

SOIL SURVEY OF MULTNOMAH COUNTY, OREGON.

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DESCRIPTION OF THE AREA.

Multnomah County is situated in the northwestern part of Oregon and includes Portland, the metropolis of the State and an important market center. Columbia County bounds it on the north for a distance of about 10 miles, and the Columbia River, which forms the remainder of the northern boundary, separates the county from the State of Washington. It is bounded on the east by Hood River County, on the south by Clackamas County, and on the west by Washington County. Gary, Government, and Hayden Islands and the major part of Sauvie Island, which are separated from the mainland and from each other by the various channels of the Columbia River, are included in the county.

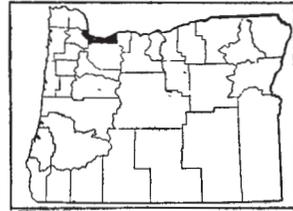


FIG. 3.—Sketch map showing location of the Multnomah County area, Oregon.

The county, which is irregular in outline, has a total area of 328 square miles, or 209,920 acres. About one-tenth of the area in the extreme eastern part of the county is in national forest. Over one-eighth of the county is occupied by the city of Portland, and one-eighth, principally in the central part of the county, is in highly improved farms. There are about 140,000 acres outside of the city of Portland susceptible to ultimate cultivation. Most of the uncultivated land is timberland, logged-over land, and overflow land along the Columbia River, which is now being diked to prevent further flooding.

The topography of Multnomah County is varied, ranging in elevation from 30 feet along the Columbia River to 5,000 feet, this being reached in the extreme eastern part of the county. A part of the Cascade Range covers the eastern part of the county, and a spur of the Coast Range runs along the entire western boundary. The main topographic features of the county consist of (1) the alluvial lands along the Columbia River and tributary streams, (2) the bench lands, and (3) the hilly to mountainous districts.

The alluvial lands occur mainly in a narrow strip along the Columbia River. In the eastern part of the county this is quite narrow, but just east of the mouth of the Sandy River it becomes broader and, including the islands in the Columbia River, reaches a width of 3 to 6 miles. The topography in this section is slightly undulating, with low mounds and ridges and shallow basins. Many of these basins are but little above the level of the river and contain water throughout the year. During the June freshets all but the higher elevated lands are overflowed, except where dikes have been built.

The bench lands extend from a few miles east of the Sandy River on the east to the Willamette River on the west. They rise to the south from the alluvial lands along the Columbia River and extend to the hill lands along the southern boundary of the county. In the eastern part of the county they attain elevations of more than 1,000 feet, and the land is nearly level to strongly rolling and deeply trenched by streams. In the western part Kelly and Rocky Buttes, and Mount Tabor, covered with a mantle of residual soil, protrude through this bench, which here is seldom more than 300 feet in elevation.

The hilly and mountainous regions occur in both the eastern and western parts of the county. East and south of the Sandy River for several miles the land rises abruptly into a rolling hill section. Farther east and including the Oregon National Forest these hills become quite rough and mountainous and are covered with a dense growth of fir timber. In the western part of the county, beginning within the boundary of the city of Portland, and running west to the county boundary, there is a steep narrow range of hills ranging from 800 to 1,300 feet in elevation. This is a spur of the Coast Range. These hills are mostly forested, but include a few farms in scattered clearings.

Multnomah County is drained by the Columbia River and its tributaries, the Willamette and Sandy Rivers. The Willamette River flows through the western part of the county, and empties into the Columbia River in the extreme northwestern part. The Sandy River in the eastern part of the county receives most of the drainage of that section. It empties into the Columbia River just below Troutdale. With the exception of the lands along the Columbia River, which are interspersed with small lakes, bayous, and marshes, the drainage of the county is excellent.

Multnomah County was organized in 1864, and its agricultural development and settlement has been determined almost entirely by the growth of the city of Portland. Although it is the smallest county in the State, it is by far the most densely populated. The total population, according to the census of 1920, is 275,898. Of this

258,288, or 93.6 per cent, is in the city of Portland. The foreign nationalities represented most largely are German, Scandinavian, English, Irish, Scotch, Swiss, Canadian, Chinese, and Japanese.

Portland is the county seat, a world port, and a city of first importance on the Pacific coast. It is an important commercial center and a point of national interest to tourists. It serves as the principal outlet for both foreign and domestic trade for the vast inland territory of over 250,000 square miles, known as the Columbia River Basin, and the Willamette Valley, with both of which it has waterway connections. The city not only provides exceptional markets for every variety of farm produce, but has extensive industries that utilize the products from a large surrounding area. It is the center of the live-stock and beef-packing industry of the entire Pacific Northwest and is a port of the first rank in the shipment of wheat. It has also very large lumber-manufacturing interests.

Multnomah County has excellent transportation facilities. The Great Northern, the Northern Pacific, Union Pacific, and the Southern Pacific Railroads, all transcontinental systems operating to points in all directions, have their terminals in Portland. Their lateral and affiliated lines reach every section of both Oregon and Washington. In addition to this, interurban lines, with numerous stations, reaching in all directions from Portland, supplement the facilities afforded by the steam roads. Both the Willamette and the Columbia Rivers are navigated by ocean vessels as far as Portland, and by river steamers above Portland.

A great amount of work has been given to road construction. Excellent paved highways radiating from Portland, with numerous well-graded feeder roads, reach practically every town and point of interest. This has been an important factor in aiding the marketing of farm products in the county and surrounding country. The Columbia River Highway is built the entire length of the county along the Columbia River and through the city of Portland. In addition to this highway, there are two other paved highways in the county to the east. The Base Line Boulevard parallels the Columbia River Highway upon the south and penetrates the central portion of the county. The Powell Valley Road is paved as far east as Gresham and serves the southern part of the county as well as part of the northern part of Clackamas County. The county to the south and west of Portland is served by the Pacific Highways, located on both sides of the Willamette River.

As the county is semiurban, schools, churches, and other institutions are numerous, and all rural improvements are well advanced.

CLIMATE.

At Portland and in the central part of the county the climate is fairly typical of the Willamette Valley. It is mild in both winter and summer, and the year is divided into a wet and a dry season, which coincide with these seasons. In the mountainous regions of the eastern part of the county greater extremes of temperature occur. The average rainfall around Portland is 44 inches, of which 19 inches fall in the winter, 10 inches in the spring, 3 inches in the summer, and 12 inches in the fall. The rainfall is quite evenly distributed during the winter months. The rainy periods seldom last more than three or four days, and gentle showers interspersed with clear and cloudy weather are the rule. Hail and severe thunderstorms seldom occur. In Portland and the surrounding farming country to the east the average snowfall is 15 inches. Snow remains on the ground for only short periods at a time. In the mountainous regions in the eastern end of the county the rainfall is greater, ranging from 60 to 100 inches annually, and snow covers the ground during the entire winter. In the range of hills west of Portland the snow remains for several days at a time.

The mean annual temperature is 52.9° F. The extreme range in recorded temperature is from 102° F., recorded in July, to -2° F., recorded in January. The average date of the last killing frost in the spring is March 19, and that of the first in the fall is November 20. Killing frost has occurred as late as May 2, and in the fall as early as October 13. The average growing season is 246 days.

The following table, compiled from the records of the Weather Bureau station at Portland, covering a period of 45 years, gives the more essential climatic data in detail:

Normal monthly, seasonal, and annual temperature and precipitation at Portland.

[Elevation, 57 feet.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1895).	Total amount for the wettest year (1882).	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December.....	41.4	65	3	6.88	7.79	20.14	3.5
January.....	39.0	62	-2	6.71	8.53	5.06	6.5
February.....	41.9	68	7	5.56	1.01	10.49	3.6
Winter.....	40.8	68	-2	19.15	17.33	35.69	13.6

Normal monthly, seasonal, and annual temperature, etc.—Continued.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1895).	Total amount for the wettest year (1882).	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
March.....	47.2	79	20	4.83	2.84	2.53	.8
April.....	51.7	90	28	3.01	1.91	4.60	T.
May.....	57.3	99	32	2.40	3.42	1.84	0
Spring.....	52.1	99	20	10.24	8.17	8.97	.8
June.....	61.8	99	39	1.72	.57	1.91	0
July.....	66.9	102	43	.61	.23	.95	0
August.....	66.4	97	43	.63	.37	.07	0
Summer.....	65.0	102	39	2.96	1.17	2.93	0
September.....	61.2	93	35	1.77	1.16	.91	0
October.....	54.2	83	51	3.33	T.	11.63	0
November.....	46.1	73	11	6.54	2.93	7.11	.6
Fall.....	53.8	93	11	11.64	4.09	19.65	.6
Year.....	52.8	102	-2	43.99	30.76	67.24	15.0

AGRICULTURE.

The agricultural development of Multnomah County has been determined almost entirely by the growth and development of the city of Portland. The county is small, and the land taken up by the city of Portland and the national forest in the eastern end of the county necessarily limits the area of land available for agriculture. The early activity of the settlers was confined largely to lumbering and the marketing of wood products drawn from the forests that covered the entire county, including the present site of Portland. With the growth of the city the demand for agricultural products stimulated the clearing of land for farm use.

The census of 1880 showed 5,523 acres in hay, yielding 9,491 tons. The chief cereal crop was oats, with 882 acres, yielding 23,839 bushels. Wheat was second, with 622 acres, yielding 12,098 bushels. Barley, corn, and buckwheat occupied a combined area of 84 acres. Potatoes, with a production of 210,475 bushels, held an important rank as a cash crop in the county. The total market-garden produce was valued at \$43,990, and orchard products at \$26,551. Forest products sold for \$61,585.

During the next decade (1880 to 1890) there was a marked increase in the production and acreage of all crops with the exception

of potatoes. According to the 1890 census there were 1,305 acres in potatoes, yielding 131,918 bushels, or 78,557 bushels less than in 1880. The hay and oat crops showed pronounced increases, hay, with an acreage of 11,943 acres, yielding 24,694 tons, and oats, on 1,289 acres, yielding 44,430 bushels. Market-garden products, including small fruits, with a value of \$89,899, showed an increase of more than double over the previous decade. There was a material falling off in the marketing of forest products.

By 1900 the agriculture of the county was fairly well developed along the lines of meeting the special needs of the market at Portland. Both the dairy and poultry industries showed marked increases. According to the 1900 census the value of all dairy products was \$346,781, poultry \$25,909, and animals sold and slaughtered \$73,535. With the development of the live-stock industry there was a marked increase in the production of hay and forage crops. Potatoes, small fruits, and truck crops became the cash crops of the county. There were 2,558 acres in potatoes, yielding 412,382 bushels; 2,687 acres of oats, yielding 110,230 bushels; 1,490 acres of wheat, yielding 37,490 bushels; and 450 acres in barley, corn, and rye combined. The value of the orchard products, grapes, and small fruit was \$157,769. The value of the small fruits alone was \$109,953. The acreage of small fruits was as follows: Strawberries, 400 acres; blackberries and dewberries, 190 acres; raspberries and loganberries, 118 acres.

Further development along the line of specialized and intensive farming took place during the next 10 years. Dairying, market gardening, the production of small fruits, and poultry raising became the dominant agricultural industries of the county. According to the 1910 census, dairy products, exclusive of home use of milk and cream, were valued at \$732,242. Vegetables were valued at \$413,582; orchard products and nuts, \$222,411; and poultry and eggs produced, \$139,189. With the development of the dairy industry, there was an increase in acreage of hay and forage crops, although not sufficient to meet the needs of the county. Oats was the principal grain crop, with an acreage of 3,119 acres yielding 143,390 bushels. Wheat occupied 355 acres, and small acreages of emmer, barley, and rye were grown. Corn grown principally for silage had a small but increased acreage.

At the present time the agriculture of Multnomah County consists chiefly of dairying, market gardening, the growing of small fruits, and the raising of poultry. This development has taken place in order to meet the demands of the Portland market. Near the city, intensified, specialized farming is highly developed, and exclusive market gardening and the growing of small fruits is practiced on small acreages. On the larger acreages in this vicinity the dairy

industry is highly specialized. Farther away from the city a combination of these branches with general farming is practiced. In the eastern and more remote sections of the county more attention is given to field crops, with potatoes as the cash crop.

The live-stock industry, of which dairying is the most important, produces more wealth than any other branch of agriculture. Dairying is more general along the Columbia River, where the overflow lands in their present state are suitable only for pasture and wild hay. Well-kept herds are also found where general farming is practiced. Animals of Holstein-Friesian or Jersey breed are most numerous. Practically all of the milk and cream is marketed in Portland by truck. According to the 1920 census the value of all dairy products, exclusive of home use, was \$1,686,185.

The raising of poultry and the production of eggs, in addition to being carried on to a limited extent on almost every farm, is a specialized industry in certain sections of the county. Within the last few years this industry has developed very rapidly, and the county now ranks as one of the leading poultry-producing counties of the State. According to the 1920 census poultry and eggs reached a value of \$388,022.

A few hogs are kept on every farm. The surplus above those needed to supply meat and lard for home use is marketed. Flocks of sheep and a few herds of goats are found in the hilly section of the county.

Truck and small-fruit crops rank next to dairying as a source of income in the county. These are grown intensively on small acreages around Portland. The farms range in size from 2 to 10 acres and are farmed both by owners and by tenants, the latter chiefly Japanese and Italians. Very intensive methods are used, and the land is kept continually in cultivation. The soils in this section are fairly well adapted to this kind of farming, but the demand of the market has had a greater determining influence in growing these crops than the factor of soil adaptation. Away from the city where truck and small fruits are grown the sandier and lighter soil types are used. Practically all of the produce grown is sold to the Portland market. A great deal is disposed of directly to the consumer through the public market. Vegetables with an acreage of 5,449, of which 3,630 acres were potatoes, reached a value of \$1,094,411, according to the 1920 census. Fruits and nuts were valued at \$670,840.

Potatoes are grown on practically every farm, and over a large part of the county they are the main cash crop. This crop occupied 3,630 acres in 1919, yielding 345,411 bushels.

Hay and forage crops in 1919 occupied 14,736 acres, yielding 38,731 tons. This production is not sufficient to meet the needs within the county, and considerable hay and feed is shipped in. Clover now oc-

cupies an important part in the agriculture of the county, where dairying and general farming is practiced. It is generally sown in the spring on fall-sown grain and produces both a hay and a seed crop the following year. Vetch, alone or with oats, is grown for hay and to some extent is used in the place of clover.

