Series 1947, No. 6 Issued September 1958

SOIL SURVEY

Thurston County Washington

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

How to Use THE SOIL SURVEY REPORT

THIS SURVEY of Thurston County will help you plan the kind of farming that will protect your soil and provide good yields. It describes the soils, shows their location on a map, and tells what they will do under different kinds of management.

Find Your Farm on the Map

In using this survey, start with the soil map, the map sheets bound in the back of the report. These sheets, if laid together, would make a large map of the county. Woods, fields, rivers, and many other landmarks are shown by conventional signs.

To find your farm on the large map, use the index to map sheets. This is a small map of the county on which numbered rectangles have been drawn to show the location of each sheet of the large map.

When you have found the map sheet for your farm, you will notice that the boundaries of the soils have been outlined and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they appear on the map.

Suppose you have found on your farm an area marked with the symbol Et. You learn the name of the soil this symbol represents by looking at the map legend. The symbol identifies Everson clay loam, 0 to 3 percent slopes.

Learn About the Soils on Your Farm

Everson clay loam, 0 to 3 percent slopes, and all other soils mapped are described in the section, Descriptions of Soils. Soil scientists described and mapped the soils as they walked over the fields and through the woodlands; dug holes and examined surface soils and subsoils; measured slopes with a hand level; noted differences in growth of crops, woods, brush, or trees; and, in fact, recorded all the things about the soils that they believed might affect their suitability for farming.

After they mapped and studied the soils, the scientists judged what use and management each soil should have and then placed it in a management group. A management group is a group of similar soils that need and respond to about the same kind of management. In the soil descriptions of this report the management group of each soil is given by an arabic number in parentheses, which follows the soil symbol for the soil.

Everson clay loam, 0 to 3 percent slopes, is in management group 4. Turn to table 2 in the section, Soil Use and Management. This table gives some of the general uses and management practices for the soils of group 4 and for all other management groups. You will then want to study table 3, which tells you how much you can expect to harvest from Everson clay loam, 0 to 3 percent slopes, under two levels of management. In columns A are yields to be expected under ordinary management, and in columns B are yields to be expected under improved management.

Make a Farm Plan

For the soils of your farm, compare your yields and farm practices with those given in this report. Look at your fields for signs of runoff and erosion. Then decide whether or not you need to change your methods. The choice, of course, must be yours. This survey will aid you in planning new methods, but it is not a plan of management for your farm or any other farm in the county.

If you find that you need help in farm planning, consult the local representative of the Soil Conservation Service or the county agricultural agent. Members of your State experimental staff and others familiar with farming in your county will also be glad to help you.

Fieldwork for this survey was completed in 1947. Unless otherwise specifically indicated, all statements in the report refer to conditions in the county at that time. This publication on the soils of Thurston County, Washington, is a cooperative effort from the—

SOIL CONSERVATION SERVICE

AND

WASHINGTON AGRICULTURAL EXPERIMENT STATION

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

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SOIL SURVEY OF THURSTON COUNTY, WASHINGTON[1]

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

General Nature of the Area

THURSTON COUNTY lies in the Puget Sound Basin in western Washington. The chief industry is lumbering and the production of wood products. Almost all of the original timber has been cut, and many of the larger mills have been replaced by smaller ones. Second-growth timber from within the county and logs brought in from out of the county are used. The growth of agriculture has been slowed by the forest. Most of the farms are small, and frequently part of the income of the farmers must come from nonfarm activities such as lumbering. The best land in the county is along the larger streams in the uplands near Olympia, the State Capital. Most of the cultivated land is used to produce feed for dairy cattle and poultry. The acreage in vegetables, fruits, and nuts is small. Population centers in the northern half of the county, in or near Olympia. The people are employed in wood processing, transportation, State activities, serving Fort Lewis in Pierce County, resort business, and processing dairy products, poultry, fruit, vegetables, and oysters.

Location and Extent

Thurston County is in western Washington at the southern end of Puget Sound (fig. 1). It is located in the glaciated Puget Sound Basin where the continental glaciers made their most southern advance in this part of the continent. The county is bounded on the east by the Nisqually River, which separates it from Pierce County. Many narrow inlets of Puget Sound form most of the irregular northern boundary, and the small regular part of this boundary joins Mason County. The county is bounded on the south and on the west by Grays Harbor County. Olympia in the north-central part is the county seat and State Capital. Olympia is 30 miles southwest of Tacoma and 59 miles southwest of Seattle. It is 120 miles north of Portland, Oreg. The total area of the county is 717 square miles, or 458,880 acres. About 1½ square miles of the Snoqualmie National Forest is in the southeastern corner.

