colloids, rendering the material very sticky and



A, State Ditch draining the south-central part of Grande Ronde Valley; B, rank growth of wheat, partly lodged, on Conley silt loam; C, greasewood vegetation on alkali area of Gooch fine sandy loam

plastic when wet. When dry it shows definite lines of cleavage, both vertical and horizontal, and breaks naturally into columns from 2 to 5 inches long and from 1 to 3 inches wide. When broken the dry surfaces of the soil aggregates are coated with black and when wet the moist surfaces glisten in the sun as though freshly coated with glue. This layer is underlain to a depth of about 6 feet by yellowish-brown or drab slightly more friable coarse granular clayey material faintly streaked with iron stains. Below a depth of 6 feet the material is generally of similar or lighter color and texture but is more friable and more mottled to a depth of many feet. Typically, no lime accumulation is present in any part of the soil although the brown phase, as mapped, includes small patches which show lime at a depth of 9 or 10 feet. The Conley soils are not affected by alkali. These soils are derived from weathered old water-laid materials of heavy texture. Conley silt loam and Conley silty clay loam, together with brown, stony, and friable-subsoil phases of the silty clay loam, are mapped.

The recent alluvial soils of the Grande Ronde Valley area are comparatively inextensive. Strictly speaking, practically no soil in the valley is of recent origin, since nearly everywhere throughout the most recent soils there is some evidence of weathering, such as the slightly platy structure of the surface soil and slight compaction and columnar structure in the subsoil. These features, however, are nowhere so pronounced as in soils of the associated series already described, and most of the so-called recent alluvial soils are friable, permeable, and easily penetrated with an auger. Soils of this character are grouped in the Catherine series. The recent alluvial soils merge imperceptibly into the adjoining soils, and most of them overlie weathered old lake deposits. The surface layers of the Catherine soils are about 4 inches thick and consist of dark grayish-brown, very dark dull-brown, or nearly black friable slightly platy material with a large content of organic matter and overlying dull-brown or dark dull-brown slightly compact, somewhat columnar-structured material of the same general texture, which extends to an average depth of 20 inches. The upper part of the subsoil is commonly of about the same texture but is a little lighter colored and more friable. At an average depth of about 30 inches the material in most places consists of brown mellow loam or silt loam which passes at a depth ranging from 4 to 5 feet into lighter-brown crumbly loam or lighter-textured material mottled with yellow and gray. Lime has not yet accumulated in any part of the soil, and there are no injurious accumulations of alkali. Two members of the Catherine series, the silt loam and the clay loam, are mapped.

In addition to soils of agricultural significance a strip of rough stony land, a nonagricultural material, is mapped on the lower mountain slopes.

In the following pages of this report the soils of the Grande Ronde Valley area are described in detail and their agricultural possibilities are discussed; the location and distribution of the different soil types are shown on the accompanying map; and their acreage and proportionate extent are given in Table 4.

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TABLE 4.—*Acreage and proportionate extent of the soils mapped in the Grande Ronde Valley area, Oregon*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Waha clay loam	4,928	2.7	Springdale loam	4,288	2.3
Tolo loam	3,392	1.8	Gooch fine sandy loam	3,072	1.8
Alicel sandy loam	5,824	3.5	Light-textured phase	256	
Coarse-textured phase	704		Gooch loam	2,688	1.8
Alicel fine sandy loam	9,088	4.9	Gravelly-subsoil phase	576	
Alicel loam	6,464	3.5	Gooch silt loam	14,400	7.8
Alicel silt loam	3,712	2.0	Gooch silty clay loam	6,464	5.4
Palouse sandy loam	1,600	.9	Gravelly-subsoil phase	3,520	
Palouse fine sandy loam	2,560	1.4	Klamath silt loam	10,752	5.8
Palouse loam	6,912	3.7	Klamath silty clay loam	6,208	3.4
Hyrum gravelly clay loam	576	.3	Conley silt loam	1,728	.9
Hyrum stony clay	2,240	1.2	Conley silty clay loam	4,992	
La Grande gravelly loam	1,408	.8	Brown phase	2,240	4.9
La Grande loam	1,792	1.0	Stony phase	1,088	
La Grande gravelly clay loam	1,984	3.5	Friable-subsoil phase	832	
Alluvial-fan phase	4,352		Catherine silt loam	8,064	4.4
La Grande silt loam	2,176	1.2	Catherine clay loam	8,960	4.8
La Grande silty clay loam	6,528	3.5	Rough stony land	31,616	17.1
Springdale gravelly loam	1,920	3.7			
Stony phase	5,056		Total	184,960	

WAHA CLAY LOAM

The virgin surface soil of Waha clay loam consists of a 1-inch surface layer of very dark dull-brown friable granular platy-structured silty clay loam and a subsurface layer of similar-colored coarse-granular or nut-structured clay loam of smooth silty texture which continues to a depth of 8 inches. The upper subsoil layer consists of very dark dull-brown compact columnar or nut-structured clay loam extending to a depth ranging from 20 to 26 inches. The lower part of the subsoil, which extends to a depth of about 48 inches, consists of lighter-brown mottled columnar or adobe-structured clay. The columns in this layer range from 3 to 8 inches in length and from 1 to 5 inches in width and when thoroughly dry become very hard and brittle. In many places this layer directly overlies basaltic bedrock and locally basaltic bowlders are scattered over the surface and mixed throughout the soil. In certain localities, however, bedrock is not reached within 20 feet of the surface. In such places the material below a depth of 4 feet consists of brown smooth-textured clay loam passing into brown compact silty clay at a depth of 11 feet. When moist the surface soil is black and the subsoil is of a tawny-yellow shade.

Areas in which enough stones occur on the surface to interfere with cultivation are indicated on the map by stone symbols. The soil in such areas is commonly more shallow than typical, bedrock occurring at a depth ranging from 2 to 4 feet, and is more strictly residual in origin than soils in which bedrock lies at a greater depth. In some places Waha clay loam apparently contains a quantity of wind-borne material. In this respect it bears a close resemblance to soils of the Alicel series, and small areas of Alicel soils have been included in mapping.

The largest area of Waha clay loam occupies about 3 square miles on Pumpkin Ridge. Smaller areas are on the lower slopes of the hills near La Grande, Cove, and Union. At Union the soil is derived from weathered gray fine-grained rock and is somewhat

lighter colored and lighter textured than this soil in other parts of the area. The relief is rolling or hilly, although very little of the land is too steep to be farmed. Drainage is generally good, except in a few small seeped areas along streams.

A large proportion of the Waha clay loam is under cultivation; the remainder is used largely for pasture. Except in the north end of the valley, where the pine forests of the higher hills are encroaching on this soil, the uncultivated areas are covered with bunch grass and dock and other weeds. Wheat is the principal cultivated crop, and smaller acreages are devoted to alfalfa, potatoes, corn, and grass meadow. There are a number of small orchards and gardens. The principal fruits are apples and cherries, both of which regularly yield well. Wheat yields are about the same as or slightly more than on Tolo loam; potato yields average about 200 bushels to the acre; alfalfa yields from 2 to 3 tons, averaging 2½ tons, from two cuttings; and corn from about 20 to 40 bushels. The apples, prunes, and cherries produced on this soil are grown mainly for home use, although small quantities are sold locally.

Improved areas of Waha clay loam are held at prices ranging from $70 to $100 an acre. Unimproved areas are sold only in conjunction with other soils.

Waha clay loam is a productive soil and is well suited to the crops common to the region. Lying on slopes from 100 to 500 feet above the valley, it is rarely affected by late spring frosts. On this account, it is especially well suited to the production of fruit. As the rainfall is slightly greater on the slopes at the north end of the valley than on the valley floor, the fact that there is less opportunity for irrigation, owing to the roughness of the relief, is in a measure compensated.

TOLO LOAM

The surface soil of Tolo loam in the virgin condition consists of a 1-inch surface layer of light-brown, light grayish-brown, or medium grayish-brown friable light-textured loam containing a quantity of leaf mold, and a subsurface layer, extending to a depth of 10 inches, of similar-colored or slightly lighter-colored, friable, structureless, light-textured, smooth silty loam, grading into lighter-brown or buff-colored slightly compact loam which contains a large quantity of very fine sand. This material, which extends to an average depth of 27 inches, is friable, permeable, and easily crumbled into a structureless mass. The upper subsoil layer, between depths of about 27 inches and 3½ feet, is of similar color but slightly heavier texture. It consists of slightly compact loam containing a comparatively large quantity of silt and very fine sand. It is easily broken down into a floury or powdery condition. This layer is underlain, to a depth of 5 or 6 feet, by richer-brown compact cloddy or coarser-granular clay which shows iron mottles when freshly exposed, and this layer, in turn, is underlain by brown or rich-brown compact clay, the compactness increasing downward to a depth of 10 or more feet. When thoroughly dry the surface layers are somewhat grayish brown but when moist or when freshly bored into they are of a yellowish or light-buff shade. The soil is noncalcareous throughout.

This soil is easily handled, and even after the naturally small content of organic matter has been depleted by cropping it retains its floury character and does not clod appreciably.

Tolo loam is inextensive. The largest areas, covering a total of less than 3 square miles, occur near the north boundary of the surveyed area on the higher parts of Pumpkin Ridge; two small bodies, which are somewhat darker in color than the typical soil, are about 2 miles east of Cove; and an area, about 1 square mile in extent, lies at the base of the mountains 4 miles north of La Grande. A part of this area is stony and is indicated on the map by stone symbols. It is partly colluvial or of alluvial-fan origin and closely resembles the stony phase of Springdale gravelly loam.

Areas of Tolo loam are hilly but in general are smooth enough for cultivation. Both surface and internal drainage are excellent. The texture and structure of the subsoil are such as to render the soil retentive of moisture, thus enabling it to withstand long rainless periods.

This soil is apparently derived from wind-borne materials, although in places weathering of the underlying basalt may have contributed to the formation of the deeper layers. The material has weathered under a cover of coniferous forest rather than grasses. This accounts for its lighter color and lower organic-matter content when compared with the associated Waha soils. Tamarack, pine, and fir are the principal timber growths, the first-named predominating in most places; hence the local name, "tamarack soil."

At the present time Tolo loam has little agricultural importance, as fully 90 per cent of it is still covered by the original timber growth. Most of the cultivated acreage is on Pumpkin Ridge. Wheat is the principal crop and small acreages are in potatoes and garden crops. Since the higher elevation of the Tolo and Waha soils affords greater immunity from frosts, spring seeding is frequently done several weeks earlier in the section where these soils occur than in the valley. Harvesting of both fall and spring varieties of wheat begins from a week to 10 days earlier in the hills than in the valleys. Fall-sown wheat yields from 20 to 30 bushels to the acre, averaging 25 bushels, and spring wheat from 15 to 22 bushels, averaging 18 bushels. Good yields of potatoes, fruits, and garden crops are obtained.

Tolo loam is held at prices ranging from $70 to $100 an acre, depending on improvements, surface features, or character of the timber growth.

Soil of this kind is mellow and easily cultivated and is well suited to the production of potatoes, apples, cherries, berries, and vegetables. It is naturally poor in organic matter, and continued cropping to grain has further depleted the supply of humus. This deficiency can be remedied by plowing under alfalfa or applying barnyard manure. The crop rotation should be broadened to include cultivated crops other than wheat.

ALICEL SANDY LOAM

The surface layer of Alicel sandy loam to a depth of about 4 inches consists of dark dull-brown slightly compact but fine-granular sandy loam with a well-defined platy structure, underlain by

similar-colored similar-structured slightly columnar sandy loam which continues to a depth ranging from 12 to 16 inches. In the virgin condition the surface layer to a depth of a few inches contains a quantity of organic matter which renders the soil mellow and friable. Where the organic matter has been depleted through cropping, the surface material is compact. If plowed when dry it breaks into clods from 3 to 10 inches in diameter which are pulverized only with considerable labor. When wet the dark color is intensified, the surface of cultivated fields appearing nearly black. The subsoil, which continues to an average depth of about 28 inches, is brown compact cloddy sandy loam, the clods, which are easily broken down, ranging from 1 to 5 inches in diameter. The underlying parent material consists of slightly weathered brown compact loamy sand which grades into similar-colored loose medium or coarse sand at a depth ranging from 4 to 5 feet. The soil is thoroughly leached of the more soluble materials and is noncalcareous.

Alicel sandy loam occurs only in a number of small irregular-shaped areas in the sand ridge or that part of the valley extending from Conley to the foot of the hills 3 miles north of Imbler. The largest tract, including about 3 square miles, lies between Imbler and the hills. Most areas of this soil occur in long narrow north-and-south strips lying from 10 to 20 feet higher than the adjacent soils. One such strip, extending through the town of Alicel, is more than 4 miles long and averages about one-tenth mile in width. Alicel sandy loam is derived from wind-blown material which in its virgin state has accumulated sufficient binding material, in the form of organic matter, to make it fairly stationary. In some of the older cultivated fields, however, where organic matter is becoming depleted, there is an appreciable movement of material by winds, proof of which are low ridges of sand along fences and roads.

Areas of this land are favorable for cultivation and, with slight expense for leveling, would be suitable for irrigation. (Pl. 3, B.) Drainage is excellent, and though the irrigation requirements are somewhat higher than in the associated finer-textured soils they are not likely to prove excessive.

Although Alicel sandy loam is only moderately extensive, it is one of the important soils of the Grande Ronde Valley area. It was originally covered with grasses, but now practically all of it is under cultivation. Most of the area north of Imbler is in apples, and most of the soil elsewhere is in wheat. A small acreage is devoted to alfalfa and a still smaller acreage to barley and rye. Potatoes and garden crops are grown with satisfactory results on practically every farm. The varieties are the same as on Alicel silt loam, except the Federation variety of wheat which is grown more exclusively on soils where moisture conditions are more favorable. The average yields of wheat are slightly below the average for the area as a whole. Alfalfa is rarely cut more than twice. Seed is produced from a small acreage in years when the second cutting is too light for hay.

Land of this kind, developed for ordinary farming, commands from $70 to $100 an acre, and that in bearing apple orchards is held at $300 or more. No undeveloped land is sold except in connection with developed tracts.

Drought frequently reduces crop yields. The surface relief is favorable to irrigation, and wherever this has been tried increased crop yields have resulted. The orchards especially would be benefited by irrigation, as most of the trees are lacking in vigor because of lack of moisture and shortage of nitrogen brought about by the depletion of organic matter in the soil. Clean cultivation of the orchards is the rule, and only rarely is a green-manure crop turned under for fertilizer. The plowing under of alfalfa, Canada field peas, or other leguminous crops is recommended. The utilization of straw as a fertilizer to replace the diminishing supply of organic matter, thus improving the physical condition and the water-holding capacity of the soil, is recommended with the suggestion that about 50 pounds of ammonium sulphate be used to every ton of straw turned under. One of the beneficial effects of the incorporation of organic matter is apparent from the fact that where the soil is properly supplied with this constituent it is mellow and easily worked, whereas elsewhere it is cloddy if plowed when dry.

Alicel sandy loam, coarse-textured phase.—The surface soil of the coarse-textured phase of Alicel sandy loam, to a depth of 4 or 5 inches, consists of dark dull-brown granular coarse sandy loam. This overlies dark dull-brown moderately compact platy-structured sandy loam which continues to a depth of about 12 inches. In its original condition the soil had a fair content of organic matter, but it is now poor in this constituent owing to continued cropping to grain. If plowed when dry the surface material breaks into clods, but these are readily pulverized to a granular condition by cultivation. The subsoil, extending to a depth of about 48 inches, is light-brown or brown compact columnar-structured sandy loam which is easily broken down to a fairly loose consistence. This layer overlies the parent material of light-brown slightly compact but permeable fine sandy loam. At an average depth of about 7 feet the material commonly becomes a little coarser textured and more open and porous, although in some places a layer which is slightly compact and cloddy occurs at about this depth.

This is one of the least extensive soils in the Grande Ronde Valley area. It occurs in only four small bodies in T. 3 S., R. 39 E. Derived from wind-blown material, the land has a typical wind-blown relief. Most of it lies on slightly elevated ridges from one-eighth to one-fourth mile wide and a mile or more long. The areas are gently sloping and favorable for cultivation, and surface drainage is well developed. The subsoil is sufficiently compact in most places to be retentive of moisture, but it is probable that under irrigation soil of this phase would be somewhat too porous and would require an excessive amount of water.