Corn has shown a greater increase in acreage during the last decade than any other crop. This is due primarily to the development of the dairy industry, the introduction of silos, and the introduction of early-maturing varieties. According to the 1920 census there were 746 acres in corn, producing 18,051 bushels, while 466 acres were cut for forage, producing 1,896 tons.

With the exception of the oat crop, which had an acreage of 3,649 acres in 1919, yielding 144,397 bushels, and wheat, occupying 3,234 acres, and yielding 83,984 bushels, the cereal crops are of minor importance in the county.

The total value of all crops in Multnomah County, according to the 1920 census, was \$2,813,708.

In the sections of the county where intensive farming is practiced, no attempt is made to rotate crops. In recent years, in the trucking sections, the growing of a green-manure crop has become necessary, owing to the lack of available barnyard manure. Many different crops are grown, and the crops are constantly changed, but not from any direct intention of practicing crop rotation. Where extensive and general farming is carried on, crop rotation is more generally practiced. The most common rotation is a three-year or four-year rotation of small grain, clover for one or two years, and a cultivated crop for one or two years. The clover is seeded in the early spring on fall-sown grain and harvested the second summer. Where livestock farming is carried on, a grass mixture is often sown with the clover, and it is allowed to remain an additional year for both hay and pasture. Where it is difficult to get a stand of clover, it is often sown alone in the early summer months, and where it fails entirely vetch, alone or with oats, is substituted.

The county ranks first in the State in the use of commercial fertilizers. The bulk of the fertilizer bought is a complete fertilizer, and is used almost exclusively in growing the truck and small-fruit crops. In the central and eastern part of the county phosphate fertilizers are used to some extent on potatoes and corn with good returns. Land plaster is in general use for dusting seed potatoes previous to planting. It is also quite commonly used at the rate of 40 to 80 pounds per acre as a top-dressing in the spring on clover¹

Day laborers, used chiefly by truck and small fruit growers, receive from \$2.50 to \$4 a day, depending upon the nature of the work. The

¹ See also the recommendation in the last paragraph under "Willamette silt loam. rolling phase"

monthly wage on dairy farms ranges from \$80 to \$125, and on general farms from \$60 to \$80 a month, board included. Owing to the large demand for labor by industrial concerns in and surrounding Portland, good farm help has been difficult to obtain even at high wages.

Sixty-eight per cent of the farms in the county range in size from 2 to 49 acres. The majority of the remainder contain from 50 to 174 acres. In the extreme eastern part of the county, a few of the farms contain more than 500 acres. The 1920 census reports 36.2 per cent of the county in farms and 45.9 per cent of the farm land as improved.

As the county is semiurban in character, land values are higher than in any other county in the State. In the less densely populated sections unimproved and in some cases partly improved land sells for \$100 to \$200 an acre, and improved land for \$200 to \$1,000 an acre. The farms are as a rule well equipped. The barns, silos, and farm machinery are of the latest design. The farm dwellings are of good appearance, modern in most respects, and indicate a general condition of prosperity.

SOILS.

The soils of Multnomah County have all developed under the influence of an abundant moisture supply and a relatively high temperature. The summers are warm and dry and the winters wet and warm. Snow falls every winter but does not form a cover to the soil for periods of more than a few weeks, except in the highlands of the eastern part of the county. In the greater part of the county the soil is rarely frozen. On account of the abundant moisture and relatively high winter temperatures the soils are subjected to active leaching, though not so active as in regions where the rainfall is heavy during the hot season of the year.

The mature soils have the typical profile of the humid soils throughout the world. The surface soils are relatively light in texture compared to the subsoils and usually lighter in color. Beneath the true soil profile the material is more friable and coarser textured than in the more completely decomposed and therefore heavier subsoil. This typical profile is well developed in the members of the Olympic, Cascade, Willamette, and Amity series, faintly developed in the Hillsboro and Powell series, but not well developed in the other soils of the area. Aside from this difference in texture between soil and subsoil the soils of the various series differ from each other in drainage, especially subsoil drainage, and in the topography of the land on which they occur.

The soils of the Olympic, Cascade, Willamette, Salem, Newberg, Toutle, and Columbia series are well drained. Those of the Powell, Amity, Wapato, and Sauvie series are imperfectly drained in

varying degrees. The soils of the Salem, Toutle, and some members of the Columbia series are so light textured in the subsoil as to be droughty. All the well-drained soils are brown in color, with yellowish-brown or faintly reddish brown subsoils, and although they were developed under the influence of a heavy timber cover the characteristics of the so-called Podsol soils, with a gray leached surface horizon and a yellowish-brown subsurface horizon with high organic matter, have never been developed. Such soils are usually developed under heavy timber cover such as that which formerly covered all this region. Their absence in this area and seemingly in the whole Pacific Northwest is a striking fact that has not yet been fully explained. It seems probable that it is, in part at least, due to the prevailing rainless summers of the region, which permit the surface soils, even in the forests, to become dry.

These soils, in their profile characteristics, therefore, are more like those of the open oak and chestnut forests of the middle latitudes of the Eastern States of the United States than those developed under the conifer forests of the Lake States. The latter, as already stated, belong in the Podsol group, while the former have the characteristics of the Brown soils of the world. In this broad classification the soils of Multnomah County belong in one group. Their differentiation into the various series is based therefore on the character and source of the materials from which they have developed and the methods of their accumulation.

The soils, according to their processes of accumulation, fall into two general groups, (1) residual soils, or those derived by the process of weathering in place of the underlying consolidated rocks, and (2) transported soils, or those that are derived from materials that have been moved some distance from the parent material in the process of accumulation.

Each of these major divisions in the classification of the soils of the survey includes a number of soil series represented by one or more soil types. The soil series consist of closely related soils, that is, of soils having a similar origin, mode of formation, color of surface and subsoil materials, profile, drainage, lime content and other essential features.

The soil type, which is determined by the relative proportion of mineral particles of the various sizes, is the unit of classification in mapping. A complete soil series would contain soils of all textures from a coarse sand to clay.

The individual soil types are designated by name, the first part of which, taken from some locality in which the material was first recognized or is typically developed, indicates the series relationship, such as the Olympic series or the Willamette series. The second part of the name indicates the class or textural relationship,

such as sandy loam, loam, clay loam, and in conjunction with the series name indicates the place of the soil in the scheme of classification, as Olympic silt loam or Willamette loam.

Subordinate variations within individual types, which, owing to their small extent or to minor technical or agricultural importance, do not warrant recognition as individual soil types, are designated as phases, and shown by means of ruling or symbols over the color used for the typical soil.

The residual soils are derived from rocks of volcanic origin. These rocks are basic in character, that is, they are relatively low in quartz. They consist largely of dark-colored, fine-grained basalt, some andesite, a rock of lighter color, and some rocks of coarse grain, such as dolerite and diorite. All these rocks have weathered deeply, although exposures are common throughout the hilly sections. The soils derived from this group of rocks have been classified in the Olympic and Cascade series.

Most of the transported soils fall into two subgroups, (1) soils derived from old valley-filling deposits that have been weathered and modified in place to some extent, and (2) soils derived from recent alluvial deposits; but a third group of soils, derived from recent unweathered wind-laid deposits, is represented.

The first subgroup is derived from sedimentary materials or in part from wind-borne or loessial deposits of considerable age. The sedimentary deposits have been carried down from the uplands and laid down in the area now occupied by the lower bench lands in the eastern part of the county and along the Willamette and Columbia Rivers and smaller streams. The deposits, which appear to be of wind-borne or loessial origin, and which are of fine and uniform texture, occupy the higher rolling and deeply dissected benches east of the Sandy River. The lower substrata of some of these deposits were undoubtedly laid down in an earlier geological period in an arm of the sea that covered the entire Willamette Valley. The upper soil layers, however, consist of deposits laid down by the present or earlier streams and of alluvial wash from the adjacent hill areas.

The soils of this subgroup, owing to long-continued weathering of the material, show the effects of leaching and an accumulation of clay in the subsoil, which is generally heavier in texture and more compact in structure than the surface layer. The less elevated of these soils form a rather smooth, uniform to undulating floor of the old valley and lie on terraces well above the present streams; the more elevated occupy remnants of high terraces and plains, now eroded and deeply trenched by the larger streams. Differences in color, drainage, and character of subsoil, give five series of soils in this group, the Willamette, Hillsboro, Powell, Salem, and Amity.

The recent-alluvial soils occur in narrow strips along the streams and upon islands in the streams. The larger areas lie along the Columbia and the Willamette Rivers, although narrow strips occur along nearly every stream in this county. They occupy bottoms and benches a few feet above the normal flow of the stream and are subject to occasional or periodical overflow. The material forming these soils does not show marked weathering, nor is the subsoil as compact as in the old valley-filling soils. The following series have been recognized in this group: Columbia, Newberg, Wapato, Sauvie, and Toutle.

The third subgroup, the soils of which are formed by the agency of wind, is represented by a single type. The material was undoubtedly first transported and deposited by water, but has since been modified by wind to such an extent as to warrant a separate classification. This soil is classified with the Burlington series.

In addition to the series of soils already enumerated, there are three types of miscellaneous materials mapped in the county, Rough mountainous land, Rough broken and stony land, and Riverwash. The Rough mountainous land includes small undifferentiated bodies of agricultural land, but the last two types are entirely non-agricultural.

The virgin soils of the area are well supplied with organic matter. Practically all of the soils are low in lime and are in many places distinctly acid.

The following outline shows the relation of the soils to the rocks of the area:

Relation of soils to the country rocks.

Soil group.	Derivation.	Kind of rock.	Soil series.
Residual soils.....	Igneous rocks.....	Basalt, andesite, dolerite, and diorite.	{Olympic. Cascade.
Transported soils...	Old valley-filling deposits.....	Mixed materials.....	{Willamette. Hillsboro. Powell. Salem. Amity.
			Recent-alluvial deposits.....	{Columbia. Newberg. Wapato. Sauvie.
		{Mixed materials.....		{Wapato. Sauvie.
			{Basaltic material.....	Toutle.
	Wind-laid deposits.....	Mixed materials.....	Burlington.

The Olympic series consists of brown to reddish-brown surface soils with somewhat lighter colored subsoils, which are typically slightly heavier or more compact than the soil and well leached.

Faint mottling with red and brown iron stains and quite pronounced mottling with gray may occur in the subsoil materials. The types are residual in origin and are derived chiefly from the weathering of basalt or of similar basic igneous rocks. In a few places andesite and diabase enter into their formation. These soils are confined to the hilly parts of the county, covering the entire mountainous section and also areas along the canyons and topping the hills in the lower hill section. The soil normally contains small iron-cemented pellets or concretions, locally known as "shot." Drainage is good to excessive. Two types of this series, one with a phase, are mapped in the present survey. They are the Olympic loam, with a stony phase, and the Olympic silt loam.

The Cascade series consists of residual soils of basaltic origin, differing from the Olympic soils chiefly in the lighter color and texture of the deeper subsoil. The soil is brown to light brown, and the upper subsoil brown to yellowish brown and normally somewhat more compact than the surface soil. They are underlain by a yellow deeper subsoil or substratum, somewhat mottled by iron stains. This substratum lies from 3 to 6 feet below the surface, and in many places has a distinctly friable structure and a fine sandy loam texture. It contains considerable micaceous material and iron-cemented pellets. The soils are well drained and occupy hilly to smoothly rolling areas. The rock giving rise to this series is more deeply weathered than that underlying the Olympic series. The Cascade silt loam, with a phase, is mapped in this county.

The Willamette series comprises types with brown surface soils, and heavier brown subsoils, free from mottling or only slightly mottled. The deeper subsoil is usually more friable and lighter in color than the upper subsoil. As mapped in this county, the series also includes rather large areas in which the substratum below the depth of 3 feet is composed of deep deposits of stratified gravel and coarse sand, and which approach in profile the soils of the Salem series. The series occupies stream terraces and benches throughout the Willamette Valley and along the Columbia River, and elevated, smooth, plateau-like areas east of the Sandy River. It is derived from unconsolidated old valley-filling deposits having their source in a variety of igneous and sedimentary rocks. The topography is undulating to smooth, and both surface and internal drainage are well established. The loam and silt loam types, the former with a phase, are mapped.

The Hillsboro series is similar to the Willamette series in color and origin, but differs in the coarser texture and more friable structure of the subsoil. The soils of this series have a brown color and are underlain by a lighter brown and slightly more compact subsurface layer.

The subsoil and substratum are light brown to yellowish brown and more friable and coarser than the surface soil. This series is typically developed along margins of terraces of the old valley-filling soils and generally separates them from the lower lying recent-alluvial soils. The topography is rolling to undulating, and both surface drainage and internal drainage are well developed. One type of this series, the Hillsboro loam, with a light-textured phase, is mapped in this county.

The types included in the Powell series have brown to light-brown surface soils, becoming browner or reddish brown when wet. The subsoil, encountered at depths of 10 to 15 inches, consists of light-brown to yellowish-brown friable material typically highly mottled with gray. In the more elevated areas, however, there is but little mottling. In its typical development the series is believed to be derived through the weathering of unconsolidated, water-laid deposits; and it is thought the mottling is caused by the accumulation of gray friable material in cavities once occupied by plant roots. As occurring in this area, however, the material giving this series of soils is uniformly fine textured, shows no stratification, and may be found on further study to be a weathered loess. Such deposits are difficult, also, to distinguish from deeply weathered basaltic and sedimentary rocks, and it is possible that, as mapped, some residual soil material may be included. The series differs from the soils of the Willamette series in the pronounced mottling and more pronounced yellowish color of the subsoil material. The series is typically developed on the high plateau land lying south and east of Gresham and bordering the Sandy River. The material giving it is of mixed origin. It was deposited by the Columbia River and adjacent streams or by winds apparently at a time when this section of the country was much lower than at present. The topography is rolling to undulating and drainage is well developed. One type of this series, the Powell silt loam, with a phase, is mapped in this survey.