The area surveyed is joined on the northeast by a similar survey of Pierce County (*1*)[2], on the south by a survey of Lewis County (*4*) and on the northwest by a soil survey of Mason County, which as yet is unpublished. Thurston County is included in an earlier reconnaissance soil survey of the western part of the Puget Sound Basin, Washington (*5*).

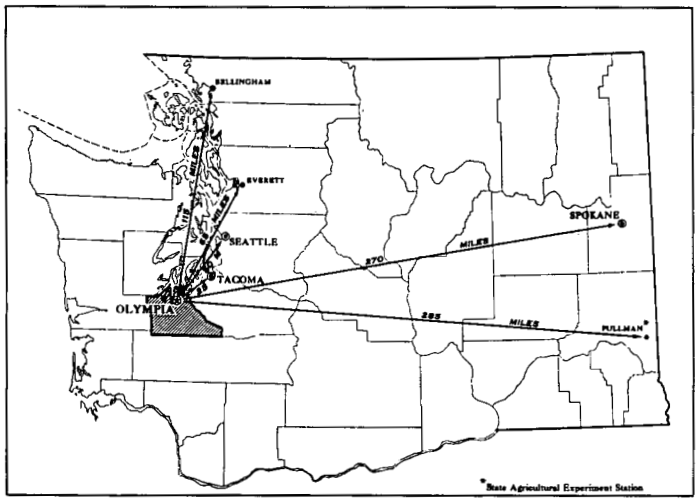

Figure 1.—Location of Thurston County in Washington, showing area surveyed.

Physiography, Drainage, and Relief

Thurston County is a glacial plain, rimmed on the western, southern, and eastern borders by mountains. It lies mainly in the Puget Trough of the Pacific Border province (*3*).

Along the western boundaries are low-lying mountain chains that include the Black Hills and adjoining ridges and spurs. In this section Capitol Peak is 2,667 feet high. The mountains are mainly rounded peaks and ridges of basalt and sandstone that extend a few miles into the county. Soils of this area are dominantly the Olympic and Melbourne.

Along the southern border are low, rolling foothills and mountain spurs. The Michigan Hills, about 700 feet high, are in this area.

Farther east, across the Chehalis River Valley and on the Lewis County border, other mountain spurs occur. On these spurs are Bald Hill, Porcupine Ridge, and Northcraft Mountain. On a ridge running into the county from the Stahl and Ladd Mountains is the highest point in the county—2,984 feet. These hills and ridges in the eastern part are mainly basalt, andesite, and sedimentary sandstone and shale of Tertiary age (*2*).

[1] Fieldwork for this survey was done while Soil Survey was a part of the Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration. Soil Survey was transferred to the Soil Conservation Service, Nov. 15, 1952.

[2] Italic numbers in parentheses refer to Literature cited, p. 70.

The extreme southeastern corner of the county is in the Cascade Mountain section. The soils of this southeastern corner are mainly of the Olympic series.

The glacial plain extends northward from the mountainous rim and occupies the rest of the county. Deposits left by the southern termination of the continental glaciers cover this area. The plain consists of many formations—rolling and hilly terminal and recessional moraines, relatively smooth ground moraines, and glacial outwash plains. These outwash plains are traversed by narrow stream terraces and stream bottoms.

The mountainous areas are well dissected by drainage channels. Deeply incised and fast flowing in their upper reaches, the Nisqually, Deschutes, and Skookumchuck Rivers become more sluggish in their lower courses. The fall of the Black River is not great enough for effective drainage, and marshy areas occur throughout most of its course. The irregular morainic areas of the upland lack drainage channels that are developed enough to give thorough drainage. Many kettle holes and basins remain undrained; lakes, ponds, or marshes often occupy these depressions. Although they lack drainage channels, most of the glacial outwash plains have soils that are open, rapidly permeable, and somewhat excessively drained. Morainic and outwash deposits often overlie consolidated sedimentary strata or preglacial layers of clay at shallow depths. These strata impede or deflect internal drainage and impart an intricate soil pattern.

The elevations of Thurston County range from sea level to 2,984 feet. The glaciated region has a general range in elevation of 100 to 500 feet. This region is rarely higher than 600 or 700 feet. The unglaciated hills and mountains have elevations ranging from 500 to 2,000 feet, but a few peaks are about 2,500 feet. The highest elevation of the unglaciated region is on Capitol Peak (2,667 ft.) in the western part of the county, and in the southeast on a spur (2,984 ft.) of Stahl and Ladd Mountains. Other elevations in feet are as follows: Olympia, 69; Nisqually, 108; Belmore, 162; Gate, 121; Rochester, 149; Tenino, 280; Yelm, 387; Little Rock, 138; Grand Mound, 162; Rainier, 430; McIntosh, 344; and Bucoda, 253.