Because of its small extent this coarse-textured soil is of little agricultural importance. About 75 per cent of it is farmed to small grains, a small acreage is in alfalfa, and the remainder, which is in native grasses, is used for pasture. The wheat acreage predominates. Except in unusually wet seasons crop yields are rather low. The soil is handled in the same manner as other Alicel soils. Sometimes the second cutting of alfalfa, when harvested for seed, returns a greater profit than a hay crop. As it is poor in organic matter,

the land could be much improved by systematically turning under alfalfa. After this is done the soil should be fairly well suited to the production of potatoes and vegetables.

ALICEL FINE SANDY LOAM

The surface soil of Alicel fine sandy loam consists of a 4-inch surface layer of very dark dull-brown platy-structured fine sandy loam, which contains a large amount of organic matter, overlying similar-colored slightly compact platy-structured fine sandy loam extending to an average depth of 15 inches. The entire surface soil is cloddy, the clods in the upper part ranging up to 8 inches in diameter and in the lower part to about 5 inches. The clods are most numerous where the organic matter has become depleted through cultivation. However, if plowed at the proper time the soil works up to a fine-granular tilth. The upper part of the subsoil consists of lighter-brown or yellowish-brown columnar loam or light clay loam sufficiently compact when dry to offer considerable resistance to a pick. At a depth of about 28 inches the material becomes a little lighter textured and less compact, passing at a depth of 36 inches into the parent material which consists of similar-colored friable sandy loam. At a depth of about 4½ or 5 feet the material grades into light-brown or tawny-yellow loose micaceous fine sand continuing to a depth of many feet. The soil is noncalcareous throughout.

Alicel fine sandy loam is the most extensive soil in the Alicel series. It occupies a large proportion of the sand ridge, the largest body extending in a north-south strip through Alicel from a point east of Island City to north of Imbler. The areas are gently undulating or wind blown and are crossed by slightly higher strips occupied by Alicel and Palouse sandy loams with here and there lower strips of the loams of these two series.

On account of its extent, this is the most important soil in the sand-ridge section. Originally bunch grass occupied the land but now it is all under cultivation, principally to wheat. A number of apple orchards are between Imbler and Alicel, a considerable acreage of alfalfa is grown, and some potatoes and vegetables are produced on nearly every farm.

This soil is handled in the same maner as Alicel sandy loam, and similar yields are obtained. As on the sandy loam, alfalfa can rarely be cut more than twice each season, as without cultivation the soil soon dries out following spring rains. In exceptionally dry years the second cutting is too short to harvest for hay and is sometimes allowed to ripen for seed. Apples and potatoes and other vegetables give about the same returns as on the other sandy soils of the sand ridge.

Most of this kind of soil, improved for general farming, commands $75 or $80 an acre, and the better apple orchards are held at $500 or more an acre.

The texture, surface relief, and drainage conditions on this soil are such as to favor irrigation. Only a comparatively small quantity of water, in addition to the natural rainfall, would be required to assure a considerable increase over present crop production. Moreover, with an adequate water supply a crop could be harvested every

year. The organic-matter content of the soil could be more readily built up since under the prevailing dry climatic conditions the straw which is plowed under rots and becomes incorporated with the soil slowly. With the exception of oats and timothy and most of the other grasses which do better on the naturally moist soils of the valley, Alicel fine sandy loam is suited to practically all the crops commonly grown in the valley. This soil would be improved by broadening the rotation and by following the suggestions offered for the improvement of other soils of the Alicel series.

ALICEL LOAM

The surface soil of Alicel loam consists of dark dull-brown fine-granular platy-structured loam about 4 inches deep which contains considerable organic matter, underlain by similar-colored slightly columnar-structured loam continuing to a depth of 15 inches. The lower material is somewhat more finely granular than the surface layer and is easily broken down into single grains. However, in the virgin condition it breaks naturally into columns from 1 to 3 inches wide and as much as 8 inches long. The subsoil, extending to a depth of about 4½ feet, is lighter yellowish-brown or tawny-yellow compact columnar-structured clay loam or loam in which the columns range from 1 to 3 inches in width and from 5 to 10 inches in length. (Pl. 2, A.) This material when dry is readily broken down under pressure. It passes gradually into the parent material which consists of light-brown or tawny-yellow micaceous pervious loose-structured very fine sandy loam, loam, or sandy loam, the texture becoming coarser and the structure looser with depth. This soil is thoroughly leached, and typically no lime carbonate is present within 10 or more feet of the surface.

Alicel loam occupies a number of long, narrow, irregular strips on the sand ridge, on the lower slope of Pumpkin Ridge, and at the foot of the mountain on the east side of the valley. One of the largest areas, ranging from one-eighth to three-fourths mile in width and 6 miles long, extends nearly south from the Summerville Cemetery. The areas on Pumpkin Ridge and on the foothills at the east side of the valley range from gently sloping to steep, although all the soil is suitable for cultivation. Elsewhere the soil occurs in shallow depressions and on low, smoothly rounded swells or ridges. The more level areas, which comprise perhaps 80 per cent of this soil, could be easily prepared for irrigation.

This soil originally supported a vigorous growth of bunch grass and sagebrush. Practically all the land has been cleared and farmed for many years, wheat always having occupied the largest acreage. Other small grains, alfalfa, potatoes, apples, and garden crops are also grown, and the yields compare favorably with those on any of the better soils of the valley.

Improved land of this kind can be bought at prices ranging from $75 to $125 an acre, depending on location, improvements, and drainage conditions.

Alicel loam is one of the most desirable soils on the sand ridge. Owing to its better moisture-holding capacity, crops are somewhat more certain on this than on the sandier soils of the ridge. Although originally well supplied with organic matter, the soil is now

poor in this constituent owing to the long-continued practice of alternating wheat and summer fallow. As a means of correcting this deficiency it is suggested that the land be more frequently given over to the growing of alfalfa or peas either to be hogged down or turned under as a green-manure crop. In addition, the grain straw, which now goes to waste, should be conserved and plowed under. It has been recognized that for every ton of dry matter plowed under about 50 pounds of ammonium sulphate or an equivalent amount of nitrogen in some other available form should be applied in order to supply the increased demand for nitrogen resulting from the increased activity of soil bacteria. As this soil is suited to other crops now grown in the valley, the practice of crop rotation could well be adopted as it is an inexpensive means of increasing yields and is effective in maintaining fertility. Some of the depressions, in which so-called hardpan occurs, could be improved by drainage, following which alfalfa should be plowed under or barnyard manure applied to increase the organic-matter content and water-holding capacity of the soil.

ALICEL SILT LOAM

In its virgin condition, the surface soil of Alicel silt loam is composed of three layers, as follows: (1) From 0 to 1 inch very dark dull-brown, platy, somewhat cloddy-structured silt loam containing a large percentage of organic matter; (2) from 1 to 4 inches dark dull-brown thinly laminated or platy-structured silt loam which is slightly compact but easily broken down by pressure in the hands; and (3) from 4 to 16 inches, brown or dark-brown friable mellow silt loam of single-grained structure. When wet the surface of cultivated fields is black. The subsoil is lighter-brown, yellowish-brown, or tawny-yellow compact somewhat columnar silty clay loam which breaks down to small soft clods which are easily broken apart. At an average depth of about 5 feet the material grades into similar or slightly lighter-colored less compact silty clay loam which becomes lighter yellow or grayish in color and more silty or floury at a depth of 7 feet. At a depth of about 10 feet the material becomes looser and coarser, grading within a few feet into permeable fine sandy loam. In the typical soil no effervescence with acid takes place, the material apparently being thoroughly leached of its carbonates.

Alicel silt loam is rather inextensive. The largest area, averaging about three-fourths mile in width and 4½ miles in length, occupies a lower benchlike position on the west slope of the sand ridge between Alicel and Summerville. Other narrow strips occur north, west, and east of Summerville, north of La Grande, and 2 miles northeast of Alicel. The land is nearly level with just about enough slope for easy irrigation. For farming without irrigation both surface drainage and underdrainage are adequate in most places.

The water table stands at a depth ranging from 4 to 5 feet during the month of May and at about 7 feet during the driest part of the season. Moist soil is usually present at a depth ranging from 3 to 4 feet. This is an indication that the soil would require only a small amount of water for supplemental irrigation.

Although inextensive Alicel silt loam is agriculturally important. It is all in cultivation. As with other soils of the Alicel series, wheat is the leading crop, and alfalfa occupies a somewhat smaller acreage. Between one-fourth and one-third of the land is left fallow every summer, this soil being used a little more continuously for wheat than the lighter-textured soils of the Alicel and Palouse series. Crop yields are generally good.

Well-developed farms on this type of soil can be bought for prices ranging from $80 to $100 an acre.

Alicel silt loam is considered one of the best all-round soils in the Grande Ronde Valley area. The relief is favorable for irrigation, and the excellent moisture-holding capacity of the soil would enable it to produce abundantly with only a small quantity of irrigation water to supplement the rainfall. The land is well suited to the production of all crops grown in the area surveyed. As a means of increasing its productiveness, it is recommended that the rotation be broadened to include a greater acreage of alfalfa or cultivated crops. Early spring plowing and thorough tillage should conserve moisture and aid nitrification. Fall disking of stubble and straw residues should aid decomposition and nitrogen fixation by free living bacteria.

Table 5 shows the results of mechanical analyses of samples of the surface soil, subsurface soil, and three layers of the subsoil of Alicel silt loam.

TABLE 5.—*Mechanical analyses of Alicel silt loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
561936	Surface soil, 0 to 1 inch	0.3	1.7	0.9	9.8	30.6	45.3	11.5
561937	Subsurface soil, 1 to 4 inches	.0	.4	.7	4.9	31.2	48.7	14.1
561938	Subsoil, 4 to 16 inches	.0	.3	.4	5.5	35.7	48.9	9.0
561939	Subsoil, 16 to 60 inches	.2	4.0	5.9	15.6	37.1	26.8	10.4
561940	Subsoil, 60 to 84 inches	.0	.1	.2	1.7	42.8	45.3	9.8

PALOUSE SANDY LOAM

The surface soil of Palouse sandy loam consists of dark-brown or dull dark-brown slightly compact platy-structured sandy loam about 5 inches thick overlying similar-colored mellow sandy loam which continues to a depth ranging from 20 to 30 inches. In the virgin condition the soil is well supplied with organic matter and is easily pulverized to a fine granular structure. When wet the color is black. The upper part of the subsoil is light-brown or yellowish-brown compact highly calcareous clay loam splotched with light spots of lime accumulation. This compact layer, ranging from 12 to 20 inches in thickness, grades at an average depth of 42 inches into similar-colored looser-structured calcareous fine sandy loam in which the white specks and spots of lime are somewhat less numerous than in the layer above. At a depth of about 5 feet the accumulated lime commonly disappears, and from here down to a depth of many feet the material is light-brown or yellowish-brown loose micaceous fine sandy loam or very fine sandy loam.

Palouse sandy loam is inextensive, occurring in only five small areas in T. 3 S., R. 39 E. One of these patches, in sections 2 and 11, lies in the southern part of the sand ridge, and the others occupy low islandlike ridges on the valley floor. The relief is slightly undulating or wind blown and is everywhere favorable for cultivation. Occurring as it does in areas a little higher than the adjacent soils, the soil is well drained.

Owing to its small extent this is not a very important agricultural soil. About 80 per cent of it is in cultivation, and the rest remains in natural grasses. Wheat, which occupies the greatest acreage, alternates with summer fallow, but the land is inclined to be droughty and except in the wetter seasons yields are low. A small acreage is devoted to alfalfa.

The value of soil of this kind ranges from $60 to $80 an acre, depending on location, the state of cultivation, and improvements.

Palouse sandy loam would be greatly benefited by supplemental irrigation, but as it lies somewhat higher than the other valley soils it is probably not feasible to water all of it by gravity.

PALOUSE FINE SANDY LOAM

The surface layer of Palouse fine sandy loam consists of dark-brown or dull dark-brown compact platy-structured fine sandy loam about 5 inches thick. This breaks down readily to a single-grained structure. When thoroughly dry the surface soil appears dark gray or dark brown but when wet it becomes black. The subsurface layer is very dark dull-brown mellow fine sandy loam which continues to a depth of about 20 inches. In the virgin condition the surface soil contains a fair amount of organic matter and is easily cultivated to a mellow tilth. However, where the organic matter has been depleted by continued cropping to grain the soil has a tendency to form clods from 3 to 5 inches in diameter. These hinder the preparation of the seed bed. In places, a slight columnar structure may be noted in the lower part of the subsurface layer, but it is less well developed in this than in the loam member of the Palouse series. The upper subsoil layer, between depths of 20 and 30 inches, is light-brown or tawny-yellow very compact clay loam through which the lime carbonate has apparently been leached into the material below. The material is somewhat columnar in structure, but it breaks down naturally into small cloddy particles which range from the size of buckshot to about one-fourth inch in diameter. Beneath this layer is slightly lighter-yellow compact calcareous loam which grades downward into similar-colored but looser-structured coarser loam or fine sandy loam, which continues calcareous to a depth of about 9 feet. Below this depth is the parent material of tawny-yellow loose micaceous noncalcareous sandy loam of various grades of fineness, gradually becoming coarser with depth. In some localities the compact part of the subsoil, between depths of 30 and 40 inches, contains sharp-pointed or spiny calcareous nodules ranging from the size of a pea to an inch or more in diameter. This layer is dense and is locally referred to as hardpan. However, it is nowhere sufficiently compact to justify this term. It is the first part of the soil to dry out, and though the soil

above and below may still be moist this material comes up dry and crumbly when bored into. It offers slight resistance to the downward passage of roots and where it occurs near the surface, lessens to some extent the water-holding capacity of the soil.

In a number of small depressions between Conley and the State Ditch the texture of the surface soil is finer than typical. This variation consists of dark dull-brown friable very fine sandy loam ranging from 18 to 30 inches in thickness, overlying lighter-colored very compact highly calcareous loam or lighter-textured material. The compact layer, locally known as hardpan, ranges from a few inches to about 1 foot in thickness and is in many places iron stained and marked with specks of lime. Where this layer is thickest it retards root development, impairs underdrainage, and reduces crop yields. It is underlain by yellowish-brown permeable light-textured material which is either noncalcareous or only feebly calcareous in the upper part.

Palouse fine sandy loam is inextensive, occurring principally in a number of narrow north-and-south strips of which the most important lie about 4 miles southeast of La Grande, near Alicel, and along the State Ditch east of Island City. Areas are smooth or very gently undulating. Typical areas on the sand ridge lie at the same elevation as bodies of Alicel fine sandy loam. In the vicinity of the State Ditch, however, a few narrow strips or potholes lie a little lower than the rest of the land. These mark the areas of included very fine sandy loams, nearly all of which are poorly drained. Elsewhere both surface drainage and underdrainage are good.

About 90 per cent of this soil is cultivated. Perhaps 40 per cent of the cultivated land is used for wheat, and most of the remainder is in alfalfa. A part of the alfalfa is irrigated and returns from 3 to 5 tons to the acre. Where the land is not irrigated, in dry years the second cutting of alfalfa is sometimes too light for hay and is harvested for seed. As it yields from 60 to 150 pounds of seed to the acre, the second crop frequently returns a greater profit than would have been obtained from a good crop of hay.

The soil is handled in the same manner as Alicel loam and Palouse loam and is held at about the same price.

Palouse fine sandy loam is a popular soil since the greater part of it is productive, well drained, and easily worked. Only the potholes, which comprise but a small proportion of the total area, are poorly drained and contain small spots of alkali. Most of the land lies favorably for irrigation and is suited to practically all the crops grown in the valley. The suggestions offered for the improvement of Alicel loam apply to this soil.