The Salem series resembles the Willamette series in color, structure, and origin, but has been separated on the basis of subsoil difference, both subsoil and substratum being gravelly. The surface soils of this series are brown to dull brown. The subsoil is brown to light brown and rather compact, though permeable. It carries a large quantity of waterworn gravel at a depth of from 30 to 36 inches. As occurring in this survey, this gravelly subsoil is underlain by a substratum of rounded gravel and coarse sand, including in many places large angular and rounded boulders. This substratum is typically stratified, usually of porous structure, sometimes cross-bedded, and in places extends to an undetermined depth. The series is one of the most extensive of the county. It occupies the elevated terraces along the Columbia and Willamette Rivers. The parent material is of mixed origin, and some of the gravel has been trans-

ported for considerable distances. The areas have a smooth to level surface and good drainage. Two types, the Salem gravelly fine sandy loam and the Salem fine sandy loam, are mapped.

The Amity series include types with brown to grayish-brown surface soils, and a compact grayish-brown subsoil, mottled with gray and rusty brown. The lower layer of the subsoil is somewhat more friable than the upper. The soils of this series, which are derived from old valley-filling deposits, differ from those of the Willamette series chiefly in the more pronounced mottling of the subsoil and in more restricted surface and internal drainage. They are distinguished from the Powell series in having less uniformly brown surface soils, and less friable subsoils with pronounced mottling of iron stains. The topography is smooth to level and drainage is always poorly developed. The series is represented in this survey by a dark-colored phase of the silt loam.

The Columbia series includes types with light grayish brown to brown surface soils, underlain by a subsoil of similar or lighter and more grayish color, and of lighter texture than the surface soil. The subsoil is, however, variable, consisting of stratified sediments without regular order of occurrence. In appearance these soils resemble those of the Hillsboro series, and are distinguished from them by their more recent deposition, lower position, and less pronounced brown color. This series, which is of recent-alluvial origin, is confined to the bottom lands along the Columbia and Willamette Rivers. The surface is marked by low mounds and ridges and interrupted by numerous channels carrying backwater. Except during overflow periods, drainage is good to excessive.

The series, as mapped in this survey, includes a number of variations or phases not typically Columbia, but placed with it because their small area and minor agricultural importance did not warrant separation. Four types, the fine sand, the sandy loam, with two phases, the loam, with one phase, and the silt loam, are mapped.

The Newberg series includes types with brown to rather dark brown soils and a subsoil of similar or somewhat lighter color. The deeper subsoil and substratum have a light sandy or fine sandy texture and porous structure. The series is of recent alluvial origin and derived from materials washed from basaltic or related basic rocks and from sedimentary rocks. The soils occupy low-lying positions adjacent to stream channels and are subject to overflow. The surface is smooth, but marked by low mounds and ridges and interrupted by sloughs or abandoned channels. The soils in their native condition were forested. The series is distinguished from the Columbia by the darker color of the soils. Only one type, the silt loam, is developed in the present survey.

The surface soils of the types included in the Wapato series are dull brown, dark grayish brown in places, mottled with gray and with yellow and brown iron stains. The subsoil, which is heavier in texture than the soil, is grayish brown or dull brown, mottled with drab or yellow. The series includes recent-alluvial deposits, occurring along streams, and alluvial-fan deposits formed at the mouths of intermittent streamways and canyons. The greater part of the area of Wapato soils is subject to overflow, and both the surface drainage and underdrainage are poor. The series in this survey is best developed along the Columbia and Willamette Rivers. It is represented by the Wapato silt loam, with a heavy phase. The latter, if of greater extent, would have been classified with a distinct series.

In the Sauvie series are grouped alluvial types with brownish-gray to dark-gray or black surface soils relatively high in organic matter. The subsoil, which is stratified, commonly consists of two layers; the upper one, which extends to 24 inches, is heavier than the surface soil and drab or slate colored, mottled with rusty brown; the lower is similar in texture to the upper, dark brownish gray to gray in basic color, and mottled with gray and brownish yellow. The two horizons are well marked throughout the series, but vary considerably in thickness. The substratum is sandy. Where this sandy layer is within 3 feet of the surface the soil is separated as a phase. This series consists of recent-alluvial sediments derived from a wide range of rocks. It occupies first bottoms subject to overflow. The topography is undulating, with low mounds and ridges and shallow basins. As mapped in this county, the series includes small bodies of the Wapato soils, which occur in basins that are under water during most of the year. Two types, one with a phase, are developed in Multnomah County.

The Toutle series comprises types with light-gray, slate-gray, or brownish-gray surface soils and subsoils. Both soil and subsoil are stratified, the material being derived almost entirely from basaltic rocks and volcanic tuffs. The soil contains a moderate quantity of organic matter. The deeper subsoil is coarse and porous and apparently consists in part of small fragments of pumice or other vesicular volcanic rocks. The soils are developed in regions of heavy rainfall, are well leached of soluble minerals, and are forested. Lower lying areas are subject to overflow, but at other times the drainage is good to excessive. Only one type of this series, the sand, occurs in the present survey.

The types in the Burlington series occur in association with the recent-alluvial soils along the Columbia River. The topography is undulating and distinctly marked by small wind-formed mounds and low ridges, the series being derived from wind-laid deposits. The soils are dark brown and high in organic matter; the subsoil

is like the soil in color and texture. The material is porous and well drained. One type of this series, the fine sand, occurs in the present survey.

The following table gives the names and actual and relative extent of the several soils developed in Multnomah County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Powell silt loam	25,664	16.2	Wapato silt loam	2,624	1.3
Hill phase	8,512		Heavy phase	64	
Rough mountainous land	23,488	11.2	Columbia sandy loam	2,048	1.2
Salem gravelly fine sandy loam	22,656	10.8	Light-textured phase	256	
Olympic silt loam	22,208	10.6	Gravelly phase	256	
Sauvie silty clay loam	21,376	10.6	Amity silt loam, dark-colored phase	2,496	1.2
Sandy-subsoil phase	768		Salem fine sandy loam	2,240	1.1
Willamette silt loam	9,152	4.3	Riverwash	2,112	1.0
Willamette loam	15,744	8.1	Sauvie silt loam	2,048	1.0
Rolling phase	1,216		Columbia silt loam	1,984	.9
Rough broken and stony land	13,056	6.2	Columbia loam	1,280	.8
Cascade silt loam	10,112	5.0	Dark-colored phase	320	
Gray phase	512		Hillsboro loam	7,296	.4
Hillsboro loam	7,296	3.7	Light-textured phase	448	
Light-textured phase	448		Columbia fine sand	4,672	2.2
Columbia fine sand	4,672	2.2	Olympic loam	2,240	1.7
Olympic loam	2,240	Stony phase	1,280		
Stony phase	1,280		Total	209,920	.....

OLYMPIC LOAM.

The surface soil of the Olympic loam consists of 10 to 14 inches of friable brown to reddish-brown loam, of rather light texture, and containing relatively large quantities of fine and very fine sand and iron-cemented pellets. The subsoil is a silty loam, generally of a lighter shade of brown than the surface soil. Pellets like those in the surface material also occur in the subsoil, but in numbers decreasing with depth.

This type is confined to a number of small areas occurring on several of the more prominent buttes in the valley section and to hills in the western section. One of the largest and most typical bodies lies about 2 miles east of Gilbert. The topography of the greater part of the type is steep, though areas occupying the crests of the hills and ridges are gently rolling. Both surface and sub-surface drainage are good to excessive, the areas occupying the slopes and in some cases the crests of the buttes having a shallow and droughty soil.

The Olympic loam is of residual origin, being derived mainly from basalt, but on the slopes and even on the tops of some of the highest peaks old waterworn gravel deposited at some earlier time by the

Columbia River may occur. Some colluvial material lying at the base of the steeper hills is also included.

The type is relatively unimportant; about 30 per cent of it has been cleared and is under cultivation. Wheat, oats, and vetch are the principal crops. The yields obtained are about the same on this type as on the Olympic silt loam.

Improved agricultural land of this type sells at \$60 to \$120 an acre, unimproved land selling at \$15 to \$60 an acre.

Where the soil is of sufficient depth this type is well adapted to the production of prunes, cherries, and walnuts. The suggestions for the improvement of the Olympic silt loam are equally applicable to this soil type.

Olympic loam, stony phase.—The Olympic loam, stony phase, is somewhat variable in its profile, but generally consists of 8 to 20 inches of brown to reddish-brown stony loam, overlying a reddish-brown stony clay loam. The quantity of rock fragments in both the surface and subsoil varies considerably, some areas consisting almost entirely of angular fragments of basalt ranging in size from small stones to boulders 2 to 3 feet in diameter and others containing only a few fragments embedded in the soil and subsoil material or lying over the surface.

The phase is confined to one continuous body, containing about 2 square miles, extending up the Columbia River from a point a little below Multnomah Falls to Warrendale. The surface is generally smooth, but has a pronounced slope toward the river. Drainage is well established over the entire area. This phase of the Olympic loam consists mainly of colluvial material from the adjacent mountain slopes. It has been transported to its present position principally by slides. The vegetation consists principally of brush and a young growth of fir.

The Olympic loam, stony phase, is of very little agricultural importance, only about 3 per cent of it being cultivated. Oats and wheat, the principal crops, give good returns in favorable seasons. The more stony areas are practically valueless, except as grazing and forest land. Improved land of this phase ranges from \$25 to \$75 an acre.

The following table gives the results of mechanical analyses of the soil and subsoil of the typical Olympic loam:

Mechanical analyses of Olympic loam.

Number.	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.	<i>Per cent.</i>
561140.....	Soil.....	1.1	2.9	2.2	11.4	34.5	37.7	10.2
561141.....	Subsoil.....	.5	2.9	2.2	8.6	28.8	46.4	10.4

OLYMPIC SILT LOAM.

The surface soil of the Olympic silt loam consists of a friable brown to reddish-brown silt loam 10 to 12 inches deep. The immediate surface may be dark brown in virgin areas. Over the greater part of the type the soil contains numerous reddish-brown iron concretions or cemented pellets, which, when wet, may be readily crushed between the fingers, but which give to the soil a rather gravelly texture. The subsoil may be either a clay loam or a silty clay loam ranging in color from brown to reddish brown.

The pellets, which are about the size of buckshot, together with a considerable quantity of very fine sand and organic matter, tend to make the soil friable and easy to cultivate and maintain in good tilth. Bedrock, which consists of old basaltic lava flows, is encountered at varying depths below 2 feet. In most areas this rock lies 6 feet or more below the surface, and it outcrops in very few places, except on land too steep for cultivation or along stream banks.

Most of the Olympic silt loam is contained in a large area lying east of Sandy River and extending in a northeasterly direction from the county line on the south to the headwaters of Bridal Veil Creek. A group of several small areas lies south and southwest of Gresham in the south-central part of the county, and small scattered areas occur in the hill section in the western part.

The topography ranges from smooth and plateaulike to rough and hilly, the areas of the latter type being too steep for cultivation. The greater part of the type, however, is smooth enough for cultivation. All the areas are well drained.

The Olympic silt loam is a residual soil derived mainly from basalt, but as mapped in the present survey it may include locally small areas derived from shale and sandstone. Much of the soil is in place, but on the steeper slopes and some of the lower elevations the soil material is colluvial. About 50 per cent of the type is under cultivation; the remainder supports a valuable growth of fir. Ferns, which are very abundant in the native vegetation, are very troublesome in the fields, and constant cultivation is required to eradicate them. The principal crops on this type are wheat, oats, and vetch. Dairying is a well-established industry.

When first cleared this soil contains a large quantity of organic matter and is generally productive, but where it has been cropped to grain for some time and the addition of organic matter has been neglected the yields have declined markedly. Over most of the type wheat now yields from 15 to 25 bushels, with an average of 20 bushels per acre. Oats yield from 25 to 65 bushels, with an average of 35 bushels per acre.

Improved land of this type sells for \$75 to \$150 an acre, depending on improvements and accessibility to market. Unimproved land may be bought for \$25 to \$50 an acre.

The Olympic silt loam is particularly well adapted to the production of fruit, such as cherries, prunes, and walnuts, and where good air drainage can be had and the elevation is not too high these crops can be grown with a large degree of success. The dairy industry can well be extended to this type, and by growing more legumes and turning under an occasional green crop the soil can be greatly improved. With the recent strong demand for lumber a great deal of the forest is being cut from this type and the land left to grow up to brush. This brush land makes excellent pasture for goats, which if pastured in sufficient number will in a few seasons clear it so that some grass mixture may be sown, fitting it for pasture for other stock. The planting of blackberries, dewberries, or loganberries in the lower lying areas between the stumps and around their bases has proved a successful way to utilize such land. The vines covering the stump protect it from drying out and thus greatly hasten its decay, which at the same time provides food for the berry plants.

The following table gives the results of mechanical analyses of the soil and subsoil of the Olympic silt loam:

Mechanical analyses of Olympic silt loam.

Number.	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.	<i>Per cent.</i>
561142.....	Soil.....	0.7	3.5	2.1	8.3	14.4	49.8	21.1
561143.....	Subsoil.....	.4	1.4	1.0	3.1	14.4	48.9	30.6

CASCADE SILT LOAM.

The surface soil of the Cascade silt loam consists of 8 to 14 inches of a brown to light-brown, smooth-textured silt loam, containing sufficient very fine sand to give it a friable structure. The subsoil is a moderately compact brownish-yellow or pale-yellow silty loam or clay loam, in places slightly mottled with gray. The rock from which this material is derived lies commonly 2 to 6 feet below the surface, though in places the weathered material has a depth of 20 feet, this condition existing where the topography is smooth or gently rolling and accumulation has gone on uninterrupted by erosion. The surface soil is very uniform in all its characteristics. Cemented pellets occur in this soil as in the Olympic soils.

The Cascade silt loam is typically developed in all parts of the hill section of the county; the largest area occurring in the hills and mountains west of the Willamette River. Other areas occur

in the vicinity of the Sandy River and near Springdale and Pleasant Home. A few areas lie within the Columbia River bottom northwest of Fairview. These have been derived from masses of rock which the river has been unable to cut from its channels. This is a residual soil derived principally from basic volcanic rocks. As with the other residual hill soils, it includes small areas of colluvial accumulation.

A great deal of this type is so rugged that there is little probability of its immediate use for agriculture. That under cultivation at the present time has for the most part a hilly or gently rolling surface. (Pl. V, Fig. 2.) The drainage of the type is complete.