Water Supply

Water is available in perennial streams, springs, and creeks. Generally the water is soft. Water for domestic use is normally taken from wells that are 25 to 75 feet deep. Deeper wells are needed in the glacial outwash or in areas that are somewhat excessively drained. Many flowing springs and streams occur in the hills and mountains, and much water from these sources is used by livestock. Some small areas, mainly around Yelm, are irrigated. In this area water is diverted by gravity from the Nisqually River. In several other places overhead sprinklers irrigate pastures, berries, and vegetables. The water for this irrigation comes from either wells or nearby lakes.

Climate

Except in the higher mountainous parts, where winter is moderately severe, the climate is temperate and

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at two weather stations*

HEADWORKS, PIERCE COUNTY, ELEVATION 985 FEET

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Driest year	Wettest year	Average snowfall
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	37.4	60	−8	6.98	1.98	25.33	4.1
January	36.6	61	−4	7.10	5.15	6.53	5.2
February	38.3	67	1	5.14	3.10	3.69	2.4
Winter	37.4	67	−8	19.22	10.23	35.55	11.7
March	42.2	78	20	4.64	1.67	7.40	2.1
April	46.6	83	24	3.77	3.74	1.65	.3
May	51.6	91	27	3.12	1.69	3.47	[3]
Spring	46.8	91	20	11.53	7.10	12.52	2.4
June	56.8	95	30	2.45	1.45	2.92	0
July	60.5	99	32	.88	.01	.09	0
August	60.2	93	32	.88	.78	2.87	0
Summer	59.2	99	30	4.21	2.24	5.88	0
September	55.6	88	23	2.39	3.26	4.39	0
October	49.4	82	23	3.98	1.31	4.15	0
November	40.8	67	15	8.41	4.95	3.82	.8
Fall	48.6	88	15	14.78	9.52	12.36	.8
Year	48.0	99	−8	49.74	[4]29.09	[5]66.31	14.9

OLYMPIA, THURSTON COUNTY, ELEVATION 27 FEET

December	40.8	64	7	9.21	11.38	11.42	1.5
January	38.4	68	−2	7.92	2.46	5.96	6.4
February	40.5	71	2	6.48	.82	15.63	2.7
Winter	39.9	71	−2	23.61	14.66	33.01	10.6
March	44.6	78	11	5.09	4.64	14.44	.3
April	49.4	90	21	3.34	4.77	2.10	.1
May	55.0	95	29	2.42	1.17	4.72	[3]
Spring	49.7	90	11	10.85	10.58	21.26	.4
June	59.8	101	33	1.59	1.90	.44	0
July	63.6	104	36	.68	.28	2.62	0
August	63.6	99	35	.70	.82	2.11	0
Summer	62.3	104	33	2.97	3.00	5.17	0
September	58.2	91	29	2.42	.06	2.38	0
October	51.6	83	23	4.42	1.04	6.17	[3]
November	44.7	73	4	8.02	.95	5.49	.6
Fall	51.5	91	4	14.86	2.05	14.04	.6
Year	50.8	104	−2	52.29	[6]30.29	[7]73.48	11.6

[1] Headworks: Average temperature based on a 27-year record, through 1944; highest and lowest temperatures on a 14-year record, through 1930. Olympia: Average temperature based on a 69-year record, through 1955; highest and lowest temperatures on a 51-year record, through 1930.

[2] Headworks: Average precipitation based on a 28-year record, through 1944; wettest and driest years based on a 27-year record, 1918 through 1944; snowfall, based on a 14-year record, through 1930. Olympia: Average precipitation and wettest and driest years based on a 78-year record, 1878 through 1955; snowfall based on a 34-year record, through 1930.

[3] Trace. [4] In 1944. [5] In 1933. [6] In 1929. [7] In 1879.

marine. The normal monthly, seasonal, and annual temperature and precipitation for Headworks, in Pierce County, and for Olympia are given in table 1.

The influence of Puget Sound and the Pacific Ocean modifies summer and winter temperatures and eliminates periods of extreme heat or cold. Warm moisture-laden winds moving eastward from the Pacific Ocean are cooled as they move up the outlying spurs of the Olympic Mountains and foothills, and they release a moderately heavy rainfall. Some winds entering through the Chehalis River Gap carry moisture into this part of the Puget Sound Basin.

The uniformity of average temperature from one season to another is caused largely by winds from the Pacific Ocean. These winds are warmer in winter and cooler in summer than those from adjacent land areas. Furthermore, the Cascade Mountains keep out the more changeable continental winds that cause the extreme temperatures on much of the continent.

In summer, days are seldom hot and nights are invariably cool. Because of unfavorable location, air drainage is sometimes poor, and there is some frost damage. Most of the year, some areas have good air drainage and neither frost nor low temperatures.

