SOIL SURVEY

Pierce County Washington

Series 1939, No. 27

Issued July 1955

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with the
WASHINGTON AGRICULTURAL EXPERIMENT STATION
and the
WASHINGTON STATE PLANNING COUNCIL

How to use THE SOIL SURVEY REPORT

FARMERS who have worked with their soils for a long time know about the soil differences on their farms, perhaps also on the farms of their immediate neighbors. What they do not know, unless soil surveys have been made, is how nearly their soils are like those on experiment stations or on other farms, either in their State or other States, where farmers have gained experience with new or different farming practices or farm enterprises. They do not know whether higher yields obtained by farmers in other parts of their county and State are from soils like theirs or from soils so different that they could not hope to get yields as high, even if they followed the same practices. One way for farmers to avoid some of the risk and uncertainty involved in trying new production methods and new varieties of plants is to learn what kind of soils they have so they can compare them with the soils on which new developments have proved successful.

SOILS OF A PARTICULAR FARM

The soil map accompanies the report. To find what soils are on any farm or other land, it is necessary first to locate this land on the map. This is easily done by finding the township in which the farm is located and by using landmarks such as roads, streams, villages, dwellings, and other features to locate the boundaries.

Each kind of soil mapped within the farm or tract is marked on the map with a symbol. For example, all the areas marked Wc are Wilkeson loam, rolling. The color in which the soil area is shown on the map will be the same as the color in the legend for the particular type of soil.

If you want information on the Wilkeson soil, turn to the section in this publication on Soil Types and Phases and find Wilkeson loam, rolling. Under this heading you will find a statement of what the characteristics of this soil are, what the soil is mainly used for, and some of the uses to which it is suited.

Suppose, for example, you wish to know how productive Wilkeson loam, rolling, is? You will find it listed in the left-hand column of table 4. Opposite the name you can read the yields for the different crops grown on the soil. This table also gives estimated yields for all the other soils mapped in the county.

If you want to know what uses and management practices are recommended for Wilkeson loam, rolling, read what is said about this soil in the section on Soil Types and Phases. Refer also to the section on Use, Management, and Productivity of Soils.

SOILS OF THE COUNTY AS A WHOLE

A general idea of the soils of the county is given in the section on Soil Series and their Relations, which tells about the principal kinds of soils, where they are found, and how they are related to one another. After reading this section, study the soil map and notice how the different kinds of soils tend to be arranged in different parts of the county. These patterns are likely to be associated with well-recognized differences in type of farming, land use, and land-use problems.

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

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

This publication on the soil survey of Pierce County, Washington, is a cooperative contribution from the—

SOIL CONSERVATION SERVICE
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SOIL SURVEY OF PIERCE COUNTY, WASHINGTON

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United States Department of Agriculture

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United States Department of Agriculture in cooperation with the Washington Agricultural Experiment Station and the Washington State Planning Council

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

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LIKE many of the other counties of western Washington, Pierce County is still to a large extent a land of forest, although, except in the mountainous regions, most of the virgin timber has been cut. The best soils are along the larger rivers where the production of many specialized crops, as peas, berries, truck-crop seeds, and bulbs, is profitable. Dairying is the most important agricultural industry, and more farm land is used for grazing than for all other uses combined. Small grains, except oats, are not extensively grown. The upland farms are small and generally owned by families who earn part of their living elsewhere. Other industries in the county include sawmills, lumber-processing plants, furniture factories, flour and feed mills, and a smelter. Tacoma, the largest city, is an important seaport and railroad center. To provide a basis for the best agricultural uses of the land, a cooperative soil survey was made by the United States Department of Agriculture, the Washington Agricultural Experiment Stations, and the Washington State Planning Council. Field work was completed in 1939. Unless otherwise stated, all information in the report refers to conditions in the county at the time of the survey.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

Pierce County, in the west-central part of Washington, is a large irregular area that extends from the summit of the Cascade Mountains northwest to Puget Sound. Several small islands and Longbranch and Gig Harbor Peninsulas are separated from the rest of the county by the Sound (fig. 1). According to the United States Census, the total land area is approximately 1,072,640 acres. Approximately

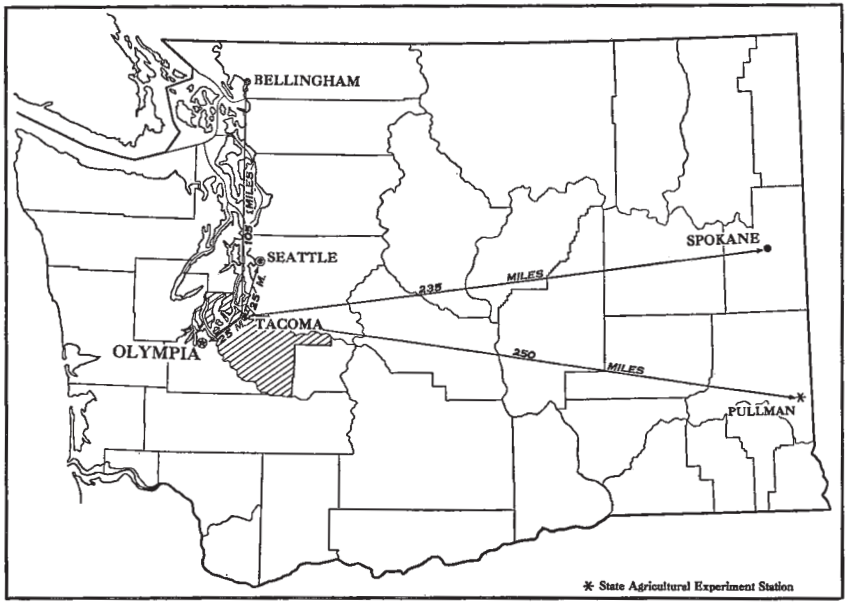

FIGURE 1.—Location of Pierce County in Washington.

702,569 acres were included in the survey. The rest makes up the National Forest area and Mount Rainier National Park, in the mountainous region in the southeastern part of the county, and the Federal Penitentiary Reservation on McNeil Island in Puget Sound a few miles from Steilacoom. All the area surveyed lies within the Puget Sound Basin, a great valley between the Olympic and Cascade Mountain Ranges. The county seat is Tacoma, the second largest city of the State. It is 25 miles south of Seattle and 235 miles west of Spokane.

The soils to the north of the county are described in the soil survey of King County (*11*)[1a] and those on the southeast by that of Lewis County (*6*). These areas together with Thurston County on the west were the subject of a much earlier, less detailed reconnaissance soil survey made in the eastern part of the Puget Sound Basin (*9*).

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

There are five main physiographic divisions in the county: (1) Glacial moraines and terraces; (2) Glacial valleys; (3) Glacial outwash plains; (4) Old plateaus and mountain foot slopes; and (5) Mountainous regions.

The Glacial moraine and terrace division, which covers most of the western half of the county, including all of the islands and the two peninsulas, is composed of material laid down by the ice of the Puget Sound glaciation. The topography in this area is undulating to rolling. Slopes vary from less than 5 to 75 percent, but most slopes, except where the land breaks into the larger valleys or into Puget Sound, are fairly gentle. These breaks in most places are relatively precipitous—some as much as several hundred feet within a short distance. Several large gullies in the southeastern part of the city of Tacoma extend back from the Puyallup Valley for a distance of 1 or 2 miles into the more level country, but as a rule the drainageways, although well established, are not deeply incised. All drainage in this part of the county is into Puget Sound through the Puyallup and Nisqually Rivers and small creeks that empty directly into the Sound. There are many poorly drained depressions and lakes in the area. Elevations [2] in this division range from a few feet above sea level to 200 feet near Steilacoom, 700 feet at Kapowsin, and 1,250 feet at Carbonado.

The Glacial valleys division, which covers about 75 square miles, includes the wide glacial troughs occupied by the Puyallup, Stuck, Carbon, White, and Nisqually Rivers and South Prairie and Ohop Creeks. Although modified by alluvium deposited by these streams, the valleys were not formed by stream action.

The Glacial outwash plains division in this county occupies the southwestern part of the mainland. It extends from Steilacoom on the north to McKenna on the south, and from a point near Kirby School on the east to the Nisqually River and the Sound on the west. The area totals about 170 square miles. This division is generally fairly level, but has sharply rising hills and mounds of morainic material. Elevations of the outwash material range from 200 feet at the top of the bluffs overlooking the Sound to about 450 at the eastern

[1a] Italic numbers in parentheses refer to Literature Cited, p. 88.

[2] All elevations used in this report were taken from topographic maps of the U. S. Geological Survey.

boundary, but morainic hills rise 100 to 250 feet above these levels. Many long low escarpments have been carved by the swiftly flowing waters that transported this material from the melting glaciers. The drainage system is very incomplete, owing to the extreme porosity of the outwash gravels and the resulting lack of runoff. Many lakes and poorly drained depressions are fed by the shallow ground waters of the region.

The Old plateaus and mountain foot slopes division covers approximately 110 square miles. From Eatonville north to Kapowsin it is separated from the glacial moraines and terraces by the glacial valley containing Ohop Lake and Lake Kapowsin. From Kapowsin to Carbonado and on to the White River the boundary is approximately a straight line. This physiographic division consists of an undulating to rolling belt of benches and low hills (pl. 1, *A*) rising from 1,200 to 1,500 feet along its western boundary to 2,000 to 2,500 where it meets the mountains to the east. The drainage pattern is well established, but except along the western boundary where the streams drop several hundred feet in 1 or 2 miles to the valley below, the stream channels are not deep. There are very few lakes and few poorly drained areas. All the area is underlain by andesitic and basaltic rocks.

The fifth physiographic division, the Mountainous regions, is that part of the Cascade Mountains included in the county. In general the mountains range in height from 2,500 to 6,000 feet, although Mount Rainier, the third highest peak in continental United States, is 14,408 feet. Some of the mountains are rocky and barren, but the majority have a good soil cover and a thick stand of fine timber.

The general slope of the county is from east to west and is fairly gentle except for the abrupt rise from the glacial moraine to the old plateau region. Elevations of towns vary. Tacoma is approximately at sea level; Puyallup, 49 feet; Sumner, 74 feet; Orting, 192 feet; Buckley, 723 feet; South Prairie, 430 feet; McKenna, approximately 300 feet; Kapowsin, 629 feet; Eatonville, 300 feet; La Grande, 944 feet; Alder, 1,147 feet; Elbe, 1,211 feet; National, 1,574 feet; Ohop, 1,500 feet; Carbonado, 1,146 feet; and Paradise Inn in Mount Rainier National Park (outside of area surveyed), 5,550 feet.

CLIMATE

The summers are generally cool and dry and the winters moist and comparatively mild. The prevailing westerly winds from the ocean and the nearness of Puget Sound cause the characteristic marine climate of the region. The county is protected from the cold winters and hot summers of the continental climate of eastern Washington by the Cascade Range on the east.

The normal monthly, seasonal, and annual temperature and precipitation, as compiled from records of the United States Weather Bureau Station near Puyallup, are shown in table 1.

Topography causes marked variations in rainfall and temperature. There is a progressive increase in average precipitation from 38.27 inches near Puyallup, where the elevation is 50 feet, to 76.91 inches at Longmire in Mount Rainier National Park (outside of area surveyed), where the elevation is 2,761 feet; and a decrease in average annual temperature from 50.8° at Puyallup to 44.6° at Longmire.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation near Puyallup, Pierce County, Wash.*

[ELEVATION, 50 FEET]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Total for the driest year	Total for the wettest year	Average snowfall
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	40. 1	63	−1	6. 40	5. 41	19. 74	0. 7
January	38. 6	66	−2	5. 49	4. 73	7. 00	3. 1
February	41. 9	69	−3	4. 00	3. 84	4. 56	2. 9
Winter	40. 2	69	−3	15. 89	13. 98	31. 30	6. 7
March	45. 1	81	21	3. 94	2. 86	6. 98	[3]
April	49. 8	90	24	2. 74	2. 03	1. 31	[3]
May	54. 4	89	30	2. 21	1. 28	4. 64	0
Spring	49. 8	90	21	8. 89	6. 17	12. 93	0
June	59. 6	97	34	1. 61	1. 15	1. 41	0
July	63. 6	99	38	. 79	. 46	. 97	0
August	63. 0	95	36	. 83	. 38	1. 81	0
Summer	62. 1	99	34	3. 23	1. 99	4. 19	0
September	58. 1	90	28	1. 84	. 25	4. 29	0
October	51. 7	78	23	3. 50	1. 48	3. 11	0
November	44. 1	70	18	4. 92	. 98	3. 25	1. 1
Fall	51. 3	90	18	10. 26	2. 71	10. 65	1. 1
Year	50. 8	99	−3	38. 27	[4] 24. 85	[5] 59. 07	7. 8

[1] Average temperature based on 40-year record, 1913 to 1952; highest and lowest temperature from 18-year record, 1913 to 1930.

[2] Average precipitation based on 40-year record, 1913 to 1952; wettest and driest on 39-year record, 1914 to 1952; snowfall on 18-year record, 1913 to 1930.

[3] Trace.

[4] In 1952.

[5] In 1933.

Seventy-three percent of the yearly average precipitation occurs during the 6 months beginning October 1 and ending March 31. There is no definite time for the beginning or ending of the rainy or dry seasons; the transitions from one to the other are gradual and variable. The driest months are usually July and August, and the wettest are November, December, and January. The lack of rain during summer months limits plant growth and yields materially, especially on soils with low water-holding capacity; but total crop failures from this cause are few. Supplementary irrigation is used to some extent, particularly on truck crops and pasture on the recent alluvial soils.

Relatively high humidity and frequent foggy mornings during winter are characteristic of the county. The average relative humidity varies from season to season, reaching complete saturation at times during winter months when the average at 8 a. m. is around 92 percent. During the summer months the relative humidity reaches a low average of 51 percent in July. For these months it is usually about 87 percent in the morning but drops to about 54 percent by evening.

The climate for the most part is moderate. The driest year (1952), recorded near Puyallup, was 13.42 inches below the average, and the wettest year (1933) was 20.8 inches above. Such extreme variation, however, is unusual. Most of the rain falls gently but steadily for a day or more at a time, and thunderstorms are uncommon. Hail is unknown, and the wind velocity seldom rises as high as 35 or 40 miles an hour. The average velocity for Tacoma is 7.9 miles an hour. The prevailing winds are from the southwest in winter months, and from the northwest in summer months. The average length of the frost-free season is 176 days at Puyallup—from April 23, the average date of the latest frost, to October 17, the average date of the earliest frost. Frost has been recorded as late as May 29 and as early as September 18, but such extremes are rare. Snow seldom falls at the lower altitudes and lasts only a few days, but deep snow covers the mountains at elevations of more than 2,000 feet during the winter months. The temperature seldom rises above 85° in summer, and in winter long periods of freezing weather are uncommon.

VEGETATION

Except for the Spanaway Prairie and few other small areas, Pierce County was covered by a dense coniferous forest. Douglas-fir was the dominant forest type and Western hemlock an important associate. Western red cedar grew in the wetter places, silver fir at the higher altitudes, red alder in poorly drained places, and black cottonwoods along the sandy stream bottoms. Coniferous saw-timber types occupy 319,000 acres, or approximately 37 percent of the total forest land. The volume of the county's 14½ billion board feet (log scale) merchantable saw-timber in 1939 was principally of Douglas-fir, Western hemlock, and Pacific silver fir (*4*).

Much of the virgin timber has been cut except in the mountainous regions. Cut-over land that has been protected from fire now supports a good growth of young trees, but large areas not so protected are devoid of forest growth or have very little reproduction. Douglas-fir is the predominant species on 91 percent of the area of second-growth coniferous types (pl. 1, *B*). Broad-leaved types consist principally of black cottonwood and red alder. Other common trees and shrubs are cascara, buckthorn, vine maple, Oregon maple, dogwood, willow, blackberry, evergreen blackberry, salmonberry, salal, Oregon grape, rhododendron, yew, madrona, elderberry, devilsclub, and wild blueberries (*Vaccinium ovatum*), commonly called huckleberry. Moss and lichens cover the forest floor, and bracken grows profusely in all open places at the lower altitudes.

The soils on Spanaway Prairie near Steilacoom are very gravelly and very porous. Under natural conditions trees probably never became established, or possibly the virgin timber was destroyed by fire

and second-growth trees were unable to compete with grass and ferns on the droughty soil. The vegetation now consists of small grass and forbs such as these: Silver hairgrass, lupines, cosmos, blue and yellow violets, prairie buttercups, shooting star, and some of the smaller bluegrasses and mosses. Since these plants make their growth before the dry summer months, they are able to maintain themselves. The mosses grow on the poorest and driest places where other vegetation is scarce. Scattered oaks grow at the edge of the prairie or in clumps upon it, but they are being slowly replaced by Douglas-fir trees that are rapidly reforesting the prairie. These trees were unable to establish themselves under natural conditions, but the weakening of the herbaceous cover by overgrazing and attempted cultivation have given them a foothold.[3]

WILDLIFE AND RECREATION

Deer, bear, and cougar are found in the more inaccessible parts of Pierce County, and pheasant, grouse, and quail are common game birds in the uplands. The many beautiful places, among which Mount Rainier and Puget Sound are outstanding; the nearly ideal summer climate in the mountains; and the good fishing attract thousands of visitors each year.

ORGANIZATION AND POPULATION

Pierce County was organized in 1852 as a part of the Oregon Territory (*5*). At that time the boundaries of the county were the Nisqually River on the south and the Puyallup River on the north. In 1901, following requests by the city of Tacoma, the northern boundary was extended to include all the Tacoma harbor area.

The earliest settlement was on the Nisqually River delta where the Hudson's Bay Company built a fort and trading post in 1833. Steilacoom, the first town, was laid out in 1853, although a store and a house had been built there in 1850, and the first farms were on the surrounding prairie. Gradually farms were started in the Puyallup Valley, and in 1861 a post office was established between the present sites of Puyallup and Sumner. Tacoma was laid out in 1868, Puyallup was organized in 1874, and Sumner in 1875. Other towns sprang up along the railroads, which were built in the latter part of the 1880's and in the 1890's.

The settlers came largely from Midwestern and Eastern States. They were chiefly native-born Americans, many being of Scandinavian ancestry. A number of Chinese and Japanese were brought in for labor by the early settlers, and their descendants are still in the county. The total population of the county in 1950 was 275,876.

INDUSTRIES

The county supports many industries. Tacoma, which has a population of 143,673, is an important seaport and industrial center. Its industries include sawmills, lumber-processing plants, furniture factories, flour and feed mills, and a smelter. Puyallup, Sumner, Buckley,

[3] For a more comprehensive discussion of the flora of this region, the reader is referred to Reconnaissance Soil Survey of the Eastern Part of the Puget Sound Basin, Washington (*9*).

Orting, Eatonville, Gig Harbor, Dupont, and Steilacoom are important trading and shipping points for their vicinities. Other trading points are Ashford, Elbe, National, and La Grande, in the southern part, and Kapowsin, McKenna, Roy, Carbonado, Wilkeson, South Prairie, Home, Vaughn, Elgin, Lakebay, Longbranch, Rosedale, and Fife, in the central and northern parts. A number of towns have sawmills, notably National, Eatonville, and Buckley. Logging is an important industry and is carried on by large- and small-scale operators, although not much virgin timber is left except in the National forest area. Some coal is mined and sandstone quarried in the vicinity of Carbonado and Wilkeson.

TRANSPORTATION

Tacoma is located on four transcontinental railroads and most of the towns in the county are served by these lines or their branches. Hard-surfaced roads lead to all parts of the county, and there is a system of connecting gravel roads. Frequent ferry service is available between the mainland and the islands and peninsula. More than 60 steamship lines connecting the United States and foreign countries use Tacoma as a port.

SCHOOLS, CHURCHES, AND HOME IMPROVEMENTS

Free transportation, mainly by buses, is provided for school children. Most of the schools are consolidated. Churches are located in many of the rural sections as well as in the towns. Most farms have well-kept houses with electricity and good water. The degree of improvement, however, depends upon the quality of the land, the character of the settlement, and the type of farming. Farms in areas suited to dairy farming, as those near Buckley, have very good improvements and well-kept fences. Those in areas best adapted to small truck farming have some very fine houses, but many small, poorly kept buildings. In areas that have been recently cleared of timber and are farmed part time, the farms have, as a rule, poorer buildings than those in other parts of the county and very few fences. Farmers in these areas usually build their own house and barns during their spare time and many are continually remodeling or repairing their buildings. Some of the older settlements, especially in the prairie region near Orting and on South Prairie, have large rambling farmhouses that have been kept in fairly good condition.

AGRICULTURE

As early as 1843 the Puget Sound Agricultural Company, a subsidiary of the Hudson's Bay Company, grazed large numbers of cattle and sheep on the tall grass of the prairies near Steilacoom. These cattle and the grain grown by the farmers who came to the county in the 1850's were sent by ship to Alaska to be traded to the Russians for furs. The prairies were farmed first, because they could be plowed and seeded at once. Very little other land was cleared for farming until after it had been logged.

In 1920, the improved land in 3,159 farms totaled 41,953 acres; in 1930, 4,696 farms had 52,204 acres of improved land; in 1940, 5,622 farms had 59,427 acres; and in 1950, 4,303 farms had 52,839 acres.

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There has been a change from general to more specialized crops. The new land under cultivation has been used to grow increasingly large acreages of hay and berries.

CROPS

The acreage of the principal crops in specified years from 1919 to 1949 is given in table 2.

TABLE 2.—*Acreage of the principal crops and the number of fruit trees and grapevines in Pierce County, Wash., in stated years*

Crop	1919	1929	1939	1949
Corn:	*Acres*	*Acres*	*Acres*	*Acres*
For grain	190	2	69	8
For forage	93	145	251	32
For silage	710	186	320	203
Wheat	423	303	263	227
Oats	1,847	950	1,245	968
Barley	82	62	16	61
Rye	196	8	18	36
All hay	13,026	15,938	20,460	15,277
Timothy and clover alone or mixed	5,626	4,491	5,584	5,934
Sweetclover	521	747	206	(1)
Alfalfa	18	159	266	313
Wild hay	994	1,339	1,437	2,444
All other cultivated grasses	1,455	2,693	4,458	3,621
Grains cut green	4,213	6,131	8,041	2,965
Legumes cut for hay	199	378	468	(1)
Hops	(1)	472	395	204
Potatoes	2,048	893	326	65
All other vegetables	989	1,856	2,968	2,359
Strawberries	308	516	297	154
Raspberries and loganberries	960	2,531	1,915	[2] 1,779
Blackberries and dewberries	594	1,386	1,156	715
	Number	*Number*	*Number*	*Number*
Apple trees	109,404	63,979	39,220	19,343
Peach do	764	1,010	3,794	12,904
Pear do	13,065	10,886	9,302	4,033
Plum and prune do	14,345	12,203	8,386	6,157
Cherry do	17,703	50,233	46,821	16,579
Apricot do	6	(1)	65	127
All nut do	76	127	2,561	4,070
Grapevines	3,213	16,806	15,985	4,742

[1] Not reported.
[2] Also includes boysenberries and youngberries.

Hay, grain, and tree fruits, except sour cherries, are grown for local consumption. Much of the hay grown in the county consists of oats, or oat-annual legume mixtures cut green. Some grain and hay are imported in order to satisfy local demands. Sources of cash income, other than dairy and poultry products, are raspberries, blackberries, loganberries, strawberries, sour cherries, peas, vegetables, hops, bulbs, and rhubarb. The raspberries, blackberries, and loganberries are either shipped fresh to middlewestern and eastern cities or canned at Puyallup or Sumner. Sour cherries are canned at Puyallup or Sumner. Most vegetables are consumed locally or in Seattle and Tacoma,

but pod peas, lettuce, and celery are shipped to other markets. Peas for canning and freezing at the local canneries are grown on increasingly large acreages. Rhubarb grown in greenhouses has a ready market.

On the Longbranch Peninsula and on the islands of the county, blueberries, commonly referred to as huckleberries, are an important crop. These berries grow wild on the poorest land and are harvested in late fall. Some are used locally but most of them are canned in Seattle and Tacoma and shipped to eastern markets.

Plowing for most crops is done in spring. Much of the plowing is done by persons hired for the purpose. Most operations are carried on with one- or two-horse implements or by hand labor, although tractors are used by some farmers having enough land to make them profitable.

Farm labor, necessary chiefly for picking berries and hops, is adequately supplied locally or from nearby cities. Women and girls are most in demand for berry picking, and transient labor is discouraged. Many of the people employed are of Japanese ancestry.

FERTILIZERS

In addition to commercial fertilizer, manure is used whenever available. The application of fertilizer is commonly dependent on the kind of crop rather than soil needs and conditions, although not entirely so. Some crops respond to small applications of boron. In the future phosphorus will probably be used more extensively than it has been in the past.

LIVESTOCK

Dairying is the most important agricultural industry, and many of the finest dairy herds in Washington are in the county. Cattle and calves of all ages numbered 23,966 in 1950. Most of the cattle raised are dairy breeds, dominantly Holsteins, although a number of beef cattle, namely Herefords, are produced near Eatonville. A total of 59,911,288 pounds of whole milk were sold during 1949. Counties surpassing this production were Whatcom, King, Snohomish, Yakima, Clark, and Skagit. Butterfat production per cow is among the highest in the State.

More land is used for pasture and hay crops than for all other crops combined. Many fields used by dairy herds are in permanent pasture of a high carrying capacity. Because dairying cannot compete with truck crops and berries on the highly productive soils of the bottom lands in Puyallup Valley, many good dairy farmers are gradually being forced to move from this area to less desirable soils of the uplands. Dairying is apparently very successful on the Buckley and Enumclaw soils near Buckley. Some areas of these soils are cut-over land that could be developed for dairy farming.

Poultry is exceedingly important; the eggs sold were 4,104,380 dozen in 1950. The county ranks third in the State both in quantity and value of the poultry produced. Poultry farms are located on many different soil types. Flocks that are allowed to range do better on productive well drained or moderately well drained soils that produce an abundance of grass than on very sandy or excessively drained soil where grass production is poor. The county has many well bred chickens and numerous modern hatcheries.

Comparatively few sheep and hogs are raised. A total of 1,071 sheep and 5,509 swine of all ages were in the county in 1950. Horses and colts of all ages in 1950 numbered 1,699.

SIZE OF FARMS AND FARM TENURE

During the 30 years from 1920 to 1950 the number of farms in the county increased from 3,159 to 4,303, but the average size of each farm increased from 37.6 acres to 38.6 acres. Only a few farms are large. The improved land in 1950 averaged about 12 acres per farm. This extremely low average of improved land is due to the large numbers of 2- or 3-acre farms operated by families who depend for the major part of their income on factories, sawmills, or logging camps. Layoffs in the lumber industries, however, have in many instances forced these families to depend on their farms for a living. The small size of these farms and the fact that they are generally so close together that expansion in many cases could be accomplished only by reducing the number of units has created a grave economic problem on the poorer soils, particularly in the area immediately southeast of Tacoma. On the better soils, as the medium-textured well drained soils of the bottom land, a few acres in truck crops or berries will support a family.

Most of the farms are operated by their owners. Of the 4,303 farms, 3,751 were operated by full owners in 1950, and only about 226 by tenants. Part owners operated 308, and hired managers 18. Most farms rent for cash.

SOIL SURVEY METHODS AND DEFINITIONS

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

The color of each layer is noted. The darkness of the surface layer is usually related to its organic-matter content; streaks and spots of gray, yellow, and brown in lower layers generally indicate poor drainage and poor aeration. Other details studied by the soil surveyor are: Texture, structure, consistence, acidity, the depth to bedrock or to compact layers, the quantity of gravel or rocks that may interfere with cultivation, the steepness and kind of slope, the quantity of soil lost by erosion, and other external features of the soil.

Texture, or the content of sand, silt, and clay in each layer, is determined by the feel and is checked by mechanical analysis in the laboratory. Texture determines to a considerable extent the quantity of moisture the soil will hold available to plants, whether plant nutrients or fertilizers will be held by the soil in forms available to plants or will be leached out, and the difficulty or ease of cultivating the soil. Structure, or the way the soil granulates and the amount of pores or open spaces between particles, indicates how easily plant roots can penetrate the soil and how readily water can enter it. Consistence, or the tendency of the soil to crumble or to stick together, determines

the degree of difficulty that will be encountered in keeping the soil open and porous under cultivation. The kind of rock material from which the soil has been developed, or its parent material, affects the quantity and kind of plant nutrients the soil may have naturally. Simple chemical tests show how acid the soil may be.[4]

On the basis of all these characteristics, soil areas that are much alike in the kind, thickness, and arrangement of their layers are mapped as one soil type. Some soil types are separated into two or more phases. For example, if a soil type has slopes that range from 6 to 25 percent, the type may be mapped in two phases, a rolling phase (6 to 15 percent slopes), and a hilly phase (15 to 25 percent slopes). A soil type will be broken into phases primarily because of differences in the soil other than those of kind, thickness, and arrangement of layers. The slope of a soil, the frequency of outcropping bedrock, the extent of its erosion, or the artificial drainage used on the soil are examples of characteristics that might cause a soil type to be divided into phases.

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

The name of a place near where a soil series was first found is chosen as the name of the series. Thus, Kapowsin is the name of an imperfectly drained soil of the uplands. Three types of the Kapowsin series are found—Kapowsin gravelly loam, Kapowsin gravelly sandy loam, and Kapowsin gravelly clay loam. These differ in the texture of the surface soil, as their names show. Kapowsin gravelly loam and Kapowsin gravelly sandy loam are divided into two phases each, because some of their area is undulating and some is moderately steep; and Kapowsin gravelly clay loam is also divided into two phases—undulating and hilly.

When very small areas of two or more kinds of soil are so intricately associated that they cannot be shown separately on a map at the scale used, they are mapped together, and the areas of the mixture are called a soil complex. Buckley-Enumclaw loams is a complex of Buckley loam and Enumclaw loam.

Bare rocky mountainsides, riverwash, or other similar areas that have little true soil are not designated by series and type names but are given descriptive names such as Rough mountainous land, Rough stony land, and Riverwash.

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[4] Indicator solutions are used to determine the reaction of the soil. Lime is detected by application of dilute hydrochloric acid. The total content of readily soluble salts is determined by the use of the electrolytic bridge. The acidity or alkalinity of the soil is expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values, alkalinity; and lower values, acidity. Terms that refer to reaction that are commonly used in this report are as follows:

	pH value		*pH value*
Extremely acid	Below 4.5	Neutral	6.6–7.3
Very strongly acid	4.5–5.0	Mildly alkaline	7.4–8.0
Strongly acid	5.1–5.5	Strongly alkaline	8.1–9.0
Medium acid	5.6–6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1–6.5		

SOILS

The soils of Pierce County are typical of the soils of many of the other counties of western Washington. They range from slightly to strongly acid in the surface soil but generally become less acid with depth. The color ranges from light grayish brown to nearly black and is brown or yellowish brown in many areas. The color is affected to a marked degree by the drainage and kind of natural vegetation. The more poorly drained areas have the darkest color. Most of the well-drained soils are brown, but the surface soil of a few is light grayish brown, and that of prairie areas is nearly black. The relative stability of the aggregates in the surface soil when in water, the good permeability, and the rapid growth of vegetation help keep erosion at a minimum.