This type is among the larger ones of the county, but owing to its unfavorable topography only about 20 per cent of it is cleared. That part still in forest supports a valuable growth of fir. The principal crops are red clover, wheat, oats, and vetch and oat hay, the clover being grown both for hay and seed. Wheat yields 10 to 25 bushels, with an average of 18 bushels per acre; oats, 25 to 70 bushels, with an average of 40 bushels per acre; clover hay, from 1 to 3 tons per acre; and clover seed, 2 to 4 bushels per acre. Besides the crops mentioned, corn is grown to some extent for silage. Kale is also grown and fed during the winter. Fruit, berries, potatoes, and vegetables produce well, and are grown both for home use and for market. On a majority of the farms the sale of dairy products constitutes the chief source of income.

A large part of this soil is in need of organic matter, and it is recommended that the practice of burning the residue from crops be discontinued and the straw and other waste material in so far as practicable be returned to the soil. Judicious rotation of crops, the growing and turning under of green manures, and probably the application of ground limestone would also prove beneficial. The growing of tree fruits and berries is giving good returns, and this industry probably could be extended advantageously.

Cascade silt loam, gray phase.—The Cascade silt loam, gray phase, is represented by a few small areas of gray soil, mainly residual in origin, but including some colluvial and alluvial footslope materials, derived from the rocks giving rise to the typical Cascade soils.

This phase differs widely in color and character from the typical Cascade soil, and if more extensive would have been placed in a distinct series of soils.

The surface soil, to a depth of 10 to 14 inches, consists of a gray or brownish-gray, smooth-textured silt loam, containing a relatively high percentage of very fine sand. The subsoil is a yellowish-gray compact silt loam or silty clay loam, mottled with rusty brown or brownish yellow. The soil of some areas also shows faint mottling of brown.

There is less than 1 square mile of this phase in the county. It is associated with the typical Cascade silt loam, and occurs along the banks of small streams or in depressions at the heads of drainage ways. About 20 per cent of it is forested. Most of the cleared area supports a heavy growth of grasses and is used as pasture for dairy cattle.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the typical Cascade silt loam:

Mechanical analyses of Cascade silt loam.

Number.	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.	<i>Per cent.</i>
561109.....	Soil.....	0.9	2.1	1.0	2.6	30.4	53.9	9.0
561110.....	Subsoil.....	.0	1.4	1.0	6.2	36.0	45.1	10.2
561111.....	Lower subsoil...	.0	2.9	2.1	11.7	25.6	49.0	8.7

WILLAMETTE LOAM.

The surface soil of the Willamette loam consists of 10 to 18 inches of a brown to yellowish-brown friable loam, carrying a relatively large proportion of very fine sand, but in most areas sufficient silt and clay to make it retentive of moisture. Some of the material included with this type is of rather light texture, approaching a fine sandy loam. As typically developed, the subsoil is a brown or yellowish-brown loam to light-textured silt loam which usually continues to a depth of 3 feet or more, the heavier textured being darker brown in color than the lighter textured subsoil.

Throughout the county this type is found closely associated with soils of the Salem series, from which it is distinguished by the absence of gravel in the 3-foot section. A deep cut on the Oregon-Washington Railway & Navigation Co.'s line through St. Johns exposes alternate layers of loose gravel and coarse sand at depths ranging from 3 to 6 feet below the surface and extending downward for 50 feet or more. This condition, of course, results in excessive underdrainage and consequent drying out of the soil during any very long period of drought. Owing to a lack of exposures, no attempt was made to separate associated small areas underlain by gravel at shallow depths and to include these with the Salem series, in which they rightfully belong.

The Willamette loam occupies a number of rather poorly defined areas in different parts of the county. The largest and most typical occurs around Gresham, extending north to Troutdale and west to a point a little beyond Wilkes School. Other areas that are quite typical lie in the vicinity of Sycamore, Mount Tabor, and Rocky

Butte, and a large area occupies most of the terrace lands of the peninsula lying between the Willamette and Columbia Rivers. Within the limits of Portland, bordering the Willamette River on the west and extending on the east to a point a short distance north of Powell Valley Road, are areas of this type that contain a rather high percentage of very fine sand, both in the surface soil and subsoil.

The Willamette loam is commonly situated along the rivers and smaller streams at elevations from 15 to 30 feet or more above the high-water mark. It has a level to gently rolling topography, with rather abrupt slopes to drainage ways. The type in the more typical areas has a subsoil sufficiently heavy to make it retentive of moisture, and crops on such areas will withstand comparatively long periods of drought. The drainage is good.

Probably 85 per cent of this type is cleared of its native forests, a rather heavy growth of fir and scrub oak. Of the cleared area probably not more than 40 per cent is under cultivation, the rest lying within the limits of Portland. The principal crops are wheat, oats, red clover, alsike clover, and oats and vetch hay. Over most of this type dairying is the principal industry, the cows being pastured on clover during the summer and carried through the winter on clover hay and corn silage. Many of the farms are almost entirely dependent for income on the sale of dairy products, principally whole milk. Besides the crops mentioned, corn, kale, potatoes, berries, vegetables, and fruits are grown on nearly every farm.

Wheat yields 20 to 40 bushels, with an average of 30 bushels per acre; oats, 35 to 90 bushels, with an average of 50 bushels per acre; clover, $1\frac{1}{2}$ to 3 tons per acre, with an average of 2 tons per acre; and potatoes, 150 to 250 bushels per acre. All kinds of fruits and vegetables yield well when properly cared for, although the type is not so well adapted to their culture as are some of the others in the valley.

Land values range from \$100 to \$350 an acre, depending on location and improvements. From \$6 to \$10 an acre cash rent is paid for land of this type.

The Willamette loam is well adapted to the culture of clovers and would be greatly benefited if used more for this purpose. The addition of organic matter to this soil would be of material benefit, increasing its water-holding capacity as well as increasing the supply of organic matter. Berries and potatoes could also be more extensively grown on this type. The areas with a light subsoil are early and could be used to advantage in growing vegetables and other early-maturing crops. Fall-sown grains do much better on these areas than spring-sown grains.

Willamette loam, rolling phase.—The surface soil of the Willamette loam, rolling phase, consists of a friable brown to light-brown loam with an average depth of 10 inches, carrying a relatively large proportion of smooth fine sand. The soil is easily cultivated, but runs together and bakes slightly owing to a deficiency of organic matter. The subsoil is a moderately compact yellowish-brown to dull-yellow loam of smooth, uniform texture. Road cuts along the Sandy River through this phase expose a substratum of partly consolidated deposits of coarse sand extending to a depth of 40 feet or more, overlying layers of gravel.

This phase occurs in two small areas on the Sandy River, one just south of Troutdale, and the other at Springdale, and in smaller areas in the vicinity of Rooster Rock and Chamberlain Hill. The topography ranges from smooth and plateaulike to roughly undulating and steeply sloping. Surface drainage is good over most of the phase. Subsurface drainage is good to excessive.

This phase is derived from old alluvial-terrace deposits, lying at the present time 100 to 300 feet above the flood plain of the Sandy River. The material composing the soil more nearly resembles that being deposited by the Columbia River than that brought down by the Sandy River at the present time. Among the coarser materials are quartzite pebbles and cobblestones that could have come only from the northern headwaters of the Columbia River.

On account of its small extent the phase is unimportant. About 25 per cent is in forest, consisting principally of fir. The rougher areas are almost entirely forested, and should remain so in order to prevent erosion. The principal crops are red and alsike clover, oats and vetch, and wheat. Dairying is the most important industry, most of the crops, with the exception of wheat, being fed to the dairy animals. Fruit, berries, and vegetables yield well and are grown for home use on nearly every farm. In general the yields of the crops on this soil are somewhat less than those obtained on the typical Willamette loam. The improved land is held at \$200 to \$300 an acre.

The growing of fruit on this phase should prove successful, the fruit produced in the home orchards being of excellent quality. Berries and potatoes also do particularly well on this soil and could be grown more extensively. Yields over much of the phase could be greatly increased by adding organic matter to the soil.

The results of mechanical analyses of a light variation of the typical soil and of the rolling phase of the type are given in the following table:

Mechanical analyses of Willamette loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
Typical soil:		<i>Per cent.</i>	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
561178.....	Soil.....	1.2	2.4	1.8	10.8	37.5	35.6	10.8
561179.....	Subsoil.....	.7	1.9	1.9	10.8	39.8	35.3	9.8
Rolling phase:								
561128.....	Soil.....	.4	1.8	.8	6.3	35.0	44.7	11.0
561129.....	Subsoil.....	.3	1.4	.7	5.7	37.3	43.8	11.0

WILLAMETTE SILT LOAM.

The Willamette silt loam consists of 12 to 24 inches of light-brown to brown or reddish-brown silt loam, resting on a moderately compact brown silt loam or light clay loam, which ordinarily continues to a depth of 3 feet or more without material change, though faint grayish mottling may appear in the lower part.

The principal area of this soil occurs within the Portland city boundary. In this area both the soil and subsoil are comparatively high in very fine sand. Small but more typical areas occur in the vicinity of Gresham and Hurlburt School and east of Mount Tabor. Just south of Carson Heights on Tryon Creek there is a small area of this type that has been deeply eroded by numerous small drainage ways issuing from the slopes of Palatine Hill.

The Willamette silt loam borders the larger drainage ways, where it occupies terracelike benches 15 feet or more above the highest overflows. The drainage of this type is good, the surface being smooth and gently sloping to gently rolling, with occasional short steep slopes leading down to drainage ways. The moderately compact structure of the subsoil enables crops to withstand comparatively long periods of drought.

With the exception of the eroded area on Tryon Creek, which supports a scattering growth of fir, this type is practically all cleared. The type as a whole is of little agricultural value, as 80 per cent of it lies within the city limits of Portland. Where cultivated it returns good crops of wheat, oats, red clover, alsike clover, and oats and vetch hay. Most of the hay is fed on the farm to dairy cattle, the products of which find a ready market in the city of Portland. Corn, potatoes, berries, vegetables, and fruits are grown to some extent on this type. Yields of from 20 to 40 bushels of wheat, with an average of 25 bushels per acre, are obtained; oats, 25 to 100 bushels, with an average of 45 bushels per acre; and clover, 1½ to 3 tons, with an average of 2 tons per acre.

The value of the agricultural areas of this type ranges from \$150 to \$500 an acre, depending on location and state of improvement.

This type is naturally productive and is well adapted to general farming. However, where it has been under cultivation for some time a falling off in crop yields has been noticed. This, it is believed, is due largely to a lack of organic matter and to shallow plowing. The application of barnyard manure and the plowing under of such green-manure crops as vetch, oats, or rye would probably produce marked beneficial results. Deeper plowing to turn up new earth and break up the hard compact layer that has formed as the result of shallow plowing is also recommended.

HILLSBORO LOAM.

The soil material of the Hillsboro loam, to a depth of 10 to 24 inches, is brown to light-brown loam, very mellow, friable, and easily worked. The proportion of very fine sand in the surface soil is relatively high and increases with the depth. The subsoil is a yellowish-brown to brown very fine sandy loam to light-textured loam.

The Hillsboro loam is typically developed in Multnomah County. A large and almost continuous area extends along the banks of the Columbia River from near Troutdale westward to the point of the peninsula on which part of the town of St. Johns is built. Other areas are found in the vicinity of Corbett Heights and Chamberlain Hill. This type is derived from an old alluvial deposit, which has been shifted and moved about to some extent by winds sweeping down the valley of the Columbia River. The type is confined largely to the banks of the Columbia River and covers a belt extending from the breaks of the higher lying plateaulike terrace to a line just above high-water mark.

The topography of the larger area of the Hillsboro loam is characterized by rather well rounded knolls and ridges running roughly parallel to the course of the river. The slope from the higher lying ground to the river is in most places quite abrupt. Nevertheless, the course of the drainage ways being parallel to the river, rapid run-off and erosion are prevented. The surface drainage and underdrainage of the greater part of the type are excellent. Underground flow of water from the higher lying plateau tends to maintain sufficient moisture in the soil for the needs of the crops during the driest seasons.

In point of use this is one of the more important types of the county. Probably 90 per cent of it is under cultivation. The uncleared area supports a heavy growth of fir. Most of this land lies at the head of the peninsula west of St. Johns, where moisture conditions are not as favorable for crop production as elsewhere over the type. The leading crops are red clover, alsike clover, wheat, oats and vetch hay, and vegetables. As elsewhere in the county,

dairying forms one of the chief industries, the clovers being used for hay or pasture in a rotation with wheat, corn, or oats. Nearly all kinds of vegetables do well. This type is used in connection with the lower lying, river-bottom soils for quick-maturing crops. Nearly any plant adapted to the climate of this section can be grown successfully on this type, berries, fruit, corn, and potatoes being produced both for commercial and home use.

Yields of both grain and hay crops are slightly higher than on other soils in the county, wheat producing from 25 to 45 bushels, with an average of 35 bushels; clover hay, $1\frac{1}{2}$ to $3\frac{1}{2}$ tons, with an average $2\frac{1}{2}$ tons; corn 30 to 70 bushels, with an average of 45 bushels; and potatoes from 200 to 360 bushels, with an average of 250 bushels per acre. Squash yields from 10 to 12 tons per acre, and cabbage from 8 to 12 tons per acre.

The Hillsboro loam is easily cultivated, and over most of its area is maintained in a high state of productiveness, either through the application of commercial fertilizer or barnyard manure. On the areas devoted to truck gardening commercial fertilizer is used to a small extent.

The price of land of this type ranges from \$200 to \$500 an acre, depending on its location and improvements.

The addition of organic matter to this soil is advisable. This will aid in the retention of moisture, will put the soil in better physical condition, and assist in making the fertilizer applied more readily available. It also provides favorable conditions for the different forms of bacterial life, which are important in maintaining soil fertility. Barnyard manure may be obtained at different places in the city of Portland and is, of course, the best form of organic matter to use; but where this can not be procured the turning under of some green-manure crop, such as vetch, oats, or rye, is recommended. Some of the small fruits, such as strawberries, raspberries, and blackberries, including the Logan blackberry, for which there is a ready market in Portland, could probably be grown more extensively on this type with profit.