Extremely low or high temperatures are rare and last only a few days. The lowest temperature recorded at Olympia is –2° F., and the highest is 104°. The average for the year is 50.8°. Near the southeastern corner of Thurston County, Headworks (elevation 985 ft.) has had an extreme low of –8° and an extreme high of 99°. The average temperature is 48°.

The mild temperatures allow farming throughout the year. Grasses and other pasture plants grow most of the time. Except for short periods of extreme wet weather, livestock may be kept on pasture almost continuously. The mild summers make the Puget Sound region a vacation land.

At Olympia the average frost-free season is 187 days. April 23 is the average date of the latest killing frost, and October 27 is the average date of the earliest killing frost. At Headworks, the average frost-free season extends from May 17 to October 5, a period of 141 days. Locally, frost has occurred as late as June 17 and as early as September 8. The growing season is long enough for most of the crops of the region to mature. Because of the great differences in elevation and the influence of the lakes, Puget Sound, and the Pacific Ocean, the differences in time that frost occurs are considerable throughout the county.

Frost pockets occur in low valleys and in depressions more often than on slopes or near bodies of water. Fog is also more frequent in low areas. The central part of the county that extends eastward from Black River is subject to frost or freezing temperatures the year round. Prairies and low bogs are especially subject to frost and freezing during the growing season. Low temperatures have retarded agricultural development of peat and muck bogs. These low temperatures prevent successful growing of crops other than hay and pasture, strawberries for plants, gooseberries, and currants.

Several variable moisture belts cross the county in a general north-south direction. These belts exist because of differences in elevation, in nearness to the ocean, and in wind direction. Precipitation is greatest in the western section. Eastward this precipitation gradually decreases until the higher elevations near the Cascade Mountains are reached. The mountains cause an increase in rainfall in the eastern parts of the county. The average total precipitation decreases from the mountains in the west to 52.29 inches at Olympia, and to 35.20 inches at Tacoma in Pierce County. Headworks, on the upper Nisqually River near the southeastern corner of the county, receives an average of 49.74 inches.

If evenly distributed, rainfall might be sufficient, but generally summers do not have enough rain for normal growth of crops. The average total rainfall for June, July, and August at Olympia is 2.97 inches. Many crops therefore do not get enough moisture during their growing period. This is particularly true in dry years. During summer, pastures usually are damaged on well-drained soils, and crops throughout the county may need moisture. On the other hand, harvesting may be delayed and crops damaged by unusually heavy summer rainfall.

Although winter moisture comes largely as rain, snowfall averages 11.6 inches annually at Olympia, 14.6 inches at Grand Mound, and 14.9 inches at Headworks. At lower elevations snow normally stays on the ground only a few days, but in the foothills it may last several weeks.

The prevailing winds are from the southwest, but during July and August they blow from the northwest. The average annual wind velocity is 7.9 miles per hour. At Tacoma the recorded maximum is 43 miles per hour. Winds blow harder and more often in winter than in other seasons. They are seldom destructive, and high velocities occur infrequently, even in winter. Destructive hailstorms and tornadoes have never occurred in this part of the State.

The proportion of cloudy to clear days is important. For a 33-year period ending in 1930, Tacoma received 38 percent of the sunshine possible. For the seasons, the percentages were: Winter, 21; spring, 45; summer, 55; and fall 32. At Olympia the average number of clear days is 118, partly cloudy 110, and cloudy 137. The annual relative humidity—more than 60 percent—causes the formation of heavy fog and dew when the temperature falls. Consequently, during much of the year, the sun is hidden by rain, fog, and clouds. These conditions influence the growing, maturing, and harvesting of crops.

Vegetation

Except for the prairie areas, Thurston County was originally covered largely by very heavy and dense coniferous forest. Douglas-fir was the dominant tree, and western hemlock was an important associate. Today western redcedar and alder grow in the wetter or poorly drained places. The prairies support grasses and ferns and a few limby or stunted firs and oaks. Except for the virgin stands in the southeastern corner of the county, most of the merchantable timber has been cut.

Following is a list of the trees, shrubs, and other woody plants that commonly occur in the county:

TREES

Scientific name	*Common name*
Acer circinatum	Vine maple.
A. macrophyllum	Bigleaf or Oregon maple.
Alnus rubra	Red alder.
Arbutus menziesii	Madrona.
Fraxinus oregana	Oregon ash.
Pseudotsuga menziesii	Douglas-fir.
Quercus garryana	Oak.
Salix sp.	Willow.
Thuja plicata	Western redcedar.
Tsuga hetrophylla	Western hemlock.