The productivity of the soils varies widely. The deep medium-textured soils on the recent alluvial deposits are the most productive, and the excessively drained soils of the terraces and uplands the least. Most of the organic soils are also very productive. The soils respond to fertilizer and good farming practices, and on many of the better ones irrigation is beneficial and profitable. Drainage would improve some areas, but many others are more productive because imperfect drainage conditions permit the retention of moisture.

SOIL SERIES AND THEIR RELATIONS

The soils can be divided into six major classes as follows: Mineral soils of the uplands; mineral soils of depressions in the terraces and uplands; mineral soils of the terraces; mineral soils of the bottom lands; organic soils; and miscellaneous land types. Within these groups the soils vary in kind of parent materials and drainage.

MINERAL SOILS OF THE UPLANDS

The mineral soils of the uplands belong to the following series: The excessively drained Everett; the well-drained Barneston, Cathcart, Indianola, Kitsap, and Stossel; the moderately drained Alderwood, Sinclair, and Wilkeson; and the imperfectly drained Bow and Kapowsin. These soils occupy a larger area than all the other soils, excluding the miscellaneous land types, combined. They were originally covered with a dense forest, and many areas are still in virgin or second- or third-growth timber. All these soils are slightly to medium acid, most have a brown or yellowish-brown surface soil and a yellowish-brown subsoil, and a few have a light grayish-brown surface soil and subsoil. Most of their surface soils contain firm or hard concretions called shot. The productivity depends on the texture of the profile, the drainage, and the composition of the parent material.

Both the Everett and Barneston soils are derived from gravelly glacial drift. The Barneston soils occur at higher elevations than the Everett, receive more precipitation, and as a rule produce slightly better timber. The soils of neither series are very good for farm crops, because of their gravelly subsoil and substratum. Both series have sandy surface soils, mostly gravelly sandy loam and gravelly loamy sand, but some areas of Everett stony loamy sand are

mapped. The sandy loam is better for timber production than the loamy sand, on which second-growth timber grows very slowly. Timber production does not seem to be greatly influenced by the range in relief (6 to 25 percent) on these two soils.

The Cathcart soil is derived from a mixture of glacial drift and sandstone and shale. It occupies only a small area that is mainly in timber.

The Indianola soils, most of which are rolling or steep, are derived from sandy glacial materials. Several areas are in cultivated crops. Alfalfa is commonly planted on cleared areas that have favorable relief. Boron deficiency is evident in most fields, but it can be controlled by the application of about 30 or 40 pounds of borax to the acre (*2*).

The Kitsap soils, providing they have favorable relief, are probably the best soils of the uplands for most farm crops. These soils are derived from silty lake-laid sediments and appear to retain moisture much better than most of the other soils of the uplands. Most farmers find the Kitsap soils strong and productive, but in need of fertilizer for best production.

The Stossel soils are derived from bouldery till and an admixture of highly colored shale; they are easily identified by their bright variable colors. They occupy but a few acres and are used only for timber.

The extensive Alderwood soils, which occur in many counties of western Washington, are derived from sandy clay till and are often closely associated with the much more droughty Everett soils. They are more productive both for cultivated crops and for timber than the Everett soils. They are underlain at depths of 18 inches to 3 feet by a cemented gravelly sandy clay hardpanlike layer. This layer, although restricting root penetration in places, retains moisture during the dry summer period and contributes to productivity. The most favorable sites for farm crops on the Alderwood series are stone-free areas having smooth or gently undulating relief and heavy sandy loam or loam surface soil.

Soils of the Sinclair series have a light-colored surface soil that is exceedingly high in shot and a hardpanlike layer not quite so consolidated as that in the Alderwood series; in other respects the two series are similar. On comparable relief the Sinclair soils are not so productive for general farm crops as the Alderwood and are mainly used for timber.

The extensive Wilkeson soils in the eastern part of the county have a hilly relief with usually rounded hills. They are derived from a mixture of loesslike material, probably pumice, and basaltic fragments that probably were affected by Cascade glaciers. These soils have very good structure, are deep and permeable, and should be productive, but they are mostly in timber. Some of the cut-over areas are used for grazing beef cattle and sheep. The few cultivated areas are not productive, probably because of lack of available nitrogen and other plant nutrients.

The imperfectly drained Bow soils are derived from nearly gravel-free tight clay till and occur in only a few areas near the bay. They resemble the Kitsap soils but have a considerably heavier textured subsoil and substratum and some stone and gravel. They are used chiefly for hay and pasture.

The soils of the Kapowsin series are the best of those derived from glacial till. They differ from the closely associated Alderwood soils in having a slightly heavier textured and more mottled subsoil. The subsoil is underlain by a sandy clay till hardpan that is as hard as that in the Alderwood series. Most of the Kapowsin soils occupy nearly level to gently sloping relief that is favorable for crops, and a fairly large percentage of them is cultivated. The yields are not high, but farmers are able to make a living by producing some grain and hay for their dairy herds.

MINERAL SOILS OF DEPRESSIONS IN THE TERRACES AND UPLANDS

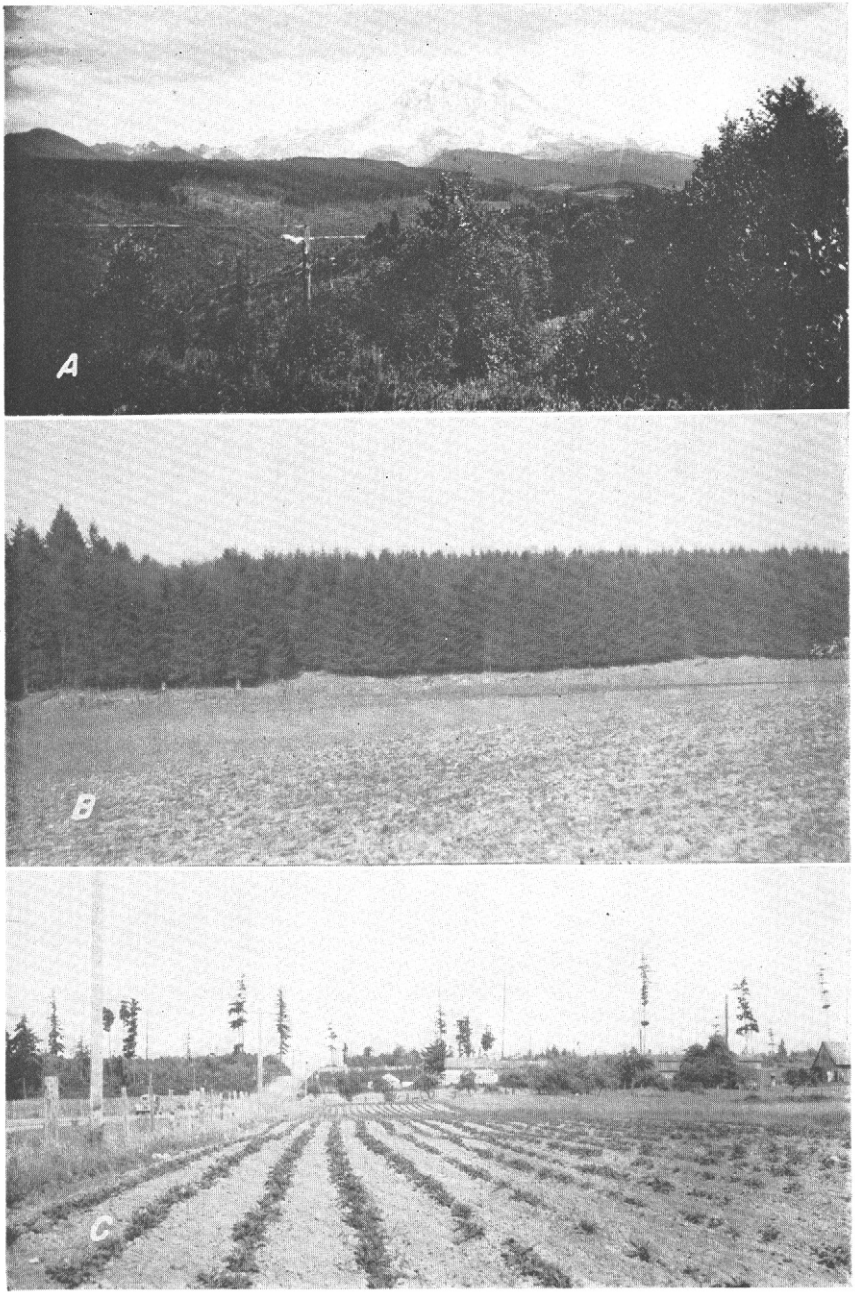
The mineral soils of the depressions in terraces belong to the Buckley, Enumclaw, and Orting series. Although these soils occur on terraces or terracelike positions, their parent materials consist of relatively compact and cemented glacial till. Buckley soils have dark-gray or black surface soils and gray subsoils, which are streaked with dull brown in the lower part. Surface runoff and internal drainage are slow. The imperfectly drained Enumclaw soils occur in association with Buckley soils, but they are at slightly higher elevations and therefore somewhat better drained in the surface layers. Orting soils have dark brownish-gray surface soils and brown mottled subsoils, are imperfectly drained, and are associated with more recent alluvial soils.

The mineral soils of the depressions in the uplands are in the Bellingham, Kopiah, McKenna, Norma, and Tisch series. All are imperfectly or poorly drained and require some form of artificial drainage before they can be used successfully for cultivated crops. They may be saturated several months each year by runoff from adjacent areas. As a consequence they produce a higher percentage of grass than soils on the better drained adjacent slopes, are generally darker and heavier textured, and have a deeper surface soil. Most areas are highly prized for pasture, and many cut-over areas are used for pasturing dairy herds. These soils are important because they provide good pasture and hay crops on farms having mainly the drier soils of the uplands that are unsuited to hay crops and late summer pasture.

The lightest colored soils of the depressions are those of the Kopiah series. Owing in part to their very dense, heavy-textured subsoil, they are the least favorable soils of the group for grass production.

The Norma, McKenna, and Bellingham soils are all closely related in drainage, position, and occurrence. All of them occupy depressions, ranging in size from 1 to 60 acres; all are dark and granular and have a high organic-matter content. They are used mostly for pasture, but some areas of the Bellingham series are used for grain and potatoes. The Norma soil has a sandy mantle over till or lake sediments and a sandy-textured subsoil. The McKenna soils have a gravelly mantle over till and have gravel or stone, or both, throughout the profile. The Bellingham soils, generally gravel free, have a silty mantle over till or lake sediments and a heavy-textured subsoil and substratum.

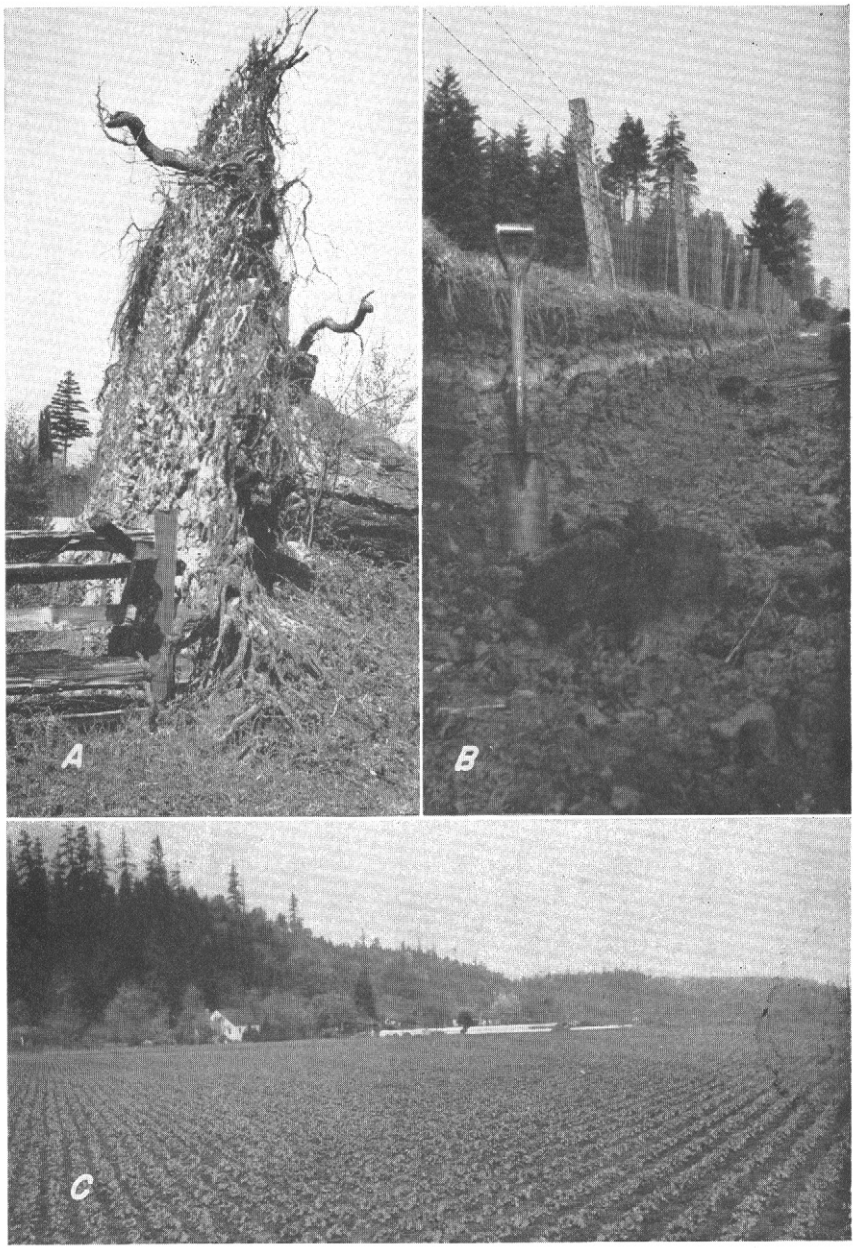
The Tisch soil is very similar to the Bellingham but has a layer or layers of diatomaceous earth, generally within 30 inches of the surface. In places where the diatomaceous layer is exposed, the soil is used for oats and appears to be fairly well adapted to that crop. Most of the Tisch soil is cultivated to grain.



A, Landscape showing old plateaus and mountain foot slopes; Mount Rainier in background; Wilkeson loam, rolling, in foreground.

B, Second-growth conifers on Everett gravelly sandy loam, rolling; Enumclaw fine sandy loam in foreground.

C, Potatoes and oats in basinlike area of Bellingham silt loam; Kapowsin gravelly sandy loam, undulating, on ridge.



A, Uprooted tree shows depth of root system and mat of roots above the hardpan on Alderwood gravelly sandy loam, rolling.
B, Roadside ditch bank in Dupont muck. The narrow white layer is diatomaceous material.
C, Lettuce on Carbondale muck in the Stuck River valley.

MINERAL SOILS OF THE TERRACES

The mineral soils of the terraces are the excessively drained Fitch, Lynden, Nisqually, Spanaway, and Skykomish soils, the well-drained Greenwater and National, and the poorly drained Edmonds. Most of them have a level or nearly level relief favorable for cultivation, but some areas of the Spanaway and Fitch soils have 3- or 4-foot mounds that are somewhat difficult to make level.

The Lynden, Nisqually, and Edmonds soils have similar texture and are derived from similar parent materials, but they are very different from one another in other respects. The Lynden soil developed under forest vegetation and has a brown friable granular surface soil underlain by a yellowish-brown subsoil that grades into very sandy material. The Nisqually soils, which developed under grass and fern vegetation, have a very dark-gray or nearly black sootlike surface soil that grades into a brown subsoil, which in turn grades into very coarse textured materials. The Edmonds soil developed under water-loving vegetation and has a grayish-brown surface soil over mottled rusty-brown and gray subsoil that grades into wet coarse-textured materials.

The Spanaway soils, which are similar in many respects to the Nisqually soils, have likewise been developed under a grass, fern, and moss vegetation and have a dark surface soil. They differ from the nearly gravel-free Nisqually soils in that they are very gravelly throughout.

The Fitch soils are as gravelly as the Spanaway, but they are not so dark and occupy a transition zone where the forests are encroaching on the prairies.

The Skykomish soils, which are exceedingly gravelly and cobbly, occur on river terraces. They have brown surface soils and light-yellowish subsoils that grade into grayish-yellow cobbly gravel materials at a fairly shallow depth. Most all areas are used exclusively for timber.

The very gravelly Greenwater soil occurs in areas of high precipitation and cold climate and is used mostly for timber. The soil in most areas contains pumice. The associated National soils also contain pumice. They are derived from medium-textured material and therefore have a much higher water-holding capacity and are more productive than the Greenwater soil.

MINERAL SOILS OF THE BOTTOM LANDS

The mineral soils of the bottom lands include the excessively to well-drained Newberg series, the excessively drained Pilchuck series, the well-drained Chehalis and Puyallup series, the imperfectly drained Sultan, and the poorly drained Wapato and Puget series. These nearly level soils, totaling about 15 square miles, occur on the alluvial bottoms of the larger streams, mostly in the valleys of the Puyallup and Stuck Rivers. They were subject to overflow until extensive systems of levees were built and the channels of the Puyallup and Stuck Rivers were straightened.

The most important agricultural soils in the county are in this group, although some of the poorest are also included. The texture range is from clays too heavy for good agricultural use to gravelly sands too droughty for any use. Raspberries, blackberries, strawberries, canning and freezing peas, hops, flower bulbs, vegetables, rhu-

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barb, and hay and pasture crops are all grown and give excellent yields. In general, hay and pasture crops, blackberries, and peas do best on the silt loam soils, although they do nearly as well on the loams. Raspberries, hops, bulbs, and rhubarb do well on loams and sandy loams.

Farms are small on these soils; and except for the very heavy and some of the very sandy and gravelly soils, nearly all of the land is under cultivation. Applications of manure and phosphate fertilizer (*13*) are needed to give the best yields, but ammonium-phosphate and complete fertilizers are used with success. Generally fertilizers are applied and tillage practiced according to the immediate needs of the crops rather than to the particular needs of the soil.

The Chehalis and Newberg soils occupy only a small acreage in the county and can be readily distinguished from the Sultan, Puyallup, and Pilchuck by their browner color. The Chehalis and Sultan are underlain by medium-textured materials, whereas the Newberg, Puyallup, and Pilchuck soils are underlain by coarse-textured materials.

The Puget soils are similar to the Sultan soils except that they are heavier and less permeable. Most areas of the Puget soils in the county occur near Tacoma in low positions where they are affected by a high water table that fluctuates somewhat with the tide and consequently would be difficult to lower.

ORGANIC SOILS

The organic soils are widely distributed throughout the county in depressions, old glacial lake basins, low back bottoms, stream valleys, and areas adjacent to lakes and along small streams. They are derived from the remains of plants in various stages of decomposition but frequently in a high state of preservation where conditions have inhibited decay. Plant succession during the accumulation was important in determining the character of the profile. The composition of the soil and the depth and degree of decomposition of organic materials are necessary considerations in determining their suitability for different uses.

Peat is an organic soil in which the remains of the plants may be identified as partly decomposed fibrous and matted materials. Rifle peat (from woody material), Mukilteo peat (from sedges), Greenwood peat (from mosses), and Tanwax peat (from microscopic plants and fine colloidal sediments) are peat soils in this area.

Muck consists of well-decomposed, finely divided organic plant remains usually mixed with considerable mineral material. The fibers of the organic materials are not readily recognizable, but the muck materials are identified by the vegetative cover or by their association with identified peats. Carbondale muck (from woody material); Semiahmoo muck (from sedges); Dupont muck (from woody material, sedges, and diatomaceous earth); and Tacoma muck (from salt-water sedges) occur in this area. Snohomish soils consist of a mineral surface soil layer of recent alluvial origin overlying organic layers of peaty and mucky materials. They are poorly drained and are associated with areas of organic soils.

MISCELLANEOUS LAND TYPES

The miscellaneous land types are Rough mountainous land, Rough broken land, Rough stony land, Riverwash, Tidal marsh, Made land, and Coastal beach. The Rough mountainous land is of the greatest extent and is valued for its timber production.

SOIL TYPES AND PHASES

In the following pages the soil types, phases, complexes, and miscellaneous land types are listed in the alphabetical order of the series. The soil types are described in the order of their extensiveness or importance in the series. The soils are described in their relation to agriculture, location, and profile characteristics. The approximate acreage and the proportionate extent of the soils mapped in the county are shown in table 3.

TABLE 3.—*Approximate acreage and proportionate extent of the soils of Pierce County, Wash.*

Soil	Acres	Percent
Alderwood gravelly loam, rolling	1, 812	0. 3
Alderwood gravelly sandy loam:		
Hilly	7, 162	1. 0
Rolling	32, 456	4. 6
Barneston gravelly loamy sand:		
Hilly	750	. 1
Rolling	11, 157	1. 6
Barneston gravelly sandy loam:		
Hilly	11, 887	1. 7
Rolling	2, 304	. 3
Barneston-Wilkeson complex	2, 628	. 4
Bellingham silt loam	1, 993	. 3
Bellingham silty clay loam	866	. 1
Shallow surface soil	621	. 1
Bow clay loam:		
Rolling	1, 855	. 3
Steep	83	(1)
Buckley-Enumclaw loams	1, 494	. 2
Buckley loam	4, 036	. 6
Hardpan	92	(1)
Carbondale muck	483	. 1
Shallow (over Rifle peat)	470	. 1
Cathcart loam, hilly	129	(1)
Chehalis silt loam	348	(1)
Coastal beach	195	(1)
Dupont muck	1, 735	. 2
Edmonds fine sandy loam	270	(1)
Enumclaw fine sandy loam	355	. 1
Enumclaw gravelly sandy loam	1, 184	. 2
Enumclaw loam	54	(1)
Everett gravelly loamy sand:		
Hilly	7, 081	1. 0
Rolling	35, 117	5. 0
Everett gravelly sandy loam:		
Hilly	7, 201	1. 0
Nearly level	2, 119	. 3
Rolling	44, 397	6. 3
Everett stony loamy sand	9, 305	1. 3

See footnotes at end of table.

TABLE 3.—*Approximate acreage and proportionate extent of the soils of Pierce County, Wash.*—Continued

Soil	Acres	Percent
Fitch gravelly sandy loam:		
Hilly	2, 938	.4
Undulating	6, 242	.9
Gravel pits	103	(1)
Greenwater loamy sand	4, 790	.7
Greenwood peat	122	(1)
Indianola loamy sand:		
Gently rolling	9, 463	1.4
Moderately steep	1, 416	.2
Indianola sandy loam, gently rolling	1, 244	.2
Kapowsin gravelly clay loam:		
Hilly	258	(1)
Undulating	2, 232	.3
Kapowsin gravelly loam:		
Moderately steep	488	.1
Undulating	24, 995	3.6
Kapowsin gravelly sandy loam:		
Moderately steep	1, 890	.3
Undulating	26, 322	3.8
Kitsap-Indianola complex	258	(1)
Kitsap loam, undulating	1, 185	.2
Kitsap silt loam:		
Steep	315	(1)
Undulating	1, 608	.2
Kopiah loam	176	(1)
Kopiah silty clay loam	310	(1)
Lynden loamy sand	970	.1
Made land	2, 097	.3
McKenna gravelly loam, nearly level	3, 081	.4
McKenna loam:		
Nearly level	438	.1
Sloping	203	(1)
Mukilteo peat	1, 248	.2
Shallow	53	(1)
National pumicy loam	417	.1
National pumicy sandy loam	2, 814	.4
Newberg fine sandy loam	475	.1
Newberg loam	146	(1)
Newberg loamy sand	139	(1)
Nisqually loamy sand	3, 377	.5
Nisqually sand	85	(1)
Norma fine sandy loam	1, 963	.3
Orting gravelly sandy loam	258	(1)
Orting loam	2, 864	
Orting sandy loam	137	(1)
Orting stony sandy loam	157	(1)
Pilchuck fine sand	5, 426	.8
Pilchuck fine sandy loam	410	.1
Pilchuck gravelly sand	1, 176	.2
Pilchuck loamy fine sand	449	.1
Puget clay	173	(1)
Puget silt loam	375	.1
Puget silty clay loam	152	(1)
Puyallup fine sandy loam	7, 874	1.1
Puyallup loam	1, 867	.3
Puyallup loamy fine sand	3, 614	.5
Puyallup sandy loam, shallow (over Buckley loam)	83	(1)
Puyallup silt loam	506	.1
Puyallup silty clay loam	78	(1)

See footnote at end of table.

TABLE 3.—*Approximate acreage and proportionate extent of the soils of Pierce County, Wash.*—Continued

Soil	Acres	Percent
Rifle peat	809	.1
Shallow	196	(1)
Riverwash	3,180	.5
Rough broken land	69,101	9.8
Rough mountainous land	132,729	18.9
Rough stony land	10,726	1.5
Semiahmoo muck	1,169	.2
Shallow	1,191	.2
Shallow (over Mukilteo peat)	2,177	.3
Shallow (over Tanwax peat)	970	.1
Sinclair gravelly fine sandy loam:		
Hilly	1,887	.3
Rolling	16,521	2.4
Sinclair gravelly loam:		
Hilly	444	.1
Rolling	6,471	.9
Skykomish stony sandy loam	438	.1
Snohomish fine sandy loam	97	(1)
Snohomish loamy fine sand	116	(1)
Snohomish silt loam	687	.1
Spanaway gravelly sandy loam:		
Deep, nearly level	12,051	1.7
Gently undulating	68,121	9.7
Moderately steep	889	.1
Stossel stony loam, hilly	1,094	.2
Sultan fine sandy loam	972	.1
Sultan loam	1,572	.2
Sultan silt loam	2,601	.4
Tacoma muck	1,747	.2
Tanwax peat	684	.1
Tidal marsh	417	.1
Tisch silt loam	1,279	.2
Wapato clay loam	257	(1)
Wilkeson loam:		
Hilly	10,710	1.5
Rolling	27,539	3.9
Wilkeson silt loam, rolling	2,628	.4
Total	702,569	100.0

[1] Less than 0.1 percent.

Alderwood gravelly sandy loam, rolling (6 to 15 percent slopes) (Ac).—This phase is important in the uplands in the northwestern part of the county. It occupies rolling relief in association with Everett gravelly sandy loam and other upland soils. The soil was developed on glacial drift materials derived from granite, basalt, diabase, sandstone, shale, conglomerate, and quartzite. Surface runoff is slow, but internal drainage is medium. Most uncleared areas, which are in second- or third-growth timber, produce Douglas-fir and alder and an undergrowth of vine maple, vines, and shrubs.

Under virgin conditions a fairly thick layer of forest litter and leaf mold covers the soil. The yellowish-brown or brown gravelly sandy loam surface soil becomes less brown and more yellow with depth and passes sharply at an average depth of 28 to 32 inches into dull-gray,

gravelly, indurated, unassorted till or hardpan that is many feet thick. The upper 15 or 20 inches contain many small brown or rust-brown concretions, accretions, or shot, which range from the size of medium sand grains to one-fourth inch in diameter (*14*). Very few shot occur below about 20 inches. Absence of shot pellets, paler color, and decreasing quantities of organic matter with depth are characteristic of the soil profile.

The entire profile above the cemented substratum is friable but has enough consistency to stand when in a cut bank. The glacial boulders scattered on the surface and throughout the profile seldom interfere with tillage. Surface runoff is slow, and the compact underlying till slows down internal drainage and causes a temporary perched water table. The excess water causes little injury in most places because it occurs during the rainy season when most plants are dormant. The hardpan holds moisture within reach of the growing plants during the summer months. The indurated till, or hardpan, is not a true soil hardpan, but the term is descriptive because the material is nearly as hard as rock. Roots do not penetrate this part of the profile but spread out along its surface, forming a distinct mat (pl. 2, *A*).

The usual minor variations occur in texture and color of the soil, and the depth to the hardpan ranges from 16 to as much as 48 inches in extreme instances. Areas associated with the Buckley and Enumclaw soils have a more weakly cemented hardpan than other areas in the county.

Use and management.—This is one of the better upland agricultural soils. It is naturally suited to most staple crops grown in the county, especially hay, pasture, fruits, and the earlier maturing berries. Most farms on this soil are small, and hay and pasture are the chief crops. On nearly all farms some fruit is grown for home use. On the peninsula in the extreme northwestern part of the county, the climatic conditions make this soil especially favorable for loganberries but market conditions have prevented the planting of large acreages.

Barnyard manure is the most common amendment used, although some commercial fertilizer is applied for fruit and berries. Cover crops are being used more frequently with berries.

Alderwood gravelly sandy loam, hilly (15 to 25 percent slopes) (AB).—The small scattered areas of this phase are closely associated with the other Alderwood soils. Very little of it is cleared of trees, brush, and stumps and cultivated, but some grapes and berries are grown on southern and western slopes and limited acreages are used for pasture. This phase is considered more valuable for timber than for crops. Soil developed on areas having slopes of more than 25 percent is classified as Rough broken land.

Alderwood gravelly loam, rolling (6 to 15 percent slopes) (AA).—This inextensive phase is closely associated with Alderwood gravelly sandy loam, rolling. The relief is more nearly level than that of the associated soil, and the texture heavier. Both runoff and internal drainage are therefore somewhat slower. Areas are seldom level enough or fine-textured enough, however, to cause a drainage problem. The first few inches of the surface soil are browner and the profile is less gravelly than in Alderwood gravelly sandy loam, rolling. The quantity of shot and the depth to the hardpan are similar in both soils.

The slope range is from 6 to 15 percent, but slopes from 4 to 6 percent are included.

The larger areas occur south and west of the Edgemont school, but scattered areas are southeast of Tacoma and near Wollochet and Arletta. Near the Edgemont school the soil contains more fine material and is less brown than usual, being similar to the associated Kapowsin soils. Where associated with the Buckley and Enumclaw soils, Alderwood gravelly loam, rolling, has a less cemented hardpan and more clay in the substratum than in other areas, but production of trees and agricultural crops is about the same.

Use and management.—The heavier texture of this phase, and the consequent higher water- and plant-nutrient supplying capacity make it a more desirable agricultural soil than Alderwood gravelly sandy loam, rolling. Most areas are under cultivation. Crops are the same as on Alderwood gravelly sandy loam, rolling, but yields are generally a little higher under the same conditions, and the percentage of the soil in berries and fruit, especially strawberries and blackberries, is probably larger.

The same methods of fertilizer application are followed as on Alderwood gravelly sandy loam, rolling. Manure is the most frequently used amendment, the available supply governing the quantity applied.

Barneston gravelly sandy loam, rolling (6 to 15 percent slopes) (Bd).—This gravelly, droughty soil, which usually is relatively stony, occurs chiefly north and east of Kapowsin, generally on rolling or strongly rolling topography. Like the soils of the Everett series, it developed on loose, permeable, gravelly drift but generally at somewhat higher elevations and under higher precipitation and more dense coniferous forests. The gravel in Barneston gravelly sandy loam is more highly weathered than that in the Everett soils and is coated with fine materials and stained with iron. All areas have rapid internal drainage.