PALOUSE LOAM

The surface soil of Palouse loam, in the virgin condition, consists of a surface layer of very dark dull-brown compact coarse-granular platy-structured loam about 5 inches thick, overlying dark-brown mellow fine-granular loam which continues to a depth of 16 inches. After extended periods of drought the surface of cultivated fields assumes a very dark-gray shade, but with a small amount of moisture the color becomes black. The soil is naturally well supplied with

organic matter, but in the Grande Ronde Valley area much of it has become deficient in this constituent by continued cropping to grain. Where this has occurred the surface soil is more compact and, if plowed when dry, clods are formed which are pulverized with difficulty. The subsoil commonly consists of three distinct layers, as follows: (1) Between depths of 16 and about 24 inches, rich-brown or yellowish-brown compact columnar-structured silty clay loam through which the lime has apparently leached into the material below, the columns, which are commonly well developed and when examined in an exposed bank display definite cleavage lines, both vertically and horizontally, ranging from 3 to 5 inches in width and from 5 to 8 inches in length; (2) tawny-yellow less compact but highly calcareous loam containing scattered particles of soft lime carbonate and extending to an average depth of about 5 feet; and (3) lighter-yellow friable calcareous very fine sandy loam which continues to become more porous and less calcareous until, at a depth ranging from about 10 to 12 feet, it passes into the yellowish loose sandy noncalcareous parent material.

This soil occurs principally in a number of patches on the sand ridge. The largest areas lie from 4 to 6 miles east of Island City. Important strips are northeast of La Grande, east of Alicel, near Imbler, and at the base of the mountains on the east side of the valley. Most of this soil occupies shallow troughs or depressions between low ridges extending north and south, but in places it extends up the slopes of the low swells and in a few places up over the crests. In the last-mentioned positions drainage is excellent, but as the depressions and potholes receive run-off from higher lands both surface drainage and underdrainage are poor in many places. Locally, free ground water remains at a depth between 4 and 5 feet until late in spring, and some of these spots contain small quantities of black alkali. However, the soil as a whole is fairly well drained and comparatively free from salts.

Although only moderately extensive, Palouse loam is of considerable importance in the agriculture of the valley. The natural grasses have long since been plowed under, and practically all the soil is now under cultivation. Wheat is the principal crop, and other small grains, alfalfa, fruits, and potatoes and other vegetables are grown on small acreages. The soil is handled in the same manner as Alicel loam, and similar yields are obtained. In some low patches where moisture conditions are best and wheat makes an especially rank growth, the straw is attacked by a disease, known as foot rot, which causes it to break just above the ground and fall over and lodge. Usually the grain is sufficiently mature for the heads to fill, but the lodged patches are an almost total loss except for pasture, since such wheat can not be harvested by machinery. Loss of this kind is sometimes prevented to some extent by deferring fall seeding as late as possible when, under a protective covering of snow, the seed lies more or less dormant until spring and the straw makes a less rank growth. Practically all crops are grown without irrigation.

Improved land of this kind commands from $70 to $100 an acre, the greater part of it being held at about $80.

Palouse loam is one of the best soils in the sand-ridge section. The surface is mellow enough for easy cultivation, and the subsoil is sufficiently compact to be retentive of moisture. The value of the land, however, would be considerably enhanced by irrigation, for which the relief is favorable. The texture and structure are such that only a small quantity of water would be required to supplement the natural rainfall. Recommendations for the improvement of Alicel loam are equally applicable to Palouse loam.

Table 6 shows the results of mechanical analyses of samples of Palouse loam, taken at several depths.

TABLE 6.—*Mechanical analyses of Palouse loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
561952	Surface soil, 0 to 5 inches	0.1	2.0	3.3	11.4	32.8	39.9	10.5
561953	Subsurface soil, 5 to 16 inches	.1	1.9	3.0	8.9	33.7	45.3	7.4
561953½	Subsoil, 16 to 34 inches	.0	2.1	3.7	10.6	39.0	37.3	7.5
561954	Subsoil, 34 to 60 inches	.0	1.9	5.1	19.5	37.3	32.3	3.9
561955	Subsoil, 60 inches to 9 feet	.0	1.5	2.9	11.1	43.0	16.3	25.2

HYRUM GRAVELLY CLAY LOAM

The surface layer of Hyrum gravelly clay loam consists of very dark dull-brown or black granular clay loam about 7 inches thick, which contains a few fine waterworn gravel and a large amount of organic matter. The subsurface layer, extending to a depth of 18 or 20 inches, is lighter-brown or richer-brown compact adobe-structured gravelly clay which shows faint rust stains or yellowish-brown mottles. Both these layers are typically noncalcareous. The underlying materials consist of yellowish-gray or grayish-yellow unassorted gravel and cobblestones which extend to a depth of many feet. The upper part of the subsoil contains a high concentration of lime carbonate and is somewhat grayer than the lower-lying materials which are commonly noncalcareous. The lower part of the subsoil consists of firmly cemented gravel embedded in yellowish-gray clay loam, in places approaching hardpan. This layer varies greatly in thickness as well as in degree of hardness. It is rarely more than 2 feet thick and in most places is about 1 foot thick, thinning out here and there and locally disappearing entirely. It terminates at a depth of about 3 feet in most places. The substratum consists principally of well-rounded gravel, cobbles, and bowlders rather firmly embedded in yellowish coarse sand. Below a depth ranging from 10 to 12 feet the gravelly material is loose and porous.

Hyrum gravelly clay loam closely resembles the La Grande soils but is more maturely weathered as is evidenced by a more compact cemented subsoil with a high lime content.

This soil occurs in only three small tracts on the remnant of a terrace in and south of La Grande. At one time this terrace was undoubtedly extensive, but streams have carried away nearly all of it and later refilled this part of the valley with similar younger materials. The soil is separated from the more recent valley soils by an abrupt escarpment from 20 to 30 feet high. It slopes gradu-

ally upward and merges with stony residual soils at the base of the hills. Drainage is good.

Owing to its small extent and the fact that much of it is used for residential purposes, this soil is of little agricultural importance. A small acreage of wheat and some alfalfa are grown under irrigation. Unless watered, the land is not well suited to alfalfa.

HYRUM STONY CLAY

The surface soil of Hyrum stony clay consists of black nut-structured or adobe clay containing a quantity of fine gravel and subangular bowlders ranging up to a foot or more in diameter. This material continues with no important change to a depth of about 24 inches, where it rests abruptly on yellowish-gray highly calcareous lime-cemented gravelly clay loam approaching a hardpan. The material of the second layer varies in thickness and degree of cementation, in places being about 1 foot thick and in near-by areas thinning out unevenly or for short stretches disappearing entirely. This layer, in turn, is underlain by brown or mottled rust-brown and gray loosely cemented highly calcareous clay loam in which are embedded a mass of subangular gravel, bowlders, and rock fragments. Below a depth of 3½ feet the fine soil material becomes lighter textured, noncalcareous, and more open and pervious.

The soil was undoubtedly extensive at one time, but it now occurs only in small fanlike areas on the lower slopes of hills and in a few small islandlike eminences on the east side of the valley. The rest was apparently eroded during the period of degradation which must have followed the draining of the lake that formerly occupied the valley. The largest area, which averages about one-fourth mile in width, extends from Cove north for about 4 miles along the base of the hills. On the lower side it merges with the alluvial-fan phase of La Grande gravelly clay loam and on the upper side with mountain soils too rough and stony for cultivation. Other patches occur near Cove, south of La Grande, on both sides of the canyon of Ladd Creek, and along the east side of the valley.

Most of the land slopes away from the valley at a rate between 500 and 800 feet to the mile. Drainage is good or excessive.

At present this soil is of no agricultural importance, as most of it is still in sagebrush and natural grasses. A small irrigated acreage at Cove is in cherries, apples, and prunes, and small patches are irrigated for pasture. Where the stones are not too thick, fair crop yields are obtained. However, the greater part of this land is only slightly better than rough stony land, although the time may come when parts of it will be cleared of stones and used for fruit production.

LA GRANDE GRAVELLY LOAM

The surface layer of La Grande gravelly loam consists of very dark-brown or black friable gravelly loam about 12 inches thick and containing, in the original condition, a good supply of organic matter. This is underlain by a mass of waterworn gravel embedded in rich-brown or reddish-brown compact clay loam. At an average depth of about 30 inches the material grades into lighter-colored, less

compact, unassorted waterworn gravel and cobbles embedded in light rich-brown or light reddish-brown loam. The material continues to become looser and coarser until at a depth between 10 and 25 feet it contains a large quantity of well-rounded bowlders from 8 inches to a foot in diameter. This soil is sufficiently open throughout to have become thoroughly leached of lime carbonate and is not calcareous in any part.

La Grande gravelly loam is one of the least extensive soils in the Grande Ronde Valley area. One of the largest tracts, containing about 1 square mile, borders Ladd Creek south of Lonetree. A narrow strip, from one-eighth to one-fourth mile wide and 5 miles long, extends eastward from the hills along the river through the city of La Grande. Other small patches are in and around La Grande and in the vicinity of Union. All this land lies opposite canyon mouths or borders drainage ways. It is derived from materials washed in from the hills. In the strip along Grande Ronde River and to less extent in the areas near Union, the materials are somewhat more recent in origin than are other La Grande soils. However, there is some evidence of aging and, as the subsoil is gravelly, this soil seems more nearly representative of the La Grande series than the Catherine. Bordering the river at La Grande and Island City are narrow strips of excessively gravelly soils, which consist principally of waterworn gravel with only a small proportion of interstitial material. Parts of this area are overflowed and bare of vegetation, whereas the rest is grown up to cottonwoods, willows, and other brush. Elsewhere this soil has been mapped as river wash, but in the Grande Ronde Valley it was too inextensive to be shown separately on a small-scale map.

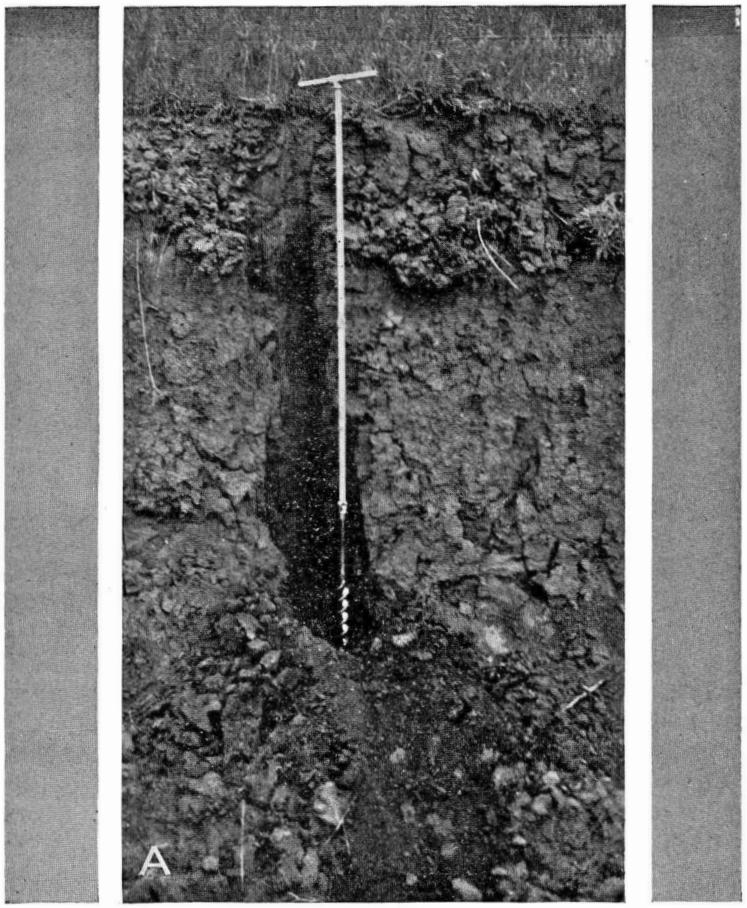
Much of the soil along Ladd Creek contains angular basaltic bowlders throughout. In places these are sufficiently numerous on the surface to interfere with cultivation. Such areas are shown on the map with stone symbols. With the exception of the body in the south part of Union, in which the water table is high, the land is well drained.

Owing to its small extent this soil has little agricultural importance. It is used for the same crops as are the other soils of the La Grande series but with somewhat poorer results. Excessively stony and gravelly areas, being droughty and hard to handle, are unsuited to cultivated crops although the stony areas provide fair dry pasture.

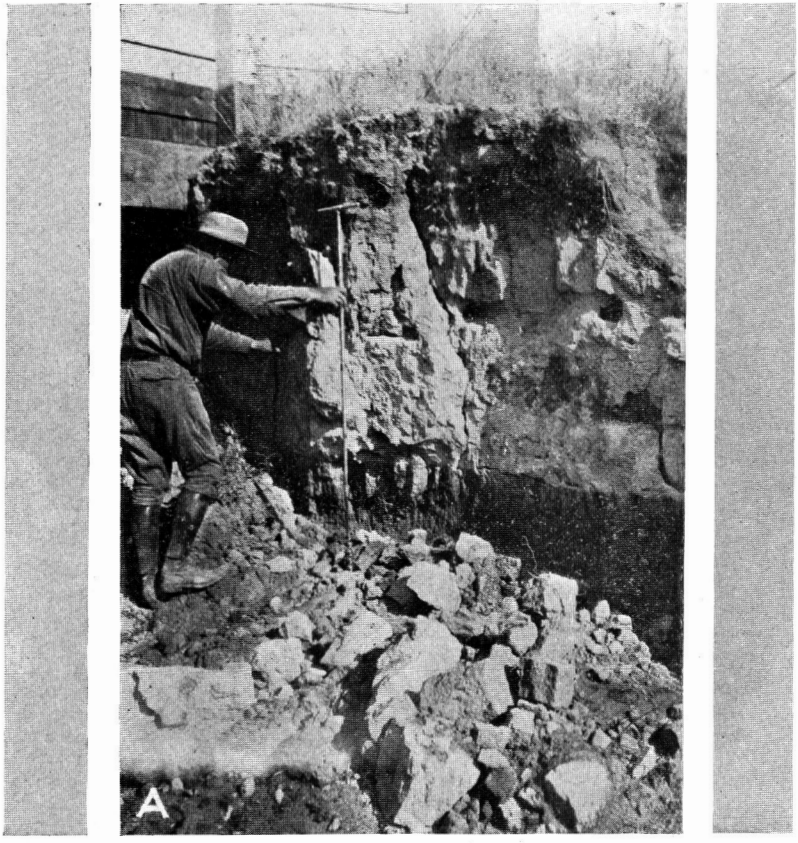
LA GRANDE LOAM

La Grande loam corresponds in all essential features to typical areas of other La Grande soils with the exception that the surface soil is a little lighter brown and that the gravelly substratum is less compact. In most places the surface soil contains less organic matter than that of the heavier members of the La Grande series, but it is friable and mellow under a wide range of moisture conditions. In places a small quantity of waterworn gravel is scattered over the surface, and small patches of gravelly loam are included in mapping.

This soil is inextensive in the Grande Ronde Valley area, occurring only within the city limits of Union and La Grande and near these



A, Typical profile in soils of the Alicel series; B, profile of Hyrum gravelly clay loam near La Grande showing dark-colored surface soil with gravel substratum and light-colored layer of lime accumulation in upper part



A, Section in ditch bank in Klamath silt loam showing unusually thick layer of light-colored volcanic ash overlying compact clays of adobe structure; B, landscape of Alicel sandy loam in foreground, with Pumpkin Ridge in the distance. The light-colored areas are stubble fields

towns. Like the gravelly members of the series it lies opposite the entrance to canyons and is composed of materials washed in by streams.

The areas are smooth or gently undulating and lie favorably for both drainage and irrigation. Subdrainage is good in the areas near La Grande, but in places near Union the water table is high, partly owing to irrigation and partly to the result of seepage from shallow streams.

La Grande loam is of slight agricultural importance since it is inextensive and a large part of it lies in towns where it is used for residential purposes. Wheat, alfalfa, prunes, apples, cherries, and potatoes and other vegetables are grown. All the crops except wheat are grown mainly on irrigated tracts. Crop yields are about the same as on La Grande silt loam.

Owing to its location within or near towns, most of this land has a high value. Orchards have about the same value as on La Grande silty clay loam, and land in grain or alfalfa a few miles from town commands from $80 to $100 an acre.

This soil is productive, friable, and easily worked. Where drainage is good it is especially well suited to fruits and vegetables. Some of the prune trees in the vicinity of Cove appear to be suffering from the effects of a high water table. This can be corrected by deepening the natural drainage channels and avoiding overirrigation.