SHRUBS AND WOODY PLANTS

Agrostis scabra	Ticklegrass.
Amelanchier florida	Serviceberry.
Berberis aquifolium	Oregon grape.
Cornus occidentalis	Dogwood.
Corylus californica	Hazelnut.
Gaultheria shallon	Salal.
Holodiscus discolor	Oceanspray, or ironwood.
Polystichum munitum	Swordfern or Christmas-fern
Prunus emerginata var. *erecta*	Wild cherry.
Pteridium aquilinum var. *pubescens*	Bracken.
Rhamnus purshiana	Cascara.
Rhododendron californicum	Rhododendron.
Rosa gymnocarpa	Rose.
R. nutkana	Rose.
Rubus laciniatus	Evergreen blackberry.
R. leucodermis	Black cap.
R. macropetalus	Blackberry.
R. parviflorus	Thimbleberry.
R. spectabilis	Salmonberry.
Sambucus callicarpa	Elderberry.
S. coerulea	Elderberry.
Symphoricarpos albus	Snowberry.
Vaccinium ovatum	Blue huckleberry.
V. parvifolium	Red huckleberry.

Most of the county was originally covered by Douglas-fir interspersed with western redcedar, western hemlock, and deciduous trees such as red alder, broadleaf (or Oregon) maple, vine maple, madrona, and willow.

The more common shrubs are cascara, dogwood, elderberry, wild cherry, serviceberry, hazelnut, and oceanspray, or ironwood.

The understory is a luxuriant and dense tangle of many different plants. It consists mainly of salal, blue huckleberry, red huckleberry, salmonberry, thimbleberry, blackberry, evergreen blackberry, blackcap, snowberry, Oregon grape, rhododendron, and rose. These plants are associated with various ferns and mosses. Bracken is the most common fern. This fern grows under many conditions, and after the land is logged, burned, or cleared, it rapidly covers the area. The swordfern, or Pacific Christmas-fern, is common on moist ground in shady areas, especially in virgin timber. Recently this fern has become popular for decoration.

In the wetter locations, alder is abundant among the evergreens, and in some wet low areas of second growth it is the dominant tree. The Oregon ash occurs along streams in very wet places. Many marshy areas are treeless, and the principal growth is mosses, cranberry bushes, spirea, skunkcabbage, wiregrass, rushes, sedges, and other water-loving plants.

The deciduous trees are associated with conifers but grow abundantly only in places that have favorable moisture in summer. Deciduous trees normally occur on moist slopes, bottom lands, or on low areas of impaired drainage. Bigleaf maple, red alder, and vine maple are common. Regardless of soil conditions, willow and other shrubs and brush are primary invaders on land that has been logged.

Almost all of the original timber has been cut or destroyed by fire. But in most of the cutover or firescarred areas, trees reseed and grow rapidly. Deciduous trees, mostly alder and maple, cover most of the logged areas. The soils, however, are rapidly restocking to more valuable timber—Douglas-fir, cedar, and hemlock. Except where successive burnings have destroyed the seed supply, reforestation is not a serious problem. Fireweed is common in cleared and burned areas.

The prairie areas cover a smaller acreage than the forested, but some of the prairies are fairly large. These large areas are in the glacial outwash plains. Thick grass is the dominant vegetation, but moss, lichens, and ferns occur. The principal grasses are ticklegrass and meadow fescue. Clumps of oak are common at the margins and on some of the prairies.

Douglas-fir is starting to invade the outer limits of the prairies. Hawks Prairie, northeast of Lacey, has individual limby fir trees scattered over the entire area. This growth is common on parts of some of the other prairies in the county.

Early History

Thurston County was first settled in 1845 at the present site of Tumwater. Settlement extended southward on Bush Prairie. The following year claims were taken up at the present site of Olympia, and a gristmill was established at Tumwater at the falls on the Deschutes River. The early settlers were mainly from the Central and Eastern States. Partly because of the California Gold Rush, settlement was slow for a long time. From Bush Prairie, settlement spread southward to the Chehalis River valley and to many prairies across the central part of the county.

The first farming was on Bush Prairie, and the first crops grown were oats, wheat, peas, hay, potatoes, and some fruits and vegetables. Meat and dairy products were also produced.

When the first settlers arrived, almost all of the county was covered by stately evergreen forests. Interspersed among the forests were many prairies. Except around the outer borders, these prairies were almost treeless. Most of the prairies extend across the central part of the county in a southwest-northeast direction. The early farming settlements were soon established in the open prairies. Around the first sawmills the settlers soon made clearings. Early transportation was by horse, stage, and boat. Goods were exported mainly by water.

After the timber was cut, the cutover land was settled, especially along streams. This land was cleared

for crops or seeded to grass for pasture. But because of the difficulty and cost of clearing, and because of the gravelly soils, only a small part of the cutover land is farmed.