In virgin forested areas the soil is covered to a depth of approximately an inch by undecomposed forest litter of coniferous needles, twigs, and woody fragments. The litter is directly underlain in places by a thin, powdery gray siliceous leached layer that is about one-fourth inch thick in the moist and shaded areas where it reaches its best development. Under these layers is grayish-brown gravelly sandy loam that contains some shot pellets and has a coating of fine soil material on the surface of the gravel. At about 12 inches the coating on the gravel is still present, but shot pellets are absent and the soil material is yellowish brown and more gravelly and sandy. At about 24 inches the gravel is yellowish gray. Roots penetrate the soil profile readily but do not extend much below 24 inches in any great number because of the coarseness of the material.

Use and management.—No appreciable areas of this phase are cultivated at present and none is likely to be in the near future. Most areas are covered by second-growth forests or brush. The phase appears to be more productive for second-growth forests than Everett soils that have comparable texture and the same slope. Fine stands of young hemlock and fir grow on areas protected from fires. A typical virgin stand had about 25 trees to the acre, some of which were about 4 feet in diameter and 120 feet high.

Barneston gravelly sandy loam, hilly (15 to 25 percent slopes) (Bc).—This phase consists of a series of hilly ridges, but some areas associated with the rolling phase have short steep slopes. In most places the soil does not differ from the rolling phase except in its steeper relief and more rapid surface drainage. On the steeper slopes the texture, depth, color, and structure of the various layers are not uniform. This phase occurs mainly in the eastern part of the area surveyed. It has no agricultural possibilities but is as good a soil as the rolling phase for forest.

Barneston gravelly loamy sand, rolling (6 to 15 percent slopes) (Bb).—This phase occurs on the same kind of relief as the associated Barneston gravelly sandy loam, rolling, but is of smaller extent and more stony, gravelly, and droughty.

On undisturbed surface soil, a 1-inch layer of undecomposed forest litter overlies a thin, powdery, ashy gray, leached layer a fraction of an inch thick. Beneath these layers there is a yellowish-brown gravelly loamy sand or gravelly sand that continues to a depth of 20 or 30 inches. The soil is more loose and sandy than Barneston gravelly sandy loam. The gravel in this horizon is slightly coated with fine materials and is usually very coarse, and rounded stones are numerous. The material is so loose and coarse-textured that roots do not penetrate very deep. Below this layer the material is very loose and porous yellowish-gray or grayish-yellow gravelly sand or stony gravelly sand that extends to a depth of many feet.

Use and management.—Some areas of this soil support a good stand of conifers, but most have been cut over and give evidence of their droughtiness by the sparseness of their cover. It is not uncommon to find 50 Douglas-fir trees to the acre that are about 12 inches in diameter for approximately 100 years of growth and about 24 inches in diameter for approximately 200 years' growth. This soil can support a fair growth of timber if protected from fire. Generally the soil is not cultivated but is used for pasture in farm units along with soils better adapted to cultivation.

Barneston gravelly loamy sand, hilly (15 to 25 percent slopes) (Ba).—This phase, which is associated with the rolling phase of Barneston gravelly loamy sand, occurs mostly in the eastern part of the area surveyed. In many places it occupies areas between the rolling phase and Rough broken land.

This soil is too rough and droughty to give satisfactory yields of agricultural crops, but it produces fair yields of timber.

Barneston-Wilkeson complex (6 to 25 percent slopes) (Be).—Intermingled areas of Barneston gravelly sandy loam and Wilkeson loam were mapped in this complex. Tracts occur on the higher terraces and on the mountain foot slopes in the north-central part of the county, generally in association with both Wilkeson and Barneston soils. Rolling and hilly phases of Barneston gravelly sandy loam constitute the major part of the complex, and rolling and hilly phases of Wilkeson loam the minor part. The Barneston soils have rapid internal drainage, whereas that of the Wilkeson soils is medium. Surface runoff for the entire complex is medium. The profile of the Barneston members of the complex is like that of Barneston gravelly sandy loam, rolling; the profile of the Wilkeson members, like that of the Wilkeson loam.

Use and management.—None of the Barneston-Wilkeson complex has been cleared. Most areas are cut-over land that supports young conifers and alder in most places but only wild blackberry and fireweed where vegetation has suffered a succession of bad burns. Its high elevation and the large amount of associated uncleared land will undoubtedly keep the complex from being put to any agricultural use in the immediate future. The size of the fir, hemlock, and cedar stumps indicate that the land will produce excellent timber if protected from fire.

Bellingham silty clay loam (0 to 3 percent slopes) (BG).—Occurring in all parts of the county except the extreme eastern part, this soil is extensively developed in the nearly flat upland depressions. It is usually limited to small areas, many of which are in long narrow stringers adjacent to small intermittent streams or at the heads of springs and seeps.

The surface soil to a depth of 8 to 10 inches is nearly black, friable, granular silty clay loam containing a high percentage of organic matter. This layer is underlain by about 10 inches of firm gray clay or silty clay mottled with yellow and brown that gradually grades into a mottled gray and rusty-brown compact silty clay many feet thick. Because the soil is very slowly pervious to water and was developed in depressions, it is poorly to very poorly drained and may be covered by water during the wet season.

Use and management.—Much of Bellingham silty clay loam is cleared of brush and used for pasture and hay. Where an area is large enough to be used for a farming unit, the soil is generally drained and cultivated for hay crops. Most areas are too small, however, to be cultivated as separate units and are usually pastured with surrounding cut-over areas. Pastures on this soil do not suffer from drought as do the well-drained associated upland soils during some seasons, and they have a high carrying capacity.

Bellingham silty clay loam, shallow surface soil (0 to 3 percent slopes) (BH).—This phase occupies low depressional areas adjacent to tidal flats or tidal marshland in association with Bellingham silty clay loam and Bellingham silt loam. Three areas of about 600 acres are on Anderson Island, and a small area is on Fox Island. The soil was developed on very plastic clay materials. It differs from the typical Bellingham soils in having a very shallow surface soil of high organic-matter content and a subsoil that is more plastic and compact.

The dark-gray to black highly organic silty clay loam surface soil is 2 to 5 inches thick. This layer grades into a gray plastic compact clay that is highly mottled with yellow and rust-brown stains. A slightly mottled gray plastic clay occurs at 20 or 24 inches and continues to a depth of several feet.

Use and management.—This soil is not suited to cultivation because it has poor drainage and plastic clay subsoil. A few acres are used for pasture but remain wet too long in spring to be used for cultivated crops. Late in summer the fields dry, and the soil has a hard massive structure that makes it exceedingly difficult to work with machinery.

Bellingham silt loam (0 to 3 percent slopes) (BF).—This soil occurs in small rounded depressions or along narrow stringers at the heads of natural drains or adjacent to seeped areas. It is very simi-

lar to Bellingham silty clay loam, but it is more extensive. Because it dries sooner in spring under comparable conditions and is easier to work, it is used more widely for cultivated crops than the silty clay loam.

The soil has a friable very dark grayish-brown to dark-gray granular slightly acid silt loam surface about 6 or 8 inches thick. This layer is underlain by a moderately compact gray clay or silty clay that is considerably mottled with yellow and brown. This subsoil layer grades into or rests on a neutral semicemented gray or bluish-gray clay till many feet thick.

Use and management.—Cultivated crops require artificial drainage but hay and pasture require little or none. Each 2 acres of cleared land support about one cow for 7 months of the year. Some of the well-managed fields of this soil produce 3 tons of clover hay, 40 bushels of oats, or about 200 or 300 bushels of potatoes an acre (pl. 1, *C*). Usually after one or two crops of oats are grown, the land is put in hay or pasture for a few years and then returned to oats. Not many farmers grow potatoes on this soil.

Bow clay loam, rolling (6 to 15 percent slopes) (BK).—The upland or glacial-terrace positions occupied by this phase are mostly on the islands, peninsulas, and near the Sound, but a few areas are near Frederickson. This soil has developed on smooth and rounded hills on positions similar to those of Kitsap silt loam, undulating, but has somewhat steeper slopes. It is not so well drained as Kitsap silt loam, undulating, and has a much more compact subsoil through which are scattered some gravel, cobbles, and stones. It is imperfectly drained. Virgin vegetation consists of good growth of Douglas-fir, cedar, and hemlock.

The surface soil consists of 8 or 10 inches of brownish-gray clay loam containing a few scattered pieces of gravel and many small shot pellets. In undisturbed virgin areas this layer is covered with a surface mat of partly decomposed forest needles, leaves, and small woody fragments. The surface soil grades into a compact gray silty or sandy clay mottled with rust brown and containing scattered gravel. At approximately 20 inches this material grades into a more compact gray silty or sandy clay that is not cemented and contains some embedded gravel. This layer is many feet thick.

Use and management.—This phase is used mostly for hay, pasture, and forest. The subsoil is too heavy and compact for successful production of cultivated crops, and the heavy-textured surface soil is more difficult to prepare for crops than the somewhat similar surface soil of Kitsap silt loam. It is not so desirable for crops as Kitsap silt loam, undulating, and is less intensively cultivated.

Bow clay loam, steep (15 to 30 percent slopes) (BL).—The majority of the slopes of this phase are about 25 percent and are too steep for cultivation. Most of them are smooth, but some are rough and gullied. Areas are generally small and lie adjacent to the rolling phase. A few small tracts have been cleared for pasture, but this phase is largely in timber, the use to which it is best suited.

Buckley loam (0 to 3 percent slopes) (BN).—This soil, which occurs on a large nearly level area near Buckley, is characterized by well-kept substantial farm homes. Although the farms are not large,

most of them are wholly under cultivation to hay and grain for dairy herds, hops and peas for cash crops, and gardens and orchards for home use. The soil is derived from semicemented Osceola till that occurs at shallow depths. This material restricts internal drainage but makes conditions very favorable for producing grass.

The surface soil is a dark-gray or nearly black granular permeable loam about 12 inches thick that is friable, very high in organic matter, and easily penetrated by roots, air, and water. It changes abruptly to a gray gritty loam or clay loam mottled with yellow and brown iron stains that indicate a saturated condition several months during the year. This subsoil layer is underlain by mottled gray, gravelly, slightly cemented heavy loam or light clay loam till containing numerous angular rocks, many of which are basalt or andesite. This soil type has developed under imperfect drainage on a relief that ranges from level to depressional.

Use and management.—Buckley loam is a valuable agricultural soil but it needs to be artificially drained for best results. It is productive where adequately drained but it cannot be worked so early in spring as better drained soils. Hay and forage crops, canning peas, and hops are the principal crops, and produce good yields when fertilized. In good years hops yield 1,000 to 1,500 pounds. Canning peas do well, but yields are not so high as on other soils. Manure is used, when available, and nitrogen-phosphorus or complete fertilizers are applied to peas and hops.

Buckley loam, hardpan (0 to 3 percent slopes) (Bo).—This phase occupies only about 65 acres, and is very similar to Buckley loam except that it is underlain at a depth of 4 to 14 inches by a cemented iron hardpan 1 to 5 inches thick. The hardpan was formed by seepage waters high in iron that apparently percolated through the Everett and associated soils and penetrated areas of Buckley loam, where the iron was deposited. In places this hardpan material has been exposed on the surface by plowing. One area is associated with Buckley loam and extends to a narrow valley, where it is adjacent to Everett gravelly sandy loam. In some respects this phase is similar to the Edmonds soil.

Use and management.—Most of the acreage of Buckley loam, hardpan, is used for hay and pasture, but the yields and carrying capacity are less than on Buckley loam.

Buckley-Enumclaw loams (0 to 3 percent slopes) (Bm).—This complex consists of Buckley loam and Enumclaw loam so mixed that they could not be shown separately on a map at the scale used. It occupies slightly higher positions than the associated Buckley loam and consequently developed under slightly better drainage conditions and has somewhat more distinct profile layers. On the other hand it generally occupies slightly lower positions than the associated Enumclaw loam and is not so well drained. Otherwise the profiles of the soils in this complex are similar to those of Buckley loam and Enumclaw loam.

Use and management.—Crops as well as fertilizer and tillage practices are the same as for Buckley loam, but yields are better because of the slightly better drainage condition and the resulting greater available moisture supply during the dry summer months. Most areas of this soil are under cultivation.

Carbondale muck (0 to 3 percent slopes) (Ca).—This soil, which is the most important muck soil in the county, occurs as relatively extensive areas in the river flood plains and in small depressions in the uplands. It was derived from well-decomposed woody material containing some decomposed sedges. In a virgin condition it was densely timbered and very wet; now most areas are cleared, drained, and used for agriculture.

The surface soil to a depth of about 10 inches is moderately acid, granular, very dark-brown to black woody muck that may contain a small quantity of silty or fine sandy mineral material. From about 10 inches down to 22 inches it consists of a moderately acid dark-brown woody muck containing embedded woody fragments and some sedge remains. Below 22 inches the material is largely a brown sedge peat with some embedded wood fragments. The raw sedge peat continues to variable depths but at an average of 60 inches it changes to dark sedimentary or colloidal peat. Mineral material may occur at depths of less than 60 inches. The average depth of the organic deposit to mineral material, although variable, is usually about 6 feet.

Use and management.—In the valleys of the Stuck and Puyallup Rivers this soil is used primarily for leafy truck crops, such as lettuce (pl. 2, *C*), cabbage, celery, and cauliflower. Other cultivated areas are used for pasture and hay crops, particularly oat hay.

Carbondale muck, shallow (over Rifle peat) (0 to 3 percent slopes) (Cb).—Areas of Carbondale muck that were underlain at a depth of about 18 inches by woody peat were mapped as a shallow phase. This phase does not differ very much from Carbondale muck, but it is less valuable for some crops. In general the agricultural value of the mucks depends upon their location in respect to air, drainage and frost and somewhat upon the degree of acidity. Areas of the shallow phase that are associated with the recent alluvial soils on the river flood plains are more desirable than those associated with some of the upland soils. The material underlying the muck on the river flood plains generally is more easily penetrated by roots than that underlying the muck in the basins of the terraces and uplands.

Cathcart loam, hilly (10 to 25 percent slopes) (Cc).—This hilly shallow soil has developed in place from gray shale and sandstone mixed with glacial materials. The surface drainage is medium to rapid, but internal drainage is slow because of the clay subsoil and underlying rock.

The first 2 or 3 inches of the surface soil is a mixture of partly decomposed organic forest litter and mineral soil. Under this layer are 4 or 5 inches of friable light-brown granular loam followed to a depth of about 18 inches by less friable light-brown loam. The grayish-brown or yellowish-brown heavy clay loam that underlies this to a depth of about 26 inches has a distinct nut structure and heavy colloidal coatings on the soil aggregates. From 26 to 34 inches there is a yellowish-brown clay that has distinct vertical cleavage; colloidal clay coats the surfaces of embedded fragments of parent rocks. Below this layer is soft shale or shaly sandstone mottled with rust red, brown, and yellow.

Use and management.—The small area of this phase in this county occurs about 1 mile northeast of Longbranch. It has been cut over and now supports a growth of fir, cedar, alder, madrona, Oregon

grape, and bracken fern. Where the Cathcart soil is extensive and occupies smooth relief, it is used successfully for general farm crops.

Chehalis silt loam (0 to 3 percent slopes) (CD).—This brown soil, which occurs only along South Prairie Creek and in the valley of Ohop Lake, is fairly high in organic matter and nitrogen. It occupies positions that may overflow during very high water unless protected by levees but it is well drained. Originally it was densely covered with timber but now most all areas are cleared, cultivated, and very productive.

The surface soil is brown granular slightly acid silt loam that becomes compact during hot summer months. In places, especially west of Eatonville, it is yellower than typical and distinctly mottled with gray and reddish brown. In this respect these areas are more typical of the Nehalem series (not mapped in the county) than the Chehalis soil. Under the surface layer is a yellowish-brown friable micaceous heavy silt loam subsoil that does not change much with depth. The subsoil is less acid than the surface soil and in places may have some gravel.

Use and management.—Chehalis silt loam is used mostly for hay and pasture in connection with dairy farms. Nearly all of it is under cultivation and produces good to high yields when properly farmed.

Coastal beach (0 to 3 percent slopes) (CE).—The assortment of sand, gravel, and cobblestones forming beaches and bars along the shore of Puget Sound makes up this land type. The beaches lie only a few feet above the normal level of the tide and are from a few feet to several yards wide. Some areas of beach sand are too small to be shown on the soil map.

Dupont muck (0 to 3 percent slopes) (DA).—Small areas of this soil occur throughout the southwestern corner of the county, usually in small bowllike depressions having poorly defined outlets. Some areas, however, occur in depressions now having good outlets.

The profile is very uniform—exceptionally so for an organic soil. The surface soil consists of about 10 inches of very dark-brown to black muck containing a relatively high percentage of mineral matter and is underlain by 2 or 3 inches of yellowish-brown ashlike finely divided siliceous or diatomaceous materials having distinct upper and lower limits (pl. 2, *B*). Beneath this layer there is a brown sedimentary peat that generally extends to a depth of several feet, but a few areas have mineral material within 18 inches of the surface.

Use and management.—In its natural state, Dupont muck supports a dense growth of spirea; however, most of the soil has been cleared, ditched, and drained and planted in hay, pasture, hops, and peas for canning and freezing. It is a productive soil and results are good with all of these crops.

Edmonds fine sandy loam (0 to 3 percent slopes) (EA).—This soil occurs in small scattered depressions in old stream valleys in the western half of the county. It developed on old glacial outwash or waterlaid materials derived from a wide range of rocks, under conditions of retarded drainage or of seepage from adjacent higher slopes. This soil has a high water table, is acid, and has developed under water-loving vegetation. Most areas are nearly level or very gently undulating.

The surface soil is permeable softly granular dark-brown fine sandy loam about 6 inches thick. It contains some shot pellets and with depth becomes lighter brown and mixed with lighter brown sandy loam. At about 15 inches the material is a yellowish-brown sandy loam that extends for about 6 inches. Below this layer are 4 to 6 inches of grayish or yellowish-brown cemented sand stained with yellow and red and underlain by yellowish-brown sand or sand and gravel.

Use and management.—Edmonds fine sandy loam is used chiefly for hay and pasture crops. Because of moisture retained by the slow internal drainage, crops on this soil do not suffer from drought as they do on the better drained soils. Nearly all areas are in agricultural crops.

Enumclaw fine sandy loam (0 to 3 percent slopes) (EB).—This soil was developed in association with Buckley loam and Buckley-Enumclaw loams on similar glacial till materials. It occupies gently undulating areas that have somewhat better drainage than Buckley loam and it is browner and lower in organic matter. It occurs only in the general vicinity of Buckley.

The 12- or 16-inch surface soil is brown or grayish-brown granular fine sandy loam. It contains some angular gravel and a few small stones but is soft and easily penetrated by roots. In virgin areas it is covered by a thin mat of forest litter, but below this layer the organic-matter content is lower than in the Buckley soils. The surface soil is underlain to depths of 24 or 30 inches by a yellowish-brown friable gravelly loam mottled to some extent by iron stains. This soil type was developed on mottled gray gravelly slightly cemented heavy loam or clay loam till. Pits in the vicinity of Buckley show that the depth of this till exceeds 40 feet.

Use and management.—This soil has a wider crop adaptation than either Buckley loam or Buckley-Enumclaw loams, but only a small part of it is under cultivation. Hay and pasture are the most important crops and produce fair yields when properly fertilized and tilled. Berries, vegetables, and fruit trees do slightly better on this soil than on Buckley loam. Much of this type is cut-over and is covered by a dense growth of young alder and some spruce. Cedar occupies many virgin areas.

Enumclaw loam (0 to 3 percent slopes) (ED).—This soil occupies a small area adjacent to Fennel Creek south of Lake Tapps in association with Buckley loam and Enumclaw gravelly sandy loam. The relief is nearly level and the drainage is moderately good. The friable dark grayish-brown slightly acid loam surface soil is 8 or 10 inches thick. This layer is underlain by a gray, mottled with rusty-brown and dark gray, loam or silt loam subsoil that rests abruptly at a depth of about 20 or 30 inches on semicemented Osceola till or stratified sandy and gravelly sediments many feet thick. Most areas of Enumclaw loam are in forest and brush, but if cleared and properly managed they should be productive for many crops or for pasture.

Enumclaw gravelly sandy loam (0 to 3 percent slopes) (EC).—This soil differs from Enumclaw fine sandy loam in being more sandy and gravelly throughout the profile, but the two soils have the same color, thickness, and sequence of horizons. Relief and drainage con-

ditions are also similar. The few cleared areas of this soil are for the most part in permanent pasture or are sown to hay crops. Yields are lower and droughty conditions more prevalent than on Enumclaw fine sandy loam. Some areas of Buckley gravelly loam along Kelly Creek, as well as areas of Tromp gravelly sandy loam, were too small to map separately and are therefore included with this soil.

Everett gravelly sandy loam, rolling (6 to 15 percent slopes) (EK).—This is one of the most extensive soils in the county. It developed on rolling topography in association with upland soils other than those of the Wilkeson series. It is on loose gravelly poorly assorted glacial drift materials somewhat stratified in places and derived from a wide range of rocks. Although the area where this soil occurs has mild rainy winters with occasional snows, the summers are dry for long periods. The soil is most commonly associated with members of the Alderwood series, but it is distinguished from them by loose uncemented substrata. It is somewhat excessively drained and droughty because of the loose structure and gravelly nature of the profile. This phase developed under a forest of Douglas-fir and alder.

The surface layer to a depth of 1½ or 2 inches is a grayish-brown mixture of partly decomposed organic matter and mineral material. Below this layer the soil to a depth of approximately 20 inches is yellowish-brown gravelly sandy loam having little structure and lacking sufficient consistency to stand in any but a very fresh cut. Below 20 inches the material is brownish-yellow loose gravelly loamy sand that grades at 24 or 30 inches into a grayish-yellow or yellowish-gray gravelly sand or fine gravel that is poorly assorted and very loose and porous. A few small areas are underlain at a depth of 30 inches or more by a semicemented hardpan. The hardpan is present particularly on small areas associated with soils of the Alderwood series. The depth of this phase is variable, and the surface soil ranges from a few inches to fairly deep.

Use and management.—The few cultivated areas of this phase are small and are generally adjacent to better soils or plots used for growing vegetables and fruits for home use. Fair yields of such crops are obtained only with intensive management practices. Several poultry farms are on this soil. Most of the area is covered with stumps and brush or with second-growth timber.

Everett gravelly sandy loam, nearly level (2 to 6 percent slopes) (EH).—This phase is composed of nearly level areas of Everett gravelly sandy loam that are associated in widely scattered parts of the county with the rolling phase. The nearly level phase is smoother, has a slightly higher water-holding capacity, and usually shows more stratification in the underlying material than the rolling phase. Very little of it is cultivated. Cultural practices are the same as on Everett gravelly sandy loam, rolling. Most of the land is forested or is stump land.

Everett gravelly sandy loam, hilly (15 to 25 percent slopes) (EG).—This phase is generally broken and cut by ravines, but some areas have smooth steep slopes. The texture, color, and thickness of the various layers are variable, but these variations have little significance because the soil has no agricultural use except possibly for pasture. Most areas are covered with stumps and brush or with second-growth timber.

Everett gravelly loamy sand, rolling (6 to 15 percent slopes) (Ef).—This phase has a more gravelly and sandy texture and a more porous profile than Everett gravelly sandy loam, rolling. It was developed on gently to strongly rolling relief, but in many places adjacent areas are steep.

The surface of the virgin soil is covered by a 1- or 2-inch layer of dark-gray undecomposed organic matter. Below this layer to a depth of 20 or 30 inches is yellowish-brown gravelly loamy sand that contains a few scattered shot pellets. This layer is underlain by a very porous yellowish-gray or grayish-yellow gravelly sand. The material is generally unassorted but may be somewhat stratified. Small boulders occur throughout the profile and underlying material.

In some areas, especially where bordering areas of Indianola soils, this phase is less gravelly and more sandy than usual and may be underlain by almost pure sand. Small areas heavier or lighter in texture than Everett gravelly loamy sand were included with this phase because they were not large enough to map separately.

Use and management.—The lower percentage of fine material and the porous nature of the profile make this phase more droughty and less suited to agriculture than Everett gravelly sandy loam, rolling. A few small areas are in garden vegetables, but even with heavy applications of fertilizer yields are low. Some cleared areas are used for poultry raising. Most uncleared areas are covered with brush and stumps, and those that have been protected from fire produce a fair growth of young conifers.

Everett gravelly loamy sand, hilly (15 to 25 percent slopes) (Ee).—This phase, which occupies hilly or broken slopes, is similar in color, texture, and thickness of the various layers to the rolling phase but it has more variations in the profile. Vegetation on the two soils is similar. This phase has practically no agricultural value.

Everett stony loamy sand (6 to 25 percent slopes) (El).—This type is similar to Everett gravelly loamy sand, rolling, but contains a greater percentage of coarse gravel and small boulders. It is associated with Everett gravelly loamy sand, rolling, and Everett gravelly sandy loam, rolling, in most parts of the county, but commonly occurs along old glacial channels in association with the Spanaway soils. This soil is unsuitable for crops or pasture.

Fitch gravelly sandy loam, undulating (3 to 8 percent slopes) (Fb).—This phase was developed in association with Spanaway gravelly sandy loam, gently undulating, in the southwestern part of the county under grass vegetation. The loose and porous nature of the soil, in addition to the undulating relief, makes the drainage of Fitch gravelly sandy loam, undulating, somewhat excessive. The profile is intermediate between the brown heavily forested Everett soils and the dark grayish-brown Spanaway soils of the prairies.

Under virgin conditions the soil is covered by a thin layer of partly decomposed organic matter consisting of mosses and forest litter. The surface soil to a depth of about 6 inches is dark-brown gravelly sandy loam, intermediate in color between the Everett soils and the Spanaway soils, but more closely resembling the Spanaway. Under this dark-brown surface soil to a depth of 18 to 22 inches is a lighter brown gravelly sandy loam that is underlain by loose yellowish-brown gravelly sand or gravel.

Use and management.—Very few areas of this phase are under cultivation, and the total cultivated acreage is small. Most areas are now either producing young fir or oak trees or have been cut over and are covered with brush and stumps. The soil produces fair stands of Douglas-fir, which replaces Oregon oak in some areas.

Fitch gravelly sandy loam, hilly (15 to 25 percent slopes) (FA).—Areas of Fitch gravelly sandy loam having a slope of more than 15 percent are mapped as a hilly phase. The profile of this soil is the same as that of the undulating phase but the thickness of the horizons varies more. The soil occupies only a few small areas, which are covered with stumps and brush or by young trees.

Greenwater loamy sand (2 to 6 percent slopes) (GB).—Apparently derived from glacial outwash brought down from the flanks of Mount Rainier, this soil occupies low terraces along the upper reaches of the Nisqually and White Rivers. In the Nisqually valley it occurs between areas of National pumicy sandy loam and the river. A few rounded boulders and gravel indicate former glacial action. The soil is somewhat excessively drained except where the water table is near the surface. Surface runoff is very slow, and internal drainage is rapid. Summers are cool and winters are cold and wet in this region.

The surface soil is a brown loose sand or loamy sand that contains some small fragments of pumicelike basaltic and andesitic materials. The subsoil is a yellowish-brown loamy sand containing many small irregular fragments of pumice and rock. In many places this layer is slightly cemented, probably by iron and silica. It is underlain by a gray coarse sand of similar mineralogical character.

Use and management.—Most areas of this soil are heavily forested; none are cleared and cultivated. The trees consist of Douglas fir, Western white pine, hemlock, and cedar, under which is an undergrowth of Oregon grape and salal. The cut-over areas should be protected from fire and allowed to reforest.

Greenwood peat (0 to 3 percent slopes) (GC).—Derived from sphagnum moss, this type occurs throughout the western part of the county in small basinlike depressions that have sluggish outlets. It is seldom associated with other kinds of peat. The water table is very high. The peat is waterlogged most of the year, and sometimes covered with water to a depth of several inches.

The surface layer of the peat to a depth of about 12 inches is yellowish-brown, raw, fibrous, and strongly acid material consisting chiefly of undecomposed sphagnum moss. Below this layer is brown or grayish-brown fine fibrous raw peat developed from mosses or sedges, chiefly mosses. The material has undergone some chemical changes and is strongly acid, but it retains its original physical character. The peat is usually several feet thick.

Use and management.—Greenwood peat is not used for general agriculture but it has some potential value as a soil amendment. Most areas are covered with Labrador-tea, but some have growths of white pine, hardhack, cranberry, and other shrubs. Most of the commercial cranberry crops in the State are grown on this peat.

Indianola loamy sand, gently rolling (6 to 12 percent slopes) (IA).—This well-drained soil derived from sandy glacial drift is widely distributed throughout the eastern two-thirds of the county,

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where it is generally associated with the Everett and Alderwood soils. Most of the soil is in small narrow strips or belts near streams or drainageways, but some large areas occur in conjunction with the Everett soils. The relief is smooth to gently rolling, the largest areas being the smoothest. Although this soil is very sandy throughout, the water-holding capacity is greater than that of the Everett soils.

The surface soil to a depth of 8 inches is dark-brown or brown loamy sand containing a few small iron-cemented concretions or pellets. This layer may be overlain by 1 or 2 inches of dark-brown undecomposed forest litter in undisturbed virgin areas. The surface soil is underlain by yellow or yellowish-brown loamy fine sand to approximately 20 inches. Under this layer is light-colored yellowish-gray or grayish-yellow fine sand or loamy fine sand that may be slightly compact. It is sometimes irregularly stratified at a depth of 3 or 4 feet. Generally the soil is free from gravel except where it merges into the Everett or Alderwood soils. On the Lakebay Peninsula southeast of Vaughn, however, the soil has a little gravel throughout the profile.

Use and management.—Yields of most farm crops on this phase are poor. The soil produces fair crops of hay, however, if the season is favorable. Alfalfa has been planted on this soil with some success by a few farmers, although it is affected by a boron deficiency in the soil (*2*). Most areas are logged over or support a stand of second-growth fir and hemlock.

Indianola loamy sand, moderately steep (12 to 25 percent slopes) (IB).—This phase has for the most part short moderately steep slopes that border areas of the gently rolling phase. The profile characteristics are the same for both phases except for variations in the depth of the different horizons. Most areas of this soil are covered by stumps and brush or by second-growth evergreens, but small areas have been cleared and are in pasture.

Indianola sandy loam, gently rolling (6 to 12 percent slopes) (IC).—This phase, which occurs in small areas throughout the western part of the county, has a profile similar to that of Indianola loamy sand, gently rolling, but is slightly finer textured, deeper, less droughty, and somewhat more productive.