LA GRANDE GRAVELLY CLAY LOAM

La Grande gravelly clay loam consists of dark dull-brown friable gravelly clay loam from 10 to 12 inches thick overlying brown or dull reddish-brown compact clay loam which contains a large quantity of waterworn gravel and cobbles. At a depth of about 30 inches the material passes into unassorted gravel and cobbles with interstitial soil material which becomes lighter colored, looser, and coarser with depth. In addition to the gravel and cobbles the soil contains a quantity of well-rounded bowlders ranging from 6 inches to a foot in diameter. Although the material is sufficiently compact to stand up vertically in banks 20 or more feet high, it is rather porous and leachy, requiring irrigation for best results. The soil is leached of lime carbonate and other soluble materials throughout.

This soil occurs in two small patches opposite the entrance to the canyon of Ladd Creek and in one extending west from Cove. The relief is that of gently sloping fans. A part of this soil on the west side of Ladd Creek occupies a fanlike terrace 50 or more feet above the rest of the land. The terrace part of this soil, as well as that along the highway west of Ladd Creek, contains a quantity of basalt bowlders scattered on the surface and mixed throughout the soil. This area is indicated on the map by stone symbols. It is unsuited to cultivated crops but is valuable for dry pasture. Areas of this soil are crossed by running streams and a number of dry drainage channels which afford excellent surface drainage. Underdrainage is commonly excessive.

This soil is unimportant agriculturally. The area near Cove and about 20 per cent of the remainder are used in the production of wheat and alfalfa. Alfalfa near Cove is irrigated, but elsewhere

all crops are dry farmed. With sufficient water alfalfa yields from 3 to 4 tons to the acre, but unirrigated fields rarely return more than 2 tons.

Owing to the character of the underlying material this soil is droughty and not well suited to dry farming. With irrigation the stone-free areas are fairly well suited to the production of any crops common to the valley.

La Grande gravelly clay loam, alluvial-fan phase.—The alluvial-fan phase of La Grande gravelly clay loam differs somewhat from the typical soil. It is undoubtedly more recent in origin since it occupies alluvial fans and foothill slopes where surface erosion has apparently been counteracted by replacement of fresh materials brought down from the hills. In this soil the waterworn gravel which characterize the subsoil of typical La Grande soils are absent and in their place are angular bowlders and rock fragments. In most places these are numerous below a depth of 10 or 12 inches and in many areas they occur throughout the soil. Where numerous enough to seriously interfere with cultivation the areas are shown with stone symbols. The alluvial-fan phase of La Grande gravelly clay loam averages heavier in texture than the typical soil, bodies of heavy clay loam and a few areas of clay being included in mapping.

Soil of this phase occurs almost entirely on the foothill slopes on the east side of the valley. From Cove, where it is about 1½ miles wide, an area tapers to a point about 9 miles northwest of that town. A few small detached areas occur on the east side of the valley between this point and Imbler, and a few narrow strips are between Union and Phys Point and south of Lonetree.

The slope of this soil upward from the valley ranges from 200 to 500 feet to the mile. In most places surface drainage is well developed, but despite the favorable slope there are a number of seeped areas that would be improved by ditching. The subsoil is heavy and compact, and underdrainage is not so favorable as the slope would indicate. In the vicinity of Cove this soil is crossed by a number of perennial streams, the water from which is distributed over the surface and used to irrigate a considerable acreage of cherries, alfalfa, tame grasses, and a variety of garden crops. The water from the hills is not well controlled, since in places natural irrigation, or at least subirrigation, is allowed to go on throughout the fall when the soil should be drying out in order to allow the trees to become dormant and thus better to withstand extremes of winter cold. In a number of cherry orchards winterkilling has taken a heavy toll of trees. With better water control and the resultant increase in vigor of the trees, frost damage in the spring could probably be greatly reduced.

This is an important soil. In the vicinity of Cove a large acreage is in cherry orchards, and some prunes, apples, and berries are grown. Elsewhere the chief crops are wheat, alfalfa, and tame grasses, with small acreages in apples, potatoes, corn, and home gardens. North of Cove much of the land is still in sagebrush and bunch grass and is used for pasture.

In some of the cherry orchards sweetclover is sown in the fall and plowed under in the spring, after which clean cultivation continues throughout the summer.

La Grande gravelly clay loam, alluvial-fan phase, has a wide range in value, depending on location and the character of improvements. Cherry orchards in the vicinity of Cove are held at prices ranging from $150 to $300 or more an acre. Land improved for general crops commands from $70 to $90 an acre and unimproved or stony tracts somewhat less.

Soil of this phase is productive under irrigation, but away from streams it is inclined to be droughty. As it is situated on the sloping fans at some elevation above the valley where air drainage conditions are good, it is somewhat more immune from late spring frosts than soils on the valley floor. Furthermore its west exposure protects it from the morning sun which reduces to some extent the destructive effect of frosts. Therefore under irrigation it is well suited to the production of cherries and other fruits. Parts of it, however, could be improved by more judicious watering, which in some places is merely equivalent to improving drainage conditions.

LA GRANDE SILT LOAM

La Grande silt loam has a surface layer of very dark dull-brown or black mellow fine-granular platy-structured silt loam 4 inches thick overlying very dark dull-brown moderately compact cloddy platy silt loam which is somewhat columnar in the lower part. If plowed when dry the material breaks into clods from 6 to 12 or more inches in diameter, but if worked under the proper moisture conditions, a mellow granular seed bed is obtained with a small amount of work. At an average depth of 20 inches the material grades into lighter-brown moderately compact columnar-structured loam which in some places is calcareous and marked with gray streaks of lime but which more often contains no visible lime carbonate. This layer terminates in most places at a depth of about 36 inches, where it passes into brown slightly compact soft cloddy loam mottled with rust yellow. The deeper part of the subsoil, extending from a depth of 42 inches to 7 feet, consists of brown slightly compact mottled gravelly loam.

The soil is inextensive. It occupies prominent positions within the city of La Grande and extends about 2 miles eastward from that city. A strip from one-fourth to one-half mile wide and 5 miles long borders Pierce Slough north of La Grande and Island City.

Areas are nearly level, yet the fall is sufficient for irrigation purposes. The land is crossed by small perennial streams and by several intermittent drainage channels which carry off excess moisture and afford fair surface drainage. The gravelly subsoil usually provides good underdrainage.

This is an important agricultural soil locally, practically all of it outside the city limits being in a high state of cultivation. Wheat occupies the largest acreage, but a number of thrifty orchards in apples, prunes, and cherries are across the river from La Grande. Some of the younger orchards are interplanted to market vegetables. A considerable acreage of alfalfa is grown alone for hay. Potatoes are grown commercially on the area north of La Grande.

Owing to its location within the city or in the vicinity of La Grande, part of this land is sold for residential purposes at $1,000

or more an acre. Well-cared-for near-by orchards are held at about the same price. Farther away, land improved for general farming can be bought for about $100 an acre.

La Grande silt loam is an excellent soil, mellow and easily worked, fairly well drained, and retentive of moisture. It is among the most productive soils in the valley and is well suited to the production of any of the crops now grown in the area surveyed. A small part of the land is irrigated. The smooth surface renders the soil well suited to irrigation, and only a small amount of water in addition to the rainfall is required to make it produce abundantly.

Table 7 gives the results of mechanical analyses of samples of La Grande silt loam taken at several depths.

TABLE 7.—*Mechanical analyses of La Grande silt loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
5619151	Surface soil, 0 to 4 inches	0.0	0.8	0.6	10.6	24.9	48.4	14.6
5619152	Subsurface soil, 4 to 20 inches	.0	.4	.2	7.8	26.9	53.8	10.5
5619153	Subsoil, 20 to 36 inches	.0	.0	.5	13.4	31.4	44.8	9.6
5619154	Subsoil, 36 to 42 inches							

LA GRANDE SILTY CLAY LOAM

The surface soil of La Grande silty clay loam consists of very dark dull-brown, platy-structured, coarse-granular silty clay loam about 16 inches thick. In the virgin condition the 4-inch surface layer contains a large amount of organic matter and is somewhat more mellow and friable than the material below. When wet, the color is black and the consistence sticky and elastic. The subsoil, occurring between depths of 16 and about 42 inches, is dark-brown moderately compact somewhat columnar-structured loam containing, in places, a few gray streaks of lime accumulation. When exposed in banks the dry material breaks naturally into clods 3 or 4 inches in diameter. This layer is nowhere sufficiently compact to interfere with water movement or root penetration. It is underlain by a mass of water-worn gravel and cobblestones embedded in slightly compact coarse sandy loam or material of finer texture which continues to a depth of many feet. As a rule, the interstitial material in this layer constitutes only a small proportion of the mass, yet the gravel and cobbles are sufficiently compacted to stand up in banks and the material is nowhere excessively porous or leachy. It is everywhere open enough to afford good underdrainage, provided outlets are available.

La Grande silty clay loam is moderately extensive in the vicinity of La Grande, Union, and Cove. One of the largest areas, averaging one-half mile in width and 4 miles in length, lies north of Island City between Grande Ronde River and Pierce Slough. Two patches lie from 2 to 4 miles north of La Grande, and a narrow strip is 2 miles south of Lonetree.

The areas near La Grande lie on the floor of the valley and are nearly level. They are mainly well drained, the river in this locality lying well below the surface and holding the normal water table at a depth of 6 or more feet. Where higher ground water obtains

it is usually the result of damming the river or near-by smaller streams, thus water logging the gravelly material which underlies this soil. The areas north of La Grande occupy a gently undulating terrace 50 or more feet above the valley floor, and here surface drainage and underdrainage are good. The tracts at Union are smooth, with a very gentle fall toward the valley. They are crossed by two good-sized streams, water from which is used for irrigation. Here, during the irrigating season, free ground water can usually be found at a depth ranging from 2 to 3 feet. Near Cove the soil occupies the lower part of a fan having a slope of 200 or more feet to the mile. These areas also receive copious irrigation, and though surface drainage is well developed underdrainage is usually inadequate, generally causing free ground water to prevail at a depth of less than 3 feet.

This soil is derived from stream-laid deposits which have their source in the volcanic rocks of the adjacent hills. Although definitely a part of the valley, it occurs in the vicinity of the hills, most of it a little removed from the mouths of large canyons. In places it overlies old lake deposits at a depth of 30 or more feet, but elsewhere much of the old lake-laid materials appear to have been swept away by the swift mountain streams, which apparently at one time entered the valley.

This is an important soil since it occupies prominent positions in the valley and is practically all in cultivation. About 75 per cent of it is devoted to wheat and most of the remainder to alfalfa, oats, and tame grasses for hay. A few excellent gardens are grown for market purposes, and some corn, potatoes, strawberries, and loganberries are produced in the vicinity of La Grande. A small acreage is in apples, cherries, and prunes. Many of the prune orchards are young, and garden crops are grown between the trees. Near Cove a part of the land is used for pasture.

Owing to its favorable location near the cities of La Grande and Union, most of this soil has a high valuation. Some orchards are said to be priced at around $500 an acre. Land improved for general farming, a few miles from town, can be bought for $100 or $125 an acre.

La Grande silty clay loam, where well drained and properly worked, is among the most productive soils in the valley. It responds readily to irrigation, only a small amount of water being required to tide over the crops in the driest summers. In places it would be improved by deepening the natural drainage ways in order to lower the water table in the spring, thus hastening drying and allowing earlier cultivation and seeding. Except in small spots in the eastern part of the town of Union, the soil is practically free of alkali. Where well drained it is suited to all the crops commonly grown in the valley.

SPRINGDALE GRAVELLY LOAM

Virgin Springdale gravelly loam has a surface mulch, about 2 inches thick, of dark-brown friable gravelly loam containing a quantity of organic matter. The subsurface layer, to a depth of 12 or 13 inches, is light rich-brown or yellowish-brown slightly compact gravelly loam, the gravel and cobbles constituting a large proportion of the mass. The underlying material, which continues to a depth

of 20 or more feet, consists of unassorted gravel, cobbles, and small bowlders loosely embedded in yellowish-brown, reddish-brown, or light rich-brown loam, the fine material constituting only a small proportion of the mass. In that part of the soil which lies along the margin of the valley, the gravel are finer and fairly well rounded, but on the upper parts of the alluvial fans, which are less reworked, there are many cobbles and bowlders, some of them a foot in diameter. Since these bowlders have been transported only short distances from the adjacent mountain sides, most of them are angular in form. Compared with other valley soils, this soil is comparatively young. No part of it contains sufficient lime to effervesce with hydrochloric acid, and it is only slightly compact.

Typical areas of this soil are not too stony for cultivation but the gravelly subsoil renders the soil too porous and leachy for best results without irrigation. When dry farmed, the crops planted usually suffer from drought.

Typical Springdale gravelly loam occurs in only a few small areas lying part way up the fans on the west side of the valley. In many places it is intermediate in position, as well as in character, between the loam member of the series and the stonier areas. The largest body, containing a little more than 1 square mile, occurs near the northwest corner of the area surveyed. Other areas are near Pleasant Grove School and along Dry Creek northwest of Summerville.

Tracts are gently sloping, being broken here and there by the steep banks of intermittent streams. Drainage ranges from good to excessive, and the soil is free of alkali.

Owing to its small extent this soil has little agricultural importance. Only about 10 per cent of it is farmed and the rest is timbered with pine, fir, and tamarack, with a heavy undergrowth of mountain balm or cinnamon bush, huckleberries, and pine grass. The same crops are grown, usually with less favorable results, as on Springdale loam.

Springdale gravelly loam, stony phase.—With increasing elevation Springdale gravelly loam becomes gradually stonier, the areas which are too stony to be conveniently farmed being designated as Springdale gravelly loam, stony phase, and shown on the map by stone symbols. The soil therefore differs from typical Springdale gravelly loam only in being more stony.

This stony soil is much more extensive than typical Springdale gravelly loam, a number of large areas being mapped on the upper part of the fans along the west side of the valley. In most places the stones are less than 1 foot in diameter and are either thickly scattered over the surface or mixed throughout the soil. In some places, where it is possible to remove the stones from the surface to below plow depth, the land is similar to typical Springdale gravelly loam. However, conditions at present do not justify this expense, as the land is thickly timbered, rather steep, porous, and excessively drained. Most of it is best suited to the continued production of timber.

SPRINGDALE LOAM

Springdale loam, in the virgin condition, has a surface mulch, from 1 to 3 inches thick, of dull-brown or brown friable loam which contains a quantity of organic matter and overlies light-brown mel-

low friable loam extending with but little change to a depth of 26 inches. The subsoil is light-brown or rich-brown slightly compact slightly mottled clay loam continuing to an average depth of 42 inches. The mottles in this layer are not caused by poor drainage but seem rather to have resulted from thin coatings of grayer material along the passageways of roots or over the surfaces of soil aggregates, which range from the size of buckshot to one-half inch in diameter. On exposure to the air or on being broken down the so-called mottling disappears. From a depth of 42 inches to many feet the substratum consists of rich-brown, yellowish-brown, or reddish-brown gravelly loam or light clay loam, in some places moderately compact but in all places sufficiently open and friable for good drainage. The gravel are mainly basaltic and unassorted but well rounded or semiangular in shape. The soil material shows but little weathering, and lime carbonate is only very faintly noticeable in any part.

This soil resembles La Grande loam but is distinguished from it by its richer-brown or more yellowish-brown color, its looser and more permeable subsoil, and its occurrence on recent alluvial fans which are typically timbered.

Springdale loam occurs only in comparatively small tracts which occupy positions intermediate between the valley floor and the mountains in the northwest part of the area surveyed. The largest bodies extend northward from the vicinity of Pleasant Grove School beyond the boundaries of the area. Other smaller areas lie west and northwest of Iowa School.

The areas are gently sloping alluvial fans, favorable to drainage and irrigation. Subdrainage is nearly everywhere ample, except in small seeped areas in the vicinity of springs. In few places is the water table within 20 feet of the surface, and the soil is free of alkali. Under irrigation the water requirements are rather high but are not considered excessive.

In its present condition this soil has little importance, as only about one-half of it is farmed. The rest is timbered.