The townsite of Olympia was first laid out in 1850. The same year, the first timber, to be used as piling, was shipped by water to San Francisco. In 1852 three sawmills were established and coal was discovered. Other towns and posts were established, and forest and farm products were shipped to Alaska and the Hawaiian Islands. Thurston County was a part of Oregon Territory when the territory was organized in 1845. In 1852 the county was established as that part of Oregon Territory north of Cowlitz divide and west of the Cascade Mountains. The following year, Pierce, King, Island, and Jefferson Counties were formed from parts of Thurston County; and, in 1854, two new counties, Grays Harbor (Chehalis) and Mason were formed. The present boundaries of Thurston County were established in 1861.

Organization and Population

Olympia, the county seat and State Capital, is in the north-central part of Thurston County. It is the population and transportation center, the only ocean port in the county, and is adjacent to some of the main agricultural lands. The fertile farms of the Chehalis River Valley are served by Gate, Rochester, and Grand Mound. A consolidated high school district centers in Rochester. The State Training School for girls is near Grand Mound. Tenino serves agricultural, timber, and coal-mining centers and has consolidated schools. Bucoda and Tono are coal-mining towns. Yelm, Rainier, and Vail serve the agricultural and logging centers in the southeastern part. Yelm is located in the only irrigation district in the county. Tumwater, East Olympia, and Lacey are residential and trading centers for the central and northeastern sections. South of Lacey are many lakes and summer resorts. South Bay and Boston Harbor are centers for the farming and resort area northeast of Olympia.

The population of Thurston County increased steadily after 1910, when it was 10,585. It was 14,571 in 1920, 31,351 in 1930, and 37,285 in 1940. In 1950, there were 44,884 people in the county, of which 18,544 were classed as urban and 26,340 as rural. According to the 1950 census, the population of the principal towns was: Olympia 15,819, Tenino 969, Tumwater 2,725, Bucoda 473, and Yelm 470.

Land Use and Types of Farms

Most of Thurston County is used for forestry. Almost three-fourths of the county is nonagricultural—steep or rough mountainous land best suited to forestry. About one-eighth is in State and National forests.

Only about one-fifth of the county has relief favorable for cultivation, and less than one-third of this is cultivated. In 1950, the total land area was 458,880 acres, and 170,640 acres, or 37.2 percent, was in farms. About one-third of the land in farms is in crops or plowable pasture; the rest is woodland, pastureland not plowable, and wasteland.

Farming is limited mainly to smoother uplands, terraces, and alluvial flood plains. Most important is a broad belt that crosses the central part of the county in a northeast-southwest direction. Probably less than half of this broad belt remains in stumps and second-growth timber.

The most intensive farming is on the fertile alluvial flood plains. The crops grown are generally used to feed dairy cattle and poultry and consist of small grains, hay, and pasture. The soils are naturally fertile and produce high yields. Some soils do not hold enough water for crops, and on them, summer pasture, clover, and alfalfa benefit from irrigation. Furthermore, in dry years irrigation is often necessary all summer for pasture.

Recently, on the alluvial soils and on the sandy prairie soils, vegetables have been grown to be sold. This enterprise, however, has been much less successful on the sandy prairie soils.

The poorly drained soils in the central part of the county are used extensively for the pasture and hay needed for dairying. Most of the well-drained uplands are too droughty for crops other than early and late pasture.

Most farms of the county produce hay and some grain to feed dairy cattle. The dairy farms are mainly south and southwest of Olympia in an area where there are many depressions and low areas. When drained, these areas are better suited to hay and pasture than most of the well-drained upland soils.

Specialized farming—growing of raspberries, strawberries, and other fruits and vegetables—is generally confined to the alluvial flood plains, the better upland soils near Olympia, and the peninsula extending into Puget Sound. In the irrigation district at Yelm, the soils are used for berries and other fruits and for hay and pasture. Because of the very low fertility and coarse texture of the soils, the Yelm district has not been very successful.

Recently, a highly intensive type of farming has been started on the sandy prairie soils south and southwest of Olympia. Fruits and vegetables are produced under irrigation and heavy fertilization. This specialized agriculture is still in the experimental stage. Because of the low inherent fertility of the soils and poor management of general farming in the past, many problems must be solved before the experiment can be called successful.

Thurston County has many small part-time farms, especially near Olympia. These farms are homes as well as places to keep a few cows and chickens and grow fruits and vegetables for family use. Most of the income is from some outside source such as lumbering or manufacturing. But these part-time farmers are not the only farmers supplementing their income from some outside source. In 1949, 1,046 farm operators reported working off their farms 100 days or more during the year.