The surface soil to depths of 7 to 9 inches is brown sandy loam containing a few small shot pellets. Under this layer to a depth of 13 to 24 inches is yellowish-brown or brownish-yellow fine sandy loam. The underlying material is a mixture of brownish-yellow, yellow, or gray loamy sand or fine sand that is sometimes stratified to a depth of 3 or 4 feet.

Use and management.—This phase is better suited to agriculture than Indianola loamy sand, gently rolling, and almost all areas are cleared and in crops. Most areas are used for hay and pasture, but small fruits and vegetables are grown on a small scale. Yields are fair to good in normal years.

Kapowsin gravelly loam, undulating (2 to 8 percent slopes) (KD).—This phase is one of the good agricultural soils of the county. It is more retentive of water and probably has a higher natural fertility than many of the other soils, especially the well-drained soils of the uplands. It occurs throughout the central third of the county.

The surface layer at a virgin site consists of dark-brown forest litter to a depth of 2 or 3 inches. This material is underlain by light grayish brown gravelly loam containing many shot pellets similar to those in the Alderwood soils. The gravelly loam becomes pale yellowish-gray or gray with depth and grades at about 12 or 16 inches into a yellowish-gray mottled sandy clay loam or clay loam. Beneath this at depths of 24 to 30 inches is dull-gray gravelly indurated unassorted glacial till many feet thick. The till resembles that underlying the Alderwood soils but is generally not so strongly cemented.

The whole profile has a lighter gray appearance when dry than that of the Alderwood soils, a higher percentage of shot pellets in the surface soil, and a finer textured and more compact subsoil. The undulating relief and the underlying impervious till make internal drainage slow and runoff very slow. Artificial drainage systems must be installed in places to get the highest yields of farm crops. Excess surface water can be removed in most places, however, if the channels of the many natural drainageways that traverse areas of this soil are deepened.

Minor variations in color, depth to hardpan, and content of stone and gravel occur throughout this phase. Areas mapped in the general vicinity of Summit, Harvard School, and Midland differ from other areas in being usually more nearly level and in having less gravel in the profile and a more silty horizon directly over a slightly softer, more silty hardpan.

Use and management.—The superior water-holding capacity and fertility of this phase make it especially adaptable for all important crops of the county. The principal crops are hay, pasture, tree fruits, raspberries, and blackberries. Oats are grown in the areas southwest of Kapowsin, and some sour cherries on slopes adjacent to the valley of the Puyallup River. Peas for canning and freezing do fairly well on this soil. The Kapowsin soils grow the same crops as the Alderwood soils and sell for about the same price.

The organic soils that have developed along the drainageways traversing the Kapowsin soils have affected the agriculture to some extent, especially in the area near Kapowsin, where they are utilized with the upland soils in dairy farming.

Fertilizer needs on this phase are about the same as on Alderwood soils used for the same crops. Manure or a nitrogen or nitrogen-phosphorus fertilizer is most commonly used.

Kapowsin gravelly loam, moderately steep (15 to 25 percent slopes) (Kc).—Most areas of this phase are closely associated with the undulating phase and have short steep slopes within rolling areas. The soil has much the same characteristics as those of the undulating phase but it varies more in texture and color. Surface drainage is medium, owing to the steep slopes, but seepage from soils above generally keep this phase from being droughty. Small cleared areas are used for pasture and for berries and fruits, especially cherries. Most areas are either timbered or cut-over land and are better suited to forestry than to agriculture.

Kapowsin gravelly sandy loam, undulating (2 to 8 percent slopes) (Kf).—This phase differs from the associated Kapowsin gravelly loam, undulating, primarily in having a sandier surface soil. Other differences are the coarse texture of the subsoil, the greater quantity

of gravel throughout the profile, and the slightly more rolling topography. Except for having fewer shot pellets, the profile, including the heavy layer above the hardpan and the hardpan itself, is similar to profiles of the finer textured soils of the series.

The surface drainage is very slow, but the impervious underlying till impedes internal drainage. There is little need for artificial drainage, however, as the impervious till and the heavy layer directly above it help to hold moisture within reach of the plant roots during the growing season.

This phase has minor variations in color, texture, and depth to hardpan, especially where associated with Alderwood gravelly sandy loam, rolling.

Use and management.—This phase is used for hay and pasture crops and for fruit and berries grown for home use. Fertilizer and tillage practices on this phase are essentially the same as on Kapowsin gravelly loam, undulating; Alderwood gravelly loam, rolling; and Alderwood gravelly sandy loam, rolling; and yields are similar in moist years. The greater water-holding capacity of this soil, however, favors better yields in dry years than on Alderwood gravelly sandy loam, rolling. The soil is valued slightly lower than Kapowsin gravelly loam, undulating, under comparable conditions.

Kapowsin gravelly sandy loam, moderately steep (15 to 25 percent slopes) (KE).—This phase has short steep slopes. The slopes are generally adjacent to areas of the undulating phase and have the same general characteristics, although they are steeper and therefore have greater variations in texture and color. Most of this phase is covered with second-growth timber or is cutover land, but a few areas are cleared and used for pasture. The use of the soil for crops would probably be prohibited by the high cost of clearing, but it is well suited to timber.

Kapowsin gravelly clay loam, undulating (2 to 8 percent slopes) (KB).—The color and sequence of horizons of this phase are the same and the depth to hardpan varies within the same limits as those of Kapowsin gravelly loam, undulating, but internal drainage is more restricted. Slopes in most places are less than 6 percent. Areas of this phase are small and are generally adjacent to Kapowsin gravelly loam, undulating; hence cropping, fertilizing, and tillage practices are the same. Crop yields and land prices are also similar to those of Kapowsin gravelly loam, undulating.

On Longbranch and Gig Harbor Peninsulas, this phase has a lighter colored surface soil and a higher content of shot than elsewhere.

Kapowsin gravelly clay loam, hilly (15 to 25 percent slopes) (KA).—The small areas of this phase are generally adjacent to areas of the undulating phase, but differ from them in having steeper slopes. Surface drainage is medium, but the soil is kept moist by seepage water from the slopes above. The hilly slope of this soil makes it more suitable for timber than for agriculture, and at present no areas have been cleared.

Kitsap silt loam, undulating (2 to 10 percent slopes) (KL).—This moderately well drained soil developed under a dense coniferous vegetation in humid cool climate from fine-textured, stratified materials, probably of glacial-lake or marine origin, that were derived from a

variety of rocks. The small areas of this phase are scattered throughout the county in association with Everett and Alderwood soils on high benches or round-topped hills, along the coastline, and in small narrow bands along drainageways. The upper part of the soil profile is leached and acid, but the parent materials are neutral, alkaline, and in places mildly calcareous.

In virgin sites this phase is covered by about 1 inch of dark-brown organic matter. Immediately beneath the organic mat and downward to a depth of 4 or 6 inches is a grayish-yellowish-brown silt loam having a few shot pellets and granular structure. This layer grades into pale yellowish-brown silt loam that has faint red and gray mottlings and a weakly developed blocky structure. At 10 or 12 inches, this soil grades into brownish-yellow heavy silt loam having strong rust-brown and gray mottling and a blocky structure. The material becomes grayer with depth, and at 18 or 22 inches it grades into a light grayish-yellow silty clay layer mottled with rust brown and gray. It is underlain at an average of 26 inches by the parent material. The compact gray silty clay parent material has thin interbedded layers of silt and very fine sand and is light gray when dry. Because it restricts rapid downward movement of water, this compact layer is in part responsible for the high water-holding capacity of this soil.

Use and management.—This phase is one of the best agricultural soils of the uplands. It is almost all under cultivation and is mainly used for hay and pasture crops. Timothy, grown with clover and oats, is the chief crop. Fruits, vegetables, and other common crops are also grown. Barnyard manure is the most important amendment used. The soil areas are small, generally not large enough to make up an entire farm, and must be used with other soils.

Kitsap silt loam, steep (15 to 30 percent slopes) (KE).—The steep slopes along drainageways and between different terrace levels that are occupied by this inextensive phase are generally smooth, but some are uneven and gullied. The surface texture may range from loam to clay loam. Most of the phase is in forest and is generally too steep for agriculture, but some small areas have been cleared and used for pasture.

Kitsap loam, undulating (2 to 10 percent slopes) (KH).—This phase occurs in small widely scattered areas on high benches and along drainageways. Like the more extensive Kitsap silt loam, undulating, it was developed over fine lake-laid or marine sediments and is free from coarse sands, gravel, and stone. The medium texture of the surface soil and subsoil prevents rapid downward movement of water and increases the water-holding capacity. Both internal and surface drainage are slow.

Under virgin conditions the soil is covered with 1 or 1½ inches of dark organic forest litter. Beneath the surface mat, the next 4 or 5 inches is brown loam, grading into yellowish-brown loam. This horizon, which contains some shot pellets, grades at about 15 inches into a brownish-yellow silt loam strongly mottled with rust brown and gray. At an average of 32 inches, this horizon is underlain by a compact laminated gray silty clay having thin interbedded layers of silt and very fine sand.

Use and management.—This phase has a high agricultural value, and a good part of it is under cultivation. It is used mainly for hay and pasture crops, but fruits and vegetables are also grown.

Kitsap-Indianola complex (6 to 15 percent slopes) (KG).—This complex consists of very closely associated areas of Kitsap loam and Indianola fine sandy loam. Kitsap loam, undulating, makes up the largest part of the complex. Indianola fine sandy loam, undulating, the less extensive member, is somewhat better drained than the Kitsap soil and has a profile similar to that described for Indianola sandy loam, gently rolling. It differs from this soil, however, in having undulating topography and a fine sandy loam surface texture that probably resulted from the mixing of finer materials from the intimately associated Kitsap soil. This complex is very limited in extent; the main body mapped is near Elgin northwest of Henderson Bay.

Use and management.—Kitsap-Indianola complex is used chiefly for hay and pasture. Most areas are under cultivation. Pasture is generally fair.

Kopiah silty clay loam (0 to 3 percent slopes) (KN).—This soil occurs only in small scattered areas in poorly drained depressions and is associated with the Wilkeson soils. Its very heavy compact subsoil was developed from the same fine-textured materials as that of the Wilkeson soil but under poor drainage conditions. This soil differs from Bellingham silty clay loam in having a more compact subsoil and a browner surface soil.

Kopiah silty clay loam includes relatively wide variations but it generally has a dark grayish-brown granular silty clay loam surface soil. The surface soil, which is about 6 inches thick, is underlain by variegated yellow and gray compact clay highly mottled with iron stains. This material grades into lighter clay and silty clay mottled with yellow and rust brown.

Use and management.—Kopiah silty clay loam has little agricultural value at present but appears to be suitable for timber. Nearly all areas have been cut over and support no timber of any present value. Some areas are used for pasture. One small area north of Alder that has a browner surface soil and a lighter colored and finer textured subsoil than is typical produces good yields of pasture and hay.

Kopiah loam (0 to 3 percent slopes) (KM).—This soil, which is similar to Kopiah silty clay loam, occupies relatively level depressional areas along the Mashel River near Eatonville. The surface soil, 5 to 7 inches deep, is light grayish-brown loam that is low in organic matter and mottled slightly with yellow and red iron stains. It is underlain by about 7 inches of compact light-gray sandy clay that is more distinctly mottled with yellow and red. Below 15 inches and extending to greater depths the material is compact, mottled gray and yellow clay loam or sandy clay. The soil is low in fertility, has poor structure, and generally remains wet late in the growing season. It produces very poor grain and is used chiefly for pasture.

Lynden loamy sand (2 to 6 percent slopes) (LA).—This somewhat excessively drained soil derived from sandy glacial outwash was developed under a dense stand of conifers in a wet cool climate having a

long growing season. Individual soil areas are small and occur chiefly in the western half of the county as benches along streams or drainageways.

To a depth of 4 or 5 inches the soil is dark-brown loamy sand that has a fairly high percentage of organic matter but is low in available nitrogen. The underlying layer, extending to a depth of 12 to 14 inches, is brown loamy sand containing some shot pellets. Below about 14 inches, the soil is yellowish-brown sand that contains a very few shot pellets and gradually grades at about 24 inches into loose, light yellowish-brown sand. At about 40 inches, the loose sand is underlain by firm gray sand mottled slightly with yellow and brown. The profile is generally free from gravel or stone. Internal drainage is very rapid in the upper soil layers, but underdrainage is not so rapid because of the compaction of the substratum. Although the permeability is very rapid, the water-holding capacity is better than that of Indianola loamy sand and much better than that of Everett gravelly loamy sand.

Use and management.—All areas of Lynden loamy sand have been cut over but only a few have been cleared and cultivated. The small areas that have been cleared are farmed with other soils. Yields of hay crops are fair, although they vary with seasonal conditions.

Made land (0 to 25 percent slopes) (MA).—This land type is composed of artificial fill. Most areas are in cities and towns, mainly in Tacoma, where marshy land has been filled in with material dredged from the harbor for use for industrial sites and harbor facilities.

McKenna gravelly loam, nearly level (0 to 3 percent slopes) (MB).—This phase consists of gravelly or stony areas that occupy basinlike glaciated positions. Most areas are associated with soils of the uplands, but a few are associated with the Spanaway and other glacial outwash soils. The phase is closely associated with Bellingham silty clay loam in many places and is somewhat similar to it in color, drainage, and position. It contains gravel and in places stone, whereas Bellingham silty clay loam is nearly free of gravel and stone to a depth of several feet.

The texture of this soil, which varies considerably in different areas, may range from gravelly sandy loam to gravelly clay loam. Some areas may be fairly stony, but most of them have an 8- or 10-inch surface layer of nearly black granular gravelly loam that is high in organic matter. This layer is underlain by 4 or 5 inches of mottled dark-gray and yellow gravelly clay loam that grades into mottled gray and rusty-brown gravelly and stony sandy clay till. The till is nearly impervious to water. It is poorly drained and some areas are under water several months each year.

Use and management.—Most areas of this phase are used for pasture or remain in timber. Pastures on cleared or cutover land have a moderately high carrying capacity and produce considerable feed during the drier part of the year when those on well-drained soil produce very little. It would be difficult to plow most areas of this soil, owing to the high gravel content. The few areas associated with the Spanaway soils do not have such compact material below the surface soil or produce so much grass during dry years as the other areas.

McKenna loam, nearly level (0 to 3 percent slopes) (Mc).—This phase occupies depressions in the uplands and in places may occur at the heads of small streams. It does not have so much gravel in the surface soil as McKenna gravelly loam, nearly level. In position, drainage, and vegetation it is very similar to the Bellingham and Norma soils.

As mapped the phase has a relatively wide range of surface-soil texture. In places it is silt loam; in other places, clay loam; and in others, fine sandy loam. Most areas, however, have a friable granular nearly black loam surface soil about 10 inches thick. This material grades into slightly more compact gravelly loam or gravelly clay loam that at a depth of about 20 inches grades into gravelly, stony, gray and rust-brown mottled sandy clay till. This fine-textured till causes very slow internal drainage, which in turn accounts for the good growth of grass and the dense vegetation with its numerous roots. Dead and decaying plant remains are the source of the dark color and high organic-matter content of the surface soil.

Use and management.—Regardless of the texture, all areas of this phase have similar use, management, and carrying capacity. Nearly all areas are used for pasture, for which they are well suited.

McKenna loam, sloping (6 to 15 percent slopes) (Md).—Although this phase occurs on 6 to 15 percent slopes, it has many characteristics of a poorly drained soil. Its development has been influenced greatly by small springs or seeps. Because the soil more nearly resembles the McKenna than any other series, it has been classified as McKenna loam, sloping. In some respects it resembles a shallow phase of sedge muck, but it has too much mineral soil in the surface foot to be classified with the mucks. The surface soil, which is about 12 inches thick, is very dark brownish gray and somewhat mucky. This layer grades into a moderately compact mineral soil that rests on gravelly cemented till similar to that underlying the associated Alderwood and similar soils.

Use and management.—This phase occupies less than 100 acres and is used mostly for home gardens, pasture, and timber. Without artificial drainage this soil would be nearly saturated many months of the year.

Mukilteo peat (0 to 3 percent slopes) (Me).—This soil consists of decomposed organic matter mainly from sedges and associated plants and some woody materials. It occupies low flat stream bottoms and old glacial lake depressions. The original vegetation on this peat was sedges in most places and small patches of tules where the water table was especially high. Unless artificially drained, the soil is wet all the year and is covered with water during very wet seasons.

The surface 4 or 6 inches of Mukilteo peat is usually composed of dark-brown mucky partly decomposed sedges and tules. Beneath this layer is brown or grayish-brown raw fibrous sedge material. The original forms of stems, leaves, and roots are more readily identified than in the layer above. At 2 or 3 feet the material becomes yellowish-brown; and at varying depths below 4 feet, it is a mixture of finely fibrous and sedimentary peat.

Use and management.—Mukilteo peat is probably not so good for most agricultural crops as Rifle peat. If adequately drained and man-

aged correctly, however, it produces good crops, especially hay and pasture.

Mukilteo peat, shallow (0 to 3 percent slopes) (MF).—Areas of Mukilteo peat that have less than 24 inches of sedge peat above the mineral soil comprise this phase. Most areas of the soil are not so productive as Mukilteo peat but they give much better yields than many other soils. Farmers use this soil for hay crops and pasture and have some areas in minor truck crops.

National pumicy loam (2 to 6 percent slopes) (NA).—This soil was developed on glacial outwash stream terraces having their source mainly in basaltic, andesitic, and pumice materials. It was formed under heavy coniferous forest, high rainfall, and considerable snow. Relief is gently sloping, and the soil is well drained. It is associated with the Greenwater soil on the old terraces along the Nisqually River in the vicinity of National.

The surface soil is light grayish brown, open, permeable loam containing some small irregular pumice fragments. It is covered with a mat of partly decomposed coniferous needles, fibers, rootlets, and twigs in undisturbed virgin areas. The subsoil is pale yellowish-brown gravelly loam containing a high percentage of small soft rounded pumice fragments. This is underlain by a gray or grayish-brown clay loam, stratified with sandy materials, embedded with small gravel, and mottled with iron stains. Some of National pumicy loam is used for hay or pasture but most areas are in young second-growth fir and hemlock.

National pumicy sandy loam (2 to 6 percent slopes) (NB).—The low positions occupied by this soil in association with National pumicy loam are near the stream courses of the Nisqually River east of Alder. Parts of it are subject to overflow during high water.

The surface layer, which is about 6 or 8 inches thick, consists of a loose friable weakly granular brown acid pumicy sandy loam. Small rounded pumice fragments are scattered throughout the layer. The material below this layer is looser, lighter colored, and sandier and contains layers of pumice as well as scattered pumice fragments. It is generally stratified with layers of sand and gravel, and in places with grayish-brown loam or light clay loams.

Use and management.—National pumicy sandy loam has a low water-holding capacity and is more droughty than National pumicy loam. It cannot be used successfully for crops but is satisfactory for forest and should be used for this purpose. Most areas support stands of young fir and hemlock.

Newberg fine sandy loam (0 to 3 percent slopes) (NC).—This soil was derived from material washed from the Wilkeson soils and occupies less than 500 acres in the valley of the Ohop Creek near South Prairie and Wilkeson Creeks. The relief is nearly level and is characterized by a few swells and swales. The soil is considerably browner than the Puyallup soils and not so easily tilled.

The surface soil consists of brown softly granular slightly acid fine sandy loam about 12 inches thick. This layer grades into a lighter brown friable subsoil that in turn grades into brown, gray, and yellow loose friable permeable sand. In some areas, especially in the southern

part of the valley along Ohop Creek, the subsoil is slightly mottled with rusty brown and yellow stains.

Use and management.—Most of Newberg fine sandy loam occupies areas affected by relatively early fall and late spring frosts and is used mainly for pasture, grain, and some alfalfa. Farms having considerable areas of this soil are apparently prosperous. Most of them are dairy farms with larger acreages than is common on the Alluvial soils along the Stuck and Puyallup Rivers.

Newberg loam (0 to 3 percent slopes) (ND).—Only about 160 acres are occupied by this soil. Areas occur adjacent to South Prairie and Wilkeson Creeks in the eastern part of the county. The soil is much browner and is derived from different materials than Puyallup loam and will probably require slightly different fertilizers for the highest yields. Newberg loam has a finer textured surface soil and slightly finer textured subsoil than Newberg fine sandy loam, but the lower subsoil is loose friable sand in both types. The plowed layer of Newberg loam is firmer and becomes harder and more compact during dry months in summer than that of the fine sandy loam, but both soils are used for the same crops—mainly grain, pasture, and hay.

Newberg loamy sand (0 to 3 percent slopes) (NE).—Practically all of this soil occurs along South Prairie Creek. It occupies only a small acreage but is more extensive than in the counties to the south. The soil is very sandy, but it warms up earlier in spring than the adjacent fine-textured soils and is therefore better for some of the early crops. In most respects, except for surface soil texture, the soil is very similar to Newberg fine sandy loam, although in places it is more yellowish brown.

Nisqually loamy sand (2 to 6 percent slopes) (NF).—The sandy counterpart of the associated Spanaway soils, this soil has developed under a grass vegetation on sandy glacial outwash materials. The relief is level to hummocky or very gently undulating. The soil is somewhat excessively drained and has very rapid internal drainage and very slow runoff.

In virgin conditions the soil has a 2-inch surface layer of well-decomposed organic matter mixed with fibrous grass roots and sand. This material is underlain to a depth of 10 to 20 inches by slightly compact very dark dull brown or nearly black loamy sand, very high in finely divided sooty organic matter. Below this layer is very dark-brown loamy sand underlain by brown or dark-brown sand at a depth of 18 to 26 inches. The color of the sand becomes lighter with depth and finally grades into a gray salt-and-pepper color at approximately 36 inches.

Use and management.—Nisqually loamy sand is more fertile and less droughty than Spanaway gravelly sandy loam, and most areas of it were under cultivation at one time. Much of the total acreage, however, is now a part of the Fort Lewis military reservation. In a large area in the vicinity of Roy, flower bulbs are being grown along with grain and hay crops. The bulbs are smaller than those grown near Sumner and Orting on more fertile soils, and they require heavy applications of fertilizer to insure a good crop. Manure is used extensively, although commercial fertilizers are also used. Some other small areas are in hay and pasture crops. If the land were irrigated, truck crops and strawberries might be profitable under good management.

Nisqually sand (2 to 6 percent slopes) (Ng).—This soil occupies level or very gentle relief and is sandier, more droughty, and less fertile than Nisqually loamy sand. The surface layer to a depth of 2 inches is a mixture of well-decomposed organic matter and black sand. It is underlain by very dark brown to black compact fine sand high in organic matter. At about 14 inches the soil is a dark-brown fine sand, and below about 28 inches it is brownish-gray or gray sand. Nearly all of the small areas of the soil are part of military reservations and are not now cultivated. The present vegetation consists of grasses, small forbs, mosses, and some fir and oak trees.

Norma fine sandy loam (0 to 3 percent slopes) (Nh).—In relief, color, position, drainage, and vegetation, this soil is similar to the Bellingham and McKenna soils. It occurs in poorly drained depressions throughout the uplands. The subsoil is sandier than the surface soil and is generally nearly gravel free to a depth of 3 or 4 feet. Internal drainage is slow, and surface runoff is very slow.

The friable, permeable, granular fine sandy loam surface soil, which is about 6 inches thick, ranges from dark grayish brown to nearly black. Its grades into slightly mottled gray, grayish-brown, and yellow permeable fine sandy loam about 10 inches thick. This material grades into loose friable coarse mottled sandy loam or loamy fine sand that may be 1½ to 2 feet thick. Below this depth the soil generally grades into gravelly sandy clay till that has a tendency to restrict water penetration. The soil above the glacial till is saturated several months of the year. The excess water, however, is apparently favorable for grass roots. The soil produces good pasture and, on areas that have been cleared and farmed, good hay crops.

Some areas of the soil are relatively sandy to considerable depths, but the subsoil and substratum are wet or moist late in summer, probably from seepage water from the adjacent hills.

Use and management.—Nearly all areas of Norma fine sandy loam are too small to be farmed separately and are used with the adjacent soils. The soil is highly prized by dairy farmers for pasture and some areas produce hay and grain, mostly oats. It is not so productive as Bellingham silt loam.

Orting loam (0 to 3 percent slopes) (Ob).—The position, development, and parent materials of this imperfectly drained soil are similar in many respects to those of Buckley loam. The soil mantle above the glacial till, however, is deeper in Orting loam, the drainage slightly better, and the surface soil lighter colored. The benches along streams where this soil was developed are, in general, level, but the relief is sufficiently undulating to provide adequate surface drainage. Internal drainage is slow because of the semicemented character of the underlying glacial till that occurs at about 28 or 30 inches. Surface runoff is very slow.

The soil is associated with more recent alluvial soils of nearly similar elevations, but the mixture of fine and coarse material indicates that it has been developed on glacial rather than on alluvial materials. The largest areas are between the Carbon and Puyallup Rivers in the vicinity of Orting. Other areas occur along Lacamas and South Prairie Creeks.

The surface soil to a depth of 8 to 12 inches is dark grayish brown gritty but sticky loam that grades into a slightly compact brownish-

gray gravelly loam showing traces of rust-brown and dark-brown mottling. At depths of 18 to 22 inches this slightly compact layer grades into a moderately compact brownish-gray gravelly loam that is strongly mottled with rust brown and rust red and becomes gray when dry. With increasing depth this material is grayer and more cemented. Varying quantities of angular gravel and some scattered small boulders, mainly basaltic in character, occur throughout the profile.

Use and management.—Almost all of Orting loam is under cultivation, and most of the farms on this soil are fairly large and have substantial improvements. Oats, hay, berries, fruit, hops, bulbs, and peas are the chief crops. About 1½ acres of pasture are required to pasture a cow during the grazing season. Hops yield 1,000 to 1,500 pounds. Narcissus, iris, tulip, and daffodil bulbs do well on this soil. Yields of green canning peas are satisfactory, although not so high as on some other soils having higher water-holding capacity. Large applications of fertilizer are required for high yields. Barnyard and stable manure or manure with phosphate supplement apparently give the best results, but nitrogen and phosphorus or complete fertilizers are used where manure is not available.

Orting sandy loam (0 to 3 percent slopes) (Oc).—This soil occurs only in the part of the county bounded by Buckley on the east, South Prairie Creek and the Carbon River valley on the south, and the valleys of the Puyallup and Stuck Rivers on the west. It occupies narrow valleylike positions between areas of Alderwood, Everett, or other upland soils. The soil is generally nearly level or gently sloping. Internal drainage is slow, and surface drainage is very slow.

The upper 2 or 3 inches is a dark grayish-brown mixture of partly decomposed organic matter and mineral material underlain by 10 or 12 inches of dark grayish-brown sandy loam having a friable crumb structure and containing many small shot. This layer grades into a grayish-brown gritty sandy loam, mottled with yellow and rust-red and brown stains and containing some shot. Below this is a compact gray loamy sand or sandy loam mottled strongly with yellow, rust red, and brown. This material is not so compact as comparable material under other types of the Orting series. In places it is underlain by friable sand and gravel.

Use and management.—Only a small part of Orting sandy loam is under cultivation. The cultivated areas are used for hay and pasture. The cutover uncultivated areas support a good growth of young fir. Bracken is the most extensive ground cover.

Orting gravelly sandy loam (0 to 3 percent slopes) (Oa).—This inextensive soil has a more sandy and gravelly profile than Orting loam but is otherwise similar. The largest area is north of Electron and northwest of Orting between the Puyallup and Carbon Rivers.

The surface soil to a depth of 12 to 16 inches is dark grayish-brown gravelly sandy loam. Underlying the surface layer to a depth of 32 inches is a brownish-gray gravelly sandy loam, mottled with rust brown and rust red. The material below this layer is brownish-gray gravelly sandy loam. The profile contains sharp angular gravel and some small boulders.

Use and management.—Orting gravelly sandy loam is suited to the same crops as Orting loam, but yields are lower owing to the consid-

erably lower water-holding capacity of the soil. Yield differences, however, are much more apparent in dry than in wet years. Fertilizer practices are similar to those used on Orting loam, and the value of farm land is much the same.

Orting stony sandy loam (0 to 3 percent slopes) (Od).—The only area of this inextensive soil occurs on a nearly level benchlike or valley position northwest of Electron. The soil is very similar to Orting gravelly sandy loam except that it has numerous stones up to a foot in diameter scattered on the surface and throughout the profile. It is used only for timber production.

Pilchuck loamy fine sand (0 to 3 percent slopes) (Pd).—Occurring on alluvial bottom lands adjacent to stream channels, this inextensive soil is subject to frequent overflow unless protected by levees. It is derived from a mixture of materials, chiefly glacial material having a high percentage of basalt.

This phase has a brownish-gray loose friable acid loamy fine sand surface soil about 6 or 8 inches thick that grades into gray and olive-gray loose permeable fine sand subsoil. This material becomes coarser and may grade into gravel at 3 or 4 feet. The soil absorbs water very quickly, but it has a very low water-holding capacity. In places the slightly mottled subsoil indicates an intermittent high water table.

Use and management.—Most of Pilchuck loamy fine sand is used for pasture or hay, but a small acreage is used for raspberries. Pasture grass produces fair yields during the rainy season in wet years, but the grass dries quickly when the dry season starts. Raspberry yields are low compared with those on the other recent alluvial soils.

Pilchuck fine sandy loam (0 to 3 percent slopes) (Pb).—This soil occurs in a few small areas along the Puyallup and Nisqually Rivers and is subject to overflow. It has slightly more body than Pilchuck loamy fine sand and is a slightly better soil. The surface soil to a depth of 8 or 10 inches is brownish-gray fine sandy loam underlain by gray loamy fine sand or sand. It has a higher fertility and greater water-holding capacity than the other Pilchuck soils, but it is not so good as Puyallup fine sandy loam. Most of the areas are cutover and have a good stand of young conifers and shrubs. A few areas are in pasture.

Pilchuck fine sand (0 to 3 percent slopes) (Pa).—This soil consists of sandy alluvial material recently deposited along most of the larger streams of the county. Much of it is subject to overflow during high water, but at other times it is extremely droughty. The surface 6 or 8 inches is brownish-gray fine sand overlying gray sand or loamy sand. Most areas are in pasture grass or support a growth of willows and brush, but some are in raspberries. The very low fertility and water-holding capacity make it one of the poorest agricultural soils in the county. Yields are low, and during the drier summer months the growth of pasture grass is very sparse.

Pilchuck gravelly sand (0 to 3 percent slopes) (Pc).—Consisting of areas of gravelly sandy material, this soil occurs along the larger streams that overflow frequently. It is more droughty than Pilchuck fine sand and is unsuitable for agricultural use. Some areas support willows, alder, and other trees, but others are nearly devoid of vege-

tation. The soil is just slightly better than Riverwash. Grass dries early in summer, and even in some of the better areas 15 or 20 acres are necessary to provide pasture for one cow for 4 months.