GOOCH FINE SANDY LOAM

The surface layer of Gooch fine sandy loam, in the virgin condition, consists of dark-gray or dark brownish-gray floury fine sandy loam about 7 inches thick, which in most places contains insufficient lime to effervesce with acid. It is underlain by lighter-gray or light-brownish calcareous platy-structured fine sandy loam which continues to a depth of about 12 inches. When wet or freshly plowed the surface soil is brown or dark brown in color and when dry it sometimes has a faint-bluish cast. The texture is rather fine, the soil grading imperceptibly into associated areas of Gooch loam. The upper subsoil layer is light-brown or grayish-brown mellow highly calcareous fine sandy loam and is underlain by a yellowish-gray very compact cloddy-structured silty clay loam layer which is profusely stained with iron or mottled with yellow. The lower subsoil layer is typically about 10 or 12 inches thick and is highly calcareous. Below an average depth of 42 inches the lime content rapidly diminishes, the texture becomes lighter, and the structure is loose and porous. The upper part of the underlying stratified materials, between depths of 42 and 60 inches, is gray or faint

yellowish-gray mottled sharp fine sand or very fine sand. Except in the first few inches the substratum is free from lime. Below a depth of 5 feet the material is light-brown clean sharp porous noncalcareous sand.

Gooch fine sandy loam is of comparatively small extent. One irregular-shaped body containing about 4 square miles occurs northeast of Lonetree. Three small areas are in the vicinity of Lonetree. The areas are flat, and both surface drainage and underdrainage are poor. The water table is high in most places, lying at a depth ranging from 3 to 5 feet in summer and nearer the surface in winter and spring. Evaporation of moisture from the surface has caused the rise of salts, with the result that much of the soil is injuriously affected by alkali, a considerable part of which is sodium carbonate or so-called black alkali, which is especially injurious to crops. As a result of the alkali content, about 80 per cent of the land is still uncleared and is covered by a growth of salt grass and greasewood. Most of the cultivated acreage is used for wheat and alfalfa, alfalfa predominating. Owing to the high water table the salt-grass areas remain green throughout the summer and provide pasturage for a large number of cattle. In the fall these areas are used for sheep pasture. Wheat occupies a somewhat smaller proportion of the cultivated acreage than it does on Gooch loam, but a proportionate acreage is sown in the fall and spring. Yields vary considerably, being affected by drainage conditions and the content of alkali in the soil. The average returns for both wheat and alfalfa are about the same as on Gooch loam and the two soils are handled in the same manner.

Developed farms can be bought for prices ranging from $75 to $100 an acre, and undeveloped tracts somewhat affected by alkali for from $35 to $65.

Gooch fine sandy loam is mellow and easily cultivated. Its chief requirement is drainage in order to lower the water table and check the rise of soluble salts. With good underdrainage and a sufficient supply of irrigation water it is possible that much of the salts could be leached out and the soil made suitable for the production of the general crops of the valley. In its present condition only the alkali-free areas are suited to cropping, the remainder being best suited to permanent pasture.

Gooch fine sandy loam, light-textured phase.—The surface layer of Gooch fine sandy loam, light-textured phase, consists of brownish-gray loose fine sand about 12 inches thick. It is underlain by light brownish-gray or darker-gray loose calcareous fine sand, which continues to an average depth of 38 inches. Except in places where a thin layer of dark dull-gray calcareous fine sandy loam extends from a depth of about 26 inches to 29 inches, the soil is almost devoid of organic matter throughout. At an average depth of about 30 inches lime carbonate has accumulated in sufficient quantity to form a 1-inch layer of gray or pinkish-gray lime-cemented hardpan. This hardpan is an effective barrier to the penetration of water and roots and in most places is the dividing line between dry and wet soil. It is underlain by light brownish-gray loose fine sand which grades into light-gray loose rust-stained very fine sand at a depth of 6½ or 7 feet. Except in a few places on the surface this light-textured soil is highly calcareous to a depth of many feet.

This is the least extensive soil in the area surveyed. It is mapped in only one small area along the railroad between La Grande and Lonetree, where it occurs as wind-blown dunes from 3 to 10 feet high separated by shallow depressions 100 or more feet wide. In many of these depressions water stands until early summer, after which the water table remains high causing an accumulation of injurious quantities of salts near the surface.

The land is used principally for pasture. It has little agricultural importance at present, owing partly to its uneven surface and partly to the presence of alkali. The dunes support a growth of greasewood, and salt grass grows in the depressions. The cost of leveling and freeing this land from salts would be high, and as the producing power would probably still be low such expense is not warranted.

GOOCH LOAM

The surface soil of virgin Gooch loam consists of a layer of dark dull-gray or dark brownish-gray slightly compact platy-structured loam 2 or 3 inches thick, underlain by similar-colored friable loam of single-grained structure which continues to a depth of about 16 inches. The subsurface layer effervesces freely with hydrochloric acid, but in most places the upper 3 inches of material has been leached of soluble lime. The upper subsoil layer is dark-gray very compact platy or adobe-structured clay loam containing a strong concentration of lime carbonate. Averaging from 10 to 12 inches in thickness, it commonly terminates at a depth of about 26 inches. In common with the corresponding layer in other members of the Gooch series, it offers some resistance to the development of roots and in many places the fine rootlets of grasses cease to grow and become matted on reaching this layer. Locally, the material is referred to as hardpan, although in no place examined was it sufficiently cemented to justify the term. It softens readily with moisture and in this condition is easily penetrated by plant roots. This layer is underlain by brownish-gray mellow fine sandy loam or loam speckled with gray particles of lime. In most places below a depth of about 3 feet there is a layer or stratum which is free from lime, the material becoming lighter textured and more mellow and pervious. Below this the material is irregularly stratified and consists for the most part of light-brown micaceous very fine sand or fine sandy loam containing black and rust-colored mottles in the lower places and being calcareous in many places. The water table rarely lies at a depth of more than 4 or 5 feet and in many places is nearer the surface.

Although many tracts of this soil are mapped in the Grande Ronde Valley area, the total acreage is small. The largest areas lie midway between Lonetree and Island City. Small patches occur near both these places, 4 miles north of Hot Lake, near Union Station. and west and north of Conley. In the last-named locality the soil occupies a pothole which if not actually flooded in winter is at least wet and water-logged until late in spring. Elsewhere the land is generally level. Both surface drainage and underdrainage are poorly developed, the latter because of the generally high level of the water table throughout the sections in which this soil occurs.

Alkali is prevalent in the largest area between Lonetree and Island City, and black stains occur locally on the surface of some of the other areas.

Where alkali occurs the natural vegetation is salt grass and greasewood. Elsewhere it consists of a variety of other grasses including bunch grass. About 50 per cent of the land is cleared and used principally in the production of wheat and alfalfa. Wheat occupies perhaps 50 per cent of the cultivated acreage. On the soil as a whole wheat yields are somewhat under the average for the area, as some of the fields are affected by poor drainage and alkali spots. Much of the alfalfa is irrigated with gravity water from local springs and streams, and where this is done yields ranging from 1 to 1½ tons at each of three cuttings are obtained. The salt-grass areas are usually green throughout the driest part of the year and provide summer pasture for cattle and horses as well as fall pasture for sheep.

Areas of this soil developed for general farming can be bought at prices ranging from $75 to $100 an acre, depending on location, freedom from alkali, and improvements. Uncleared areas more or less affected by alkali are priced from $35 to $65.

The greater part of this soil is in need of drainage in order to lower the water table and prevent the further rise of alkali to the surface. With adequate underdrainage and a sufficient supply of water for irrigation, the land could probably be considerably improved by leaching out the salts.

Gooch loam, gravelly-subsoil phase.—A gravelly-subsoil phase of Gooch loam, including about three-fourths square mile, is differentiated on the map. It occurs in two small areas 1 mile northwest and one-half mile east of Union. Soil of this phase differs from the typical soil in that waterworn gravel are embedded in mottled or iron-stained sandy loam at a depth ranging from 2 to 3 feet. The gravelly layer is commonly water-logged, the profuse mottling indicating development under poor drainage conditions. The mottles become evident in most places about 6 inches above the gravel, and in this respect the soil resembles the La Grande soils. It differs from the La Grande soils, however, in having a lighter-colored surface soil and a larger content of lime in the subsoil. This soil is comparatively free from alkali. It is used principally in the production of wheat and alfalfa, with about the same results as are obtained on typical Gooch loam.

GOOCH SILT LOAM

The surface soil of Gooch silt loam, in the virgin condition, includes a 1-inch surface layer of dark, dull-gray, friable, fine-granular silt loam containing a quantity of grass roots, and a second layer, continuous to a depth of 9 inches, of similar-colored granular platy-structured silt loam which is readily broken down to a single-grained structure. Both these layers are highly calcareous in most places, although the surface layer is in some places only mildly calcareous. Viewed under certain shades of light, especially from a distance, the dry surface of cultivated fields has a faint bluish cast, but following rains the color is nearly black. The upper subsoil layer is lighter-

gray or faint bluish-gray, slightly compact, highly calcareous, floury or single-grained silt loam passing at a depth of 20 inches into somewhat lighter-gray, compact, highly calcareous, honeycombed or vesicular-structured silty clay loam which breaks down first into coarse granular particles and, with a little further pressure, into single grains. At an average depth of 60 inches the material is gray or brownish-gray, calcareous, moderately compact but granular silty clay loam mottled with yellowish-brown and gray specks of lime. When moist, the color is somewhat browner, and the mottles are more pronounced. During the driest part of the season water usually stands at a depth ranging from 6 to 7 feet. At the latter depth the water-logged material is usually light-gray or nearly white, highly calcareous, silty clay. This material may extend to a depth of 10 or more feet, where it is underlain by light-colored, noncalcareous, very fine sandy loam which becomes lighter textured and more permeable with depth.

Gooch silt loam grades imperceptibly into the associated soils of the Palouse and Alicel series and as these higher-lying darker areas are approached the color becomes browner, the boundary between the soils usually lying at the base of slight elevations.

This is one of the most extensive soils in the valley part of the area. It occupies the major part of the lower valley lands bordering Grande Ronde River from the vicinity of Phys Point to near the north boundary of the area. Other extensive bodies occur north and northwest of Hot Lake, north of Island City, and east of La Grande. Areas are low, level, and valleylike and are favorable to irrigation. Surface drainage is poorly developed. In places the water table is from 3 to 5 feet below the surface during the driest part of the season and nearer the surface during the winter and spring.

This is one of the more important soils in the Grande Ronde Valley area, since it is not only extensive but is nearly all under cultivation. Nearly one-half of the tilled acreage is summer fallowed every second year, and most of the remainder is used for growing wheat, alfalfa, and oats. Wheat occupies by far the largest acreage. Because some of the soil is too wet for early spring plowing, as much of it as possible is prepared in the fall.

Crop yields are fairly good. Oats and barley usually occupy only a small acreage and are used locally for feeding work animals. Alfalfa does well.

Improved land of this kind is held at prices ranging from $75 to $125 an acre, much of it being held at about $90.

Gooch silt loam is naturally productive, but the greater part of it has become depleted of organic matter through continued cropping to grain. A special effort should therefore be made to restore this constituent. A broader rotation which will include a green-manure crop such as alfalfa or peas to be plowed under is recommended. Canada field peas have been grown for this purpose and have given excellent results. As this soil has a high lime content it is well suited to alfalfa. The wetter areas, where free from alkali, are well suited to the production of tame grasses, either for hay or for pasturage. Much of this soil could be improved by draining, which would allow earlier plowing and, therefore, better preparation of the land

in the spring. Small areas affected by alkali are especially in need of drainage. They are temporarily improved by the plowing under of straw or barnyard manure but can be permanently improved only through drainage.

GOOCH SILTY CLAY LOAM

The surface soil of Gooch silty clay loam includes two distinct layers, a 3-inch surface layer of dark dull-gray or dark brownish-gray coarse-granular platy-structured silty clay loam, and a subsurface layer extending to a depth of about 6 inches, of dark-gray or dark brownish-gray silty clay loam which is rather compact and somewhat cloddy when dry but is readily broken down into a coarse-granular structure. The upper subsoil layer is dark brownish-gray moderately compact platy somewhat columnar-structured silty clay loam extending to an average depth of 18 inches. The lower subsoil layer, which extends to a depth of about 5 feet, consists of light-gray calcareous powdery silty or very fine sandy material. The three layers below the surface layer effervesce with dilute hydrochloric acid. The subsoil is underlain by a stratum of lake-laid noncalcareous clay which is mottled with rust color and yellow. At a depth of 6½ or 7 feet there is in many places a layer of dark-gray or black mottled compact clay which overlies light-textured pervious materials at a depth ranging from 9 to 10 feet. In most areas of this soil free ground water is present at a depth of about 4 feet.

Although Gooch silty clay loam occurs mainly in comparatively small tracts the total acreage is considerable, since the soil is widely distributed throughout the lower-lying parts of the surveyed area. Some of the most prominent tracts occur east of Island City along the La Grande-Cove market road, along the base of the hills south of the railroad between La Grande and Lonetree, and northwest of Conley. Other small areas occur at various points along Grande Ronde River between Rhinehart and Cove. This soil occurs mainly either as low flat areas near the margin of the valley or as bottom land along drainage ways. Although much of it is crossed by intermittent streams it is too low and flat to have good surface drainage, and underdrainage is restricted by a high water table.

This is a rather important agricultural soil in the Grande Ronde Valley area. Fully 90 per cent of it is used for crop production. Of this probably 80 per cent is given over to wheat and the remainder to alfalfa, oats, a little barley, and tame grasses for hay. The uncultivated areas support a good growth of wild grass, some of which is used for hay and some for pasture. Of the wheat grown, about the same proportions are sown in the fall and spring as on Gooch silt loam, and where the land is free from alkali yields are about the same. However, owing to the more unfavorable drainage conditions on this soil, resulting in a slightly greater acreage affected by alkali, the average yield is a little less. In normal seasons, three cuttings of alfalfa with an average yield of about 3½ tons to the acre are obtained, timothy yields about 1½ tons, wild grasses about 1 ton, and oats and barley do well, returning from 35 to 60 bushels.

The price of improved land of this kind ranges from $75 to $100 an acre, depending on improvements, location, drainage, and free-

dom from alkali. Unimproved tracts are not sold separately but are held at a considerably lower price.

Drainage is the most pressing requirement of Gooch silty clay loam. Poor drainage has been the cause of all alkali troubles, and the water-logged condition of the underlying material keeps the surface soil wet and cold, delaying spring cultivation and seeding. Owing to its more plastic consistence this soil is a little harder to work than Gooch silt loam, but this obstacle can be overcome to some extent by increasing the supply of organic matter.

Gooch silty clay loam, gravelly-subsoil phase.—The gravelly-subsoil phase of Gooch silty clay loam differs from the typical soil in several important respects. The surface color ranges from gray to brownish gray becoming black when wet, and the texture grades from heavy silt loam to clay. At a depth ranging from 24 to 36 inches a 6 or 8 inch layer of iron-stained or rust-mottled heavy sandy loam or clay loam is present, overlying a mass of waterworn gravel and cobbles which are loosely embedded in material of similar color and texture. This material extends to a depth of many feet. The surface soil is intermittently calcareous, but the upper part of the subsoil and in many places the gravelly layer effervesce strongly with hydrochloric acid.

In places this soil appears to be of somewhat more recent deposition than typical Gooch soils, although the presence of lime accumulations indicates that it is undoubtedly older than the Catherine soils. Its gravelly profile resembles that of the La Grande soils but its lighter color distinguishes it from this series. The material has sufficiently distinct characteristics to warrant its recognition under a distinct soil series but owing to its small extent in this area it is included as a phase of the Gooch soils.

This soil occurs in only one body comprising about 4 square miles in the vicinity of Union. The areas are smooth, with a gentle fall in the direction of the valley. Surface drainage is fairly well developed but underdrainage is poor, the mottled gravelly subsoil usually being saturated at a depth between 3 and 4 feet. This soil is of only local importance, although practically all of it is in cultivation. A small proportion is irrigated. The same crops are grown, with a little better success, as on typical Gooch silty clay loam.

Owing to its favorable location near Union and its greater freedom from alkali, this soil commands a slightly higher price than the typical soil.