TABLE 2.—*Soils arranged by management groups, and suitable uses and fertilization for each group*

Management groups and soils	Uses	Fertilizer [1]
Group 1.—Undulating and rolling, gravelly, moderately coarse to medium textured soils underlain by cemented glacial till:		
Alderwood gravelly loam, 3 to 8 percent slopes. Alderwood gravelly sandy loam, 0 to 3 percent slopes. Alderwood gravelly sandy loam, 3 to 15 percent slopes. Delphi gravelly loam, 3 to 15 percent slopes. Kapowsin gravelly loam, 0 to 3 percent slopes. Kapowsin gravelly loam, 3 to 15 percent slopes.	Grasses and grass-legume mixtures	*To establish stands:* 400 pounds of 4–12–8. Work fertilizer into surface just before seeding. *Old stands:* 400 pounds of 4–12–8. Apply fertilizer broadcast early in spring, yearly.
	Clovers and vetches	*To establish stands:* 300 pounds of 5–20–20. Broadcast and work into soil before seeding. *Old stands:* 300 to 400 pounds of 0–20–20. Broadcast fertilizer early in spring, yearly.
	Oats for hay	30 to 35 pounds nitrogen; 200 pounds superphosphate or 100 pounds treble superphosphate. With 6 to 8 tons of manure, add 200 pounds of superphosphate. Broadcast nitrogen fertilizer in spring; apply phosphate at time of seeding.
	Strawberries	800 to 1,000 pounds of 5–10–10; 10 to 15 tons of manure or cover crop plowed under before planting. Broadcast one-half to two-thirds of fertilizer in spring and remainder after harvest. In starting beds, one-half to two-thirds of fertilizer may be placed in bands approximately 3 inches to one side of plants and 3 inches below surface of soil.
Group 2.—Undulating and rolling, medium to moderately fine textured soils underlain by bedrock or mixed silty sediments:		
Bucoda silty clay loam, 5 to 15 percent slopes. Cathcart gravelly loam, 3 to 15 percent slopes. Melbourne silty clay loam, 3 to 15 percent slopes. Melbourne stony loam, 3 to 15 percent slopes. Olympic silty clay loam, 6 to 15 percent slopes. Olympic stony clay loam, 6 to 15 percent slopes.[2] Prather silty clay loam, 3 to 8 percent slopes. Prather silty clay loam, 8 to 15 percent slopes. Salkum silty clay loam, 3 to 8 percent slopes. Salkum silty clay loam, 8 to 15 percent slopes. Wilkeson silt loam, 3 to 15 percent slopes.[3]	Grasses and grass-legume mixtures	*To establish stands:* 400 pounds of 4–12–8. Work fertilizer into surface just before seeding. *Old stands:* 400 pounds of 4–12–8. Apply fertilizer broadcast early in spring, yearly.
	Clovers and vetches	*To establish stands:* 300 pounds of 5–20–20. Broadcast and work into soil before seeding. *Old stands:* 200 to 300 pounds 0–20–20. Broadcast fertilizer early in spring, yearly.
	Strawberries	10 to 15 tons manure or cover crop plowed under before plantings; 800 to 1,000 pounds 5–10–10. Broadcast one-half to two-thirds of fertilizer in spring and remainder after harvest. In starting beds, one-half to two-thirds of fertilizer may be placed in bands approximately 3 inches to one side of plants and 3 inches below surface of soil.
	Oats for hay or grain	30 to 35 pounds nitrogen; 200 pounds superphosphate or 100 pounds treble superphosphate. Or use 6 to 8 tons manure; 200 pounds superphosphate. Broadcast nitrogen fertilizer in spring; apply phosphate at time of seeding.
Group 3.—Undulating and rolling, moderately coarse to medium textured soils underlain by glacial lake and glacial outwash materials: Elma loam, 0 to 3 percent slopes Giles fine sandy loam, 0 to 3 percent slopes.[4] Giles fine sandy loam, 3 to 15 percent slopes.[4] Kitsap silt loam, 0 to 3 percent slopes. Kitsap silt loam, 3 to 15 percent slopes.	Grasses and grass-legume mixtures	*To establish stands:* 400 pounds of 4–12–8. Work into surface just before seeding. *Old stands:* 400 pounds of 4–12–8. Apply fertilizer broadcast early in spring, yearly.
	Clovers and vetches	*To establish stands:* 300 pounds 5–20–20. Broadcast and work into soil just before seeding. *Old stands:* 200 to 300 pounds 0–20–20. Broadcast fertilizer early in spring, yearly.
	Oats for hay	30 to 35 pounds nitrogen; 200 pounds superphosphate or 100 pounds treble superphosphate. Or use 6 to 8 tons manure and 200 pounds superphosphate. Broadcast nitrogen fertilizer in spring; apply phosphate at time of seeding.
	Strawberries	10 to 15 tons manure or cover crop plowed under before planting; 800 to 1,000 pounds of 5–10–10. Broadcast one-half to two-thirds of fertilizer in spring and remainder after harvest. In starting beds, one-half to two-thirds of fertilizer may be placed in bands approximately 3 inches to one side of plants and 3 inches below surface of soil.
	Raspberries	600 to 800 pounds 5–15–10 or 700 to 1,000 pounds 4–12–8. Or use 8 to 12 tons manure and 400 to 500 pounds superphosphate or 200 pounds of treble superphosphate. Fertilizer applied in a band 2 to 4 inches deep in a furrow 12 to 18 inches from base of plant about the time growth starts in the spring, yearly.