Puget silt loam (0 to 3 percent slopes) (PF).—The fairly recently deposited slightly modified alluvial materials that make up this soil are dominantly of medium or fine texture. They accumulated under ponded or stagnated drainage conditions near Commencement Bay in the valley along the Puyallup River. The soil, which has a small total area, occurs on flat or slightly depressional areas and has a fluctuating high water table. It is very poorly drained and has a finer textured subsoil than Sultan silt loam, but both soils originally supported dense forest growth.

The surface soil to a depth of 8 or 12 inches is gray or brownish-gray silt loam. Below the surface for many feet, the soil is gray silt loam mottled with yellow and brown and generally stratified with finer textured layers.

Use and management.—The number of agricultural crops that can be produced on Puget silt loam are restricted owing to the high water table and very poor drainage, which are very difficult to control because the soil is so near sea level. Most areas now produce only fair permanent pasture and hay crops, but if adequately drained this soil could produce many crops.

Puget silty clay loam (0 to 3 percent slopes) (PG).—Only a few small scattered areas of this soil are mapped. It occurs chiefly in the valley of the Puyallup River, where it generally occupies very poorly drained, usually uncultivated depressions.

The surface soil to a depth of 6 or 8 inches is grayish-brown silty clay loam that becomes gray on drying. The subsoil is gray clay or silty clay highly mottled with iron stains. Because it is generally in low-lying positions, it is very difficult to drain artificially.

Use and management.—Puget silty clay loam will produce hay and pasture crops when properly drained. Since the areas are too small to occupy entire fields, they are included with more valuable surrounding soils for which high prices may be paid.

Puget clay (0 to 3 percent slopes) (PE).—This soil consists of recent fine-textured alluvium that occurs on nearly level or depressional areas near tidelands. One area occurs near Ord Bay on Anderson Island and others are near the tidelands of Commencement Bay near Tacoma. The total acreage is small.

To a depth of 6 to 10 inches or more, the soil is gray slightly laminated clay highly mottled with iron stains. It is underlain by a lighter gray laminated clay or clay loam that is mottled and streaked with yellow and brown and has thin layers of silty or fine sandy materials in places.

Use and management.—Owing to the low wet positions, fine texture, and dense massive plastic character, no attempt is made to grow anything on this soil but permanent hay and pasture crops. Yields are only fair. Some small depressional areas are marshy and support a growth of cattails, sedges, and willows. The slightly better drained areas are grass-covered or have a scattering of trees and shrubs characteristic of the stream bottoms.

Puyallup loam (0 to 3 percent slopes) (PK).—This is one of the most extensive and productive alluvial soils of the county. It occurs in association with the Sultan, Puget, and Pilchuck soils and with other members of the Puyallup series in all the larger stream valleys, especially in the valleys of the Puyallup and Stuck Rivers. The soil occupies stream-bottom positions, generally below the Sultan soils but above the Pilchuck. Under natural conditions it is better drained than the Sultan loam and has a greater water-holding capacity than the Pilchuck soils.

The surface soil to a depth of 8 or 10 inches is grayish-brown loam. Beneath this layer is gray and grayish-brown fine sandy loam slightly mottled with yellow and brown. This fine sandy loam becomes sandier with depth and in some places is underlain by gray loamy sand.

Use and management.—Because of the sandy texture of its subsoil, Puyallup loam is slightly more droughty than Sultan loam and not quite so productive. The same crops are grown and the same quantities and proportions of fertilizer are applied as on Sultan loam, but yields are generally slightly lower, particularly in dry years. The soil is considered desirable for agriculture. The yields of most of the common and special crops grown in the county—truck crops, cherries, apples, berries, oats, hay and pasture—are fair to good. The pasture on 1 acre of land is sufficient for a cow for 6 or 7 months. This soil is easily worked and does not bake in summer.

Puyallup fine sandy loam (0 to 3 percent slopes) (PH).—This soil, which occurs mainly in the valleys of the Puyallup and Stuck Rivers, differs from Puyallup loam in having a slightly sandier surface soil and usually a sandier subsoil. It is also more extensive and slightly more droughty.

The surface soil to a depth of about 10 inches is grayish-brown permeable fine sandy loam or sandy loam. This layer is underlain by gray mottled loamy fine sand that grades into fine sand, usually at a depth of less than 2½ feet.

Use and management.—Puyallup fine sandy loam is suitable for the same crops (pl. 3, *A*) as Puyallup loam, but because of the more sandy texture the yields are slightly lower in average years and considerably lower in especially dry years. Areas are usually not large and consequently are farmed with one or more of the associated alluvial soils. Quantities and kinds of fertilizers should be about the same as on Puyallup loam. Prices paid for this soil are about the same as for the other good soils of the Puyallup and Stuck River valleys.

Puyallup silt loam (0 to 3 percent slopes) (PN).—This soil, which differs from Sultan silt loam in having a fine sandy loam or loamy fine sand subsoil, occupies small areas in the Puyallup and Stuck River valleys.

The surface soil to a depth of about 12 inches is grayish-brown friable granular silt loam. This material is underlain by fine sandy loam, loamy fine sand, or fine sand that may have some rusty-brown mottling caused by a fluctuating water table. Many areas of this soil are subirrigated, but many others need supplementary irrigation in order to give the best yields during dry periods in summer.

Use and management.—Puyallup silt loam is nearly as good a soil as Sultan silt loam and exhibits only a slight tendency to droughti-

ness. Like Sultan silt loam, it produces excellent pasture. It is used largely for pasture, although it is well adapted to other crops. Yields are about the same on the two soils wherever fertilizer applications and tillage practices are the same.

Puyallup silty clay loam (0 to 3 percent slopes) (Po).—All of the very small acreage of this soil occurs near Commencement Bay in the valley of the Puyallup River adjacent to areas of tidal peat. It is gray or brownish-gray silty clay loam to a depth of 12 or 14 inches where it is underlain by iron-stained gray sand. The sand in the underlying layer makes the soil droughty despite the fine texture of the surface layer. The soil is not especially fertile. The two areas mapped are being used with fair success for pasture grass.

Puyallup loamy fine sand (0 to 3 percent slopes) (PL).—This soil occurs along the larger streams and is adjacent to areas of Pilchuck loamy fine sand. It differs from the latter in having a slightly browner surface soil, slightly more fertility, and less droughtiness. The grayish-brown loamy fine sand surface soil is about 8 or 10 inches thick and is underlain by gray slightly mottled loamy fine sand. The soil is droughty and yields are generally low except in especially wet years. Farmers, however, attempt to grow all the common crops. Fertilizer applications are similar to those on other valley soils, but except in extremely wet years, results are not good. Some areas are subject to overflow.

Puyallup sandy loam, shallow (over Buckley loam) (2 to 6 percent slopes) (PM).—This soil occupies about 40 acres in one tract about a mile east of Buckley. It consists of alluvial material recently deposited by the White River on an area of Buckley loam. The deposition is made up chiefly of material similar to the Puyallup soils, but it also contains some material very similar to the Greenwater. Owing to the underlying soil, internal drainage is considerably slower than is normal in either the Greenwater or the Puyallup soils. The relief ranges from level to undulating but it has some sags and ridges.

The soil consists of a brownish-gray friable permeable sandy loam that contains some pumice and rests abruptly upon the nearly black surface soil of the buried Buckley loam. The depth to what was formerly the surface soil of the Buckley loam is about 30 or 36 inches, and the thickness of the black Buckley soil ranges from 12 to 40 inches. This phase varies considerably from place to place in texture, color, and pumice content. In some places it is somewhat stratified, whereas in others it is uniform to the old buried surface soil.

Use and management.—This phase is adapted to a wider range of crops, including garden vegetables, berries, fruit trees, and root and tuber crops, than Buckley loam, but grain hay and pasture grass do better on the latter. Nearly all of the soil is cultivated.

Rifle peat (0 to 3 percent slopes) (RA).—The material composing this soil is somewhat disintegrated dark-brown woody peat having a more or less granular structure to depths of 18 to 24 inches. The soil occurs in association with Mukilteo peat in some areas and with the Snohomish soils in the valley of the Stuck River. The water table fluctuates greatly. The peat is flooded during the rainy season but is only moist during the dry months in summer in most years. This condition accounts for the partial decomposition of the surface materials.

A, Raspberries on Puyallup fine sandy loam in the Puyallup River valley.
B, Dairy cows grazing on Tacoma muck near Tacoma.
C, Cut-over and burnt-over area of Wilkeson loam, rolling.

The immediate surface is nearly black, but the material becomes browner with depth and includes pieces of embedded rotted wood. The surface layer is underlain by matted brown raw remains of sedge in which the original forms of stems, leaves, and roots are easily identified. In most areas the peat is several feet thick.

Use and management.—Rifle peat supports a mixed growth of deciduous trees, brush, and cedar, hemlock, and some Douglas-fir, but many areas have been cleared and drained and are now being cultivated. Vegetables are grown to some extent, especially in small areas in the valley of the Stuck River. Other areas scattered throughout the western half of the county are used for hay and pasture with excellent results. Under cultivation and proper drainage, the peat decomposes and becomes more mucky. In a few areas it has been too well drained and its value has been impaired.

Rifle peat, shallow (0 to 3 percent slopes) (RB).—Areas of Rifle peat that had less than 2 feet of organic material over mineral soil were mapped as the shallow phase. The soil occurs in a few widely separated areas of 5 to 20 acres each, generally in association with Rifle peat, in basins in the uplands. The underlying mineral soil is generally fine-textured and may have some embedded stones. This phase is used chiefly for forests and pasture. Where drained and cultivated, it is fairly productive but less so than Rifle peat.

Riverwash (0 to 3 percent slopes) (RC).—This miscellaneous land type consists of areas of sand and gravel in the beds of the larger streams. It is overflowed during high water but is exposed most of the year. A few willows grow on this material, but in most places it supports no vegetation and has no agricultural value.

Rough broken land (25 to 60 percent slopes) (RD).—Areas of steep or broken relief along drainageways, on escarpments or bluffs, and in small hilly areas make up this miscellaneous land type. The soil material varies greatly because of the topography and the mixed nature of the parent rocks, but most of it is similar to the various upland soils. Lack of uniformity in development prevented the separation of the different soils on the map. Most of this land type is cutover and is covered with second-growth timber, but some areas have been cleared and are being used as pasture. None is cultivated. The land type is best suited to forests and should not be cleared further for agricultural use.

Rough mountainous land (25 to 60 percent slopes) (RE).—Large areas of undifferentiated soils in the eastern part of the county, which because of steep and broken topography, stoniness, or high altitude are dominantly nonagricultural, were mapped in this miscellaneous land type. Some tracts that could be cultivated but are inaccessible at present may be included. Large areas are covered by soil material similar to that from which the Wilkeson soils have developed, and smaller ones by soils resembling the Barneston and other upland soils. Some areas have little or no soil cover.

Use and management.—Most of the virgin timber in the county is on this land type. Many square miles have been burned or closely cutover; subsequently they have grown up in little more than fireweed and blackberries. Some sheep are grazed, but this practice should be discouraged in most places because excellent timber can be grown.

Sheep tend not only to prevent the establishment of new timber stands on the barren areas but to injure young growth already established. Well-managed cutover land supports a good growth of young fir and hemlock.

Rough stony land (25 to 60 percent slopes) (RF).—Most of this miscellaneous land type is on areas of steep broken relief. Much of the surface is covered with bare rock outcrops and the rest has only a few inches of soil cover. All areas having timber of any value have been cut over. This miscellaneous land type has no agricultural value and should have a carefully managed program of reforestation.

Semiahmoo muck (0 to 3 percent slopes) (SA).—This muck soil is derived from sedges that are so well decomposed that the original fibers are no longer recognizable. It may have some intermixture of mineral material, but organic matter with a distinct granular structure predominates. It is very poorly drained and may be covered with water during the wet season, but upon being ditched and drained it becomes an excellent soil. It is more extensive than Carbondale muck and occurs in widely scattered areas in the uplands and stream valleys. Although it may be associated with any of the mucks or peats, it frequently occupies entire isolated depressions. The native vegetation is principally cattails, coarse grass, and spiraea.

The surface soil of Semiahmoo muck to a depth of 6 or 8 inches is a very dark-brown granular sedge muck containing sedge roots from the present vegetation. Between 8 and 16 inches there is a brown to dark-brown sedge muck with some embedded flattened sedge fragments or layers of sedge peat. This layer is underlain by a raw fibrous sedge peat that merges into sedimentary or colloidal peat, generally at an average depth of 50 inches but in places at 5 or 6 feet. A mineral substratum occurs at an average depth of 6 feet, but it may occur at only 2 feet.

Use and management.—Most areas of Semiahmoo muck are drained and farmed. The major crops, especially in the stream valleys, are leafy truck crops. Other crops are blackberries, celery, and lettuce. Areas in the uplands are used mainly for pasture and hay. The yields are slightly less than on Carbondale muck, but management practices are very similar for both. Heavy applications of complete fertilizer are used when the soil is cropped intensively. When properly managed, it is one of the most productive soils in the county.

Semiahmoo muck, shallow (0 to 3 percent slopes) (SB).—Areas of Semiahmoo muck underlain at a depth of 2 feet or less by mineral soil were classified as the shallow phase. Many areas are small and are associated with soils of the uplands; others may contain 50 to 100 acres and occupy back-bottom positions in the river flood plains. The upper part of this soil is very similar to Semiahmoo muck but the lower part grades into mineral soil. In the river flood plains the underlying mineral soil is stratified and mottled and ranges from sands to clays. In the upland basins, the underlying mineral soils are generally gravelly, stony, and medium-textured, but some areas may be semicemented and mottled. Where associated with Semiahmoo muck, this phase generally occupies the outer ridges; it is used for the same crops but yields slightly less.

Semiahmoo muck, shallow (over Mukilteo peat) (0 to 3 percent slopes) (Sc).—More than 2 square miles of Semiahmoo muck that has raw sedge peat below a depth of about 2 feet were classified in this phase. Most areas range from 200 to 500 acres and many occur in back-bottom positions in the river flood plains, where they are associated with the Sultan and Puyallup soils as well as with other mucks and peats. Generally, where the soil is associated with the recent alluvial soil on the river bottoms, it is not so acid as in the small basins in the uplands. This phase, especially in those areas in alluvial bottoms that have a long growing season, is highly prized for truck and seed crops. Some areas are used for pasture, for which they are well adapted.

Semiahmoo muck, shallow (over Tanwax peat) (0 to 3 percent slopes) (Sd).—Areas of Semiahmoo muck that grade into a sedimentary peat at about 2 feet are mapped as this phase. Tracts range from 10 to 125 acres and occur mainly in the alluvial flood plains in back-bottom positions associated with deep Semiahmoo muck and Puyallup soils. When adequately drained and fertilized, this phase is used successfully for the production of truck crops. It is not so productive as Semiahmoo muck.

Sinclair gravelly loam, rolling (6 to 15 percent slopes) (Sh).—This moderately well drained upland soil was developed under dense coniferous forests in a humid cool climate on glacial till materials that had their source in a variety of rocks, including granite, basalt, diabase, sandstone, shale, and conglomerate. It has a much grayer surface soil and more shot than the associated Alderwood soils, and in places it is not so well drained in the upper 2 feet of the profile. The gray color of this soil is most pronounced when the soil is dry. The largest areas of the phase are east of McKenna. Other areas are small and scattered.

The soil occurs on rolling relief. Surface drainage is slow and internal drainage is medium. The underlying cemented substratum stops downward percolation, but sufficient lateral drainage occurs to prevent the development of a perched water table over the hardpan except in very rainy seasons. An important variation of this phase occurs in the northwestern part of the county, where the soil is developed on more nearly level areas having slower internal drainage. In these areas many more shot pellets are in the surface horizons, and the mottling is more pronounced than in more typical areas.

Under virgin conditions the surface is covered with a fairly thick layer of forest litter and leaf mold. Under the litter the upper 12 to 18 inches is light brownish-gray gravelly loam containing many rounded shot pellets. This layer grades into gray or pale yellowish-brown gravelly loam that is faintly mottled with yellow and gray and contains a few shot in the upper part. The gravelly loam is underlain at depths ranging from 20 to 36 inches by a grayish-brown, gravelly, indurated, unassorted glacial till resembling that underlying the Alderwood soils but slightly softer and in some places mottled in the upper part.

Use and management.—A small acreage of this phase is cleared and cultivated. The rest is cutover land covered in some instances with a heavy second growth of timber. Pasture and hay are the important crops, and yields are about the same as on Alderwood gravelly loam,

rolling, under comparable tillage and fertilizer practices. Limited acreages of oats and wheat are grown and yields are moderate. Some fruit and vegetables are produced for home use.

Sinclair gravelly loam, hilly (15 to 25 percent slopes) (SG).—This phase occurs most frequently along small streams or drainageways and between different levels of Sinclair gravelly loam, rolling. Areas are small and have short moderately steep slopes. The few small areas that have been cleared are used for pasture. Moderately steep slopes and medium runoff make this soil unsuitable for agriculture. Most areas remain as cutover land or support a stand of second-growth timber.

Sinclair gravelly fine sandy loam, rolling (6 to 15 percent slopes) (SF).—This phase differs from Sinclair gravelly loam, rolling, chiefly in having a coarser texture, a lower water-holding capacity, and a lack of mottling in the profile. The largest acreages of this phase occur east of McKenna in association with Sinclair gravelly loam, and in the western part of the county, but there are small scattered areas in other parts.

The surface of the soil under virgin conditions is covered by a layer of forest litter and leaf mold 1 or 2 inches thick. Under the litter, the soil is a light brownish-gray to grayish-brown gravelly fine sandy loam that becomes more grayish or pale yellowish brown at 8 or 12 inches and grades abruptly into grayish-brown gravelly, indurated, unassorted till at depths of 24 or 36 inches. There are many shot pellets between 4 and 8 inches. Like Sinclair gravelly loam, rolling, this phase has rolling relief and slow surface drainage, but the coarser texture of the profile permits more rapid downward and lateral drainage and reduces the water-holding capacity of the soil.

Use and management.—Only a small acreage of this phase is cleared and cultivated. Hay and pasture are the most extensive crops, but loganberries are an important cash crop, especially on areas in the western part of the county. Very little commercial fertilizer is used; but since most farms raise either cows or chickens, considerable manure is applied to the soil. The price of this land is about the same as Alderwood gravelly sandy loam, rolling. The uncleared areas are predominantly cutover land with some second-growth timber.

Sinclair gravelly fine sandy loam, hilly (15 to 25 percent slopes) (SE). —This phase consists of small areas that generally have short moderately steep slopes. It is adjacent to or within areas of the rolling phase. The moderately steep slope and medium runoff of this phase make it poorly suited to agriculture. The few small areas that have been cleared are used for pasture or for loganberries. The best use of this soil is for forest.

Skykomish stony sandy loam (2 to 6 percent slopes) (SK).—This soil occupies gently sloping terraces and occurs in only a few small areas. It has more stones on the surface and through the profile than any other soil in the county and consequently tillage is nearly impossible.

The 2- or 3-inch brown stony sandy loam surface layer is low in organic matter and contains large quantities of stone and gravel. This layer is abruptly underlain by a yellowish-brown loose very gravelly loamy sand that becomes lighter colored and coarser textured with

depth. Internal drainage is very rapid and runoff is very slow. The soil is very droughty.

All of Skykomish stony sandy loam has been cut over and now supports a fair growth of young fir and hemlock and an understory of moss, ferns, salal, and other plants.

Snohomish silt loam (0 to 3 percent slopes) (SN).—This mucky mineral soil, which grades into muck or peat, or both, at a depth of about 20 inches, occurs in relatively large areas in the valley of the Stuck River and in smaller areas in the valley of the Puyallup. It is poorly drained; runoff and internal drainage are very slow.

The surface soil to about 11 inches is brownish-gray friable permeable silt loam high in organic matter and generally slightly mottled with yellow and brown. This layer gradually grades into slightly finer textured, more mottled material that rests at 18 or 26 inches on peat or muck. The organic layers, which may extend to many feet, are about neutral or slightly acid. The water table may be at 5 or 6 feet during July and August.

Use and management.—The use of Snohomish silt loam depends upon the degree of artificial drainage. Areas that have had little drainage are used chiefly for hay and pasture, but those that are adequately drained are used intensively for seed production, truck crops, and berries. Tillage practices, fertilizers, and crop yields are similar to those on Sultan silt loam.

The soil is nearly level and slightly to medium acid. It can be easily worked into a good seedbed. Because the underlying organic layers have an exceedingly high water-holding capacity, crops do not suffer for lack of moisture during the drier parts of the growing season. Generally, where the soil is associated with the Puyallup and Sultan soils in the river valleys, it is less acid and more productive than in the small depressions in the uplands or on terraces.

One area about midway between Lake Kapowsin and Ohop Lake has a slightly finer textured surface soil than areas in the valleys of the Stuck and Puyallup Rivers and is used for pasture of high carrying capacity. The frost hazard would probably be greater on this area than on the areas near Sumner.

Snohomish fine sandy loam (0 to 3 percent slopes) (SL).—This soil occurs chiefly in areas of 40 acres or less in the valley of the Stuck River. The surface soil to a depth of about 11 inches is grayish-brown fine sandy loam underlain by gray or brownish-gray fine sandy loam or silt loam. At 14 to 24 inches the soil is underlain by peat or muck. Some small areas that have a sandy loam surface soil texture were included with this soil. When this soil is adequately drained, the same crops are grown as on Snohomish silt loam, but under the same conditions the latter will give slightly better yields.

Snohomish loamy fine sand (0 to 3 percent slopes) (SM).—This soil consists of a 10- or 12-inch layer of grayish-brown or brownish-gray loamy fine sand recently deposited on peat or muck. Although the surface soil is loose and sandy, the organic soil very near the surface keeps it from being as droughty as Pilchuck loamy fine sand, which it resembles except for the organic substratum. When adequately drained, Snohomish loamy fine sand is utilized with adjacent areas of peat and muck soils for growing vegetables, but it is of less value for this purpose.

Spanaway gravelly sandy loam, gently undulating (1 to 6 percent slopes) (SP).—This extensive phase was developed on gravelly and sandy glacial outwash plains south of Tacoma between Loveland and McKenna and Puget Sound. It occupies smooth, ridged, and hummocky relief having low rounded mounds and shallow intervening basinlike depressions. The soil is somewhat excessively drained; runoff is very slow and internal drainage very rapid. Vegetation consists of grass, ferns, and moss and a few open stands of oak that in time are replaced by Douglas-fir and hemlock.

This phase has a very dark-brown to nearly black (moist) granular sooty acid gravelly or cobbly sandy loam surface soil. The surface soil is underlain at 12 to 24 inches by grayish-brown poorly assorted cobbles and gravel that extend to a depth of several feet. Variations in the number of cobbles and gravel occur from place to place but are of little significance in the use of the land.

Use and management.—The first farms in the county were located on this phase because it was in grass and did not require clearing. This soil is gravelly, droughty, and poorly suited to farm crops, although some areas are being used for hay or for small fruits and vegetables. Most areas are used for pasture, and about 15 acres are required to graze a cow for 5 months.

Much of this soil was farmed before World War I or until the Government purchased a large area for a military reservation at Fort Lewis. Many city workers from nearby Tacoma have homes on small acreages of this soil, especially near Spanaway, Steilacoom, and American Lake. They generally have a garden and some poultry to supplement their income. Yields are poor and returns are very low in contrast with those from the Puyallup, Sultan, and other recent alluvial soils.

Because grading is not necessary, roads are not difficult to build on this soil, and the very rapid internal drainage makes them passable during the rainy season.

Spanaway gravelly sandy loam, deep, nearly level (1 to 3 percent slopes) (So).—This phase, which consists of areas of Spanaway gravelly sandy loam in which the dark-colored soil material is deeper than 24 inches, was developed on nearly level areas or in slight depressions. Individual areas are generally not large. Because of their deeper profile, the soils have a greater water-holding capacity and are slightly more productive than the gently undulating phase. They are also less stony and gravelly than the gently undulating phase but have enough gravel to be droughty.

The soil to a depth of 12 or 14 inches is very dark-brown or black (moist) gravelly sandy loam underlain by brown gravelly sandy loam. This in turn is underlain by grayish-brown or grayish-yellow poorly assorted cobbles or gravel at depths of 28 to 36 inches.

Use and management.—Some areas of this soil are being used for pasture or for vegetables, small fruits, and hay crops. The yields are larger than on Spanaway gravelly sandy loam, gently undulating, but neither phase is fertile and yields are not high. More areas of the deep phase than of the gently undulating phase are being farmed because farmers have a tendency to seek out the better spots for cultivation.

Spanaway gravelly sandy loam, moderately steep (15 to 25 percent slope) (SR).—This phase generally occurs on a series of low

ridges, but some areas are on steeply sloping isolated hills. The profile is the same as that of the gently undulating phase, but it is more droughty because of the greater surface runoff. The soil is not farmed and most of it is covered with grass, small forbs, and moss and supports a stand of young fir or hemlock trees.

Stossel stony loam, hilly (15 to 30 percent slopes) (Ss).—This hilly phase occurs on short slopes bordering the mountains and foothills in the upper White River area. Individual areas are small, scattered, and of only minor importance. The soil was developed from glacial till deposits laid over highly colored shale. The till is densely massed with stone and boulders, which occur on the surface and are embedded throughout the soil profile.

This soil is generally variable and nondescript, the character and depth of the horizons differing considerably within a short distance. It has a dark-brown organic layer ranging from 1 to 3 inches thick, composed largely of needles, leaves, small twigs, and moss in varying degrees of decomposition. In places a thin ashy-gray layer is developed just beneath the organic layer, but it is of sporadic occurrence. In many places the organic layer directly overlies a brownish-gray granular loam containing some shotlike pellets. This material is embedded with numerous stones and angular boulders, which protrude from the surface. From depths of 7 to 18 inches the soil is yellowish-brown stony sandy loam that contains some shot pellets and orange and yellow mottling. Beginning at about 18 inches the material becomes more grayish and at about 24 inches it consists of stony gravelly clay loam that is yellowish brown and has yellow and rusty-brown inclusions. Below 48 or 72 inches lies highly colored and variegated boulder clay, which in turn overlies interbedded shale of varying colors.

Use and management.—The only areas of Stossel stony loam, hilly, in the county are unfavorable for crops because of their inaccessibility, excessive stoniness, and strong slopes. The soil is best adapted to forest.

Sultan silt loam (0 to 3 percent slopes) (Sv).—This is one of the most extensive and productive Alluvial soils in the county. It occurs in the larger nearly level stream valleys, especially the valley of the Puyallup River. It was derived from medium-textured sediments washed from glaciated areas and consists of mixed materials in which glacial flour predominates. The original vegetation consisted of a dense stand of conifers, but nearly all areas are now cleared and cultivated.

The 10- or 11-inch surface soil is friable and softly granular and works readily into a good seedbed. In a cultivated field it is brownish gray when dry and grayish brown when wet. The surface soil gradually grades into stratified layers of permeable fine sandy loam, silt loam, or silty clay loam, which is mottled with iron stains. These layers continue many feet. The water table may be 6 or 8 feet from the surface during summer.

Use and management.—Much Sultan silt loam is used for crops and is especially valuable for pasture. It is also used successfully in small acreages for blackberries, raspberries, strawberries, and canning and freezing peas.

Fertilizers are generally used on the fruit, berry, and truck crops. Barnyard manure and a phosphate fertilizer give the best results, but a complete fertilizer or nitrogen-phosphate fertilizer is generally used when manure is not available. The price of this land is very high, and the farms are small.

Sultan loam (0 to 3 percent slopes) (Su).—This soil differs from Sultan silt loam chiefly in having a lighter texture and more open and better internal drainage. It occurs in all the larger valleys and is of considerable extent. Individual areas are not so large as those of Sultan silt loam, but they are scattered and intermixed with areas of other soils of the Sultan series and soils of the Puyallup and Pilchuck series.

The surface soil to a depth of 10 or 12 inches is grayish-brown permeable granular loam. The subsoil is gray or brownish-gray loam mottled with yellow and brown. The subsoil is somewhat variable and in some places includes stratified layers of coarser or finer textured materials.

Use and management.—Sultan loam is variable for the production of raspberries, and much of it is planted to this crop. Other crops grown are hops, blackberries, canning and freezing peas and other vegetables, and narcissus, iris, and tulip bulbs. Barnyard manure with phosphate or a complete fertilizer is used for all crops. This land sells for high prices and the farms are small, many of them being only 10 or 15 acres.

Sultan fine sandy loam (0 to 3 percent slopes) (St).—This soil is more sandy and less drought-resistant than Sultan loam. It occurs chiefly in the valleys of the Puyallup and Stuck Rivers in small scattered areas in association with other members of the Sultan series and the Puyallup and Pilchuck soils. The total acreage, however, is considerable.

The surface soil to 9 or 10 inches is grayish-brown fine sandy loam; it is underlain by gray silt loam or very fine sandy loam mottled with yellow and brown.

Use and management.—The same crops are grown on this soil as on Sultan loam, but pasture crops do not do so well on it because of its tendency to become droughty in midsummer. Blackberries and peas also yield better on the finer textured soils. Other crops yield only slightly less than on Sultan loam. Fertilizers and tillage practices are the same as on the other Sultan soils, and land prices are about the same.

Tacoma muck (0–3 percent slopes) (Ta).—This soil occurs at the mouths of the Puyallup and Nisqually Rivers in low flat coastal areas adjacent to tidal marsh and tideland. It developed from partly decomposed salt-tolerant grass, sedges, and other plants mixed with fine tidal sediments. The areas have numerous tidal inlets and some sandbars and are covered with salt water at extremely high tide. The surface soil is a mixture of muck, peat, and silty mineral soil, which is grayish brown and mottled with yellow, red, and brown. The surface material ranges from 2 to 20 inches thick and is usually underlain by a layer of raw coarse fibrous peat or muck, 10 or 20 inches thick. This layer grades into stratified bluish-gray colloidal clay or finely fibrous sedgy material and sandy layers. It is impossible to drain Tacoma muck without constructing dikes; consequently most of it is being used in its natural state for what pasture it will provide (pl. 3, *B*).

Tanwax peat (0 to 3 percent slopes) (Tc).—This soil was developed chiefly in the southwestern quarter of the county from microscopic plants and fine colloidal sediments accumulated in glacial-lake and ponded-water depressions under conditions of very poorly developed drainage and a cool climate. It is distinguished from the associated Rifle peat by its fine spongy character and the absence of woody or other fibrous materials other than those formed by rootlets of water-loving shrubs and plants. During fall, winter, and spring months, water covers most areas to a depth of several inches or 1 or 2 feet.

The soil is composed of 1 or 2 feet of dark-brown very finely fibrous peat developed mainly from fine colloidal sediments underlain by rich-brown sedimentary peat. The peat usually supports a dense growth of spiraea, the fine roots of which give the surface material a finely fibrous character. The body of the peat is made up of the remains of microscopic and other aquatic plants so small that their individual outline is not recognizable. A few mosses and sedges grow on this peat.

Use and management.—Some areas of Tanwax peat have been ditched and drained and are being used for hay and pasture. The soil produces fair yields but it is not so good as either Mukilteo peat or Rifle peat. Most areas are within the boundaries of the Fort Lewis military reservation and remain in their natural state.