The lighter-textured part of the soil, which occurs nearest Union, is easily cultivated, but the area lying about 3 miles north of the town is clayey in texture and consequently is sticky and plastic when wet and hard and intractable when dry. The heavier areas are especially well suited to grasses, and the rest of the land is suited to the general crops of the valley.

KLAMATH SILT LOAM

The surface soil of Klamath silt loam consists of three divisions, a surface layer, 5 or 6 inches thick, of dull brownish-gray or dark bluish-gray silt loam of fine texture, friable consistence, and good organic-matter content; a similar-colored thinly laminated or platy-structured silt loam layer extending to a depth of 12 inches and

breaking down into a coarse granular structure; and a similar-colored silt loam layer of columnar structure which falls apart naturally to a single-grained structure. The upper subsoil layer, between depths of about 24 and 30 inches, consists of dark bluish-gray slightly compact columnar-structured silt loam which shows streaks of lime accumulation and becomes light gray when dry. All the material above this depth is intermittently calcareous, although the upper surface layer in most places is lime free. Between depths of 30 and 40 inches the material consists of gray, slightly compact, columnar, vesicular-structured silty clay loam which is generally noncalcareous. This rests abruptly on light-gray or white siliceous very fine sand of single-grained or powdery structure when dry but having a somewhat cheesy consistence when wet. At an average depth of 56 inches this layer grades into white very compact flourlike silty material which is in places solidified into a soft shalelike mass. These layers, like the underlying compact heavy-textured lake-laid strata, are everywhere noncalcareous. The white deposits have the appearance of diatomaceous material, but microscopic examination shows them to be composed almost entirely of sharp siliceous mineral particles, probably volcanic ash which was apparently borne in by winds and deposited in the former lake. At a depth of about 6 feet the material is underlain by strata of yellowish-gray and yellowish-brown compact cloddy or adobe-structured silty clay mottled and streaked with yellow and rust brown.

Klamath silt loam is one of the most extensive soils in the lower-lying part of the Grande Ronde Valley area. It occurs principally in the south end of the valley, one of the largest bodies, covering about 12 square miles, extending northeast from Hot Lake. Other prominent areas are west of Hot Lake and in the vicinity of Summerville and Cove.

Areas are flat, and both surface drainage and underdrainage are inadequate. In the southern part of the valley the water table in the greater part of this soil recedes to from 3 to 4 feet beneath the surface in the driest part of the year but during wet seasons or following heavy rains the depth to it is much less. In places water stands near or actually on the surface. In the large area near Hot Lake small depressions are a feature of the landscape. Some of them go dry in periods of prolonged drought but others retain water throughout the year causing the surrounding land to remain water-logged and in places more or less charged with alkali. A considerable acreage of this soil which was formerly flooded by Catherine Creek is now protected by levees.

In some of the wetter areas the surface soil to a depth of 6 or 8 inches contains a large amount of decaying grass and tules. Such areas approach peat and muck in character and, being poorly drained, are shown on the map by marsh symbols.

Klamath silt loam is not of great agricultural importance, as about 30 per cent of it is still covered by water grasses, which are mowed for hay or used for pasture. The same crops are grown and in about the same proportions as on Klamath silty clay loam, and where drainage conditions are similar like results are obtained.

Land values are about the same as on Klamath silty clay loam.

Much of the Klamath silt loam would be greatly improved by drainage. It is said that in some areas which contain a large amount of organic matter the surface remains loose and fluffy for some time following cultivation, thereby preventing satisfactory germination of seed. Where this condition exists it has proved better practice to summer fallow or fall plow the land and allow it to settle during the winter, seeding in the spring rather than in the fall. Were satisfactory drainage provided this soil would be well suited to irrigation. Its mellow surface renders it easier to cultivate than the heavier soils of the valley and makes it suitable for a wide range of crops.

Table 8 shows the results of mechanical analyses of samples of Klamath silt loam.

TABLE 8.—*Mechanical analyses of Klamath silt loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
5619106	Surface soil, 0 to 5 inches	0.1	0.4	0.4	4.4	21.9	62.9	10.0
5619107	Subsurface soil, 5 to 12 inches	.0	.1	.2	4.2	20.3	67.0	8.1
5619108	Subsoil, 12 to 24 inches	.0	.1	.3	4.4	25.7	61.2	8.2
5619109	Subsoil, 24 to 30 inches	.0	.0	.1	1.7	21.2	60.2	16.7
5619110	Subsoil, 30 to 41 inches	.0	.0	.0	.5	16.6	70.0	12.8
5619111	Subsoil, 41 to 56 inches	.0	.0	.0	.3	17.1	77.4	5.0

KLAMATH SILTY CLAY LOAM

The surface horizon of virgin Klamath silty clay loam consists of a 4-inch surface layer of dark dull-gray or dark bluish-gray granular platy-structured silty clay loam containing a large amount of organic matter, overlying lighter-colored dull-gray or bluish-gray coarse-granular silty clay loam which continues to a depth of 30 inches. This layer is rather compact or columnar in structure and is stained with iron or mottled with yellow in many places. It rests on light-gray friable very fine sandy loam mottled with yellow, which grades at a depth of about 36 inches into similar-colored slightly mottled clean sharp very fine sandy material becoming more mottled and finer textured at a depth of about 5 feet.

These light-colored layers are apparently volcanic ash, but they may contain a small percentage of diatomaceous material laid down in the extensive lake which formerly covered the valley. The deposits are highly siliceous and are everywhere noncalcareous. The substratum, below a depth of 6½ feet, consists of a succession of heavy-textured old lake-laid deposits which continue to a depth of many feet. The upper part, between depths of 6½ and 9 feet, consists of brownish-drab or dark bluish-gray compact adobe-structured clay brilliantly mottled with orange or bright-rust color. Commonly this soil is free of lime throughout, but locally the surface soil is slightly calcareous and in places the compact layer just above the gray material will effervesce with hydrochloric acid.

Klamath silty clay loam, together with Klamath silt loam, occupies the greater part of the south end of the valley. Some of the most prominent areas occur at the margin of the valley near Phys Point, southwest of Lonetree, and along the railroad between Union Station

and Hot Lake. Other areas are scattered throughout the valley, notably south of Conley and southwest of Summerville.

This soil occupies low level areas, most of which are poorly drained. Throughout most areas free ground water is present at a depth ranging from 3 to 5 feet during the driest part of the year and at a much slighter depth during winter and spring. In places this condition has resulted in so-called alkali spots, although the salts are not so troublesome as on soils of the Gooch series.

In some of the wet areas the surface layer, to a depth of 1 or more feet, contains a large percentage of organic matter which consists of partly decayed tules and natural grasses. In such places the soil material resembles peat and muck and had it been more extensive would have been so mapped. Where especially poorly drained these areas are shown on the map by marsh symbols. One such body, averaging about one-fourth mile in width and 1 mile in length, lies near the hills 2 miles southwest of Lonetree. Others occur near Hot Lake, but they are too small to be indicated on the map. These marsh areas are covered with marsh grass, rushes, and tules and are too wet to walk over except in the driest summers. Elsewhere, the natural vegetation consists of a variety of grasses, and here and there on areas where alkali is prevalent sagebrush, salt grass, and greasewood are to be seen.

Klamath silty clay loam is an important soil, as it occupies a considerable acreage in the valley. However, only about 60 per cent of it is under cultivation, the remainder, poorly drained and more or less affected by an accumulation of salts, being in natural grasses which are used for hay or pasturage. Wheat is the principal cultivated crop, although a considerable acreage of alfalfa and some oats are grown. A large acreage of the wild grasses is cut for hay. Fully 60 per cent of the wheat is sown in the spring, as fall-sown wheat is frequently damaged by winterkilling. Good yields are obtained where the soil is well drained, but owing to poor drainage conditions, the occasional occurrence of alkali, and the presence of the siliceous layer in the subsoil, the soil as a whole yields somewhat less than the alkali-free soils of the Catherine series. Where the gray material lies at a depth of 4 or 5 feet, as it does southwest of Summerville and in the area near Conley, the upper part of the soil has the appearance of being recent. In such areas the soil resembles the Catherine soils and is considerably more productive than where the white deposits are near the surface.

Improved land of this kind is on the market at prices ranging from $65 to $85 an acre, and pasture land is held at a somewhat lower price.

The greatest need of Klamath silty clay loam is drainage. With this provided the soil would be favorable for irrigation and suited to the general crops of the valley. Owing to the greater moisture supply it is better suited to oats and grasses than are the upland soils. Its productiveness varies greatly with drainage conditions, the presence or absence of alkali, and the nearness to the surface of the white powdery material which is apparently of low producing power.

CONLEY SILT LOAM

The surface soil of Conley silt loam consists of dark dull brownish-gray or black mellow silt loam which contains a quantity of organic matter, overlying dark dull bluish-gray, compact, columnar silt loam at an average depth of about 7 inches. The subsoil, between depths of about 20 and 42 inches, is dark dull-gray compact cloddy-structured silty clay loam in which the surfaces of the clods and soil aggregates show a vitreous or colloidal coating of black. The deeper part of the subsoil, between depths of 42 inches and 7 or more feet, is yellowish-brown moderately compact silty clay profusely iron stained or mottled with rust yellow. The subsoil layers are somewhat less compact and impervious than in other Conley soils. When wet, the surface soil is black. It is naturally friable and can be cultivated under somewhat wetter conditions than can associated soils. This soil resembles La Grande silt loam in the upper part but is distinguished from it by the absence of gravel in the lower part. It differs from Catherine silt loam in being older or in having a more compact or maturely weathered subsoil which nearly everywhere contains a larger amount of colloids. The soil is noncalcareous throughout.

Conley silt loam is inextensive, the largest areas occurring in and around the town of Summerville. Two small areas are a little northeast of Island City and one is 1½ miles southeast of Imbler.

Areas of this soil are nearly level or very gently sloping. Nearly everywhere the relief is such as to favor irrigation. Surface drainage is generally well developed, but in many places underdrainage is inadequate. Until early summer the water table stands under much of the land at a depth ranging from 3 to 4 feet, and during the driest part of the season water is rarely more than 6 feet below the surface. Under present farming conditions this is not a disadvantage, since it forms a dependable reserve supply of moisture for the use of crops and no ill effects are likely to be brought about through the rise of alkali. In case the land should be irrigated, only a small quantity of water would be required. The application of any considerable quantity without provision for underdrainage would be likely to prove disadvantageous rather than beneficial.

On account of its small extent, this soil is not of great importance. However, practically all of it is in cultivation, wheat, alternating with summer fallow about every third year, occupying about 80 per cent of the acreage and alfalfa most of the remainder. About 40 per cent of the wheat grown is fall sown. Owing to the favorable moisture conditions the straw makes a vigorous growth and is sometimes attacked by foot rot, which causes it to lodge. Small patches in potatoes, berries, and vegetables return very good yields.

Conley silt loam is held at prices ranging from $75 to $125 an acre, depending on location and improvements.

This is an excellent soil, productive, well situated, and easily worked. A broader rotation to include a leguminous crop is recommended to maintain its productiveness.

CONLEY SILTY CLAY LOAM

The surface soil of Conley silty clay loam consists of the three following distinct layers: (1) A 1-inch surface mulch of dark-gray,

black, or dark bluish-gray granular platy-structured heavy loam or silt loam containing a quantity of grass roots; (2) slightly lighter bluish-gray granular silty clay loam extending to a depth of 4 inches; and (3) light bluish-gray platy or small-granular structured silty clay loam extending to a depth of about 16 inches. The upper subsoil layer, extending to an average depth of about 26 inches, is dark brownish-gray or drab compact columnar-structured clay apparently containing a large amount of colloidal material which renders the clay sticky and plastic when wet. When dry the colloidal material covers the surface of the soil aggregates with a thin black coating. Underlying this is a layer of yellowish-brown or drab moderately compact coarse-granular structured clay containing fine gray streaks and faint iron mottles, which grades at a depth of about 6 feet into similar-colored but more mottled and more friable clay continuous to a depth of many feet. As mapped in this area the texture ranges rather widely, some of the soil north of Iowa School being very silty whereas that east of Imbler approaches clay. In places, such as in the low part of the valley 2 miles north of Iowa School, gray heavy sticky clay occurs at a depth of about 8 inches, and bedrock is reached at a depth ranging from 2 to 4 feet.

This soil is apparently derived from the weathering of old stream deposits laid down over maturely weathered lake-laid clays. The soils have developed under conditions of poor drainage and are characterized by a fair content of organic matter in the surface soil and an absence of lime in all layers. It is principally in this last-mentioned feature that the soil differs from Gooch silty clay loam, the Gooch soils all being highly calcareous.

Conley silty clay loam is fairly extensive in the lower parts of the valley. The largest area, ranging from one-fourth mile to 1½ miles in width and 6 miles long, occupies the trough of the north-and-south valley lying between the sand-ridge country and the mountains to the west. Other areas occur along Dry and Spring Creeks in the vicinity of Summerville and on the east side of Grande Ronde River near Imbler and Cove.

Although all areas of Conley silty clay loam lie near streams, many are too flat to afford good surface drainage. Furthermore, the low position of this soil in the trough of the valley causes it to serve as a catchment basin for water from higher lands, and the excess water is slow in running off, not only because of the level surface but also on account of the comparatively slow movement of water through the impervious subsoil.

This soil is locally important in the valley southwest of Summerville. Here a large proportion of it is devoted to wheat or oats, alternating with summer fallow, the rest being in natural grasses which are either cut for hay or used for pasturing cattle and sheep. On the east side of the valley a smaller proportion of the land is in small grain and a larger proportion in pasture or wild hay.

The productiveness of the land depends on the depth to the underlying clay, on drainage conditions, and on treatment. Shallow, poorly drained fields seldom yield as much as 15 bushels of wheat to the acre. On the better-drained areas this crop returns from 18 to 24 bushels, with an average of about 20 bushels to the acre. Oats yield from 15 to 40 bushels to the acre, averaging about 25 bushels,

and wild grasses produce from 1 to 2 tons of hay and some additional pasturage.

Improved land of this kind is on the market at prices ranging from $60 to $75 an acre and unimproved land from $45 to $60.

Conley silty clay loam is a difficult soil to handle and under the prevailing system of clean cultivation between grain crops is becoming more and more depleted of organic matter and more apt to bake and become compact. When plowed for summer fallowing, the plow must be followed immediately with the harrow, otherwise the soil will clod badly and yields the following year will be poor. The chief requirement for the improvement of this soil is better drainage, after which the soil would dry out earlier in the spring, allowing earlier seeding. Drainage can best be accomplished by digging ditches leading into drainage ways, which in many places will necessitate straightening and deepening the natural outlets. Following this, alfalfa, sweetclover, or some other leguminous crop should be plowed under to increase the supply of organic matter.

Conley silty clay loam, brown phase.—The surface soil of Conley silty clay loam, brown phase, to an average depth of 8 inches is brown or dull-brown granular platy-structured silty clay loam. This overlies similar-colored platy or fragmental-structured clay which continues to a depth of about 19 inches. In the virgin condition, the 1-inch surface layer is rich in organic matter and is more finely granular than the material below. The upper subsoil layer, to an average depth of about 30 inches, consists of brown adobelike prismatic or columnar-structured clay which grades into brown more friable silty clay loam extending to an average depth of about 6 feet. The columns in the upper part of this layer are from 2 to 5 inches in length and from 1 to 3 inches in width. They have definite vertical and horizontal lines of cleavage. The clayey vitreous material is very compact, gummy, and plastic and apparently contains a large proportion of colloids, the moist surface of the columns glistening in the sun as if freshly coated with glue. The deeper part of the subsoil is brownish-gray friable clay loam, which may extend to a depth of many feet without material change or may grade into grayer more compact calcareous clay loam at a depth of 8 or 9 feet. Typically the soil is noncalcareous throughout.

The brown phase of Conley silty clay loam is inextensive. The largest areas are south of Lonetree and at the margin of the valley in the vicinity of Cove. Four patches are near Iowa School, one is at the base of the slope north of La Grande, and one is near the center of the valley east of Island City.

The areas near Cove slope gently toward the valley, providing good surface drainage, but all the other areas are nearly level and surface drainage is poorly developed. The areas near Iowa School stand from 5 to 10 feet higher than typical Conley silty clay loam, but the compact subsoil layer remains moist and gummy during the driest part of the season. The water table, however, is from 5 to 7 feet below the surface, whereas at the base of the hill north of La Grande free ground water occurs at depths between 2 and 3 feet.