Hillsboro loam, light-textured phase.—The material of the Hillsboro loam, light-textured phase, to a depth of 20 to 24 inches, consists of a light-brown fine sandy loam, a darker color being developed in the upper part carrying more than the usual quantity of organic matter. The subsoil material below this depth is brown to yellowish-brown fine sandy loam, the latter color being developed in the subsoil of the majority of the areas. Over a small part of the phase the content of silt and clay is low and the texture is a fine sand to a depth of 36 inches or more.

The phase is confined to two small areas, one near Park Rose, and the other about 1 mile north of Fairview. The areas represent old

valley-filling deposits, and extend from the level of the present overflow land to an elevation of 70 feet or more above. The material of these deposits, as is the case with the typical Hillsboro loam, has been shifted to some extent by the wind, and is now found in low, well-rounded knolls and ridges, with a general slope toward the river. The drainage of the soil is good to excessive. The area near Park Rose is subirrigated to some extent, but that north of Fairview is likely to be droughty toward the close of a long dry season.

This phase occupies an area of less than 1 square mile. Probably 90 per cent of it is under cultivation, and of this area at least half is used for the production of early vegetables. The uncleared area supports a scattering growth of fir and oak and is used for pasture. Vegetables, wheat, oats, vetch, and clover are practically the only crops grown. Dairying, which is practiced to some extent, utilizes the oat, vetch, and clover hay which is produced. All kinds of early vegetables are grown on this soil and yield abundantly when properly cared for. Commercial fertilizers are used to some extent on the areas devoted to truck gardening.

The Hillsboro loam, light-textured phase, as a whole would be greatly benefited by the liberal application of organic matter, either in the form of barnyard manure or green-manure crops. That being used for vegetable gardening on which a great deal of commercial fertilizer is used should be plentifully supplied with organic matter, which in this case can probably best be supplied by applying barnyard manure.

The following table gives the results of mechanical analyses of the soil and subsoil of the typical Hillsboro loam:

Mechanical analyses of Hillsboro loam.

Number.	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.	<i>Per cent.</i>
561130.....	Soil.....	1.4	2.5	1.0	7.5	29.0	45.9	12.7
561131.....	Subsoil.....	.5	1.3	1.0	11.3	33.7	46.7	5.6

POWELL SILT LOAM.

The surface soil of the Powell silt loam consists of 10 to 15 inches of a brown to light-brown smooth-textured silt loam, carrying sufficient micaceous material and very fine sand to give it a friable structure. Under moist field conditions the soil has a rich-brown or reddish-brown color. The subsoil consists of a friable light-brown or yellowish-brown silt loam or very fine sandy loam, mottled with gray. The mottling appears at an average depth of 10 to 12 inches and is uniform to a depth of 3 feet or more. Small included areas

lying near the heads of drainage ways or in shallow depressions are grayish brown in color and closely resemble the soils of the Amity series. Owing to their small extent no attempt was made to map them. Along some of the steeper stream banks the mottling in the subsoil does not appear above the depth of 20 inches, and is in general less pronounced than on the more level areas.

This type is the most extensive of the soils of Multnomah County, covering 12 per cent of its area. It is typically developed in the high-plateau region lying to the south and east of Gresham and bordering the Sandy River on the west. Other areas of considerable size lie west of the Willamette River in the low rolling hill area adjacent to Multnomah, as well as capping some of the low mountains to the north of this place.

In the vicinity of Gresham and to the east the topography resembles that of an old terrace in which the streams are deeply intrenched. The general slope of this area is toward the west, with only a very gradual slope to the stream banks, which are usually quite abrupt. To the west of the Willamette River, however, the topography is more broken, and in some cases the slope is sufficient to interfere with cultivation. Drainage of this type is excellent, only a few small areas lying near the heads of streams being in the need of artificial drainage.

The Powell silt loam is derived, through weathering, from old unconsolidated deposits of mixed origin. While these are in part water laid, they include fine-textured materials that appear to be loess. In mode of occurrence and in physical characteristics it resembles the residual soils of the Cascade series, and in some cases has been separated from them only with considerable difficulty. In many elevated areas of its occurrence it exists as a capping from 3 to 30 or more feet deep on basalt. On the steeper slopes, where it has been eroded away, there is a gradual merging of this soil into the residual soils of the Cascade series, and some areas of this residual soil may be included.

The type was originally heavily forested with a valuable growth of fir, which has been cleared from about 60 per cent of its area. Dairying forms one of the chief industries on the farms of this type, the majority of the crops grown being utilized in feeding the cows and young stock. In late years, however, Japanese vegetable gardeners have come to recognize this soil as well adapted to their needs, and in areas favorably situated as regards freedom from frost there are now large plantings of cabbage, cucumbers, and potatoes, as well as vegetables of earlier maturity. Raspberries and strawberries are occupying a larger acreage each year, indicating a general trend toward specialized and intensive farming methods, to which the type

is well adapted. Among the principal grain and hay crops are red clover, wheat, oats and vetch, and corn. The clover is either pastured or else cut for hay and fed with silage to the dairy cattle during the winter. The oats and vetch are usually fed in the spring as succulent feed or cut and fed as hay.

Wheat yields 15 to 30 bushels, with an average of 20 bushels per acre; oats, 30 to 70 bushels, with an average of 40 bushels per acre. Red clover seed yields from 2 to 6 bushels per acre, and the clover hay, 1 to 3 tons per acre. Potatoes yield 100 to 300 bushels, cabbage yields 5 to 8 tons, and cucumbers from 4 to 5 tons per acre.

A fair average yield for strawberries is 250 crates, Logan blackberries 3 tons, and raspberries $1\frac{1}{2}$ to 2 tons per acre.

The Powell silt loam is easily cultivated and most of the type is maintained in good physical condition. A three-year rotation of wheat, clover, and oats and vetch is usually followed. The wheat is sown in the fall, and the following spring, about the 1st of March, clover is sown in the wheat. The second year the clover generally is cut for hay and then pastured or else left to mature a crop of seed. The ground is then plowed and the following year a crop of oats and vetch, or oats alone, is obtained. A four-year rotation, including a cultivated crop, such as corn, potatoes, or cabbage, is sometimes used, and is very good. The three-year rotation has the advantage, however, of getting the clover on the land oftener, with the consequent addition of more organic matter from this crop. Some system of fertilization is in general use among the berry growers, and the growing of vetch as a winter cover crop to be turned under in the spring is becoming a common practice. Various fertilizers are used, but in general mixtures containing nitrogen, potassium, and phosphoric acid are applied. Where the elements are used separately, nitrogen is usually applied as sodium nitrate. The quantity used varies from 100 to 250 pounds per acre. Potash applications vary from 50 to 100 pounds per acre, and superphosphate is applied at the rate of 350 to 500 pounds per acre. Superphosphate is generally applied in the fall, and the more soluble compounds of sodium nitrate and of potassium are generally applied in the spring at the time of plowing under a green-manure crop.

Improved land of this type sells for \$250 to \$700 an acre, depending on location and improvements. Unimproved land may be obtained at \$75 to \$125 an acre.

Where this soil has been cropped to grain for a long time, the organic content is generally low, and the turning under of a green-manure crop, such as vetch or oats, would be very beneficial. A great deal of the type is acid and would respond favorably to an application of 2 to 4 tons of ground limestone per acre. The limestone should preferably be applied to the clover crop, thus making it nec-

essary to apply it in the fall before planting the wheat in which the clover is to be sown. The same utilization of the logged off land is suggested for this type as for the Olympic silt loam.

Powell silt loam, hill phase.—The surface soil of the Powell silt loam, hill phase, is a brown to light-brown smooth-textured silt loam, 10 inches deep, containing considerable micaceous material and a relatively large proportion of very fine sand. The subsoil is a friable or slightly compact yellowish-brown or brownish-yellow silt loam or loam.

This phase is comparatively extensive, covering in all about 3 square miles. It is most extensively and typically developed in the vicinity of Ross Mountain. Other smaller areas are found on the west side of the Willamette River near Palatine Hill and also bordering the Columbia River Valley in the northwestern part of the survey. The topography is rolling or hilly to steep and broken, some of the areas being too rough for cultivation. Plate VI, Figure 1, shows the character of the surface of the smoother areas better suited to farming. In places the streams have cut deeply into the soil, leaving steep banks, in which are often exposed basaltic boulders coming from the underlying bedrock, over which the material of the phase has been deposited to undetermined depths. Drainage, both surface and subsurface, is good to excessive.

The phase owes its origin to the weathering of old, unconsolidated deposits, apparently laid down in quiet water or deposited by winds at a much earlier stage in the development of the Columbia River Valley. In the eastern part of the survey deposits of this kind are now found occasionally at elevations of 1,100 to 1,400 feet or more above the present channel of the river. As the phase merges into the residual soils in the eastern part of the area, the mantle of old fine-textured materials becomes thinner and outcrops of basaltic bedrock and areas of residual soils are numerous, especially in the canyons. Undoubtedly some residual material is included with this type.

About 80 per cent of the phase is still covered with a dense virgin forest of fir. The cleared areas are devoted principally to dairying, the chief crops consisting of clover, wheat, and oats. More specialized crops, such as berries, potatoes, and vegetables, are grown in small areas in locations near markets. The yields obtained compare favorably with those on the typical Powell silt loam, and with better methods of farming the phase should prove valuable in the production of all crops suited to the climate of this region. The higher lying areas, however, are probably better adapted to the general farm crops than to fruit culture, owing to the frequent occurrence of unseasonable frosts.

Improved land of this phase of the Powell silt loam sells for \$150 to \$400 an acre, depending on location and improvements. Unimproved land is held at \$50 to \$125 an acre.

Deeper plowing and the turning under of green-manure crops would improve the productiveness of this soil, as well as make cultivation more easy. This soil responds to phosphate fertilizers, usually applied to the cash crops, and the use of land plaster on clover is profitable.

The following table gives the results of mechanical analyses of a sample of the soil and subsoil of the typical Powell silt loam.

Mechanical analyses of Powell silt loam.

Number.	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.	<i>Per cent.</i>
561136.....	Soil.....	0.0	0.5	0.8	4.1	33.0	49.3	12.3
561137.....	Subsoil.....	.7	2.5	1.1	5.6	35.9	42.7	11.4

SALEM GRAVELLY FINE SANDY LOAM.

The surface soil and subsoil material of the Salem gravelly fine sandy loam is a brown or light-brown, loose gravelly fine sandy loam, containing a relatively large proportion of coarse and medium sand, the quantity increasing somewhat with increasing depth. Some of the included material is of rather heavy texture, and some soil of true loam texture may be included. In profile the material is not marked by any decided change in color, though the shade of brown becomes somewhat lighter with depth. When wet the surface material develops a reddish tinge. The gravel particles in this type range in size from that of a pea to 4 or 5 inches in diameter, the majority being about half the size of a hen's egg. A bed of loose gravel somewhat stratified and cross-bedded forms the substratum.

This type forms an almost unbroken body extending from the county line, within the city limits of Portland on the south, to the breaks of the terrace in its descent to the Columbia River on the north. On the south it follows roughly the north bank of Johnson Creek, and on the north the break of the terrace to a line about a mile west of Gresham. A few isolated areas lie near the larger one. The surface of the type is smooth, shows few minor irregularities, and has a gentle slope to the drainage ways. Excessive subdrainage is a general characteristic of the type.

The Salem gravelly fine sandy loam is an old alluvial soil, deposited at a time when the Columbia River flowed at a high level. At the present time the terrace upon which the soil occurs stands 200 to 300 feet or more above the present overflowed bottoms along the

river. This type constitutes a large proportion of the terrace soils of the county.

About 80 per cent of the Salem gravelly fine sandy loam is cleared and under cultivation, and some of it has never supported a forest growth within historic times. The present timber growth consists principally of a young growth of fir. Dairying and stock raising is carried on to a considerable extent on this type, oats, vetch, and clover being grown in a rotation with wheat, and pastured or harvested and fed on the farm. Berries, potatoes, tree fruits, and truck crops are grown to some extent. Areas within the city limits of Portland not used as building sites are devoted mainly to the growing of potatoes and early vegetables. Yields on this type are somewhat low, crops suffering from lack of moisture during seasons of drought. Improved land of this type sells for from \$100 to \$300 an acre.

This is an excellent soil for poultry, and it would seem that more poultry could be kept advantageously in connection with the other types of farming now followed. The growing of berries and small fruits would also seem to offer opportunity for extension. The type in general would be greatly benefited by plowing under green-manure crops.

SALEM FINE SANDY LOAM.

The surface soil of the Salem fine sandy loam consists of 12 inches of a friable brown fine sandy loam commonly of rather heavy texture. From 12 to an average depth of 30 inches the subsoil is a brown silty fine sandy loam or loam. Below 30 inches waterworn gravel, the particles varying in size from one-half inch to several inches in diameter, is encountered. The gravel may be found either as a loose gravel layer or as scattering gravel or rock fragments with considerable finer interstitial material, which passes into the loose gravel layer at varying depths below 3 feet. In a few places large basaltic boulders occur in this type, and occasionally outcrop.

The Salem fine sandy loam, which is of small extent, occurs in a number of widely separated areas. Two of the more important lie, respectively, a short distance southwest of Wilkes School, and southwest of Troutdale. Both these areas are typical and are largely under cultivation. Small areas occur in the vicinity of Rocky Butte, and others 1 mile east of Gilbert, at Fairview, and near Gresham.

This type is derived from old valley-filling deposits, lying from 25 to 100 feet or more above the present overflow lands. The surface of the greater part of the type is smooth, but has sufficient slope to insure excellent drainage. In this county the type represents a transition type between the gravel-free soils of the Willamette series and the Salem gravelly fine sandy loam.

About 90 per cent of this type has been cleared of forest; the rest supports a growth principally of fir and oak. Wheat, oats, vetch, and clover produce good crops under favorable moisture conditions. In dry seasons yields are somewhat less than on types with heavier subsoils. Fall-sown grain yields much better than that sown in the spring. All kinds of berries and small fruits that mature in the spring or early summer do well on the Salem fine sandy loam. Dairying is the chief source of income on farms located on this type. The value of improved land of the type ranges from \$100 to \$300 an acre.

The following table gives the results of mechanical analyses of the soil and subsoil of the Salem fine sandy loam:

Mechanical analyses of Salem fine sandy loam.