Tidal marsh (0 to 1 percent slopes) (Td).—This land type occurs on low-lying wet saline marshy coastal areas traversed by winding tidal sloughs and covered by saline waters during high tide. The most extensive areas are at the mouth of the Puyallup River near Tacoma. In some places the soil material is chiefly mineral, but in others it is modified by decomposed organic matter that ranges from a few inches to several feet thick. Where the drainage is slightly better, Tidal marsh grades into Tacoma muck. Tidal marsh supports a growth of salt-tolerant grass and plants and is of no agricultural value.

Tisch silt loam (0 to 3 percent slopes) (Te).—The level poorly drained areas occupied by this soil in depressions or along small streams are similar to those occupied by the Bellingham and McKenna soils. Tisch silt loam is associated with the better drained Kapowsin and Alderwood and the somewhat excessively drained Everett series. A layer of diatomaceous material ranging from a few inches to 2 feet thick within the upper 3 feet of the soil profile is characteristic.

To a depth of about 10 inches the soil is silt loam, dark grayish brown in moist field conditions and light brownish gray when dry. Below this layer to variable depths ranging from a few inches to several feet is a layer of light gray or brownish gray diatomaceous earth, underlain by greenish gray or bluish gray fine sand.

Use and management.—Most areas of Tisch silt loam have been cleared and drained by the use of open ditches and are being used for a variety of crops. On much of it hay crops give good yields. Several tracts near Roy are being used with success for hops and flower bulbs. The yields are not so high as on Sultan silt loam or Puyallup silt loam, however, and the bulbs grown are smaller.

Wapato clay loam (0 to 3 percent slopes) (Wa).—This poorly drained recent Alluvial soil was derived from fine-textured mixed sediments, mostly from material washed from the Wilkeson soils. Along the alluvial flood plains or small valleys it is associated with the medium-textured Chehalis silt loam and the coarse-textured Newberg

fine sandy loam. In most places the Newberg soils are adjacent to the streams, have a swell-and-swale relief, and are subject to frequent overflow; the Chehalis soil occupies slightly higher elevations, has a level relief, and is rarely overflowed. Wapato clay loam occupies back-bottom positions on the basin part of the valleys and may be flooded part of the year. Most of the total area occurs along the lower part of Ohop Creek west of Eatonville.

The surface soil is a grayish-brown to brownish-gray granular clay loam, in places mottled to the surface with yellowish brown. This layer, about 9 inches thick, grades into a slightly acid silty clay loam subsoil, noticeably mottled with gray and rusty brown. The lower subsoil, below a depth of 24 or 30 inches, is much lighter colored and is considerably finer textured and more compact than the upper subsoil.

Use and management.—Because of the low-lying position and the fine-textured subsoil, surface and internal drainage are very slow and artificial drainage is necessary for the production of cultivated crops. Most areas are used for pasture or hay.

Wilkeson loam, rolling (6 to 15 percent slopes) (Wc).—This phase is not only one of the most extensive soils of the county but one of the best soils in the uplands for timber production. It was developed under a heavy coniferous forest cover in a climate characterized by heavy rainfall, cool relatively dry summers, and mild wet winters. The parent material is a mixture of silty materials, pumice, and andesitic fragments of questionable origin. The soil occurs in the eastern part of the county and extends northward as far as Carbonado and westward as far as Ohop and Eatonville. It continues into the mountains to the east, where it was mapped with Rough mountainous land because of the excessively steep topography.

In virgin and undisturbed forested areas, the upper 1 or 2 inches are a dark grayish-brown mixture of some mineral soil with organic matter or with undecomposed needles and forest litter. Underneath this cover is brown loam having a granular structure and containing many soft round shot pellets. This loam grades at about 8 inches into yellowish-brown silt loam that has a well-defined nut structure, is more compact than the layer above, and contains some shot. The penetration of roots and air is good but not so good as in the layer above. At about 20 inches the material becomes a lighter yellowish-brown clay loam with a blocky structure. Root distribution at this depth is poor and there are very few shot. The clay loam is about 10 or 12 inches thick and is underlain by variegated gray silty clay loam mottled with gray, yellow, and rust-brown stainings. Over the surface and throughout the various layers of the soil are scattered fragments of basic igneous rock that are heavily coated with fine soil materials.

The natural drainage of the soil is moderately good, and internal drainage is medium.

Use and management.—Only a very small acreage of this phase is under cultivation at present. The yields of hay, chiefly oats cut green or alsike clover and timothy, are fairly good. A considerable acreage is used for pasturing beef cattle and sheep. No attempt has been made to clear this pasture land of stumps, but the brush is cut and grass mixtures, mainly orchard grass with some clover, timothy, and bluegrass, are sown between the stumps. Such pasture has a good carrying capacity even in the drier seasons.

By far the greater part of this phase has been cut over (pl. 3, *C*) and supports young fir, hemlock, and some shrubs or has been burned over and now produces little vegetation but fireweed and blackberries. Some virgin timber, chiefly hemlock, remains in the eastern areas adjacent to Mount Rainier National Park.

Wilkeson loam, hilly (15 to 30 percent slopes) (WB).—This soil is widely distributed in association with the more extensive rolling phase. It usually occupies hilly topography along drainageways and the more irregular relief in the upland areas between the rolling phase and Rough mountainous land or Rough stony land. The surface soil is usually thinner than on the rolling phase, and stones and rock outcrops are more common. Internal drainage and runoff are medium. The subsoil is less mottled than the subsoil of the rolling phase.

Wilkeson silt loam, rolling (6 to 15 percent slopes) (WD).—This phase occurs in the eastern part of the county on rolling uplands in association with the much more extensive Wilkeson loam, rolling. Both surface drainage and internal drainage are medium.

In undisturbed areas this phase is covered to a depth of 1 or 2 inches by a partly decomposed organic forest litter consisting of moss, needles, and woody fragments mixed with a little mineral soil. Immediately under this litter is granular brown silt loam containing many soft rounded soil aggregates and penetrated by a well-distributed root system. This layer is underlain at 10 or 12 inches by pale yellowish brown clay loam having a granular structure and containing few, if any, shot. Roots penetrate this clay loam and are well distributed through it, but few occur in the succeeding layers. At about 24 to 30 inches is a light grayish-yellow silty clay loam mottled with yellow and brown stains. At about 40 inches the material becomes variegated gray silty clay loam mottled with gray, yellow, and brown.

Use and management.—Most of the virgin timber on this phase has been cut, but only a very small acreage is cultivated. Young fir, hemlock, and small shrubs cover a part of this soil. Fire has burned over large areas, and now the vegetation consists of fireweed, wild blackberries, ferns, and some grass.

USE, MANAGEMENT, AND PRODUCTIVITY OF SOILS

USE SUITABILITY GRADES

The soils of the county differ widely in physical characteristics and consequently in their use suitability and management needs. Such differences are caused by a number of soil features, such as texture, consistence, quantity and character of organic matter, chemical characteristics (including reaction), moisture conditions, profile depth, stoniness, and slope or lay of the land. These features affect the use and management of the soil through their influence on productivity, workability, and conservability.

Productivity, as used here, refers to the ability of the soil to produce crops under prevailing farming practices. The soil may be productive of a crop but not be well suited to it because of poor workability or conservability, or both. Workability refers to ease of tillage, harvesting, and other field operations. It is affected by such soil

characteristics as texture, structure, consistence, moisture conditions, organic matter, stoniness, and slope or lay of the land. Conservability refers to the ease of maintaining the productivity and workability of the soil when it is cultivated.

The soils are placed in 10 grades in descending order of their desirability for the present agriculture. The best soils for crops are those that can be conserved with minimum effort and are very productive, easily worked, and retentive of moisture. The First-grade soils are better than the Second-grade; likewise, the soils of each succeeding class are further from the ideal than those of the preceding class; that is, they are generally less productive, less easily worked, and more difficult to conserve. The grade and land classification of cropland are for the sites that are adequately drained naturally or artifically, and properly cleared.

FIRST-GRADE SOILS

First-grade soils constitute excellent cropland under the management commonly practiced. They differ in degree of profile development, character of parent material, color, structure, and other respects, but they are relatively similar in general physical suitability for agricultural use. All are fairly well supplied with plant nutrients and organic matter as compared with other soils of the county, but even the most fertile soil is responsive to amendments when planted to some crops. Good tilth is easily maintained, and the range in moisture conditions for tillage is comparatively wide. The physical properties favor movement of air and moisture, and roots penetrate all parts of the subsoil freely. The range in moisture conditions for tillage is narrowed, however, and air and moisture movement is restricted to some extent in the imperfectly drained soils of this grade. None of the soils are characterized by any particularly adverse soil condition. They are almost free from stones, their relief is favorable to soil conservation and tillage, and none are severely eroded or highly erodible.

These soils have medium to relatively high natural productivity, and their fertility and soil material are relatively easily conserved. They are well suited to most of the exacting crops and intensive cropping practices under prevailing systems of management.

First-grade soils include the best of the recent Alluvial soils along the river flood plains or bottoms and the best of the organic soils. They are as follows:

Carbondale muck
Carbondale muck, shallow (over Rifle peat)
Chehalis silt loam
Dupont muck
Newberg fine sandy loam
Newberg loam
Puyallup fine sandy loam
Puyallup loam
Puyallup loamy fine sand
Puyallup silt loam
Rifle peat
Semiahmoo muck
Semiahmoo muck, shallow
Semiahmoo muck, shallow (over Mukilteo peat)
Semiahmoo muck, shallow (over Tanwax peat)
Snohomish fine sandy loam
Snohomish silt loam
Snohomish loamy fine sand
Sultan fine sandy loam
Sultan loam
Sultan silt loam

SECOND-GRADE SOILS

Second-grade soils are good to very good cropland under present farming practices. They have a greater diversity in physical characteristics than the First-grade soils. They are relatively similar to

each other in physical suitability for agricultural use but they may differ in productivity, workability, and conservability within a limited range. Each is moderately deficient in one or more of these.

In general the Second-grade soils are at least moderately productive of most crops grown in the county, and their physical properties are moderately favorable to tillage, the maintenance of good tilth, and movement and retention of moisture. None of these soils occupy very strong relief and none are extremely stony or severely eroded. Internal drainage is slow to very slow in many of them. The deficiency of each of these soils in one or more desirable characteristics is not great enough to make the soil poorly suited to agricultural use.

The Second-grade soils, which include some of the peats, the best soils of the upland depressions, and the best upland soil, are:

Bellingham silt loam
Bellingham silty clay loam
Kitsap loam, undulating
Kitsap silt loam, undulating
Mukilteo peat
Mukilteo peat, shallow
National pumicy loam
Rifle peat, shallow
Tanwax peat
Tisch silt loam

THIRD-GRADE SOILS

Each of the Third-grade soils is characterized by one or more shortcomings in its workability, productivity, and conservability that make it less desirable than a Second-grade soil for the production of the common cultivated crops under prevailing farming practices. One or more of the following undesirable features are prominent: (1) Slow internal drainage, (2) shallow depth of soil profile, or (3) fine texture. These shortcomings are not sufficiently great to make the soil definitely unsuited physically to cultivated crops.

Third-grade soils are fairly good cropland under prevailing farming practices, but their best use is for pasture for dairy herds. Some of the most successful farms in the county are on these soils. Their desirability for farming is lowered mainly by the limited number and kinds of crops that can be produced. The Third-grade soils are:

Bow clay loam, rolling
Buckley-Enumclaw loams
Buckley loam
Buckley loam, hardpan
Enumclaw fine sandy loam
Enumclaw loam
Newberg loamy sand
Orting loam
Orting sandy loam
Puyallup sandy loam, shallow (over Buckley loam)
Puyallup silty clay loam
Wapato clay loam

FOURTH-GRADE SOILS

Fourth-grade soils are fair cropland under prevailing farming practices. Many farms located on these soils are being successfully farmed, but the crop yields are not high and crop production requires much work. Pasture and grain are the two principal crops. The Fourth-grade soils are:

Bellingham silty clay loam, shallow surface soil
Edmonds fine sandy loam
Enumclaw gravelly sandy loam
Kapowsin gravelly clay loam, hilly
Kapowsin gravelly clay loam, undulating
Kapowsin gravelly loam, undulating
Kapowsin gravelly sandy loam, undulating
Kitsap-Indianola complex
Kopiah loam
Kopiah silty clay loam
Lynden loamy sand
McKenna gravelly loam, nearly level
McKenna loam, nearly level
McKenna loam, sloping
Norma fine sandy loam
Orting gravelly sandy loam
Pilchuck fine sandy loam
Puget clay
Puget silt loam
Puget silty clay loam

FIFTH-GRADE SOILS

Fifth-grade soils are poor cropland and do not produce enough to provide a satisfactory income for farmers using them. Most of the soils in this grade are low in fertility and, with the exception of the Nisqually, most of them produce only timber. This grade includes:

Alderwood gravelly loam, rolling
Cathcart loam, hilly
Indianola loamy sand, gently rolling
Indianola sandy loam, gently rolling
Nisqually loamy sand
Nisqually sand
Sinclair gravelly fine sandy loam, rolling
Sinclair gravelly loam, rolling
Wilkeson loam, rolling
Wilkeson silt loam, rolling

SIXTH-GRADE SOILS

Sixth-grade soils are very poor cropland and are used mostly for grazing. Timber production is low on most of these soils. The low productivity is due to droughtiness, low fertility, or a high water table that cannot feasibly be lowered. The soils of the class are:

Alderwood gravelly sandy loam, rolling
Pilchuck loamy fine sand
Spanaway gravelly sandy loam, deep, nearly level
Spanaway gravelly sandy loam, gently undulating
Spanaway gravelly sandy loam, moderately steep
Tacoma muck

SEVENTH-GRADE SOILS

Owing to their droughtiness, Seventh-grade soils are dominantly best suited to forest. If the soils were cleared, their nearly level relief would not be so difficult to farm as the steep relief of the Eighth-grade soils. The Seventh-grade soils are:

Greenwater loamy sand
Greenwood peat
National pumicy sandy loam
Pilchuck fine sand
Pilchuck gravelly sand

EIGHTH-GRADE SOILS

Because of their relief, Eighth-grade soils are best suited to forest. If they were cleared and cultivated, they would produce fair yields but production would be very costly and difficult to maintain. The Eighth-grade soils are:

Barneston-Wilkeson complex
Bow clay loam, steep
Indianola loamy sand, moderately steep
Kapowsin gravelly loam, moderately steep
Kapowsin gravelly sandy loam, moderately steep
Kitsap silt loam, steep

NINTH-GRADE SOILS

Ninth-grade soils are dominantly used for forestry because of their relief, low fertility, or droughtiness. If these soils were cleared and cultivated, the yield would be lower than on the Eighth-grade soils. The Ninth-grade soils are:

Alderwood gravelly sandy loam, hilly
Barneston gravelly loamy sand, hilly
Barneston gravelly loamy sand, rolling
Barneston gravelly sandy loam, hilly
Barneston gravelly sandy loam, rolling
Everett gravelly loamy sand, hilly
Everett gravelly loamy sand, rolling
Everett gravelly sandy loam, hilly
Everett gravelly sandy loam, nearly level
Everett gravelly sandy loam, rolling
Everett stony loamy sand
Fitch gravelly sandy loam, hilly
Fitch gravelly sandy loam, undulating
Orting stony sandy loam
Sinclair gravelly fine sandy loam, hilly
Sinclair gravelly loam, hilly
Skykomish stony sandy loam
Stossel stony loam, hilly
Wilkeson loam, hilly

TENTH-GRADE SOILS

Tenth-grade soils are nonagricultural but may produce timber. They include the miscellaneous land types. The Tenth-grade soils are:

Coastal beach
Made land
Riverwash
Rough broken land
Rough mountainous land
Rough stony land
Tidal marsh

LAND USE[5]

The most widespread land use in the county is for forest. Saw timber volume is in excess of 14,000,000,000 board feet, log scale. Large acreages are in second growth timber. Only 165,932 acres, or 15.5 percent of the total land area of the county, was in farms in 1950.

Inasmuch as dairying is the most important agricultural enterprise, more land is used for grazing than for all other crops combined. Dairying is carried on in practically all parts of the county, but most of the grazing land is on soils of the uplands. On these soils and soils such as the Orting and Buckley loams, a common practice is to plow and reseed pastures at 3- or 4-year intervals. Pastures on the Alluvial soils produce high yields of forage, and many are plowed only at long intervals, since well-fertilized pastures once well established produce heavily for years. Renovation, which includes clipping and reseeding followed by harrowing of the turf, is a general practice. On the Alluvial soils adjacent to Tacoma, Puyallup, and Sumner the competition for land by the growers of vegetables, fruits, and nursery stock has resulted in such high land rentals that dairymen cannot compete and are forced to look somewhere else for pasture.

Farming that combines dairying and the production of such cash crops as peas and sweet corn for processing is increasing in importance on Buckley loam and other good soils at some distance from large population centers. If the crop is cannery peas, pasture grasses and legumes are seeded with it, the peas being used as a nurse crop. Most of the land on dairy farms is used for pasture, and much of the hay used on these farms is imported from other areas.

Poultry raising is the second most important agricultural enterprise in the county. Farms specializing in poultry are located without much regard to soils, since nearly all the feed necessary is imported from other areas.

Pierce County is one of the leading counties in the United States in the production of raspberries and blackberries. In 1949, over 10,425,314 pounds of raspberries, 5,671,901 pounds of blackberries and dewberries, and 506,247 pounds of strawberries were produced. Raspberry production is confined for the most part to the sandy loams, fine sandy loams, loams, and silt loams of the Puyallup and Sultan series, both of which are Alluvial soils. A small acreage is on the better drained areas of the Alderwood and Kapowsin soils. Although much of the acreage in blackberries is on the muck soils, particularly around and within the city limits of Puyallup, plantings of considerable extent are on mineral soils not adapted to raspberries.

[5] This section was prepared by Karl Baur, associate soil scientist, State College of Washington, Western Washington Agricultural Experiment Station, Puyallup, Wash.

Strawberries have been very successfully grown on some of the upland soils of the area, mainly because the crop is harvested before the dry season in summer. They are a good crop for farmers having soils of the Alderwood and Kapowsin series and other upland soils of similar profile characteristics. The acreage of this crop and the yields produced are relatively low, however, because of the susceptibility to plant diseases of varieties now in use. All indications point to an increase in acreage when disease-resistant varieties are available. The mineral soils of the river bottom are also, for the most part, well adapted to the production of strawberries.

Tree fruits are grown for home use and for sale on a limited scale on nearly all of the soils of the county but principally on the prairie soils of the Spanaway and Nisqually series; on the hilly, very rapidly drained soils such as the Everett, Barneston, and other soils of similar profile characteristics; and on the peat and muck soils. The tree fruits grown commercially are chiefly sour and sweet cherries, peaches, and apples. There are a few small plantings of filberts.

Commercial crops of vegetables are grown principally on the muck, silt loam, loam, and sandy loam soils in the Puyallup and White River Valleys where yields are excellent and of high quality. Supplemental irrigation by sprinkler systems is in use on many of the farms and is growing in popularity.

Horticultural specialty crops are increasing in importance. One-third of the daffodil bulbs and large quantities of iris, tulip, and other bulbs produced in the United States are grown here. The list of such specialty crops as ornamental shrubs, herbs, cuttings, and flowers is long. Most of these crops are grown on the sandy loams, fine sandy loams, loams, and muck soils of the river valleys. Fine-textured soils are avoided, and only a very small acreage of the soils of the uplands is used for this purpose.

Fertilizer recommendations for most soils and crops may be obtained from publications of the State College of Washington Agricultural Experiment Station, which are available in the office of the county agricultural agent.

MANAGEMENT

More land is used for grazing in Pierce County than for all other crops combined. Small cereal grains are of minor importance except for oats. The raising of truck and berry and fruit crops is extensive (*12*). Intensive farming methods are used for these crops, and the soils are heavily fertilized. As the information available on fertilizing and managing various crops on specific soil types is limited, the discussion that follows is more or less general.

The Alluvial soils of the stream bottoms, where intensive farming is practiced, should be given amendments of complete fertilizers. Heavy applications of barnyard manure reinforced with nitrogen, phosphoric acid, and potash are recommended. Systematic crop rotation is impractical in areas where this intensive type of farming is followed, particularly where tree fruits and other specialized crops are grown. Where specialized crops are not grown, however, crop rotations are essential if maximum productivity is to be maintained.

The characteristically low content of available nitrogen in the soils, especially in the light-colored soils of the uplands, must be raised be-

fore these lands can be successfully farmed. Available nitrogen can be best supplied and maintained when intertilled small grains and grass or legume crops are grown in the rotation. All available barnyard manure, as well as green-manure crops, should be used to supplement the rotation. The small cash returns from grain crops do not warrant the use of commercial fertilizers for small grain crops following legumes, especially when the legume is fertilized with superphosphate. Nitrogen and phosphate may be necessary for small-grain hay crops when they do not follow a legume. Potash and lime applications seem to be beneficial in some cases, but more experimental data is necessary before any definite conclusions can be reached. The addition of lime has been found beneficial to crops grown on the Nisqually soils. There is a marked difference in the response of different crops to fertilizers on the same soil and in the response of the same crops on different soils (*15*). The farmer must select his fertilizer carefully and use those kinds best suited to his needs and soil-crop combination.

In a crop rotation, such intertilled crops as tuber and root crops and corn may be used. For the next crop following an intertilled crop in the rotation, wheat, oats, rye or others in the small-grain group may be selected. Provided there is an abundance of moisture available, a grain crop may also be used as a nurse crop for the grass or legume crop that is to follow for the third step in the rotation. Red and alsike clovers, peas, alfalfa, and beans are some of the legume crops from which selection may be made. As a practical rule, a legume crop should be used in a rotation at least every fourth year, or preferably 1 year in a 3-year rotation.

The most common green-manure crops are the vetches mixed with cereals (*7*). Fall-seeded crops are the most satisfactory. Rosen rye and hairy vetch is a recommended mixture for this region, since oats and wheat suffer more from winter injury. Fall seeding is usually done between September 15 and October 15. Spring-seeded green-manure crops most commonly used are wheat or oats with field peas. On well-drained soils, seeding should be done late in February or early in March. The recommended time to plow under a green-manure crop is when a maximum yield of good quality and active organic matter is attained. For leguminous crops this stage of maturity is reached when the blossoms appear, and for nonleguminous grain crops at the time the heads are beginning to come out of the sheaths.

The well-drained fertile lowlands make the best pastures. Of the alluvial soils, Sultan soils are preferred, and many of the dairy farms have pastures on these soils and on the finer textured types of the Puyallup soils. The Kapowsin, Sinclair, and Alderwood soils of the uplands make fair pastures. The Kapowsin is preferred because of its high water-holding capacity. Because of their porous and coarse character, the droughty soils, such as those of the Everett and Barneston series, do not show an appreciable increase in yields when fertilized.

In preparing the land for pasture, two or three cultivated crops should be grown to eliminate weeds before seeding the pasture. Early spring seeding is recommended. On cultivated lands, it should be done in March or April; on partly cleared unplowed lands, February

seedings are safest. Except on droughty soils a nurse crop, preferably a legume, such as peas, can be used. From 20 to 24 pounds of grass seed should be sown to the acre, the quantity depending on the soil type. Recommended forage species (*8*) for stream bottoms and upland depressions are as follows: Alta fescue, Italian ryegrass, English ryegrass, orchardgrass, Kentucky bluegrass, and red, white, alsike, and subterranean clovers. When nurse crops are used, one-half to two-thirds of the ordinary quantity of seed grain is sown with the forage mixture.

On land not suited to other crops because it remains wet during a large part of the winter and spring, reed canarygrass is recommended. A mixture of meadow foxtail and big trefoil (*Lotus uliginosus*) has also proved satisfactory for wet lands. Approximately 10 pounds of seed to the acre will produce a good stand and a pasture of high carrying capacity. Pastures should be regularly fertilized if they are to produce the highest yields, because grass is a heavy user of nitrogen. A practical application is six to eight loads of manure reinforced with 300 to 400 pounds of superphosphate an acre.

When grasses and legumes are used for hay crops rather than for pastures, a mixture of alsike clover and alta fescue or Italian ryegrass should be used (*7a*). Red clover at the rate of 12 pounds an acre may be substituted for alsike clover but is not so well adapted to imperfectly drained soils as alsike. Timothy may be used in place of Italian ryegrass, although it is not so desirable a hay for dairy cows. A grain-legume mixture of gray winter oats and hairy or common vetch is a popular hay-crop mixture. Spring oats planted with field peas is also recommended.

Heavy fertilization is essential for the maximum production of truck crops. The growing of several crops each season puts a heavy drain on plant nutrients, which therefore must be replenished by the addition of barnyard manure and commercial fertilizers. Truck crops and small fruit produce good results from large applications of manure, but usually small quantities supplemented with commercial fertilizers are preferable.

Root crops and tubers such as beets, mangels, and potatoes respond best to complete fertilizers; but under less intensive farming, 6 to 8 tons of manure supplemented by 200 to 300 pounds of superphosphate an acre will give satisfactory yields when it is used with a regular crop rotation. Under intensive farm methods, however, in addition to manure, it may be necessary to apply the following, or its equivalent, an acre; 100 to 125 pounds of sulfate of ammonia, 300 to 400 pounds of superphosphate, and 80 to 120 pounds of muriate of potash.

On soils that grow the leafy vegetables—cabbage, asparagus, celery and rhubarb—12 to 15 tons of manure and 600 to 800 pounds of superphosphate should be applied. On muck and peat soils, one-half of the quantity of manure plus 120 to 160 pounds of P_2O_5 and 35 to 50 pounds of K_2O is usually sufficient. When manure is not used, 60 to 70 pounds of nitrogen, 120 to 150 pounds of P_2O_5, and 35 to 50 pounds of K_2O should be used on the mineral and organic soils. On mineral soils lettuce requires 75 pounds of nitrogen, 70 pounds of P_2O_5, and 125 pounds of K_2O. Where lettuce is grown on muck and peat soils, the addition of 50 pounds of nitrogen, 180 pounds of P_2O_5, and 150 pounds of K_2O an acre should give the desired results.

Table beets, carrots, and sweet corn respond well to 12 to 15 tons of manure reinforced with 600 to 750 pounds of superphosphate an acre. When manure is not used, the recommended application is 4 to 50 pounds of nitrogen, 125 to 160 pounds of P_2O_5, and 60 to 75 pounds of K_2O an acre. Garden peas and beans may be fertilized with 30 pounds of nitrogen, 125 pounds of P_2O_5, and 100 pounds of K_2O.

Strawberries, an important cash crop, usually receive about 15 to 20 tons of manure; but when manure is reinforced with 400 to 600 pounds of superphosphate, 6 to 8 tons of manure is sufficient for the best yields. When no manure is used, 30 to 60 pounds of nitrogen, 50 to 100 pounds of P_2O_5, and 30 to 60 pounds of K_2O are applied. Strawberries should be fertilized after the crop is harvested or in the fall.

Raspberries and blackberries, the two main cash crops in the valley of the Puyallup River, are most economically fertilized with 8 to 12 tons of well-rotted manure and 400 to 600 pounds of superphosphate an acre. Without the manure, 20 to 35 pounds of nitrogen, 90 to 150 pounds of P_2O_5, and 50 to 75 pounds of K_2O are usually satisfactory.

In fertilizing orchards, a cover crop, such as vetch or rye, is commonly plowed under as green manure. Fall-seeded hairy vetch and Rosen rye are the best for this region. Nitrogen and occasionally phosphate and potash are applied, depending on the inherent fertility of the soil. Preliminary studies with the placement of fertilizer near the seed of the cover crop have indicated that a more efficient use of fertilizers can be made. Studies of the placement method of fertilization are now being made with special equipment (*15*).

The truck crop varieties adapted to the soils of Pierce County include the following: Peas—Alaska, Surprise, and Perfection; peas for freezing, the Tall Alderman and Thomas Laxton; cauliflower—snowball; brussels sprouts—Half Dwarf Improved; asparagus—Mary-Washington; celery—Golden Self-Blanching; rhubarb—Victoria and Linnaeus; beans—Stringless Green Pod, Oregon Lima, and Kentucky Wonder; lettuce (head)—New York, and (leaf)—Black-Seeded Simpson; spinach—Improved Thick Leaved; tomatoes—Scarlet Dawn, Bonny Best, and John Baer; sweet corn—Golden Bantam, Seneca "60," Golden Gem, and Seneca Golden; carrots—Imperator, Nantes, Chantenay, and Danvers Half Long; turnips—Purple Top White Globe, and Purple Top Milan; table beets—Early Wonder, Eclipse, Crosby Egyptian, and Detroit Dark Red; potatoes—Netted Gem, Irish Cobbler, and Early Rose.

The most common variety of strawberries is the Marshall, which is a heavy yielder and requires a rich soil and intensive culture. Other varieties as the Ettersburg and Corvallis are grown to a lesser extent. The Corvallis is adapted to the fine-textured soils. The Cuthbert and Washington are the two important varieties of raspberries. The Washington, the result of hybridizing the Cuthbert and Lloyd George, has been recently put on the market. As the Cuthbert is susceptible to winterkilling, the Washington was developed to take its place and has proved to be very successful. Another new hybrid is the Tahoma, classed among the sour varieties of red raspberries. Tahoma plants are resistant to winterkilling, but will probably be subject to diseases and insects attacking red raspberries in western Washington.

The blackberry varieties are Texas, Evergreen, and Brainerd. The Evergreen also grows wild and a large supply of berries comes from

this native plant. It quickly spreads to uncultivated fields and is a common weed along roads and fence lines.

Grape varieties commonly grown are the Concord, Campbell Early, Delaware, Niagara, and Agawam.

The Montmorency variety of the sour cherries is most extensively grown. Sweet cherries are largely Royal Ann, Bing, and Lambert. Pear varieties most commonly grown are the Bartlett, Anjou, and Winter Nelis. Esopus, Spitzenburg, and Golden Delicious are apple varieties.

The control of plant insects, pests, and diseases is an essential in attaining maximum high-quality production. The more serious pests attacking small fruits are the redberry mite, western raspberry fruit worm, strawberry root weevil, and the yellow currant fly. The flea beetle is one of the more injurious insect pests of the potatoes and tomatoes. The most common diseases of peas are downy mildew, powdery mildew, and cladosporium spot. Pea weevil, pea moth, and pea aphids are common pests. The most serious fungus diseases of strawberry plants are gray mold rot and the various leaf spots. The State College of Washington Agricultural Experiment Station may be consulted for insect and disease-control measures.

PRODUCTIVITY

The natural factors influencing the productivity of land are mainly climate, soil, drainage, and relief or lay of the land. The physical characteristics of the soils, especially those affecting moisture storage, are important. Erodibility, however, is not a serious problem in this area. The type of management, including the use of amendments, has considerable effect on what the soils will produce. Crop yields over a long period furnish the best available summation of the factors contributing to productivity, and they are used whenever available as the basis for determining productivity estimates. Some range in the productivity of nearly all the soils is to be expected.