Owing to its small extent, this is one of the less important soils of the valley. However, it is practically all in cultivation. Wheat, summer fallowed about 2 years in 5, occupies perhaps 80 per cent of

the acreage. Most of the remainder of the soil is in natural grasses, which are either cut for hay or pastured, and in small patches of corn, potatoes, berries, fruit, and vegetables. Cherries and apples appear to do well where the water table is not too high but give poor results in the wetter areas. Soil of this phase is handled in the same way as Conley silty clay loam but is usually more tractable, requiring less work in preparing the seed bed.

Land of this kind has a current value ranging from $75 to $100 an acre, depending on location and improvements.

This soil is somewhat more desirable than typical Conley silty clay loam, since most of it has better surface drainage and is more easily prepared for crops. The subsoil is favorable for the retention of water, but in places the water table is too high and should be lowered by deep ditching since this soil, when once saturated, is naturally slow to dry out.

Conley silty clay loam, stony phase.—Conley silty clay loam, stony phase, differs from the typical soil in having a browner more shallow surface soil, with gravel and subangular bowlders scattered on the surface and mixed through the soil, and in its position on foothill slopes or alluvial fans instead of on the valley floor. It is, in part, a timbered soil, whereas typical soils of the Conley series are treeless. The stony phase is sufficiently different to warrant recognition under a separate series, but it is included with the Conley soils because of its small extent. The surface soil consists of a 7-inch layer of dull brownish-gray platy-structured silty clay loam containing a fair quantity of organic matter. The subsoil is dark very compact adobe-structured gravelly clay to a depth of 20 inches, where it passes into yellowish-brown compact adobe-structured gravelly clay mottled with yellow or rust color. At an average depth of 36 inches the material grades into mottled drab adobe-structured very compact clay containing a somewhat larger amount of fine gravel. The subsoil when wet is very gummy or colloidal and on exposure to the air bakes in bricklike clods which are exceedingly intractable. This soil is difficult to handle, not only because of this characteristic but on account of the numerous bowlders scattered over the surface and mixed throughout the soil. It is apparently free from accumulations of lime carbonate.

This is an inextensive soil, practically all of it occurring in small areas on the lower part of the fans on the west side of the valley. The largest area, from one-fourth to one-half mile wide and 2½ miles long, borders the highway north of Iowa School. One patch lies at the foot of the hill 2 miles west of Hot Lake.

The relief is that of gently sloping alluvial fans. All the areas mapped are crossed by one or more intermittent streams and the fall is generally sufficient for good surface drainage. The heavy compact subsoil, however, retards underdrainage, resulting in a water-logged condition until the streams dry up in spring. Following this, the surface soon dries out, becoming hard and intractable.

This soil is of little agricultural importance, as only a small part of it is cultivated. It lies at the margin of the timber belt, the upper part of some areas being covered with pine and the lower part with grasses.

Fair yields of wheat and alfalfa are obtained where irrigation is practiced, but the soil is too droughty for best results under dry-farming methods.

Conley silty clay loam, friable-subsoil phase.—The surface soil of Conley silty clay loam, friable-subsoil phase, consists of a 3-inch layer of dull dark-gray or black platy-structured silty clay loam of high organic-matter content, overlying similar-colored compact cloddy silty clay loam which continues to a depth of 20 inches. When disturbed the material breaks into clods from 3 to 8 inches in diameter which later break into aggregates somewhat larger than buckshot. This material overlies dark dull-brown friable silty clay loam having a rather coarse nut structure but finally breaking down into particles about the same size as those in the layer above. At an average depth of 36 inches the material consists of brown or grayish-brown friable smooth-textured silty clay loam passing at a depth of 48 inches into yellowish-brown silty clay loam mottled with yellow and gray.

Conley silty clay loam, friable-subsoil phase, occurs only in a number of small bodies, most of which lie near the margin of the valley in seeped areas or along drainage ways. The largest areas are at and about 3 miles north of Cove. The other bodies occur along the west side of the valley near Summerville, and from 4 to 5 miles northeast of La Grande. Areas are nearly level or very gently sloping, and surface drainage is well developed. Underdrainage, however, is only fair, the water table rarely falling to more than 3 or 4 feet below the surface during the driest periods.

Soil of this phase is of little agricultural importance. About one-half of it is farmed to wheat and alfalfa in about the same proportion as Conley silt loam, and most of the remainder is in wild grass which is used for pasturage. Because this soil is hard to handle, the seed bed is usually more poorly prepared than on Conley silt loam, and yields of all crops average less.

No recent sales of this land are reported but its value is said to be somewhat less than that of Conley silt loam.

This soil is difficult to handle when either too wet or too dry but if worked at the proper time it breaks down readily into a mellow tilth. Its chief need is better underdrainage and an increase in the organic-matter content in order to improve the structure. The land is suitable for the production of oats and tame grasses, either for hay or for permanent pastures.

CATHERINE SILT LOAM

The 4-inch surface layer of Catherine silt loam ranges from dark grayish-brown to dark dull-brown friable slightly platy-structured silt loam containing a large amount of organic matter. This is underlain by dark dull-brown slightly compact platy-structured somewhat columnar silt loam which continues to a depth of about 20 inches and then grades into brown friable silt loam extending to a depth of about 30 inches. In most places a layer of brown mellow loam occurs at this depth. At a depth of about 5 feet this grades into lighter-brown crumbly loam mottled with yellow and gray.

This is a recent alluvial soil, and the soil layers vary somewhat in detail. The material overlies old lake-laid deposits which occur in most places at a depth of 5 or more feet.

Gravelly areas and areas with stones in the subsoil occur in the narrow valleys east of Union and Cove. The stones are principally basaltic and, since they have been carried only short distances by the streams, are mainly subangular in form. They are most numerous in the subsoil. The surface soil to plow depth is in most places free enough of stone for cultivation. In places along Catherine Creek near Union, the surface soil is somewhat lighter colored than typical. These areas are rather lighter in texture, approaching loam. As a whole, however, the soil material is smooth and silty, becoming somewhat plastic when wet. The large organic-matter content makes it mellow and easily worked and gives it a high moisture-holding capacity.

Catherine silt loam occurs only in narrow strips along stream courses, but the total acreage is rather large. Important areas occur in various places along Grande Ronde River, particularly near Island City and both north and south of Hardscrabble School. Prominent areas are at Union bordering Catherine and Little Creeks, at Cove, and along Spring and Willow Creeks near Summerville.

The greater part of the land is smooth and lies favorably for irrigation, but some areas are somewhat undulating and broken by shallow depressions which have long since ceased to function as active drainage ways. Since the digging of the State Ditch, shortening by many miles the course of Grande Ronde River through the valley, very little of this soil has been flooded, but in some of the lower areas lying at some distance from the channels the water table is too high for best results. Very rarely do crops on this soil suffer seriously from drought.

About 70 per cent of the land is farmed, perhaps 10 per cent is in brush bordering the streams, and the remainder is either in wild or cultivated grasses or is used for pasture. Wheat, alfalfa, and oats are the principal crops. Potatoes are grown with good results on nearly every farm; there are a number of excellent gardens; and, near Union and Cove, a small acreage is in berries and orchards, chiefly cherries and apples. The grainfields are summer fallowed about once in three years, partly, it is said, to conserve moisture but chiefly for the purpose of ridding the land of weeds. About 30 per cent of the wheat, which with summer fallow occupies about 80 per cent of the cultivated acreage, is fall sown. All crops return about the same favorable yields as on Catherine clay loam.

Catherine silt loam sells at prices ranging from $70 to $100 an acre, though some especially well-improved farms near towns are held at $125 an acre.

This soil is naturally one of the most productive in the area surveyed. It is especially well suited to the production of small grains, alfalfa, potatoes, and garden crops, and were it not for its low position and consequent frost susceptibility it would be well suited to fruit. Its favorable texture and organic-matter content render it easily cultivated and highly retentive of moisture. It is well suited to irrigation which in many places could be provided by gravity or by pumping from streams or shallow wells. The productiveness can be maintained by plowing under an occasional crop of alfalfa, by adding barnyard manure, and by adopting a broader system of crop rotation.

Table 9 gives the results of mechanical analyses of samples of Catherine silt loam.

TABLE 9.—*Mechanical analyses of Catherine silt loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
5619162	Surface soil, 0 to 4 inches	0.0	0.8	0.1	2.4	17.6	62.0	16.6
5619163	Subsurface soil, 4 to 20 inches	.0	.0	.0	2.7	24.8	49.0	23.3
5619164	Subsoil, 20 to 30 inches	.0	.0	.1	7.6	28.9	51.6	12.0
5619165	Subsoil, 30 inches to 5 feet	.0	.0	.1	9.7	31.5	48.1	11.2
5619166	Subsoil, 5 to 9 feet	.0	.1	.4	12.3	28.5	47.4	11.6

CATHERINE CLAY LOAM

Catherine clay loam varies from place to place depending somewhat on its position with reference to streams. Typically the 4-inch surface layer ranges from dull dark-brown to black silty clay loam or clay having a slightly compact platy or coarse-granular structure when dry. The content of organic matter is large and when wet the material is sticky and plastic. This layer overlies brown mellow soft-granular clay loam mottled with rust yellow and gray, which becomes a little more silty and more mottled at a depth of 18 or 20 inches. At a depth of about 38 inches the material grades into light-brown incoherent or loose micaceous sand, which is profusely rust stained or mottled with yellow and gray. Below a depth of 7 feet much of the material is dull brownish-gray highly micaceous sandy loam or sand which is somewhat less mottled than the layers above.

Included areas of clay texture lie between Phys Point and Cove and that part of the area on the east side of Catherine Creek east of Hot Lake. Elsewhere the greater proportion of this soil consists of clay loam. In the vicinity of Union gravel underlies parts of the soil at a depth ranging from 4 to 5 feet. Here the soil resembles the La Grande soils but, occurring as it does at the mouth of a canyon, where until recently uncontrolled floods brought down fresh material from the higher-lying fans, the greater part of the profile more nearly resembles that of soils of the Catherine series. In the narrow valley of Mill Creek east of Cove, angular stones occur throughout the soil and here and there on the surface. This is really a stony phase but is not mapped separately because of its small extent. Near the center of the valley, particularly along Grande Ronde River in sections 31, 32, and 33, T. 2 S., R. 39 E., the profile shows a 2-foot stratum of light-gray volcanic ash at a depth ranging from 3 to 9 feet. Where it occurs between depths of 3 and 5 feet the soil is mapped with the Klamath soils, but where it occurs at greater depth it is assumed that the material has little effect on crop growth and it is mapped with the Catherine soils.

Catherine clay loam occupies strips from one-eighth to three-fourths mile wide bordering many of the streams of the valley. The largest areas occur along Catherine Creek between Hot Lake and Union, along Grande Ronde River for a distance of about 15 miles from a point 2 miles east of Island City, along the base of the hill east of Phys Point, and at the margin of the valley 6 miles to the north. Smaller bodies lie in various places along Grande Ronde River and on Willow Creek at Summerville.

Areas of this soil are level or very gently sloping and are broken here and there by steep stream banks. Until the State Ditch was dug through the central part of the valley some 25 years ago most of this soil along the river was badly overflowed. Having a naturally high water table, the soil was slow in drying out following floods, some of it remaining water-logged the year round. Alluvial material deposited along the streams by the recurring floods has raised the soil along the stream bank slightly above that farther away. Now that the water table has been lowered, these slight ridges are well drained. Other areas which were marshy and poorly drained until a few years ago are along Catherine Creek east of Hot Lake. Here the drainage has been corrected by ditching and distributing the summer surplus water over the fields. Much of the area at the base of the hill near Phys Point is still more or less water-logged the year round. Here during the summer the water from the strongly flowing streams issuing from the hills southeast of Cove is practically all absorbed before it reaches the old channel of the river a mile or two away. Elsewhere, throughout areas of this soil are a number of small low areas that are in need of drainage.

Catherine clay loam is an important soil. About 75 per cent of it is in cultivated crops, 20 per cent in wild grasses, and the rest in brushy growths along the streams. The principal crops are wheat, alfalfa, oats, and timothy and clover hay. Potatoes, apples, berries, and vegetables are grown in small patches for local markets and home use. This soil is summer fallowed in order to clean the fields of weeds but not so frequently as are some of the other soils of the valley. Wheat occupies a large proportion of the cultivated acreage. About 60 per cent of it is spring sown, as fall-sown grain is inclined to winterkill on this low moist soil. Crop yields are average. In the vicinity of Union and Cove about 15 per cent of the potatoes are grown on irrigated land and the rest on dry-farmed land. However, as much of the dry-farmed Catherine soils is naturally subirrigated these soils are, when well drained, among the safest in the valley for potato production.

Improved land of this kind can be bought at prices ranging from $75 to $125 an acre. Unimproved land, which occurs mainly in narrow strips along streams, is never sold separately, and its value is considerably less.

Catherine clay loam is one of the most productive soils in the Grande Ronde Valley area. The lighter-textured areas when well drained are especially well suited to the production of potatoes. This soil is much better suited to the production of oats, timothy, and tame grasses than any of the drier higher-lying soils in the area surveyed. It is also well suited to wheat and alfalfa. All of it lies favorably for irrigation. In places it would be greatly improved by drainage. Plowing under organic matter is also suggested as a means of improving its physical condition and maintaining its productiveness.

ROUGH STONY LAND

In addition to the important agricultural soils of the valley floor and the adjoining alluvial fans, a marginal strip of rough stony land is included in the Grande Ronde Valley area. This kind of material, as the name implies, consists of rugged mountain slopes too steep and stony for cultivation. It also includes somewhat

smoother areas which are too stony or shallow to be plowed. Most of the last-mentioned areas occur as islandlike masses in cultivated fields on Pumpkin Ridge or as small knolls rising from 50 to 100 feet above the adjoining soils on the east side of the valley.

The soil material is dark dull-brown or black compact clay loam or clay either overlying solid rock at a slight depth or having a quantity of loose basaltic bowlders scattered over the surface or mixed through the soil. At the base of Mount Emily on the west side of the valley the slope is precipitous. In most places, however, the land slopes away from the valley at a rate ranging from 500 to 1,000 feet to the mile, and at the upper margin the slopes climb at a rate ranging from 1,500 to 2,500 feet to the mile.

Along the west side of the valley this land is timbered with pine, fir, and tamarack, and some of it on Pumpkin Ridge, south of La Grande, and east of Cove is covered with a growth of pine and fir. Near Cove the tree growth is more scattered and the undergrowth less dense than elsewhere. Most of the rough stony land on the east side of the valley and some on Pumpkin Ridge is treeless, the natural vegetation being sagebrush, dock, and bunch grass, with here and there along the draws clumps of chokecherries. This land has no value for cultivation. The open bunch-grass areas have considerable value as grazing land, and other areas are best suited to the production of timber.

IRRIGATION

Supplemental irrigation will be very helpful to agriculture on many of the Grande Ronde Valley area soils. Those which would probably respond most favorably to irrigation occupy the more elevated areas of the valley and include Alicel sandy loam, Alicel loam, Palouse sandy loam, Palouse fine sandy loam, Palouse loam, La Grande loam, and La Grande gravelly loam. Soils suited to supplemental irrigation but with a low water requirement are Alicel silt loam, La Grande silt loam, La Grande silty clay loam, Catherine silt loam, and Catherine clay loam.

The practice of irrigation has kept pace with agricultural development on the valley soils which are easily watered by gravity, and most of the natural stream flow for the growing season has been appropriated for use on lands to which it could be readily diverted by ditches. Use of water obtained by small pumping plants is increasing. In 1926 the Eastern Oregon Agricultural Experiment Station participated in a cooperative irrigation trial with water pumped from Willow Creek and used on Alicel sandy loam and Alicel fine sandy loam to aid in the production of staple field crops. Under irrigation a second cutting of alfalfa yielded 1½ tons, whereas on adjacent dry-farmed land alfalfa yielded nothing. On the irrigated land a good growth was obtained after the second cutting. Irrigation doubled the yield of potatoes on land included in these trials. The corrugation method was used successfully for the distribution of water. With a larger head of water, strip borders would probably save labor in irrigating level areas. Alfalfa received two heavy and potatoes three light irrigations.