Number.	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.	<i>Per cent.</i>
561144.....	Soil.....	0.9	2.5	3.7	10.7	38.8	33.0	10.3
561145.....	Subsoil.....	.7	1.8	1.9	13.8	37.0	35.4	9.4

AMITY SILT LOAM, DARK-COLORED PHASE.

The surface soil of the Amity silt loam, dark-colored phase, consists of 12 inches of grayish-brown or dark-brown silt loam, in some lower lying areas mottled with brownish yellow. The subsoil consists of two layers, an upper layer, extending from 12 to 20 inches, of a grayish-brown silty clay loam, mottled with gray and rusty brown, and a lower layer, from 20 to 36 inches, of gray or yellowish-brown silty clay loam, mottled with rusty brown and brownish yellow. The mottling, which has resulted largely from poor drainage and lack of aeration, is much more pronounced in the lower lying areas.

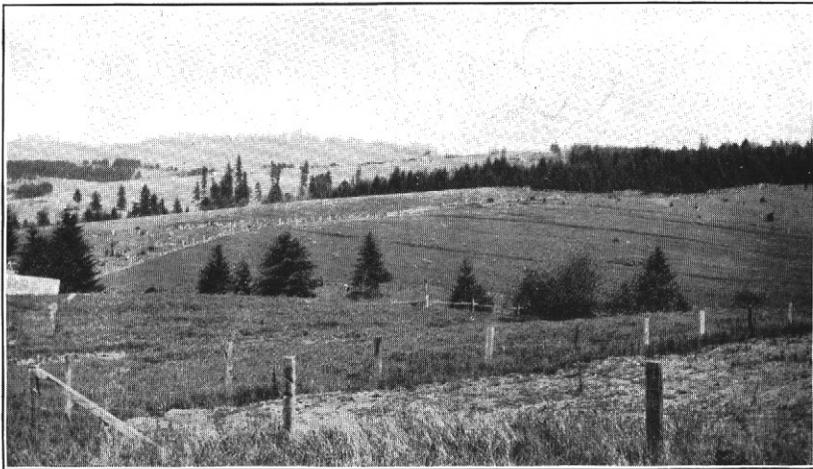
A number of small areas of this phase occur in the county. The largest and most typical lies about one-half mile north of Gresham, another on Beaver Creek a short distance above its confluence with the Sandy River, while others are developed west, east, and south-east of Gresham, and in the vicinity of Springdale and Multnomah.

This phase is derived from old valley-filling materials and lies well above the present courses of the streams, where it is commonly associated with soils of the Powell or the Willamette series. It owes its origin to the same processes of formation as the types with which it occurs, but owing to poorer drainage it has taken on its characteristic mottling. During the wet season water often stands over the surface for days at a time.



S. 10928

FIG. 1.—OVERFLOW LANDS OF THE COLUMBIA RIVER BOTTOMS.



S. 10517.

FIG. 2.—TOPOGRAPHY AND AGRICULTURAL DEVELOPMENT OF THE CASCADE SILT LOAM.

About 80 per cent of the type is under cultivation, the principal crops grown being oats, vetch, wheat, and red clover. The yields of these are slightly lower than on the surrounding better drained soils. The uncleared areas support a forest of oak and fir. Improved land is valued at \$150 to \$250 an acre.

The principal needs of this soil are drainage and the incorporation of organic matter. Where these are supplied the phase compares favorably in yields with the Willamette loam and its rolling phase. The deepening of the present drainage channels would be of material benefit over most of the phase, but tile drainage would be much more satisfactory, and in the end probably more economical.

COLUMBIA FINE SAND.

The Columbia fine sand consists of a brownish-gray to grayish-brown fine sand or very fine sand, carrying occasional pebbles or cobblestones and showing no development of a distinctive subsoil to a depth of 36 inches. The type is for the most part very uniform in texture and structure, though an occasional area is found in which the texture of the surface or subsoil may be slightly heavier than typical. The type in the present survey is slightly grayer than typical.

This type is confined almost entirely to the immediate banks of the Columbia River, and lies slightly higher than the other soils of the river bottoms. The surface slopes gently away from the river. The areas occurring on Ross and Swan Islands in the Willamette River are the only ones not found in the flood plain of the Columbia. The more important areas of the type occur north of Park Rose and on Government Island; other areas of considerable size lie at the mouth of the Sandy River. The topography is slightly irregular, owing to narrow depressions formed during floods. The drainage is good to excessive.

About 20 per cent of the type is under cultivation, the rest being in pasture or covered with a dense growth of willow, alder, ash, and brush. The crops include wheat, oats, corn, alfalfa, clover, and potatoes. This type, like most other cultivated soils in the river bottom, is used largely for the production of winter feed for stock that is pastured on the more poorly drained soils during the summer.

Wheat yields from 15 to 25 bushels, with an average of 20 bushels per acre; and oats, 35 to 60 bushels, with an average of 40 bushels per acre. Alfalfa and clover give about the same yields, 1 to 2 tons per acre. The yield of potatoes ranges from 75 to 150 bushels per acre. The corn is used principally for silage, the ordinary yield being 8 to 10 tons per acre.

This type is sold only in connection with other soils. The price ranges from \$50 to \$150 an acre, depending on improvements and accessibility to market.

Where this soil has been cropped for some time it is beginning to show a deficiency of organic matter, a condition which should be carefully avoided, as a plentiful supply of this constituent aids greatly in the retention of moisture. During the greater part of the year this type is completely shut off from the mainland except by boat, so that the roads have been neglected somewhat and are almost impassable even during periods of low water.

COLUMBIA SANDY LOAM.

The surface soil of the Columbia sandy loam consists of a dull-brown to light-brown light-textured sandy loam, with an average depth of 12 inches, containing a relatively large quantity of fine, coarse, and medium sand. The subsoil consists of a grayish-brown coarse sand. The sand particles are angular, indicating that the material has not been transported very far before being deposited. Very little of the finer grades of material appear in the subsoil. Differences in color in the surface soil of this type are due entirely to variations in the content of organic matter. The type as a whole is well supplied with this constituent. Owing to the assorting power of running water, the texture of the type is somewhat variable, small areas being found consisting almost entirely of fine and medium sand and some in which the soil is of coarse sandy texture.

The Columbia sandy loam is confined entirely to the Columbia River bottoms, some of the more important areas occurring on Sauvie Island and near the mouth of the Sandy River. The type commonly occupies a position slightly higher than that of the soils with which it is associated. The surface is sloping and for the most part slightly undulating. The depressions are long and narrow and roughly parallel the course of the river. The type is seldom overflowed and the drainage is good.

About 50 per cent of this type is forested with a dense growth of willow, alder, ash, and underbrush. Only a very small proportion of the cleared area is utilized as pasture, the rest being cropped regularly. The type is one of the most important in the Columbia River bottoms, being utilized both for truck farming and dairying. Among the general farm crops are clover, alfalfa, wheat, corn, and oats. In the areas devoted to trucking all kinds of vegetables as well as strawberries are grown. This type is used quite extensively in connection with the dairy industry for the production of winter feed, the clover and alfalfa being cut for hay and the corn being

utilized in part as a silage and in part as a grain crop. The cream, which is the principal product marketed from the dairy farms, is hauled to boat landings, where it is picked up by river steamers making daily trips between Portland and St. Helens, a small town located north of Portland.

The yields of some of the principal crops are as follows: Wheat, 20 to 40 bushels, with an average of 25 bushels per acre; corn, 45 bushels of grain or 8 to 10 tons of silage; alfalfa hay, from 1 to 2½ tons; and clover hay, from 1 to 2 tons per acre.

Under irrigation vegetables yield abundantly. Cabbage yields from 10 to 14 tons, squash from 10 to 12 tons, spinach from 5 to 8 tons, potatoes from 250 to 350 bushels, and cauliflower from 300 to 400 crates of one dozen heads each per acre.

In connection with the production of vegetables, part of the area lying directly north of Troutdale has been equipped with a system of irrigation. The water required is pumped from the Sandy River by means of a gasoline pumping outfit, and is stored in tanks from which it is distributed by means of a system of overhead pipes. A rotation which is practiced to quite an extent on this type consists of spinach and cabbage. The spinach is seeded in the spring as soon as the danger of frost is past and is harvested about the middle of June. The land is then put in shape for cabbage, which occupies the land the rest of the year. Another practice followed to some extent is the planting of spinach between rows of sweet corn. The corn is planted 3 feet apart, which allows room for three rows of spinach. The spinach is harvested several weeks before the corn is ready for market. Another rotation consists of early potatoes followed by either cauliflower or late cabbage. The growing of strawberries has also proved very successful. This crop, however, has the disadvantage of occupying the land the whole year.

Commercial fertilizers are used only to a small extent. A locally manufactured brand of complete fertilizer is the principal one used at the present time. The application of nitrate of soda alone is reported to give equally good results. Where cropped intensively, these soils are soon exhausted and require fertilization, which up to the present time has been supplied by the liberal application of barnyard manure. There is probably no better way to maintain the productiveness of this type.

Land under irrigation is held at \$400 an acre; other improved land can be bought for \$100 to \$300 an acre, depending on location and improvements.

This type of soil is very productive and yields a good quality of vegetables. It would seem that more of the land could be put under irrigation. The growing of asparagus should prove very profitable,

as the soil is especially well adapted to this crop. The acreage in strawberries could be extended with profit. It is very essential that the supply of organic matter be maintained, and where stable manure can not be secured the turning under of green-manure crops should be practiced.

Columbia sandy loam, light-textured phase.—The surface soil of the Columbia sandy loam, light-textured phase, consists of a brown sand to an average depth of 15 inches. The color varies from a light grayish brown to a darker brown, depending on the proportion of organic matter present. The subsoil consists of a gray to grayish-brown coarse sand, and represents in part the gray material of the Toutle series over which the Columbia material has been superimposed. This type is of recent-alluvial origin, but since its deposition the soil material has been shifted about to some extent by winds so that the surface is somewhat hummocky.

Only two small areas of this phase of the Columbia sandy loam occur in the survey, one on each side of the Sandy River, a short distance above its mouth. The slope of the surface is away from the river. The type is rarely overflowed, and the drainage is excessive.

About 20 per cent of the phase supports a small growth of willow, alder, and ash; the rest, with the exception of about 5 per cent, which is cultivated, has a fair growth of native grasses that furnish excellent pasturage in the spring. The principal crops are peas and beans, which yield only a small return. The chief value of the phase lies in the early spring pasturage which it affords.

Land values range from \$100 to \$300 an acre, depending on improvements.

By installing an overhead irrigation system and keeping the soil well supplied with organic matter, this soil can be used in the production of vegetables quite successfully, though it is not as well adapted to this purpose as is the Columbia loam or sandy loam.

Columbia sandy loam, gravelly phase.—The surface soil of the Columbia sandy loam, gravelly phase, to a depth of 20 to 24 inches, consists of a grayish-brown to dark-brown friable sandy loam, containing a considerable quantity of waterworn gravel, together with a few boulders of like character. The subsoil is somewhat variable, consisting for the main part of compact waterworn gravel with finer interstitial material. It may also include an occasional layer of loam or of fine sand.

This phase is confined to a few small areas in the northwestern part of the county. The largest of these occurs on Sauvie Island. This area is composed mainly of basaltic material transported by the Columbia River. Another smaller area occurs on the west side of

Multnomah Channel, at the mouth of a small stream having its source in the adjacent basaltic hills, and represents a small area of alluvial-fan material. Neither in mode of occurrence nor in origin of material is this area typical of the Columbia soils. Another small and less gravelly area extends along the east bank of the Willamette River from the county boundary on the south to a point a short distance above Ross Island. The soil of these gravelly areas is browner than the typical Columbia material, and if of greater extent it would have been placed in a distinct series of soils. The topography is smooth, with sufficient slope to insure good drainage. The phase is seldom overflowed.

On account of its small extent the phase is of little importance; about 80 per cent of it is under cultivation, and the rest supports a heavy growth of fir. The principal crops are wheat, oats, corn, and clover. The land is devoted to dairying and stock raising, the cattle being pastured on the more poorly drained soils during the summer and carried through the winter on clover hay and silage. The yields obtained on this soil are about the same as on the Columbia loam.

Land of this phase, sold in connection with associated soils, brings from \$50 to \$150 an acre.

COLUMBIA LOAM.

The surface soil of the Columbia loam consists of 8 inches of a light-brown to dark-brown friable loam. The subsoil, to a depth of 36 inches or more, is a grayish-brown coarse sand, and in part at least represents material of the Toutle series over which the Columbia material has been superimposed. The soil over the greater part of this type is shallow, though in places it may extend to a depth of 15 inches before the sand subsoil is encountered. The type as a whole has a comparatively high organic content, which gives rise to its dark-brown color. The area lying northwest of Troutdale, which is slightly darker in color than that lying next to the river, is especially rich in this constituent.

One of the most important areas of the type, both as regards size and use, lies northwest of Troutdale. Other areas of importance are mapped on Sauvie Island and on Government Island. The topography of the greater part of the type is smooth, and only occasionally interrupted by a channel scoured out by floods. The surface drainage and subdrainage of the type are in the main good, though in some places the underdrainage is somewhat retarded, owing to a high water table. This condition exists in a part of the area lying northwest of Troutdale. The type is subject to annual overflow, except some of the higher lying areas.

The native vegetation consists principally of fir, with some alder and ash, and at the present time covers about 30 per cent of the area of the type. The rest, with the exception of about 60 per cent which is cultivated, is covered with native grass and is used as pasture. The crops include peas, beans, wheat, clover, corn, and oats. On Sauvie Island a considerable part of the type is used in the production of winter feed for dairy and beef cattle. The more poorly drained areas furnish summer pasturage.

The growing of peas and beans is still in a more or less experimental stage. Many varieties have been tested during the last year, with only fair success. The pea crop is contracted for by a local cannery, and the beans are thrashed and sold to local wholesale houses. Wheat yields 15 to 30 bushels, with an average of 20 bushels; and oats, 40 to 65 bushels, with an average of 45 bushels per acre. The corn, used principally as silage, yields 12 tons per acre. Clover yields from 1 to 2½ tons of hay per acre.