Estimates of the expectable yields of the more important crops on each of the soils of the county are given in table 4. The soil types and phases are listed alphabetically.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of weathering and soil development acting on the parent material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point depend on (1) the physical and mineralogical composition of the parent material; (2) the climate under which that material has accumulated and has existed since accumulation; (3) the plant and animal life in and on the soil; (4) the relief or lay of the land; and (5) the length of time the forces of development have acted on the soil material. The influence of climate on soil and plants depends not only on temperature, rainfall, and humidity but also on the physical characteristics of the soil or soil material and on the relief, which, in turn, strongly influences drainage, aeration, runoff, erosion, and exposure to sun and wind.

TABLE 4.—*Estimated average acre yields that may be expected over a period of years from the principal crops on soils of Pierce County, Wash., under average management practices without supplemental irrigation* [1]

Soil	Corn silage	Oats	Wheat	Barley	Oat hay [2]	Mixed hay	Alfalfa hay	Pasture [3]	Potatoes	Canning peas	Strawberries	Raspberries	Blackberries	Suitability for forest
	Tons	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	
Alderwood gravelly loam, rolling	(4)	35	20	30	2.2	2.0	2.6	3.5	125	(4)	2.0	2.4	2.2	Good.
Alderwood gravelly sandy loam:														
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Rolling	(4)	30	16	25	2.0	2.0	2.4	3.0	110	(4)	2.0	2.2	2.0	Do.
Barneston gravelly loamy sand:														
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Fair.
Rolling	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	Do.
Barneston gravelly sandy loam:														
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Good.
Rolling	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	Do.
Barneston-Wilkeson complex	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Very good.
Bellingham silt loam	10.0	85	(4)	35	3.0	3.0	(4)	4.0	175	1.3	(4)	(4)	3.0	Fair.
Bellingham silty clay loam	10.0	80	(4)	35	2.8	3.0	(4)	4.0	(4)	1.3	(4)	(4)	3.0	Do.
Shallow surface soil	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Bow clay loam:														
Rolling	8.0	70	30	35	2.8	3.3	3.5	3.5	250	1.3	2.0	2.0	2.3	Do.
Steep	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Buckley-Enumclaw loams	7.0	80	35	35	2.8	2.6	3.0	3.6	200	1.8	2.5	(4)	(4)	Do.
Buckley loam	6.5	80	35	35	2.8	2.5	3.0	4.0	180	2.0	2.5	(4)	3.0	Do.
Hardpan	(4)	(4)	(4)	(4)	(4)	2.0	(4)	3.0	(4)	(4)	(4)	(4)	(4)	Do.
Carbondale muck	10.0	90	(4)	40	3.2	3.5	(4)	5.0	300	(4)	(4)	(4)	5.0	Poor.
Shallow (over Rifle peat)	10.0	85	20	35	3.0	3.5	(4)	5.0	300	1.7	(4)	(4)	4.5	Do.
Cathcart loam, hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Good.
Chehalis silt loam	10.0	85	35	40	3.0	3.4	4.5	4.5	200	1.5	2.5	2.5	3.0	Excellent.
Coastal beach	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Poor.
Dupont muck	(4)	70	(4)	30	2.5	2.8	(4)	3.0	190	1.4	(4)	(4)	2.3	Do.
Edmonds fine sandy loam	6.0	75	(4)	30	3.2	3.0	(4)	4.0	230	1.2	(4)	(4)	3.0	Good.
Enumclaw fine sandy loam	6.5	65	35	35	3.0	3.0	3.5	4.0	180	1.2	2.5	2.8	3.0	Fair.
Enumclaw gravelly sandy loam	5.0	50	25	25	2.0	2.0	2.5	3.0	165	1.0	2.0	2.5	2.5	Do.
Enumclaw loam	8.5	80	35	35	3.0	3.0	3.5	4.0	250	2.0	2.5	2.5	3.2	Do.
Everett gravelly sandy loam:														
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Nearly level	(4)	(4)	(4)	(4)	(4)	(4)	(4)	1.5	(4)	(4)	(4)	(4)	(4)	Good.
Rolling	(4)	(4)	(4)	(4)	(4)	(4)	(4)	1.5	(4)	(4)	(4)	(4)	(4)	Do.
Everett gravelly loamy sand:														
Rolling	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)
Everett stony loamy sand	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	Fair.
Fitch gravelly sandy loam:														
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Undulating	(4)	(4)	(4)	(4)	(4)	(4)	(4)	1.5	(4)	(4)	(4)	(4)	(4)	Do.
Greenwater loamy sand	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Good.
Greenwood peat	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	Poor.

See footnotes at end of table.

TABLE 4.—*Estimated average acre yields that may be expected over a period of years from the principal crops on soils of Pierce County, Wash., under average management practices without supplemental irrigation* [1]—Continued

Soil	Corn silage	Oats	Wheat	Barley	Oat hay [2]	Mixed hay	Alfalfa hay	Pasture [3]	Potatoes	Canning peas	Strawberries	Raspberries	Blackberries	Suitability for forest
	Tons	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	
Indianola sandy loam:														
Gently rolling	(4)	30	(4)	(4)	1.8	1.6	2.0	2.5	125	(4)	1.5	1.7	(4)	Poor.
Moderately steep	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Indianola sandy loam, gently rolling	(4)	35	(4)	(4)	2.0	2.0	2.5	3.0	150	(4)	1.8	2.0	(4)	Do.
Kapowsin gravelly clay loam:														
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Undulating	7.0	50	25	35	3.0	3.0	3.0	4.0	170	1.0	2.0	2.2	2.6	Do.
Kapowsin gravelly loam:														
Moderately steep	(5)	(5)	(5)	(5)	(5)	(5)	(5)	3.0	(5)	(5)	(5)	(5)	(5)	Do.
Undulating	6.0	40	25	30	2.8	2.8	3.5	2.7	150	1.0	2.0	2.0	2.5	Do.
Kapowsin gravelly sandy loam:														
Moderately steep	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Undulating	6.5	45	20	30	2.5	2.6	3.0	2.5	140	1.0	1.8	2.0	2.3	Do.
Kitsap-Indianola complex	6.0	60	25	25	2.5	2.5	3.0	3.5	160	1.0	2.0	2.3	(4)	Do.
Kitsap loam, undulating	7.0	80	30	30	3.0	3.0	3.5	4.0	175	1.2	(4)	(4)	2.3	Do.
Kitsap silt loam:														
Steep	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Undulating	7.5	85	30	30	3.2	3.0	3.5	4.0	175	1.2	(4)	(4)	2.5	Do.
Kopiah loam	(7)	(7)	(7)	(7)	(7)	(7)	(7)	3.5	(7)	(7)	(7)	(7)	(7)	Fair.
Kopiah silty clay loam	(7)	(7)	(7)	(7)	(7)	(7)	(7)	3.3	(7)	(7)	(7)	(7)	(7)	Do.
Lynden loamy sand	(4)	(4)	(4)	(4)	2.4	2.5	(4)	3.0	150	(4)	2.0	2.0	(4)	Do.
Made land	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Variable.
McKenna gravelly loam, nearly level	(4)	(4)	(4)	(4)	2.8	3.0	(4)	3.5	(4)	(4)	(4)	(4)	(4)	Fair.
McKenna loam:														
Nearly level	(7)	(7)	(7)	(7)	3.0	3.0	(4)	3.5	(7)	(4)	(4)	(4)	(4)	Do.
Sloping	(7)	(7)	(7)	(7)	3.0	3.0	(4)	3.5	(7)	(4)	(4)	(4)	(4)	Do.
Mukilteo peat	(4)	60	(4)	(4)	2.5	2.7	(4)	4.0	(4)	(4)	(4)	(4)	2.5	Poor.
Shallow	(4)	60	(4)	(4)	2.5	2.6	(4)	3.5	(4)	(4)	(4)	(4)	2.5	Do.
National pumicy loam	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	Excellent.
National pumicy sandy loam	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	Do.
Newberg fine sandy loam	9.5	65	30	25	2.5	3.0	4.0	3.5	180	1.2	2.0	2.3	2.5	Do.
Newberg loam	10.0	70	30	30	2.8	3.2	4.0	4.0	200	1.4	2.0	2.5	2.6	Do.
Newberg loamy sand	5.0	45	20	20	1.7	2.0	(4)	2.8	(4)	(4)	(4)	(4)	(4)	Good.
Nisqually loamy sand	(4)	35	10	15	1.2	1.5	(4)	1.5	100	(4)	1.5	(4)	(4)	Poor.
Nisqually sand	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	Do.
Norma fine sandy loam	8.0	70	(4)	(4)	3.0	3.0	(4)	4.5	(4)	1.0	(4)	(4)	2.0	Fair.
Orting gravelly sandy loam	5.5	50	15	20	2.3	2.0	(7)	3.0	170	1.0	1.8	2.5	2.5	Do.
Orting loam	6.5	60	20	25	2.5	2.0	3.0	3.5	180	1.2	1.9	2.5	2.5	Do.
Orting sandy loam	(7)	(7)	(7)	(7)	2.3	2.0	(7)	3.3	(7)	(7)	(7)	(7)	(7)	Do.
Orting stony sandy loam	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Pilchuck fine sand	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	Good.
Pilchuck fine sandy loam	(7)	(7)	(7)	(7)	3.3	3.5	(4)	4.0	(7)	(7)	(7)	(7)	(7)	Excellent.
Pilchuck gravelly sand	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	Fair.
Pilchuck loamy fine sand	(7)	(7)	(7)	(7)	2.3	2.5	(4)	2.5	(4)	(4)	(4)	(4)	(4)	Good.

Puget clay	(7)	(7)	(7)	(7)	(7)	(7)	(4)	4.0	(4)	(7)	(4)	(4)	(4)	Do.
Puget silt loam	(7)	(7)	(7)	(7)	3.5	3.5	(4)	4.5	(4)	(7)	(7)	(7)	(7)	Do.
Puget silty clay loam	(7)	(7)	(7)	(7)	3.5	3.5	(4)	4.5	(4)	(7)	(4)	(4)	(7)	Do.
Puyallup fine sandy loam	11.0	80	28	40	4.0	3.8	(4)	4.5	250	1.4	2.5	3.4	2.7	Excellent.
Puyallup loam	11.0	85	30	40	4.5	4.0	(4)	5.0	250	1.5	2.5	3.5	2.8	Do.
Puyallup loamy fine sand	9.0	70	25	30	3.5	3.5	(4)	4.0	200	1.0	2.0	2.0	2.5	Do.
Puyallup sandy loam, shallow (over Buckley loam)	10.0	75	28	35	3.6	3.6	(7)	4.5	240	1.3	2.3	2.8	3.0	Good.
Puyallup silt loam	12.0	100	40	45	5.0	4.5	(4)	5.0	250	1.6	2.5	3.5	3.0	Excellent.
Puyallup silty clay loam	(7)	(7)	(7)	(7)	(7)	4.5	(4)	4.5	(7)	(7)	(7)	(7)	(7)	Do.
Rifle peat	(4)	90	(4)	40	3.0	3.0	(4)	4.5	190	2.0	(4)	(4)	2.8	Poor.
Shallow	(4)	85	(4)	40	3.0	3.0	(4)	4.5	180	2.0	(4)	(4)	2.7	Do.
Riverwash	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Fair.
Rough broken land	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Good.
Rough mountainous land	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Rough stony land	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Fair.
Semiahmoo muck	(4)	80	(4)	35	2.8	3.0	(4)	4.5	250	(4)	(4)	(4)	4.0	Poor.
Shallow	(4)	70	(4)	30	2.5	3.0	(4)	4.5	200	(4)	(4)	(4)	3.0	Do.
Shallow (over Mukilteo peat)	(4)	80	(4)	35	2.8	3.0	(4)	4.5	250	(4)	(4)	(4)	4.0	Do.
Shallow (over Tanwax peat)	(4)	70	(4)	30	2.5	3.0	(4)	4.5	200	(4)	(4)	(4)	3.0	Do.
Sinclair gravelly fine sandy loam:														
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Good.
Rolling	(4)	30	16	25	2.0	1.8	2.4	3.0	115	(4)	1.8	2.0	2.0	Do.
Sinclair gravelly loam:														
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Rolling	(4)	35	20	30	2.2	2.0	2.6	3.5	125	(4)	2.0	2.4	2.2	Do.
Skykomish stony sandy loam	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	Fair.
Snohomish fine sandy loam	9.0	85	30	35	3.4	3.3	(4)	5.0	240	1.8	(4)	(4)	5.0	Good.
Snohomish loamy fine sand	8.0	80	25	35	3.0	3.0	(4)	4.5	180	1.5	(4)	(4)	2.5	Do.
Snohomish silt loam	10.0	90	30	40	3.5	3.3	(4)	5.0	280	2.0	(4)	(4)	5.0	Do.
Spanaway gravelly sandy loam:														
Gently undulating	(4)	(4)	(4)	(4)	(4)	(4)	(4)	1.5	(4)	(4)	(4)	(4)	(4)	Poor.
Deep, nearly level	(4)	(4)	(4)	(4)	(4)	(4)	(4)	1.7	(4)	(4)	(4)	(4)	(4)	Do.
Moderately steep	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Do.
Stossel stony loam, hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Good.
Sultan fine sandy loam	11.0	80	40	40	4.2	4.2	(4)	4.5	240	1.6	3.5	5.0	4.0	Excellent.
Sultan loam	12.0	90	40	40	4.5	4.5	(4)	5.0	250	1.8	3.5	5.0	4.5	Do.
Sultan silt loam	12.0	90	40	40	4.5	4.5	(4)	5.5	250	2.0	3.5	5.0	5.0	Do.
Tacoma muck	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	Poor.
Tanwax peat	(4)	50	(4)	20	2.3	2.5	(4)	3.0	(4)	(4)	(4)	(4)	2.3	Fair.
Tidal marsh	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	Poor.
Tisch silt loam	9.0	70	(4)	30	2.8	3.0	(4)	3.5	200	1.5	2.0	(4)	2.5	Fair.
Wapato clay loam	9.0	80	35	35	3.2	3.3	(4)	4.2	(4)	1.5	(4)	(4)	(4)	Do.
Wilkeson loam:														
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Very good.
Rolling	(4)	(7)	(7)	(7)	2.5	2.5	3.0	3.5	(7)	(4)	(7)	(7)	(7)	Do.
Wilkeson silt loam, rolling	(4)	(7)	(7)	(7)	2.7	2.6	3.0	3.5	(7)	(4)	(7)	(7)	(7)	Do.

[1] Yields under good management, which includes use of adapted varieties, properly balanced fertilizers, and possibly supplemental irrigation, may be as much as 100 percent greater than those indicated. The greater relative increases due to good management will tend to be on the soils giving low yields under common or ordinary management.

[2] Usually an oat-annual legume mixture.

[3] Air-dry weight equivalent to that of hay.

[4] Soil not well suited to crop.

[5] Not suitable for agricultural use.

[6] Not adapted for general agricultural use, but when properly managed it is adapted to cranberries and blueberries.

[7] Not in general agricultural use.

ENVIRONMENT AND GEOLOGY OF SOILS

Pierce County borders the southeastern part of Puget Sound, and a large proportion of the area surveyed lies within the physiographic region known as the Puget Sound Basin. Since the foothills and mountain slopes occur well within the Puget Sound Basin and rise rapidly eastward to the crest of the Cascades, there is a wide range of environmental conditions and parent material. This pronounced range in relief has a marked influence on climate, vegetation, and soils.

The parent materials, although differing considerably, are largely glacial deposits of various kinds of rock. The soils of the county have been formed by forces of environment, principally climate and vegetation, acting on these glacial deposits. These forces have been in part restricted or modified by retarded drainage and unfavorable relief. The climate adjacent to the coast is maritime, but that in the higher interior is modified continental. The precipitation range is from about 30 inches adjacent to the coast to about 100 inches in the Cascades. Except in a few areas under grass, the soils were developed under a forest vegetation that was mainly coniferous and consisted of Douglas-fir, hemlock, cedar, some spruce, pine, and a few deciduous trees, principally alder and maple.

The brown, acid, permeable soils that have developed throughout the timbered uplands and terraces are classified in the Brown Podzolic soil group (*1*). The dark soils that have developed on the flat lower lying stream bottoms and upland depressions are considered azonal or intrazonal.

Geological formations outcropping in Puget Sound Basin are of Tertiary age. The Puget Sound region was one of constantly shifting land and water areas and of frequent alternations of fresh and salt water (*3*). In this region the Pliocene was primarily a time of uplifting movement and subsequent erosion.

In the succeeding Pleistocene three epochs identified with glacial encroachment occurred—the Admiralty (glacial), Puyallup (interglacial), and Vashon (glacial).

Good exposures of the Admiralty till are rare, but those positively recognized are deeply weathered only in a few instances where stained by percolating water. A fine exposure exists on Cole Point on Anderson Island.

The Puyallup, or interglacial, epoch—a time of diastrophic movement and erosion followed by a subsequent sinking—is thought to have contributed the major glacial land features and drainageways.

The ice of the Vashon epoch advanced on Puget Sound from the north as did that of the Admiralty epoch. It extended at its maximum as far as the Admiralty glaciation and in no known instance did the Admiralty extend beyond it. In many places the Vashon deposits have only thinly mantled the glacier-scoured Miocene and Eocene sedimentary strata and the miocene extrusives (largely andesite but containing basalt). This condition is found in the undifferentiated soils of the mountains and mountain slopes. Several andesite and basalt outcrops occur in the Vashon terminal moraine.

The Vashon glaciation largely determined the minor features of relief and drainage because it leveled off old glacial deposits and rock

outcrops. It filled up valleys and subsequently dammed streams to form lakes or diverted the streams to new courses, as when the Puget Sound Glacier blocked the lower drainage courses west and north and the Puyallup River drained south via Ohop Channel. The outwash from the Vashon glaciation includes the comparatively level area covered with coarse clean gravel in the southwestern part of the county, as well as extensive areas to the south.

Although the Vashon glaciation contributed most of the drift from which the soils are developed in the area, glaciers from the Cascade range contributed some minor deposits. The largest of these deposits were laid down by the Osceola Glacier or mud flow. The partially cemented character of the Osceola drift and the presence of silts and clays indicate that the area on which the drift occurs was at one time submerged by marine or glacial lake waters that retarded normal soil development and internal drainage on generally level relief. A small area of the Osceola drift is in Pierce County south of the White River and in the vicinity of Buckley but most of it is in the adjoining King County on the north between the White and Greenwater Rivers.

Irregular lines of contact appear between the contemporaneous drift sheets of the Puget Sound Vashon Glacier and Osceola Glacier. A definite margin of contact usually exists between the area covered by the Puget Sound glacier and the driftless area east and south of it.

The Puget Sound Glacier crowded up on the slopes east of Eatonville and deposited glacial till at elevations as high as 1,200 feet. East of this terminal moraine at the top of the steep rock slope there is little evidence of glaciation and the origin of the parent material of the soil is not definitely known. According to Bretz (*3*), the Rainier glacial ice of Mount Rainier never altered the area more than to remove a residual soil. This area may possibly be the result of an old glaciation—older than the Admiralty or the Vashon. In some localities numerous fragments of igneous rocks are found throughout the soil profile. Outcrops, largely andesite and basalt, occur at higher elevations. They are so numerous in Rough mountainous land and Rough stony land that soil developed from them is partly or wholly residual.

The Vashon drift is yellowish gray to bluish gray arenaceous material filled with smooth rock fragments. It was derived chiefly from granite, mica schist, and gneiss; but some sandstone, shale, argillite, quartzite, and occasionally basalt and andesite are included. The Osceola drift differs from the Vashon in containing more basic materials derived chiefly from andesite and basalt, and it is darker gray, less acid, and contains a higher percentage of finer materials.

Miocene and Eocene sedimentaries, principally sandstone, which contribute residual material to the subsoil of the soils developed on shallow drift materials, occur in a few limited areas.

CLASSIFICATION AND DESCRIPTION OF SOILS BY HIGHER CATEGORIES

The orders and great soil groups represented by one or more soil series in Pierce County are as follows: (1) zonal, (2) intrazonal, (3) azonal.

Since not all of the soils in the county have been sufficiently studied nor all of the soil groups adequately defined, it cannot be determined definitely in which group a soil belongs. It is possible that in time

some of the soils now listed under one group may be changed to another or that new soil groups may be created. In this report, therefore, classification of the soils into great soil groups is tentative. In addition, many of the soil groups are in complex patterns, and there are transitional soils that have some characteristics of two or more groups. The Barneston soils, for example, have some characteristics of both the Brown Podzolic soils and the Podzols.

ZONAL SOILS

Soils of the zonal order are those having well-developed soil characteristics that reflect the influence of the climatic and vegetative factors of soil genesis. In the county the zonal soils are made up of the Brown Podzolic, Podzol, and Prairie soils.

BROWN PODZOLIC SOILS

The Brown Podzolic soils include somewhat excessively to moderately well drained medium to strongly acid soils having a thin organic covering over a brown granular shotty layer that gradually becomes lighter colored and less shotty with depth. Soils belonging to this great soil group in the county are members of the Alderwood, Barneston, Cathcart, Enumclaw, Everett, Indianola, Kapowsin, Kitsap, Lynden, Sinclair, Skykomish, and Wilkeson series. The soils reflect chiefly the influence of climate and vegetation in their development. Temperature, both winter and summer, and the quantity and distribution of precipitation have had a very marked influence on their development.

The Brown Podzolic soil zone includes the Puget Sound Basin where the mean annual precipitation ranges from 31 to 60 inches, the average January temperature from about 33° to 38° F., and the average July temperature from about 60° to 63°. Summers are relatively dry, and spring, fall, and winter seasons are wet.

Within this area most of the soils, which were originally forest-covered, have the following well-defined characteristics when developed from open permeable materials on smooth relief and under adequate external and internal drainage.

Dark grayish-brown (10YR 3/2)[6] or very dark brown (10YR 2/2) friable loose very strongly acid (pH 5.0) organic layer that is 2 or 3 inches thick and underlain abruptly by brown (10YR 5/3) coarse granular or fine nuciform layer that is about 10 inches thick and consists of water-stable aggregates that are dark brown (10YR 3/3) when moist. There is a noticeable change in color between the dry and moist soil. This layer, especially in the upper part, contains a large number of brown iron shot pellets ranging in size from small peas to sand grains. It has a pH value of about 5.5 and does not expand or contract greatly at the extremes of moisture. It is underlain by pale brown (10YR 6/3) faintly granular material similar in texture and acidity and 10 to 20 inches thick. The parent material is light yellowish brown (10YR 6/4) or light gray (10YR 7/2), generally strongly acid (pH 5.1 to 5.5), and in many series semi-indurated or indurated. There is little or no zone of clay accumulation in the profile, but iron, manganese, and phosphorus have apparently accumulated in the shot.

[6] Provisional soil color names proposed by the 1946 committee on soil color; color of dry soil unless otherwise stated. Symbols express Munsell notations.

The shot pellets in the upland soils are apparently a normal development in the profile. Wheeting (*14*) believes that these pellets form as the result of the precipitation and dehydration of soluble iron and aluminum compounds around a nucleus of sand grains or gravel or other focal points during the dry summers, when a general downward movement and a formation of a clear-cut B horizon are inhibited.

The shot soils are formed under forest vegetation and in places are best developed when internal drainage is restricted. The shot particles are richer in sesquioxides and particularly in phosphorus than the soils surrounding them. Because of the similarity in composition of B horizons in normal podzolic soils and of shot in these normally developed soils, the shot are considered parts of a diffused B horizon scattered throughout the weathered portion of the profile.

The profile described is characteristic of all of the soils of the Brown Podzolic group, but several of the series have qualities that would permit them to be classified also as members of other soil groups. Some areas of the Barneston and Wilkeson soils, which occur at elevations exceeding 2,000 feet, have characteristics of the Podzols. Most all areas of the Kitsap soils have a grayer surface soil and more mottled subsoil than the other members of the Brown Podzolic soil group. Some areas of the Lynden soil have characteristics of the Ground-Water Podzol soils. The Sinclair soils are grayer and not so brown as other series in this group, one reason being the high shot content of the Sinclair soils. If the shot are pulverized, the soil mass is nearly as brown as the Alderwood soils.

All the series in the Brown Podzolic group have some characteristics in common. Each of the series, however, differs from the others in some morphological characteristics that can be detected when the soils are examined and mapped in the field. The Barneston, Everett, Indianola, and Lynden soils are all developed from loose permeable glacial materials. They differ less in morphological characteristics than in the textural character of the drift and in the topographic position and relief.

The Everett and Barneston soils were developed from similar gravelly loose drift and are separated on the basis of differences in textural character and position. The Barneston soils are located in the eastern part of the county where the annual rainfall is higher. Consequently they have been more thoroughly leached and have developed deeper solums than the Everett soils. The stones and gravel are characteristically coated with fine material. The Barneston profiles have more shot and show more iron staining than those of the Everett soils. The Everett soils occur on terraces or kames and eskers and on glacial outwash terraces, whereas the Barneston soils have a pronounced relief that includes areas that are more morainic and are characterized by hummocks and kettleholes. Although a few areas of the Everett soils are nearly level and show little evidence of being water-worked, the drift is better assorted than that of the Barneston soils.

An examination of the more typical profile of the upland soils shows that the soil-forming processes have not had sufficient time to change the parent materials greatly. Developed under a coniferous forest, the forest litter is high in bases compared with the mineral soil below, and it decomposes slowly and mixes very little with the mineral soil. The soil is brown and characteristically low in available nitrogen. The distinctly developed gray A_2 horizon, common to

a Podzol, is absent or very thin except in a few places at higher elevations that have a cool climate and higher rainfall. Although organic acids may form, they may not be sufficiently effective in leaching the surface soil because of the mild rainy season and especially dry summers. The acidity of the organic matter is rarely much below pH 5.0.

The following is a profile description of Everett gravelly sandy loam, rolling, in a virgin area of the SE¼SE¼ sec. 22, T. 21 N., R. 3 E. on gently undulating relief under coniferous forest:

A_0 ½ to 0 inches, very dark grayish-brown (10YR 3/2) partly decomposed very strongly acid (pH 5.0) loose organic layer consisting of needles, small twigs, moss, and roots; in lower part some very dark-gray mineral matter.

B_{21} 0 to 12 inches, brown (10YR 5/3; 4/3, moist) very fine crumb to single grain, strongly acid (pH 5.5), very friable gravelly sandy loam; the aggregates durable even when in water for several minutes; some rusty iron shot pellets that can be cut with a knife but cannot be crushed between the fingers.

B_{22} 12 to 21 inches, pale-brown (10YR 6/3) very friable strongly acid (pH 5.5) single-grained gravelly loamy sand having a few shot concentrated in the upper part; the gravel slightly coated and stained with manganese, colloidal clay, and silica.

B_3 21 to 31 inches, light olive-gray (5Y 6/2) loose gravelly coarse sand; (pH 5.5); single-grained structure, the gravel clean and free from stains.

C 31 inches +, pale-yellow (5Y 7/3) porous poorly assorted sands, gravel, cobbles, and stone; (pH 5.5).

A profile of Barneston gravelly sandy loam, rolling, would be very similar in color and composition to Everett gravelly sandy loam, rolling, except that the B_{22} layer is slightly finer textured and the gravel in the B_3 layer has thin coatings. In places a thin gray leached A_2 layer occurs immediately below the A_0 layer.

Unlike the Everett and Barneston soils, the Indianola and Lynden are derived from sandy glacial materials and are nearly gravel free. The Indianola soils differ from the Lynden in occupying rolling uplands and having slightly more soil development. The Lynden soil occurs on smooth glacial outwash terraces of stratified sands, and the Indianola soils on kamelike deposits and eskers. Areas of the Lynden soil that have a high water table have a profile similar to that of the Edmonds series, which is a Ground-Water Podzol.

The Alderwood soils differ from the Everett series in having a slightly finer textured subsoil and a gray semicemented or indurated layer at 3 or 4 feet that may extend to a depth of 50 to 60 feet or more. They may also be slightly more acid than the Everett soils. These two soil series often occur side by side.

The Sinclair soils differ from the Alderwood soils in being grayer and in having much more shot, which in places makes up 50 percent or more of the material in the upper horizons. The shot occurs particularly in the finer textured types such as the loam and clay loam. The relief of the Sinclair soils in most areas is rolling to hilly. Internal drainage is slightly more restricted, and during the rainy season, the Sinclair soils remain wetter for longer periods than the Alderwood.

The mechanical analyses, organic-matter content, and pH value of Sinclair gravelly fine sandy loam, rolling, are given in table 5.

TABLE 5.—*Mechanical analyses,*[1] *organic-matter content, and pH value of Sinclair gravelly fine sandy loam, rolling*[2]

Depth in inches	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Organic matter[2]	pH
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
0 to 14	5. 1	7. 3	7. 3	19. 1	16. 3	37. 7	7. 2	2. 7	5. 6
14 to 28	5. 5	10. 1	9. 4	17. 7	15. 1	36. 2	6. 0	1. 3	5. 3
28+	2. 6	8. 7	9. 4	21. 8	16. 8	34. 1	6. 6	. 0	5. 6

[1] Analyses by the Division of Soil Management and Irrigation. Sample collected in sec. 21 or 22, T. 18 N., R. 4 E.
[2] Organic matter determined by H_2O_2.

The Skykomish soil differs from the Everett soils in having developed from loose very permeable gravelly and stony stream-terrace materials rather than from gravelly glacial materials. The color, acidity, and texture are very similar in the profiles of the two series. The Skykomish soil occupies only a few areas in the county and is not so typical as the Skykomish soils of Snohomish County.

The soil of Cathcart series has developed from shallow Vashon drift over an old consolidated sandstone and shale formation. The profile is typical of the Brown Podzolic soils.

Kitsap soils have developed from laminated silts and clays of glacial lake or marine deposits. They occupy gently sloping or level upland terraces that have occasional steep breaks. The surface drainage is moderately good but internal drainage is more restricted than in the other soils of the Brown Podzolic group. The restricted drainage has caused darker gray surface soils that are less brown than in the typical profile of this soil group and that are distinctly mottled. The subsoils range from a mottled rusty yellowish brown and gray to a mottled brownish gray and yellowish brown. The surface soil in many places has nearly as much shot as that of the Sinclair soils. Restricted internal drainage has apparently retarded soil development, and the Kitsap soils have relatively shallow profiles in which oxidation has been limited.

Soils of the Wilkeson series have a typical Brown Podzolic profile. They have developed on the slopes and foothills of the Coast Range in the eastern part of the county. The surface soil of Wilkeson silt loam, rolling, consists of a brown (10YR 5/3) granular friable silt loam that is composed of water-stable aggregates. Some shot occur in this layer, which is about 10 inches thick. The pH may range from 4.8 to 5.5. The subsoil is a pale-brown (10YR 6/3) granular clay loam. When moist this layer is dark brown (10YR 4/3) and slightly plastic. The substratum is yellowish brown (10YR 5/4) when moist and consists of a mottled moderately plastic silt loam or silty clay loam that continues to a depth of many feet.