In all places, the irrigated crops continued green later in the season. Part of the wheat was irrigated too late to be much benefited, but where water was applied earlier the wheat heads were longer, the stalks taller, and the kernels larger and somewhat heavier. Irrigated potatoes showed more luxuriant tops and larger, more uniform tubers.

The land used in this experiment had been long cropped to grain. Dry-farmed alfalfa in the vicinity on May 25 yielded from 1½ to 2 tons to the acre where not injured severely by frost. The second cutting was not worth harvesting. Spring wheat yields on the sand ridge were very light.

Water storage would make extension of irrigation possible. The free-working soils with natural drainage, situated in the sand-ridge district, are regarded as the most promising lands of the valley for the extension of irrigation farming. These lands are now devoted largely to alternate wheat and fallow under dry farming.

Continuous grain farming, together with wind erosion, has developed rather serious nitrogen, humus, and weed problems with land in the Grande Ronde Valley area. Irrigation of suitable soils would eliminate the summer fallow and necessitate increasing the number of and reducing the size of farm units. Drainage should precede irrigation on soils containing some alkali or being imperfectly drained. Supplemental irrigation would greatly facilitate soil improvement where a crop rotation including the use of soil-building legumes is practiced and barnyard manure and crop residues are plowed under.

SOIL ALKALI AND FERTILITY

Samples of certain soils collected by layers in localities which appeared to be saline or alkaline were collected and submitted to the Oregon Agricultural Experiment Station for determination of the amount and kind of alkali present. The results are presented in Table 10.

TABLE 10.—*Determinations of reaction and alkali*[1]

[Parts of alkali per million]

Laboratory No.	Soil sample	Depth	pH	Total salts	Chloride (Cl)	Sulphate (SO_4)	Total carbonates as (Na_2CO_3)	Carbonate (CO_3)	Bicarbonate (HCO_3)
		Inches							
1	Gooch loam	0- 4	11.75	3,580	344	715	1,892	-------	-------
2	----do	4-20	9.82	-------	-------	-------	-------	-------	-------
3	----do	20-44	8.52	427	43	58	56	-------	-------
4	----do	44-60	8.52	405	48	88	24	-------	73
5	Gooch silt loam	0- 4	10.38	2,772	45	58	2,397	-------	-------
6	----do	4-12	10.61	2,857	40	150	2,691	-------	-------
7	----do	12-26	9.70	935	27	49	827	123	101
8	----do	36-60	8.94	397	24	41	183	-------	308
15	Gooch silty clay loam	0- 4	10.55	3,240	45	111	2,639	-------	-------
9	----do	4-24	10.56	2,326	14	114	2,155	-------	-------
10	----do	24-51	10.04	1,155	27	43	1,089	-------	-------
11	Gooch fine sandy loam	0- 4	10.17	2,817	35	49	719	30	46
12	----do	4-20	10.75	2,590	72	152	938	-------	-------
13	----do	20-48	10.47	3,075	32	160	606	-------	-------
14	----do	48-64	10.38	1,252	40	107	815	60	15
16	Klamath silt loam	0- 4	8.47	590	43	64	203	-------	58
17	----do	4-20	9.21	1,267	40	407	508	81	64
18	----do	20-54	9.72	977	32	67	604	-------	213
19	----do	54-68	9.19	455	27	35	219	-------	73

[1] Analyses by H. W. E. Larson. Sample No. 2 was lost while the soil solution was being prepared. It was impossible to get accurate readings on most of the carbonates and bicarbonates because of the color of the solution.

Soils of the Gooch series have been affected periodically by surface water or a high water table, and the greatest pH value, intensity and amount of alkalinity (total carbonates), and salinity (sulphates and chlorides) are found in the surface layers. In soils represented by

Klamath silt loam, the samples analyzed commonly show the most alkali in the subsoil hardpan layers. According to the analyses this soil offers some possibilities for reclamation.

The intensity of alkalinity or concentration of salinity is unfavorable for growth of staple crops throughout all the soils shown in these samples. The alkali-affected areas are largely in the south-central part of the valley. The reclamation of such land involves deep drainage, chemical treatment, and abundant irrigation. Heavy applications of sulphur or sulphates as well as the growth and decay of organic matter aid flocculation of the soil or neutralization of black alkali (sodium carbonate) where drainage and irrigation are provided. Lands as strongly alkaline as the samples indicate do not seem to be capable of prompt or economic reclamation under conditions existing in the Grande Ronde Valley area. With fairly adequate water control sweetclover and grass pasture may be obtained and gradual soil improvement may be realized.

The surface soils of several soils in this area show a reaction value as follows: Waha clay loam, 6.3; Tolo loam, 6.3; Hyrum stony clay, 6.7; Hyrum gravelly clay loam, 7.3; Springdale loam, 6.3; Springdale gravelly loam, 6.3; Conley silty clay loam, 6.2; Klamath silty clay loam, 6.1; Conley silt loam, 6.2; Catherine silt loam, 6.4; and Catherine clay loam, 6.3; pH 7.0 is neutrality, a lower value indicates acidity, whereas a higher figure indicates alkaline reaction. Growth range for staple field crops is from about pH 4.8 to 7.5 with optimum reaction at about pH 6.0.

Fresh-water meadow soils like those of the Catherine and Conley series are moderately acid and may respond to lime. The official sample of Klamath silty clay loam also shows moderate acidity. The sand-ridge soils are practically neutral.

The pH values of some of the soils of this area from determinations made in the laboratories of the Bureau of Chemistry and Soils, Washington, D. C., are shown in Table 11.

TABLE 11.—*pH determinations of soils in the Grande Ronde Valley area, Oregon*[1]

Soil No.	Soil type	Depth	H-electrode	Soil No.	Soil type	Depth	H-electrode
		Inches	*pH*			*Inches*	*pH*
561936	Alicel silt loam	0- 1	7. 19–7. 23	5619106	Klamath silt loam	0- 5	8. 19–8. 29
561937	do	1- 4	6. 79–6. 73	5619107	do	5- 12	8. 39–8. 39
561938	do	4- 16	6. 83–6. 80	5619108	do	12- 24	8. 42–8. 40
561939	do	16- 60	9. 53–9. 45	5619109	do	24- 30	8. 47–8. 35
561940	do	60- 84	7. 79–7. 79	5619110	do	30- 41	7. 72–7. 80
561941	do	84–108	7. 40–7. 49	5619111	do	41- 56	7. 39–7. 45
561942	do	108–120	7. 39–7. 39	5619112	do	56- 68	7. 32–7. 40
561901	Waha clay loam	0- 1	6. 37–6. 37	5619113	do	68- 84	7. 32–7. 33
561902	do	1- 8	6. 35–6. 33	5619114	do	84–108	7. 30–7. 27
561903	do	8- 26	6. 33–6. 33	5619130	Springdale loam	0- 1	6. 79–6. 82
561904	do	26- 48	6. 67–6. 73	5619131	do	1- 7	5. 93–5. 97
561905	do	48–122	6. 83–6. 83	5619132	do	7- 26	6. 17–6. 19
561906	do	122–192	6. 83–6. 79	5619133	do	26- 42	6. 10–6. 12
561948	Palouse fine sandy loam.	0- 5	6. 72–6. 77	5619134	do	42- 60	5. 87–5. 90
				5619144	Hyrum stony clay	0- 8	6. 47–6. 53
561949	do	5- 20	6. 49–6. 52	5619145	do	8- 24	6. 49–6. 55
561950	do	20- 30	8. 83–8. 95	5619146	do	24- 26	8. 13–8. 13
561951	do	30–108	7. 17–7. 17	5619147	do	26- 42	8. 00–8. 03
561976	Gooch silt loam	0- 1	8. 25–8. 25	5619151	La Grande silt loam	0- 4	7. 63–7. 68
561977	do	1- 9	9. 17–9. 17	5619152	do	4- 20	7. 30–7. 40
561978	do	9- 20	8. 55–8. 60	5619153	do	20- 36	7. 95–8. 03
561979	do	20- 60	8. 32–8. 27	5619154	do	36- 42	7. 63–7. 70
561980	do	60- 84	8. 32–8. 23	5619155	do	42- 84	7. 49–7. 40
561981	do	84–126	8. 33–8. 37				

[1] These soils are tschernosems or border on them.

Chemical analyses for the most important nutrients are available for a few of the chief soils of the Grande Ronde Valley area and indicate that the total supply of potassium, phosphorus, and nitrogen is fairly good. Analyses of the displaced soil solution from Cathcrine silt loam taken from the Eastern Oregon Experiment Station fertility plots at Union show a good total concentration and rather plentiful amounts of sulphate, phosphate, and potassium ions and fair amounts of nitrate and calcium ions. Good response is obtained from well-rotted manure and nitrate on nonlegumes, and sulphur or gypsum on legumes pays on many of the soils of the valley.

DRAINAGE

Soils in the Grande Ronde Valley area in need of drainage are Klamath silt loam, Klamath silty clay loam, Conley silty clay loam, Gooch fine sandy loam (saline), Gooch loam (saline), Gooch silt loam, and Gooch silty clay loam. A preliminary drainage survey of the valley was made in 1927, and a report showed that it was entirely feasible to drain the upper end of the valley and that much relief could be afforded the farmers on the lower end. Topographic data are lacking for the most westerly part of the valley. Storage of water for irrigation would help somewhat, but a reservoir for irrigation waters might need to be partly filled before the peak of the run-off. The chief improvements suggested include removal of rock from the river channel below Imbler; straightening, cleaning, and shortening the river channel in the lower part of the valley in order to eliminate oxbows; some cleaning and diking of the main channel and its tributaries; and construction of important laterals leading through low flat areas to the river. Thus deeper outlets for intercepting foot-slope ditches and farm tile lines which would control ground water and alkali would be afforded. Drainage improvements should precede any important extensions of irrigation for the above-named soils. Intercepting drains are needed in the vicinity of Cove, and district outlet ditches for this sloping land will not be necessary.

SUMMARY

The Grande Ronde Valley area is in Union County, near the northwest corner of Oregon. The total area comprises 289 square miles, or 184,960 acres. It is a basinlike area most of which lies from 2,700 to 3,000 feet above sea level, closely encircled by the Blue and Wallowa Mountains. It is traversed by Grande Ronde River, which is an extremely tortuous stream with a sluggish current.

The alluvial stream valley, which occupies the south and east parts of the basin, is flat and poorly drained. The sand ridge occupying the north-central part has a gently undulating wind-modified surface, and drainage is well developed. The foothills and alluvial fans bordering the valley are well drained and are for the most part smooth enough for cultivation.

The valley was originally treeless, but the surrounding mountains and basins along the west side are timbered with pine, tamarack, and fir.

This area was settled in the early sixties of the last century. La Grande is the county seat and principal town of Union County.

All except the poorly drained parts of the valley are occupied, although settlement is rather sparse on account of the prevalence of large farms. Extensive areas in the poorly drained sections are untenanted.

Transportation facilities are good, the valley being crossed by the transcontinental line of the Union Pacific Railroad. No point in the valley is more than 7 miles from a shipping point.

Portland is the principal market for grain and livestock. Quantities of wheat are milled within the valley. Apples, cherries, and prunes are sold in eastern cities.

The climate of this area is temperate. It is characterized by scant rainfall, a wide range in temperature, low relative humidity, rapid evaporation, and abundant sunshine.

The rainfall is sufficient to grow wheat every second year by summer fallowing. Irrigation would undoubtedly prove profitable, since it would make possible the growing of some crops every year.

The agriculture of the Grande Ronde Valley area consists of the growing of wheat and fruit for sale, the growing of alfalfa and other forage crops for sale and for home use, dairy farming to some extent, hog raising, the winter grazing of beef cattle and sheep, and the production of potatoes and other vegetables for local markets and home use. Wheat is the most important crop, followed by alfalfa, other hay crops, apples, and cherries.

Improved farm machinery is in general use. Improved farms sell at prices ranging from $70 to $125 an acre.

In addition to rough stony land, a nonagricultural material, 11 soil series are represented in the Grande Ronde Valley area by 28 soil types and 9 subordinate phases. These may be grouped into hill soils, soils of the terraces and alluvial fans, wind-blown soils of the sand ridge, and soils of the valley floor.

The hill soils include members of the Tolo and Waha series. The Tolo soils are light colored and timbered and the Waha are dark colored and mainly unforested.

The terraces and fans include soils of the Hyrum and La Grande series. The soils of the latter series are extensive and among the most important soils in the southern part of the valley. The Springdale soils occupy the timbered alluvial fans on the west side of the valley. They are somewhat open and porous and are but little used for agriculture.

The sand-ridge section includes soils of the Palouse and Alicel series, which are among the most important in the area surveyed.

The valley proper includes soils of the Gooch, Klamath, Conley, and Catherine series. These soils are level and more or less poorly drained. The Catherine soils, however, are highly productive.

Rough stony land is almost entirely nonagricultural.

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[PUBLIC RESOLUTION—No. 9]

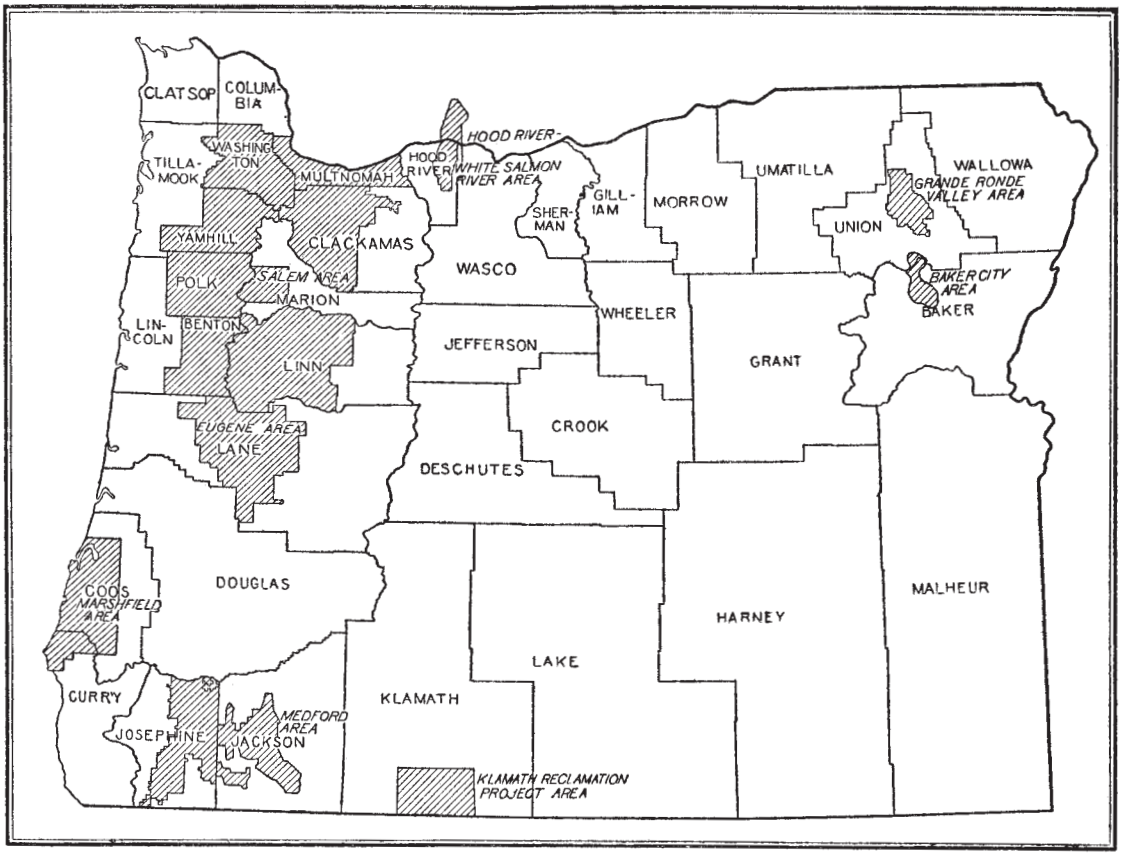
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture"

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Oregon, shown by shading

U. S. GOVERNMENT PRINTING OFFICE: 1930

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