Improved land of this type ranges in price from \$100 to \$300 an acre, depending on location and improvements.

This type, when well drained, is well adapted to the production of corn and vegetables. In the growing of peas and beans it is probable that a small application of complete fertilizer in the spring, together with inoculation of the soil, would give good results.

Columbia loam, dark-colored phase.—The surface soil of the Columbia loam, dark-colored phase, consists of a dark-brown to black loam, containing a high percentage of organic matter. The depth of the surface soil varies considerably, ranging from 6 to 20 inches, but on an average is not over 8 inches. The subsoil consists of a grayish-brown medium to fine sand. The phase includes areas, too small to map, in which the organic content is sufficiently high to make the soil Muck or Peat.

This phase occupies long, narrow depressions, roughly paralleling the course of the river, and lying between the recent-alluvial soils of the Columbia River bottoms and the higher lying terrace soils. It is confined to three small bodies. The most important one from the standpoint of use is located just north of Troutdale; another lies near Park Rose, and the third about 1 mile north of Fairview. The drainage is somewhat restricted, though the areas north of Troutdale and Fairview have been improved greatly by the construction of dikes and the installation of pumping plants.

Although of small extent, the phase is of considerable importance agriculturally, about 70 per cent of it being under cultivation. The rest supports a rank growth of grasses and sedges. The main crops are cabbage, onions, and celery. Excellent yields are obtained.

The following table gives the average results of mechanical analyses of the soil and subsoil of the typical Columbia loam:

Mechanical analyses of Columbia loam.

Number.	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.	<i>Per cent.</i>
561165, 561167.....	Soil.....	2.2	5.8	3.4	11.4	19.9	36.4	21.2
561166, 561168.....	Subsoil.....	5.6	15.4	8.2	36.4	23.6	7.6	3.2

COLUMBIA SILT LOAM.

The surface soil of the Columbia silt loam, to an average depth of 18 inches, consists of a brown to dull grayish brown silt loam, containing a relatively large proportion of organic matter and very fine sand. The subsoil is in two layers. The first, extending to a depth of 24 inches, consists of a light-brown fine sand; the second, a grayish-brown coarse sand. The depth at which the sandy layer is encountered varies greatly, in some places being found not above 30 inches. As developed in the present survey, this soil contains more organic matter and has a darker color than the typical Columbia.

This type forms several scattered areas in the Columbia River bottoms. One of the more important areas from the standpoint of use lies about $1\frac{1}{2}$ miles northwest of Troutdale. Other areas of considerable size are mapped on Sauvie, Government, Hayden, and Percy Islands in the Columbia, and on Swan Island in the Willamette River.

The topography for the most part is smooth, with only slight irregularities caused by erosion and deposition during times of overflow. Some of the areas, notably on Hayden, Swan, and Percy Islands, are sometimes quite deeply gullied during floods. The drainage of the type is good, except in a few places where the underdrainage is slightly retarded.

About 70 per cent of the type is forested with fir, or willow, alder, and ash, the rest being either cultivated or used as pasture. The yields of the principal crops, which include wheat, oats, corn, clover, beans, and peas, are about the same as on the Columbia loam.

Land values of the area of this type which lies within the Sundial diking project range from \$200 to \$300 an acre. Improved land not diked sells for \$40 to \$100 an acre.

When diked this soil can be used very successfully in the production of a great number of different crops; when thoroughly drained it is best adapted to corn and vegetables.

The following table gives the results of mechanical analyses of the soil, subsoil, and lower subsoil of the Columbia silt loam:

Mechanical analyses of Columbia silt loam.

Number.	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.	<i>Per cent.</i>
561171.....	Soil.....	0.3	1.5	1.5	5.4	18.8	56.5	16.3
561172.....	Subsoil.....	.6	11.5	12.3	31.6	20.9	17.9	5.1
561173.....	Lower subsoil...	2.5	31.1	16.7	31.0	9.9	6.8	2.1

NEWBERG SILT LOAM.

The surface soil of the Newberg silt loam consists of a brown silt loam of smooth texture and moderate organic content, extending usually to a depth of 10 to 18 inches. The subsoil is slightly lighter in color than the soil. It also is noticeably lighter in texture than the surface soil and in the lower part grades into a fine sand or fine sandy loam. Both surface soil and subsoil are free from gravel or coarse-textured gritty materials.

There is less than a square mile of this type of soil in the county. It is confined to two small areas of soil extending along Johnson Creek just south of Portland. In origin, mode of occurrence, and surface features the type is similar to the soils of the Columbia series, from which it is distinguished by its more pronounced brownish color. The Newberg materials are derived from fewer kinds of rocks than the Columbia, the deposits coming mainly from basalt and sedimentary formations.

Owing to its location near the city, the agricultural value of this type is overshadowed by its value for suburban uses. It is, however, a productive soil, still utilized in general farming and trucking.

WAPATO SILT LOAM.

The Wapato silt loam consists of a surface soil of dark-brown, smooth-textured, friable silt loam, 12 inches deep, resting on a subsoil of slightly compact brown clay loam or silty clay loam, mottled with gray and in places with yellow and brown iron stains. The texture of this type as mapped varies considerably, some areas being low in silt and high in clay. Others approach a sandy loam in character. The areas in which these variations occur are not of sufficient size to warrant a separation on the map. A few areas lying on the Willamette and Columbia Rivers are of rather pronounced grayish color, but these also are not shown on account of their small size.

This type is confined principally to the overflow land along the smaller streams. The largest area, however, which lies just south

of Fairview, occupies a poorly drained depression formerly an old lake bed. Other comparatively important areas are mapped on both sides of the Willamette River in the southern part of the county. Other areas lie along Beaver and Johnson Creeks. The type is subject to annual overflow, and both surface drainage and subdrainage are restricted, except in some light-textured areas.

The Wapato silt loam is a productive soil, but owing to its small extent it is relatively unimportant in the agriculture of the county. About 60 per cent of the type is under cultivation; the rest is either in forest consisting of a dense growth of oak, ash, and alder, or is covered with native grasses. Wheat, oats, corn, and potatoes are the principal crops, the corn being used largely as a source of silage to feed dairy cattle. Wheat yields 20 to 40 bushels, with an average of 30 bushels; oats from 40 to 90 bushels, with an average of 60 bushels; and potatoes from 100 to 250 bushels per acre.

In growing grain following a cultivated crop the land is not plowed, nor is it the custom to plow land that has been plowed in the spring. The usual practice is to disk thoroughly, harrow, and sow the seed. When this is done under the proper moisture conditions a very good seed bed is prepared.

Owing to small areas of this type, it is not sold in separate tracts, but it usually has a value slightly higher than the soil with which it is associated.

The principal need of this type is drainage, which can best be accomplished by tiling. When properly drained the soil is well adapted to the culture of corn, potatoes, and vegetables.

Wapato silt loam, heavy phase.—The Wapato silt loam, heavy phase, consists of small areas of soil of heavy texture and dark color. These really represent an occurrence of a soil of the Cove series as recognized in the previous western Oregon surveys. In all there is but 64 acres of the soil in the county.

The surface soil consists of 12 inches of a dark-gray to black, heavy clay loam or clay, containing a relatively large quantity of silt and of organic matter. The subsoil is a heavy black clay loam or clay, which in places is mottled with brown or yellow. Basaltic bedrock is encountered over the greater part of the phase at depths ranging from 24 to 36 inches.

SAUVIE SILT LOAM.

As typically developed the surface soil of the Sauvie silt loam, to an average depth of about 8 inches, consists of a brownish or dull-gray silt loam, containing a relatively large quantity of organic matter. The subsoil is a drab silty loam or light clay loam, mottled with gray and rusty brown.

As occurring in this survey, however, a number of variations that depart from the typical soil in color and in texture are included. In the small area in the southwestern part of Sauvie Island the surface soil has the texture of a rather light loam and a somewhat more pronounced brown color than typical. The small area lying 1 mile east of Switzler Lake has a soil grayer than typical. In the large area lying in the city of Portland the soil is gray, and both soil and subsoil are mottled with yellow.

Small areas of this type are scattered through the bottoms of the Columbia and Willamette Rivers, where they commonly occupy a position slightly higher than the surrounding land. The largest area, and the only one not found in the river bottoms, occurs within the city of Portland, occupying apparently what was formerly a lake bed.

The surface, like that of other overflowed bottom types, is somewhat uneven, owing to erosion and deposition during floods. A position slightly higher than that of the surrounding soils gives the type comparatively good drainage. The areas are very seldom overflowed.

About 80 per cent of the type is free of forest. In the forested areas the growth consists principally of oak, alder, ash, and a heavy undergrowth of small brush. The cultivated area is used principally in the production of vegetables. On the rest there is a good growth of grasses, which supply hay and pasturage for dairy and other cattle. Late crops of nearly all vegetables, including potatoes, do very well on this type. Only a small area is used in the production of wheat and forage crops, but excellent yields are obtained from the land devoted to this use.

Improved land of this type, excepting the area in Portland, sells for from \$50 to \$200 an acre, prices varying widely with differences in location and improvements.

Areas of this type that are comparatively free from overflow could be used more extensively in the production of wheat and forage crops. In connection with the production of vegetables, a readily available nitrogenous fertilizer, if applied in the spring toward the close of the rainy season, would produce marked results.

The following table gives the results of mechanical analyses of the soil and subsoil of the Sauvie silt loam:

Mechanical analyses of Sauvie silt loam.

Number.	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.	<i>Per cent.</i>
561150.....	Soil.....	0.0	1.0	1.1	7.6	17.8	53.7	18.9
561151.....	Subsoil.....	.8	1.4	2.9	14.9	24.2	41.9	14.0

SAUVIE SILTY CLAY LOAM.

The surface soil of the Sauvie silty clay loam consists of 10 to 12 inches of a brownish-gray to dull-gray silty clay loam, of rather heavy texture, containing relatively large proportions of micaceous material and organic matter. The subsoil commonly consists of two layers; the upper one, which extends to an average depth of 24 inches, is a drab silty clay loam or silty clay, mottled with gray and rusty brown, and the lower one is a dark-brown silty clay loam, mottled with gray and brownish yellow. The depth at which these different layers appear varies greatly, and the upper layer may be entirely absent in low-lying areas. The texture of this soil is somewhat variable. The land is overflowed every year, and the surface is marked by series of ridges and depressions. On the former the texture is commonly a silty clay loam; in the latter a clay loam. A small body in the northwestern part of the county, which contains gravel, has been indicated on the map by gravel symbols.

This type forms the greater part of the overflowed land of the Columbia River bottoms. The largest area lies on Sauvie Island in the northwestern part of the county. From this island the type continues in an unbroken body, except for interruption by the Willamette River and other stream channels and sloughs or lakes, to the east as far as the Sandy River. A few isolated areas are found elsewhere in the county. There is one on Government Island, and another a short distance above Rooster Rock.

The topography for the most part is smooth, except for the minor irregularities and depressions caused by the water moving over the surface in time of flood. These depressions are of varying size, some storing sufficient water to form permanent lakes; others only enough to be intermittent. The drainage of the greater part of the type is deficient, and the subdrainage is especially poor, on account of the existence of a high water table during part of the year.

In point of area this is one of the more important recent alluvial soils in the county. Owing, however, to the fact that the water drains away slowly after the spring floods, probably not over 10 per cent of the land is cultivated. The rest is used for pasture and hay land. The forest, which is composed principally of ash, vine maple, and oak, is rather scattering, so that almost all the land can be used as pasture. The principal crops are wheat and oats, which give good yields, wheat returning from 25 to 45 bushels, with an average of 30 bushels, and oats from 40 to 90 bushels, with an average of 60 bushels per acre. Wild hay ordinarily yields $1\frac{1}{2}$ tons per acre.

This type is used in connection with some of the lighter textured types on which are grown clover, alfalfa, or corn for winter feed, almost exclusively for production of beef cattle and for dairying. It supplies pasturage except during the time of high water. Any surplus hay cut on this type is baled and sold in Portland, where there is always a ready market. Cream is the principal source of income, the skimmed milk furnishing feed for hogs. The chief need of this type is protection from overflow by diking and drainage.

Land values range from \$50 to \$200 an acre, depending on location and improvements.

Sauvie silty clay loam, sandy-subsoil phase.—The surface soil of the Sauvie silty clay loam, sandy-subsoil phase, consists of 8 to 10 inches of a grayish-brown or brownish-gray silty clay loam, faintly mottled with gray, and carrying a high content of organic matter. The subsoil is composed of two parts; an upper layer, extending to an average depth of 24 inches, consisting of a drab silty clay loam, mottled with rusty brown, and a lower layer of grayish-brown to gray fine sand. This lower subsoil contains much moisture throughout the year.

This phase occupies a little more than 1 square mile. The largest area lies about one-half mile south of the junction of the Columbia with the Sandy River. Another area of some importance is mapped 1 mile north of Fairview. The areas are confined to the overflowed bottoms of the Columbia River. They commonly occupy depressions from 2 to 4 feet lower than the surrounding land. The drainage is deficient to good, depending on the elevation of the surface above the general level of the river. The areas are overflowed practically every year.

Owing to its small extent and to the fact that water stands on much of it until late in the spring, the phase is of comparatively little importance. Within the last year about 5 per cent of it has been put under cultivation. The greater part of the phase supports a heavy growth of native grasses and is used either as pasture or hay land. The pastures are used principally for dairy cattle, though a few beef cattle, sheep, and goats run on the land during the summer. (Pl. VI, Fig. 2.)

Unimproved land of this phase is held at \$50 to \$100 an acre; that under cultivation at \$250 an acre.

The principal need of the phase is diking to prevent overflow.

Results of mechanical analyses of samples of the surface soil, subsoil, and lower subsoil, taken from one of the heavier textured variations of the typical soil, are given in the following table:

Mechanical analyses of Sawvie silty clay loam.

Number.	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.	<i>Per cent.</i>
561152.....	Soil.....	0.0	3.2	2.6	4.9	3.6	52.0	33.8
561153.....	Subsoil.....	.0	2.4	1.9	5.7	3.5	53.3	33.5
561154.....	Lower subsoil	.0	1.3	1.2	9.6	18.7	48.6	20.9

TOUTLE SAND.