The mechanical analyses, organic-matter content, and pH value of a sample of Wilkeson silt loam, rolling, are given in table 6.

TABLE 6.—*Mechanical analyses,*[1] *organic-matter content, and pH value of Wilkeson silt loam, rolling*[2]

Depth in inches	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Organic matter[3]	pH
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
0 to 10	1. 3	3. 5	3. 6	11. 8	19. 4	51. 4	9. 0	10. 8	5. 3
10 to 28	. 9	2. 9	4. 3	14. 1	18. 8	49. 6	9. 4	2. 0	5. 5
28 to 40	. 3	2. 0	3. 3	9. 7	16. 0	59. 8	8. 9	. 7	5. 6
40+	. 6	5. 0	2. 9	6. 5	9. 9	58. 3	16. 8	. 3	5. 5

[1] Analyses by the Division of Soil Management and Irrigation.
[2] Sample collected in sec. 35, T. 18 N., R. 5 E.
[3] Organic matter determined by H_2O_2.

At high elevations there are rock outcrops of basalt and andesite. Some areas at lower elevations are quite commonly very stony, whereas others are free or nearly free of stones. In limited areas in the high mountains the soils tend to have a thin gray A_2 horizon immediately below the organic mat.

The Kapowsin soils are derived from glacial till and usually occupy smooth relief. They are associated with many small areas of the Humic Gley soils and the Bog soils. Areas of Kapowsin gravelly loam, undulating, tend to be hummocky and have small swampy spots only a few yards in diameter, but this condition is not so common in Kapowsin gravelly sandy loam, undulating. The drainage as a whole, however, is moderately good. The Kapowsin soils differ from the Alderwood soils in having a zone of illuviation above the cemented substratum. This zone is apparently the result of an accumulation of silts and clay caused by continuous leaching.

The following is a description of Kapowsin gravelly loam, undulating, collected from a virgin area on a slope of about 6 percent and under coniferous vegetation:

A_0 1½ to 0 inches, dark-brown to black organic layer, partly decomposed and consisting of small twigs, bark, cones, needles, leaves, and roots mixed with black mineral matter at the point of contact with the highly organic mineral soil below.

A_1 0 to 4 inches, very dark gray highly organic gravelly loam having a large number of roots and a few shot in the lower part of the horizon.

B_1 4 to 16 inches, yellowish-brown gravelly loam; numerous shot up to ¼ inch in diameter; gravel stained and coated with fine material.

B_{21} 16 to 23 inches, grayish-brown compact gravelly loam, gritty and highly mottled with yellow and rusty-brown stains; very few or no shot; sticky when wet.

B_{22} 23 to 26 inches, brownish-gray loam variegated with rusty brown and gray; very compact and sticky when wet.

C 26 inches +, gray sandy loam cemented till.

The mechanical analyses, organic-matter content, and pH value of a sample of Kapowsin gravelly loam, undulating, are given in table 7.

TABLE 7.—*Mechanical analyses,*[1] *organic-matter content, and pH value of Kapowsin gravelly loam, undulating*

Depth in inches	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Organic matter[2]	pH
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
0 to 4	3. 2	7. 0	7. 5	18. 0	15. 3	39. 0	10. 0	11. 9	5. 5
4 to 16	3. 4	6. 7	8. 0	17. 0	13. 7	41. 0	10. 2	2. 2	5. 3
16 to 23	3. 7	7. 0	8. 1	15. 1	12. 0	44. 4	9. 7	. 8	5. 5
23 to 26	5. 2	8. 7	9. 4	19. 1	15. 4	36. 2	6. 0	. 1	5. 6
26+	3. 5	6. 9	8. 1	19. 0	15. 8	37. 2	9. 5	. 0	6. 8

[1] Analyses by the Division of Soil Management and Irrigation.
[2] Organic matter determined by H_2O_2.

The Enumclaw soils have developed from compact Osceola drift and have somewhat restricted drainage because of the nearly level relief and slowly permeable parent materials. As a consequence of the restricted drainage, the surface soil is dark and the subsoil mottled. Nearly impervious layers may occur at a relatively shallow depth, frequently not deeper than 18 to 20 inches.

The mechanical analyses, organic-matter content, and pH value of Enumclaw fine sandy loam are given in table 8.

TABLE 8.—*Mechanical analyses,*[1] *organic-matter content, and pH value of Enumclaw fine sandy loam*[2]

Depth in inches	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Organic matter[3]	pH
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
0 to 11	7. 2	12. 2	9. 0	18. 7	14. 7	27. 4	10. 8	2. 7	5. 0
11 to 20	8. 1	14. 1	9. 8	18. 5	14. 6	27. 3	7. 6	2. 5	5. 2
20+	13. 7	13. 2	9. 8	18. 2	13. 5	22. 2	9. 4	. 1	5. 5

[1] Analyses by the Division of Soil Management and Irrigation.
[2] Sample collected in sec. 5, T. 19 N., R. 6 E.
[3] Organic matter determined by H_2O_2.

PODZOLS

The Podzols in the county are zonal soils having a thin mat of partly decayed leaves over a very thin dark grayish-brown humic mineral soil and a pale-gray A_2 horizon over a brown or yellowish-brown B horizon. Characteristically, these soils lie in a transition belt between the less acid granular Brown Podzolic soils and the more strongly developed Podzols of the higher mountains to the east where there is considerable snow in winter.

These imperfectly developed Podzols have the unique profile characteristics typical of this region of cool climate and dry summers. Owing largely to irregular relief, the morphology of the Podzols ranges from that of an incipient or inperfectly developed gray A_2 horizon to a very well-developed thick gray A_2. The ortstein layer is weakly developed in many of the well-drained sites.

Most of the soils of this zone occur at elevations exceeding 1,500 or 2,000 feet. The mean annual precipitation probably ranges from 60 to 100 inches or more. The mean annual temperature is usually less than 48° F., but the average January temperature is less than 33°. The ground is frozen more often and to a greater depth than at lower elevations. Although the Podzols are well represented in the large areas of undifferentiated soils included in Rough mountainous land, the only soil series of this group in the county are the Greenwater, National, and Stossel.

The soil of the Greenwater series is derived from sandy stream-terrace materials in areas where winters are cold and wet and summers cool and somewhat foggy. It has developed under a dense stand of conifers and some understory of shrubs. It is characterized by a thin organic mat that covers a gray leached A_2 horizon ½ to 3 inches thick, which is underlain by brown friable, single-grained, loamy sand material that becomes coarser and lighter colored with depth. Pumice fragments may occur throughout the profile. The pH value ranges from about 5 or 5.5 in the surface to 6.5 or 6.8 at 30 inches. In places this soil may have a semicemented layer at about 30 inches. These areas are probably influenced by a high water table.

The National soils are somewhat similar to the Greenwater soil but are derived from somewhat finer textured sediments and have been influenced more by pumice. In virgin areas these soils also have a thin A_2 horizon that is destroyed under cultivation.

The mechanical analyses, organic-matter content, pH value, and pumice content of National pumicy loam are given in table 9.

TABLE 9.—*Mechanical analyses*,[1] *organic-matter content, pH value, and pumice content of National pumicy loam*[2]

Depth in inches	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Organic matter[3]	pH	Greater than 2.0 mm. pumice
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*		*Percent*
0 to 5	8. 6	11. 8	5. 2	10. 9	10. 2	30. 7	22. 6	19. 8	5. 0	25
5 to 14	9. 2	14. 6	4. 1	8. 9	8. 6	30. 0	24. 6	4. 7	5. 1	25
14 to 34	21. 8	17. 2	3. 0	7. 1	8. 1	29. 3	13. 5	3. 7	5. 3	48
34+	2. 2	4. 8	6. 0	14. 3	12. 3	36. 6	23. 8	1. 5	5. 3	16

[1] Analyses by the Division of Soil Management and Irrigation.
[2] Sample collected in sec. 28, T. 15 N., R. 6 E.
[3] Organic matter determined by H_2O_2.

The Stossel soil has the characteristic gray A_2 horizon below a thin organic mat. The gray layer grades into the varicolored materials that are common to the Stossel soil. This soil is under a dense forest cover at a high elevation where fog, snow, and cold winters occur.

PRAIRIE SOILS

The Prairie soils in the county occur in the somewhat excessively drained grass- and fern-covered areas. These areas have a dark grayish brown to black (moist) soft granular sootylike shot-free deep surface soil over brown loose to slightly hard subsoil that becomes paler

with increasing depth. The soils have a pH of about 5.5 to 6 and do not have a zone of clay accumulation. The outstanding difference between the soils of this group and the soils of the Brown Podzolic group is in the color, shot content, and feel of the upper 20 or 30 inches of the profile. The color is typical of soils having a grass or fern vegetation.

Either these areas were never forested or the forest was destroyed by fire and replaced by grass. Trees could not become established on these soils until recently, when the grass was destroyed by overgrazing or by cultivation. At present, forests are encroaching on these prairies, and almost cover the soils of the Fitch series.

According to Nikiforoff (*10*) this group of soils is also referred to as "black-brown" soils and may be a transitional link between the true Chernozems and the most weakly podzolized meadow soils of the forested belt. In spite of their very dark, not infrequently black, color when moist, these soils do not belong to the Chernozems and are classed as an independent group of Prairie soils. One of the differences between the Prairie soils and the Chernozems is the lack in the Prairie soils of a horizon of carbonate accumulation.

In this group are the Spanaway, Nisqually, and Fitch soil series. Of the three, the Spanaway is by far the most extensive; the Nisqually and Fitch occupy only a few small scattered areas.

The Spanaway soils are developed on the comparatively level glacial outwash of the Vashon glacier. This outwash is exceedingly porous with very little, if any, interstitial fine-textured material. The growth of moss on the surface is a striking characteristic of the Spanaway soils. The dark surface is seldom shallower than 12 inches, and in slight depressions it may be more than 24.

The following description of Spanaway gravelly sandy loam, gently undulating, in the NW corner, SE¼, sec. 4, T. 18 N., R. 3 E., is representative of Prairie soils in this area:

A_{11} 0 to 1 inch, very dark-brown (10YR 2/2) sooty gravelly sandy loam; organic matter is well decomposed and consists largely of grass roots and moss.

A_{12} 1 to 14 inches, very dark grayish brown (10YR 3/2; 2/1, moist) gravelly sandy loam, high in organic-matter content; very friable and sooty; structure very fragile and indefinite; strongly acid.

B 14 to 18 inches, grayish-brown (10YR 5/2; 4/2, moist) very friable gravelly sandy loam; less acid than above horizon.

C 18 inches +, porous poorly assorted light grayish-brown or light yellowish-gray gravelly sand and gravel; numerous stones up to 6 inches in diameter. In places the gravel is cemented by silica.

Unlike the Spanaway soils the Nisqually soils are free from gravel and stones. They generally occupy old channel courses within areas of the Spanaway soils. Hog-wallow mounds, which are very characteristic of the Spanaway soils, rarely occur in the Nisqually soils.

The Fitch soils occupy higher positions and are now forested. Like the Spanaway soils, they are exceedingly gravelly and stony, but the surface color is dark grayish brown rather than very dark grayish brown. They are intermediate in color between the Spanaway and Everett series but resemble the Spanaway more closely. They occupy nearly level to gently rolling positions, but within the true outwash plain abrupt kamelike morainic hills are usually occupied by Fitch soils. The dark grayish-brown surface soil is underlain by a porous gravelly subsoil. The series is believed to have been developed under

the influence of grass and fern vegetation, but the area was invaded by forest many years ago, and the soil developed a lighter color.

The mechanical analyses, pH, and organic-matter content of a sample of Fitch gravelly sandy loam, undulating, are shown in table 10.

TABLE 10.—*Mechanical analyses,*[1] *organic-matter content, and pH value of Fitch gravelly sandy loam, undulating*[2]

Depth in inches	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Organic matter[3]	pH
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
0 to 6	18. 9	19. 4	14. 2	17. 7	8. 5	15. 7	5. 6	5. 3	6. 4
6 to 12	19. 3	21. 7	16. 4	18. 5	7. 1	12. 4	4. 6	2. 9	6. 2
12 to 26	17. 7	21. 4	16. 2	19. 7	7. 8	13. 2	4. 0	2. 1	6. 0
26+	18. 3	24. 3	20. 1	21. 4	6. 7	7. 0	2. 2	. 6	5. 7

[1] Analyses by the Division of Soil Management and Irrigation.
[2] Sample collected in sec. 36, T. 18 N., R. 2 E.
[3] Organic matter determined by H_2O_2.

INTRAZONAL SOILS

Intrazonal soils include any of the great groups of soils with more or less well-developed soil characteristics that reflect the dominating influence of some local factor of relief, parent material, or age over the normal effect of the climate and vegetation.

The intrazonal soils have developed largely under conditions of excessive moisture in depressions or low-lying land throughout the county. Most of them are hydromorphic. Unlike the brown soils formed under coniferous forest or the nearly black soils formed under grass and fern vegetation, these soils have developed under a dense growth of deciduous trees, brush, grass, and water-tolerant vegetation that has contributed large quantities of organic residues of high base content to the soil. Characteristically, the soils have dark surface soils and rusty brown, gray, and orange mottling throughout the profile. The dark color is caused mainly by the kind of vegetation. The mottling is caused by reduction resulting from the poor drainage.

The intrazonal soils of the county are classified in the following great soil groups: (1) Humic Gley, (2) Ground-Water Podzols, (3) Planosols, (4) Bog, and (5) Half Bog.

HUMIC GLEY SOILS

The Humic Gley soils have developed in depressions and positions adjacent to seeped areas where the saturation is high in winter and spring and often throughout summer. The soils have formed from materials laid down as glacial till and glacial and postglacial outwash, and from basaltic material formed in place. Conditions of excessive moisture have prevented the formation of zonal profile characteristics and the soils have a hydromorphic character. The surface horizon of high organic accumulation is a distinct feature of the profile of these dark soils. The surface soils are relatively thick and dark grayish brown, very dark grayish brown, or dark gray, and the subsoils are iron-stained or mottled with orange, rusty brown, yellow, green or blue. These colors result from changes in moisture conditions that promote excessive reduction and oxidation and hydration and dehy-

dration. The substrata range from clayey and gravelly till to glacial or postglacial outwash.

The Humic Gley soils in the county belong to the Bellingham, Buckley, McKenna, Norma, Orting, and Tisch series. All of these soils have a somewhat similar hydromorphic character but may differ in origin and character of the parent material.

McKenna loam, nearly level, may be considered representative of the Humic Gley great soil group in the county. Following is a profile description of this soil as observed in an excavation dug in a long, narrow depression in SE¼SW¼ sec. 13, T. 17 N., R. 2 E., under a grass and tree vegetation:

A_g 0 to 9 inches, very dark-gray or very dark grayish-brown (10YR 3/1 or 3/2) very strongly acid (pH 5.0) granular loam that is black (10YR 2/1) and friable when moist and very slightly sticky when wet; mottled with specks of orange and rusty brown material; water-stable aggregates about 3 mm. in diameter; very high organic-matter content. According to mechanical analyses (table 11), the soil contains 46.9 percent clay, but its high organic-matter content, causes it to feel and act like a loam; therefore it is classified as a loam.

B_g 9 to 13½ inches, dark-gray or dark grayish-brown (10YR 4/1 or 4/2) softly granular medium acid loam; friable and very dark gray or very dark grayish brown (10YR 3/1 or 3/2) when moist; fairly stable in water but slakes much sooner than layer A_g.

CG 13½ to 36 +, gray (10YR 6/1) gravelly fine sandy loam gley layer that is not nearly so mottled as layer A_g and is dark-gray (10YR 4/1) when moist; slakes readily in water; no definite structure; many feet thick; more bluish with depth; stony in places.

The mechanical analyses, organic-matter content, and pH value of the McKenna loam, nearly level, are given in table 11.

TABLE 11.—*Mechanical analyses,*[1] *organic-matter content, and pH value of McKenna loam, nearly level*[2]

Depth in inches	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Organic matter[3]	pH
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
0 to 9	1. 5	2. 5	2. 2	8. 0	8. 6	30. 3	46. 9	21. 4	5. 0
9 to 13½	7. 9	7. 6	5. 9	14. 7	14. 4	27. 9	21. 6	2. 7	5. 6
13½ to 36+	8. 2	9. 2	7. 3	17. 1	16. 2	28. 0	14. 0	1. 6	5. 6

[1] Analyses by the Division of Soil Management and Irrigation.
[2] Sample collected in SE¼SW¼, sec. 13, T. 17 N., R. 2 E.
[3] Organic matter determined by H_2O_2.

The Bellingham and Norma soils have profiles very similar to those of the McKenna soils. The Norma soils, however, have sandy to medium-textured subsoils in contrast to the gravelly stony subsoils of the McKenna series. The subsoils of the Bellingham series are fine-textured and are more stratified than those of either the Norma or McKenna soils. Most of the Bellingham soils are stone free and have a very low gravel content.

The Tisch soil differs from the Bellingham soils in having a 2- to 20-inch layer of diatomaceous earth that occurs in the upper 3 feet of the profile. In a few places the diatomaceous earth is said to be 20 feet thick. The percentage of silica in this material ranges from 90 to 95 percent. The mechanical analyses, organic-matter content, and pH value of a sample of Tisch silt loam are given in table 12.

TABLE 12.—*Mechanical analyses,*[1] *organic-matter content, and pH value of Tisch silt loam*[2]

Depth in inches	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Organic matter[3]	pH
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
0 to 7½	0. 2	0. 6	0. 9	4. 9	5. 3	41. 7	46. 4	18. 3	4. 7
7½ to 10	. 0	. 2	. 5	3. 7	7. 2	47. 5	40. 9	9. 4	4. 8
10 to 48	. 2	. 6	. 4	2. 2	4. 2	72. 9	19. 5	4. 0	5. 3
48 to 60	. 1	1. 2	6. 5	43. 5	29. 9	16. 0	2. 8	. 3	4. 4

[1] Analyses by the Division of Soil Management and Irrigation.
[2] Sample collected in sec. 3, T. 17 N., R. 4 E.
[3] Organic matter determined by H_2O_2.

In the mechanical analysis of this soil, the first two layers appear to have enough clay to be very heavy textured. They are, however, smooth silt loams. The material analyzed as clay (less than 2 microns in size) is very high in clay and has considerable diatomaceous earth, which does not have all the properties of clay even when of clay size. It is likely that these diatomaceous particles have slower settling velocities because of their shape.

The Buckley soils have developed from Osceola drift and owe their imperfect drainage to the level relief and slowly permeable parent material. In virgin areas they are covered with grass vegetation. The dark surface soils of the Buckley series change abruptly to mottled gray and yellowish-brown medium-textured subsoils that are gritty and gravelly and have angular fragments largely of partly decomposed basalt and andesite. Nearly impervious layers occur at a shallow depth, frequently not deeper than 18 or 20 inches.

The mechanical analyses, organic-matter content, and pH value of Buckley loam are given in table 13 as follows:

TABLE 13.—*Mechanical analyses,*[1] *organic-matter content, and pH value of Buckley loam*[2]

Depth in inches	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Organic matter[3]	pH
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
0 to 11	4. 8	9. 0	6. 5	14. 9	13. 7	35. 3	15. 8	13. 6	4. 8
11 to 13	5. 9	9. 8	8. 3	17. 0	14. 3	31. 0	13. 7	4. 7	4. 8
13+	7. 3	11. 2	8. 0	15. 6	13. 3	28. 5	16. 1	. 8	4. 8

[1] Analyses by the Division of Soil Management and Irrigation.
[2] Sample collected in sec. 5, T. 19 N., R. 6 E.
[3] Organic matter determined by H_2O_2.

The imperfectly drained Orting soils are similar to the Buckley soils and have probably been influenced by Osceola till or material washed from it. They differ from the Buckley soils in having browner surface soil and a slightly less compact subsoil and in being deeper to the slightly impervious basaltic and andesitic material, which usually occurs at a depth of 28 or 30 inches.

The mechanical analyses, organic-matter content, and pH value of Orting loam are given in table 14.

TABLE 14.—*Mechanical analyses*,[1] *organic-matter content, and pH value of Orting loam*

Depth in inches	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Organic matter[2]	pH
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
0 to 9	11. 2	13. 9	9. 2	18. 7	13. 6	22. 5	10. 9	4. 0	5. 2
9 to 14	11. 3	13. 9	10. 1	19. 4	13. 9	21. 8	9. 6	. 8	5. 7
14+	11. 6	14. 5	10. 2	18. 9	13. 6	22. 6	8. 6	. 5	5. 9

[1] Analyses by the Division of Soil Management and Irrigation.
[2] Organic matter determined by H_2O_2.

GROUND-WATER PODZOLS

The only Ground-Water Podzol in the county belongs to the Edmonds series. The characteristics of this soil approach those of the Ground-Water Podzols but the process of podzolization has not yet reached the stage of producing the true Ground-Water Podzols. The water table is high, and the excessive moisture has had a strong influence in determining the character of the profile. The soil is closely related to the Custer soils, which occur in a number of other counties in the State of Washington.

The Edmonds soil has developed from sandy glacial outwash material. It generally has a luxuriant vegetation that includes grass and sedges. The soil has a dark-grayish-brown highly organic granular surface soil that distinctly overlies the ortstein layer. A podzolized A_2 horizon has not yet developed. In some places the ortstein layer is very well developed and hardened, but in others it is less well developed and fragmental pieces are widely dispersed throughout the loose mottled sandy layers below.

PLANOSOLS

The Bow and Kopiah series are classified as Planosols. The Bow is not so typical of the Planosols group as the soils in Skagit County, which occupy more extensive areas. The soils in Skagit County have a well developed claypan subsoil and a gray leached layer ¼ to 1 inch thick above the claypan. In Pierce County the Bow soils have a thin acid organic mat that rests on the brownish granular friable surface soil 8 to 10 inches thick. This layer grades into a stony acid light grayish brown flourlike layer, is about 6 inches thick, and is underlain by compact thick massive clay that has a thin coating of dark-colored material on the natural structure blocks. This clay layer is grayish brown and very plastic in the upper part and grades into bluish-gray material that has a few cobbles, boulders, and gravel. These soils have some characteristics of the Humic Gley soils.

The Kopiah series is poorly drained and has a light-colored mottled profile throughout. The A_2 horizon is inconspicuously developed.

BOG SOILS

The Bog soils are an intrazonal group of soils with a mucky or peaty surface soil underlain by peat developed under swamp or marsh types of vegetation mostly in a humid or subhumid climate. Eight soil series of this group have been recognized and mapped in the

county: The Carbondale, Dupont, Greenwood, Mukilteo, Rifle, Semiahmoo, Takoma, and Tanwax. They are important soils and occupy many square miles.

These organic soils are derived from organic remains of plants in various stages of decomposition. The kind of plants and the stage of decomposition are important factors in identification and classification of the soils. The Bog soils are formed in low basins or shallow depressions where standing water or seepy conditions result from a continuous high water table. Generally they have formed from remains of plants in the following stages of ascending succession: (1) Aquatic vegetation in open water forming the sedimentary peat; (2) sedges and reeds in open marshes accumulating sedge peat; and (3) brush, shrubs, trees, and water-tolerant vegetation in swamps and forest forming woody peat. The latter stages may be followed by sphagnum, lignum, and other mosses after the bases become exhausted and the acid condition can no longer be tolerated by the other plants.

Peats are organic soils in which partly decomposed fibers and matted materials can be observed. In the county there are woody, sedge, moss, and sedimentary peats. Woody peat is classified as Rifle peat, sedge peat as Mukilteo peat, and moss peat (a highly acid well-preserved sphagnum peatmoss sold commercially but not farmed) as Greenwood peat. The small areas of sedimentary peat mapped are classified as Tanwax peat.

Mucks consist of well-decomposed finely divided organic remains, usually mixed with more or less mineral soil. The fibers of the organic material are not readily recognizable. The mucks mapped in the county include woody muck, classified as Carbondale muck; sedge muck, classified as Semiahmoo muck; Tacoma muck, developed from salt-tolerant vegetation; and Dupont muck, characterized by a layer of diatomaceous material resting on woody or sedge peat.

HALF BOG SOILS

The only soil that has been classified as a Half Bog in the county is in the Snohomish series. This soil consists of dark highly organic mineral material underlaid by mucks and peats in various stages of decomposition.

AZONAL SOILS

The azonal soils of the county, which include only the Alluvial soils, have developed from transported and relatively recently deposited material. They are characterized by a weak or undeveloped profile. All the Alluvial soils have been placed in this group, although some have characteristics of the intrazonal soils. The soils derived from recent alluvium occur on stream bottoms and deltas in the general vicinity of active streams where sediments have been transported and deposited by recurring floods. Where conditions are relatively stable, much accumulated organic matter has become mixed with the soil and made the color dark; but under unstable conditions and frequent overflows, the soils are gray and more or less iron-mottled. The gray color and mottling are the result of a high water table, which prevents oxidation.

On the basis of drainage the Alluvial soils can be classified into two groups: (1) Somewhat excessively to moderately well drained, and

(2) poorly and very poorly drained. The first group includes the Chehalis, Newberg, Pilchuck, Puyallup, and Sultan; and the second group, the Puget and Wapato.

The Pilchuck, Puyallup, and Sultan soils are derived from glacial flour and basaltic materials and are somewhat similar in color. The colors range from grayish brown to pale brown. The subsoils are mottled in varying degrees—the Sultan soils the most, and the Pilchuck the least. Many areas of the Pilchuck and Puyallup soils, however, have little or no mottling. The Pilchuck soils occupy positions most likely to be overflowed and have the coarsest textured subsoils. The Sultan soils occupy slightly depressional or back-bottom positions and have the finest textured profile. The Puyallup soils, intermediate between these two soils, have a medium-textured profile. The surface soil in all these soils is strongly to medium acid, and the subsoil and lower subsoil slightly to strongly acid.

The mechanical analyses, organic-matter content, and pH value of Sultan silt loam are given in table 15.

TABLE 15.—*Mechanical analyses,*[1] *organic-matter content, and pH value of Sultan silt loam*[2]

Depth in inches	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Organic matter[3]	pH
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
0 to 10½	0. 0	0. 1	0. 3	0. 9	2. 0	77. 3	19. 4	2. 9	5. 6
10½ to 15	. 0	. 2	. 7	11. 2	32. 0	34. 6	21. 3	1. 4	5. 6
15 to 19	. 0	. 1	. 4	17. 6	47. 9	29. 6	4. 4	. 3	5. 7
19 to 40	. 2	. 5	. 4	1. 8	9. 8	77. 9	9. 4	. 4	6. 0
40+	. 0	. 2	. 1	23. 0	48. 8	24. 7	3. 2	. 0	6. 0

[1] Analyses by the Division of Soil Management and Irrigation
[2] Sample collected in sec. 17, T. 20 N., R. 4 E.
[3] Organic matter determined by H_2O_2.

The organic matter decreases rapidly with depth, ranging from about 2.9 percent for the 0- to 10½-inch layer of Sultan silt loam to 0.3 percent for the 15- to 19-inch layer. As a general rule the lighter the surface soil texture, the lower the organic-matter content; and the finer the texture, the higher the organic-matter content.

The fertility of the azonal soils is much higher than that of the zonal soils. The available nitrogen is also probably higher than in the zonal soils.

The Newberg and Chehalis series are derived more from sandstone and shale than from basaltic materials and are browner than the other soils of the group. In texture and position the Newburg soils are similar to the Pilchuck soils, and the Chehalis soil to the Puyallup soils.

The Puget and Wapato soils are poorly and very poorly drained and are subject to continuous flooding during winter. They have a gley layer somewhat similar to that of the Humic Gley soils. Like the Wapato and Chehalis, the Puget and Sultan soils are derived from similar parent materials. These soils occupy back-bottom positions on the recent alluvial flood plains and the low-lying areas of the flood plains and deltas. They have fine-textured profiles and are mottled from the surface to a depth exceeding 8 or 10 feet.

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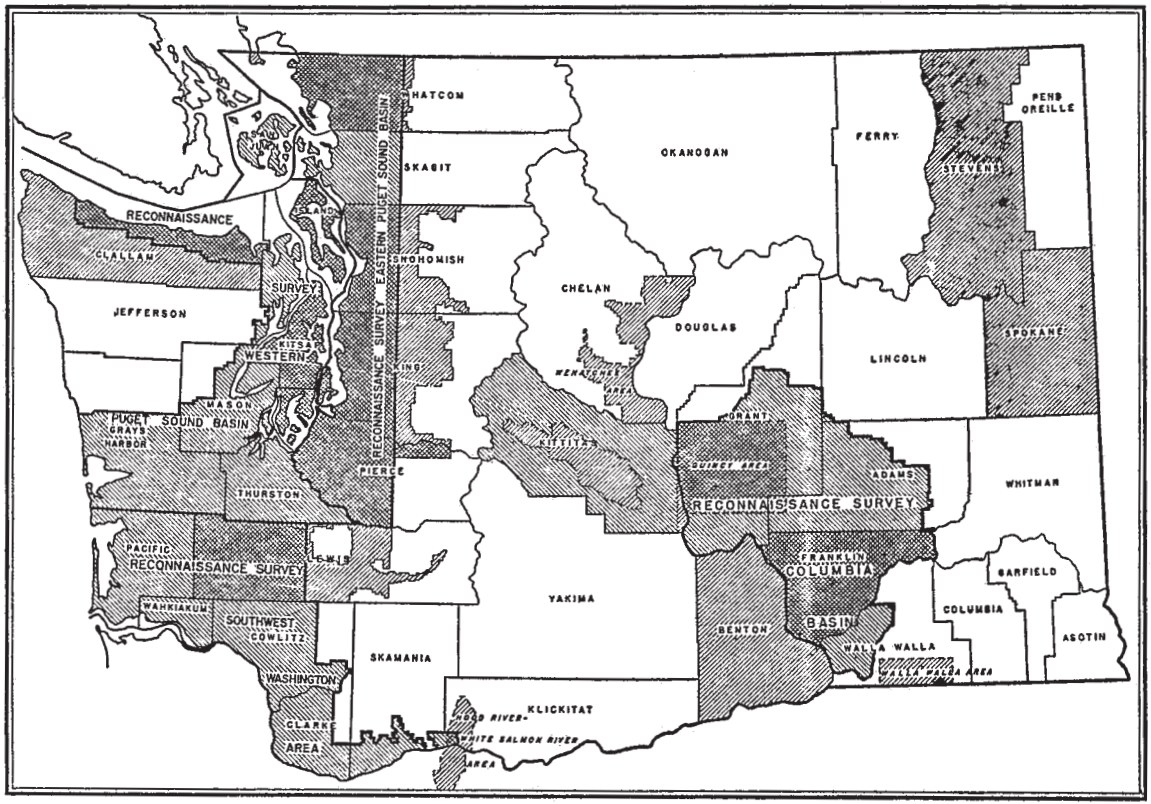

Areas surveyed in Washington: Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching; cross hatching indicates areas covered by both detailed and reconnaissance surveys.

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