The Toutle sand consists of 36 inches or more of a brownish-gray to drab sand, which is uniform in color and texture throughout the soil profile. At depths varying from 5 to 10 feet, scattering cobblestones and boulders appear and the proportion of these increases with increasing depth until basaltic bedrock is encountered.

The type is confined almost entirely to the channel of the Sandy River, which in cutting its way through the rock formation in which it is now deeply entrenched has broadened its channel in places where it encountered the least resistance, and is now depositing its coarser sediments in time of flood in these localities, where the current is less swift. At the present time the soil occupies positions 20 feet or more above the low-water stage of the river, but is subject to annual overflow. The material composing the type consists chiefly of angular basaltic sand grains, their shape indicating that the material has not been transported far from the place of origin.

The Toutle sand is almost entirely covered with a dense growth of willow, alder, ash, and underbrush. Owing to its leachy, porous texture and the frequency of overflow, it is not used for agriculture.

The following table gives the results of mechanical analyses of the soil and subsoil of the Toutle sand:

Mechanical analyses of Toutle sand.

Number.	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.	<i>Per cent.</i>
561159.....	Soil.....	6.6	16.5	9.4	31.1	21.8	11.4	3.2
561160.....	Subsoil.....	14.6	36.9	13.7	22.6	7.2	4.1	0.9

BURLINGTON FINE SAND.

The Burlington fine sand, to a depth of 36 inches or more, consists of a loose, porous brown to dark-brown fine sand, which in places has a rather fine loamy texture and as mapped includes some areas of fine sandy loam material. The surface soil and subsoil are very similar in character throughout the area mapped, except that the surface 6 inches contains slightly more organic matter and is slightly darker than the subsoil.

Two of the largest areas of the type occur in the west-central part of Sauvie Island; other small areas, consisting merely of wind-blown knolls, lie northwest of Troutdale. The topography varies from gently undulating to rolling or dunelike, the higher mounds and ridges rising in some instances 30 feet or more above the surrounding land. The drainage of the type is good to excessive.

The Burlington fine sand is of wind-laid origin, the material coming from sand deposits laid down by the Columbia River along its banks. The material was originally derived from a variety of rocks, principally quartz-bearing, though mingled with it is some basaltic sand.

On account of its small extent the type is of little agricultural importance. Only about 20 per cent of it is cultivated, and the rest is utilized as pasture. The native vegetation consists of grasses and a scattering growth of brush, scrub oak, and some fir. The principal crops are wheat, oats, corn, clover, and potatoes. The yields obtained on this type are somewhat less than on the Columbia fine sand, owing to the leachy character of the soil. The cultural methods for the crops grown are the same as on other types in the county.

The value of land of this type is out of proportion to its agricultural value, owing to the fact that it offers excellent building sites for farms located in the river bottom. The land is held at \$100 to \$200 an acre.

This soil can be made to produce very good crops, if the supply of organic matter is maintained. All kinds of berries and vegetables do well on the type and are of excellent quality. Their successful commercial production, however, will probably require irrigation.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Burlington fine sand:

Mechanical analyses of Burlington fine sand.

Number.	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.	<i>Per cent.</i>
561101.....	Soil.....	0.0	0.8	3.4	67.4	9.3	11.9	7.3
561102.....	Subsoil.....	.0	.7	3.9	76.9	9.1	6.2	3.3

ROUGH MOUNTAINOUS LAND.

Throughout the mountainous section of the eastern and western parts of the county are found heavily forested areas, quite inaccessible except by faintly defined trails, which under the conditions of the present survey were not thought to warrant the expense of detailed mapping. This type of miscellaneous soil materials is com-

posed largely of areas too rough and broken to be cultivated, though with future development small areas may be tilled.

The soils throughout the type are of residual origin and are principally of brown or chocolate-brown color. In the western part of the county they are underlain almost entirely, at depths ranging from 6 to 10 inches, by a brownish-yellow clay loam subsoil. In the eastern part of the county the subsoil is for the most part a brown to reddish-brown silty clay loam. Rough mountainous land represents mainly areas of Olympic and Cascade materials. Over the greater part of its area the soil is very shallow, bedrock being generally encountered at depths ranging from a few inches to 2 or 3 feet. Scattered boulders and smaller rock fragments are present on the surface of the shallow and steep areas.

The largest area of Rough mountainous land is in the western part of the county, where it forms the greater part of the hill section as far south as the limits of Portland. Other important areas lie along the Sandy River and in the vicinity of Larch Mountain.

A small part of the type is used for grazing, but the greater part of it is heavily forested with fir. In the vicinity of Larch Mountain a large area has been burned over and now supports a heavy growth of fern and brush. A few of the smaller areas, which can be used for grazing, have some value in animal husbandry, but most of the type should be left in forest.

ROUGH BROKEN AND STONY LAND.

This type is composed of areas too rough and stony for cultivation, and adapted only to forestry and grazing, part of it being even too steep for the latter purpose. The areas are underlain principally by basalt, and large detached boulders are scattered over the surface. Along the bluff leading down to the Sandy River there are numerous outcrops of a sandstone formation.

The largest area of Rough broken and stony land is in the eastern part of the county. It includes the slopes of the drainage ways and the bluffs along the Columbia River. Other large areas lie along the Sandy River from Troutdale south to the county line. A small area is found at Rocky Butte.

The greater part of the type was originally covered with a valuable growth of fir. A part of the area in the vicinity of Larch Mountain has been burned over recently and it now supports a growth of fern and brush and a scattering stand of young fir. The steeper bluffs leading down to the Columbia River are devoid of vegetation. A few of the areas lying in the vicinity of settlements are used for grazing, but most of the type is valued only for its timber growth.

RIVERWASH.

Riverwash includes the loose sand and gravel beds in the flood plains of the Willamette and Columbia Rivers. The material is usually a brownish-gray or yellowish fine sand, though large areas of gravel with little interstitial fine material are developed where the current of the water is swift. The greater part of the type lies but a few feet above the normal level of the streams and is subject to frequent overflow. In some of the higher areas a few alders or willows have gained a foothold, but most of the area is barren. On account of the light gravelly nature of the type and the frequency of overflows the land has no agricultural value.

SUMMARY.

Multnomah County, situated in the northwestern part of Oregon, along the Columbia River, has an area of 328 square miles, or 209,920 acres.

The topography of the county is varied, ranging from the comparatively level alluvial lands along the Columbia River and tributary streams, to the hilly and mountainous districts along the eastern and western boundaries.

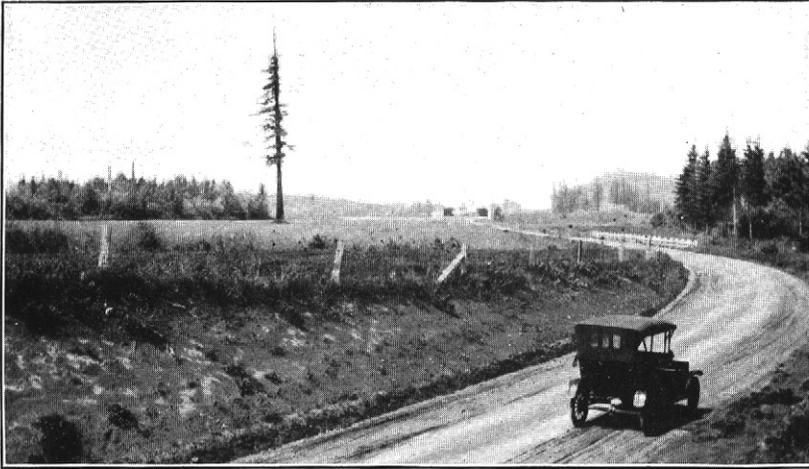
Multnomah County is drained by the Columbia, Willamette, and Sandy Rivers, and tributary streams.

Multnomah County is the smallest and also the most densely populated county in the State. Portland, which is the county seat, had in 1920 a population of 258,288, and the total population of the county is 275,898.

A number of transcontinental railroads have their terminals at Portland. Ocean-going vessels ascend the Columbia and Willamette Rivers to Portland, and the streams are navigable for considerable distances above Portland for river boats. Several paved highways lead to different parts of the county, and good earth roads reach all the smaller towns.

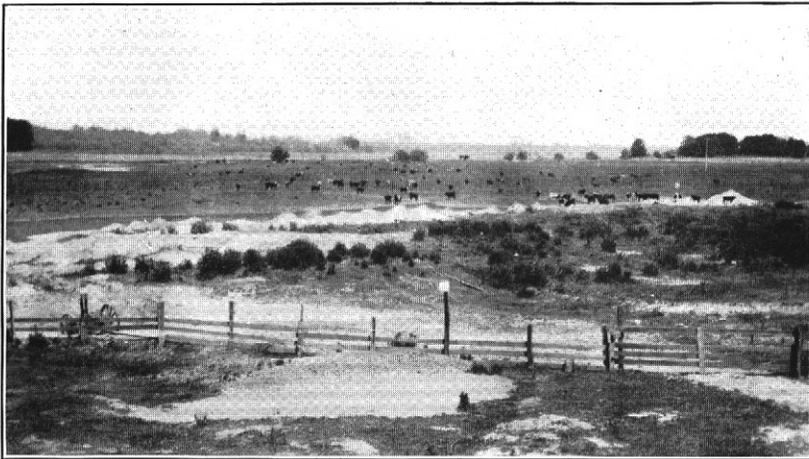
The climate of this part of the State is mild both in summer and winter. The highest recorded temperature at Portland is 102° F., the lowest is -2° F., and the annual mean temperature is 52.8° F. The annual rainfall varies from 44 inches at Portland to 60 or even 100 inches in the mountainous district. The average growing season extends from about the middle of March to a little after the middle of November.

The agriculture of Multnomah County consists chiefly of dairying, market gardening, the growing of small fruits, and the raising of poultry. The city of Portland affords an excellent market for all poultry products, fruit, and truck crops.



S. 1050C

FIG. 1.—ROLLING UPLAND TERRACES OCCUPIED BY THE HILL PHASE OF THE POWELL SILT LOAM.



S. 10926.

FIG. 2.—CATTLE GRAZING ON RECENTLY DIKED SAUVIE SILTY CLAY LOAM IN THE COLUMBIA RIVER BOTTOMS.

Based on their processes of accumulation, the soils of Multnomah County fall into two general groups, residual and transported. Soils of the first group are derived entirely from igneous rocks, largely fine-textured, dark-colored basalt, but in part coarser grained andesite, diorite, and dolerite. The weathering and decomposition in place of these formations give rise to soils of the Olympic and Cascade series.

The surface soils of the Olympic series are brown to reddish brown, and the subsoils lighter brown. The soils are well drained. The topography varies from uniformly sloping to hilly and mountainous. The soils are being largely devoted to fruits, and to field crops produced in connection with dairying.

The surface soils of the Cascade series are prevailingly brown to light brown in color, and the subsoil yellowish brown to yellow. The soils are friable, well drained, and comparatively smooth. They are utilized largely for field crops.

The transported soils include materials derived from both old and recent sedimentary or alluvial formations and wind-laid deposits. The older ones occupy terraces and include types of the Willamette, Hillsboro, Powell, Salem, and Amity series.

The soils of the Willamette series have brown surface soils and subsoils. The latter are somewhat more compact than the surface soils, but rest on a more friable substratum. The types have a smooth to undulating surface and are well drained. The soils are utilized largely in the production of field crops. Some small areas are devoted to trucking.

The Hillsboro series includes types with brown surface soils, a lighter colored subsoil and a lighter textured more friable substratum. The soils have a rolling to undulating surface and are well drained. Probably 90 per cent of their area is under cultivation, the crops including both trucking and general farm crops. Dairying is an important industry.

The Powell soils are brown to light brown and rest on lighter colored, mottled, friable subsoils. These soils occupy elevated plateaus, and have a rolling to undulating surface and good drainage. Dairying is the leading type of farming. Berries and truck crops are grown to some extent.

The surface soils of the types of the Salem series are brown, the subsoils brown and compact, and the substratum porous, being composed of rounded gravel and coarse sand. These soils form smooth elevated terraces along the Columbia and Willamette Rivers. Drainage conditions are excellent. Local areas of these soils are utilized for trucking, but their principal use is the growing of small grains, vetch, and clover in connection with dairying.

The Amity series consists of types with brown or grayish-brown surface soils, underlain by compact mottled grayish-brown subsoils. The soils have a smooth surface and poor subdrainage. Oats, vetch, wheat, and clover are the principal crops.

The recent alluvial soils occur in bodies of considerable size along the Columbia River, and as narrow strips along nearly every stream in the county. Soils of the following series in this group occur in Multnomah County: Columbia, Newberg, Wapato, Sauvie, and Toutle.

The surface soils and subsoil of the types in the Columbia series are light brown, light textured, and friable. The areas occur mainly immediately along the banks of the Columbia River and the drainage conditions are good, except during flood periods. Small grains, clover, alfalfa, potatoes, and truck crops are the principal products.

The types in the Newberg series have brown surface soils and lighter colored, lighter textured subsoils. The soils of this series are confined to the bottoms of some of the smaller streams. Drainage is good except during occasional periods of overflow.

The Wapato series includes types with dull-brown surface soils and heavier textured, mottled subsoils. The soils occupy low-lying areas along the Columbia River, and are imperfectly drained. Small grains are the principal crops. A large area of the type is used as native pasture.

The types of the Sauvie series have brownish-gray to dark-gray surface soils, and dark-drab or slate-colored mottled subsoils. The substratum is predominantly of stratified sandy materials. These soils form the greater part of the overflow lands along the Columbia River, and, except where diked, are subject to annual overflow. They are largely used for grazing, though the better drained areas give excellent yields of vegetables.

Only one type of the Toutle series occurs in the county. It consists of 36 inches of sand of brownish-gray to drab color. The type is largely confined to the vicinity of the Sandy River. Present conditions do not favor the use of this soil for agriculture.

Small areas of wind-blown material have been classified with the Burlington fine sand. The soil is brown to dark brown and has an undulating to hummocky topography. Drainage is good to excessive. Little of this soil is under cultivation, but it is used for pasture.

Three types of miscellaneous soil materials, mainly nonagricultural, have been recognized in this survey. They are Rough mountainous land, Rough broken and stony land, and Riverwash. These types have a restricted use for grazing. The first two mentioned are valued chiefly for their forest resources.

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