TABLE 2.—*Soils arranged by management groups, and suitable uses and fertilization for each group—Continued*

Management groups and soils	Uses	Fertilizer [1]
Group 4.—Imperfectly or poorly drained upland or terrace soils:		
Bellingham silty clay loam, 0 to 2 percent slopes. Bellingham silty clay loam, 2 to 8 percent slopes. Bellingham silt loam, 0 to 2 percent slopes. Edmonds fine sandy loam, 0 to 3 percent slopes. Everson clay loam, 0 to 3 percent slopes. Everson fine sandy loam, 0 to 3 percent slopes. Everson silt loam, 0 to 3 percent slopes. McKenna gravelly clay loam, 0 to 3 percent slopes. McKenna gravelly loam, 0 to 3 percent slopes. Meskill silty clay loam, 3 to 15 percent slopes. Meskill silt loam, 0 to 3 percent slopes. Norma clay loam, 0 to 3 percent slopes. Norma loam, 0 to 3 percent slopes. Tisch loam, 0 to 3 percent slopes. Tromp fine sandy loam, 0 to 3 percent slopes. Tromp-Tisch complex, 0 to 3 percent slopes.	Grasses and grass-legume mixtures	300 to 400 pounds of 3–10–10, or 200 pounds of 6–20–20. Work fertilizer into surface just before seeding.
	Oats for hay or grain	30 to 35 pounds nitrogen and 200 pounds superphosphate or 100 pounds treble superphosphate. Or use 6 to 8 tons manure and 200 pounds superphosphate. Broadcast nitrogen in spring; apply phosphate at time of seeding.
		Response to potash often good on soils of group 4; to check response use complete fertilizer as for grasses or add 60 to 65 pounds of potash (K_2O).
Group 5.—Very poorly drained organic soils:		
Greenwood peat, 0 to 2 percent slopes.[5] Mukilteo peat, 0 to 2 percent slopes. Mukilteo peat, shallow over dense clay, 0 to 2 percent slopes. Rifle peat, 0 to 2 percent slopes. Rifle peat, shallow over dense clay, 0 to 2 percent slopes. Semiahmoo muck, 0 to 2 percent slopes. Semiahmoo muck, shallow over dense clay, 0 to 2 percent slopes. Tacoma muck, 0 to 2 percent slopes.[6]	Grasses and grass-legume mixtures	200 to 300 pounds of 0–20–20, or 200 to 300 pounds of 5–20–20. Work fertilizer into surface just before seeding.
	Blackberries, boysenberries, loganberries, youngberries.	500 to 800 pounds of 5–20–20, or 800 to 1,000 pounds of 3–10–10; or, with 8 to 12 tons manure, use 400 to 500 pounds superphosphate. Spread manure early in spring; phosphate may be applied with manure or placed in furrow nearest berries when plowing away in spring. Other fertilizer applied in same manner in spring, yearly.
	Blueberries	300 to 500 pounds 0–20–20 or 300 to 500 pounds 10–20–20. Broadcast around plants in April.
	Vegetables	Heavy applications of a complete fertilizer.[1]
Group 6.—Well to imperfectly drained soils underlain by medium or moderately fine textured materials of the bottom lands or alluvial fans:	Grasses and grass-legume mixtures	400 pounds of 4–12–8 or 150 pounds of 11–48–0 and 45 to 65 pounds of potash (K_2O). Work fertilizer into surface just before seeding and apply yearly early in spring to old stands.
	Clovers and vetches	300 pounds of 5–20–10, or 300 pounds of 5–20–20, or 400 to 600 pounds 3–10–10. Broadcast and work into soil before seeding and early in spring on old stands, yearly.
Chehalis loam, 0 to 2 percent slopes. Chehalis silty clay loam, 0 to 2 percent slopes. Galvin silty clay loam, 0 to 5 percent slopes. Galvin silt loam, 0 to 5 percent slopes. Maytown loam, 0 to 2 percent slopes. Maytown silty clay loam, 0 to 2 percent slopes. Shuwah silty clay loam, 0 to 2 percent slopes. Sultan fine sandy loam, 0 to 2 percent slopes.	Alfalfa	*To establish stands:* 300 to 400 pounds of 5–20–20, or 100 to 150 pounds 11–48–0 and 60 to 65 pounds of potash (K_2O). Apply at the time of preparing seedbed. *To old stands:* 300 to 400 pounds 0–20–20, or 300 to 400 pounds 0–20–10. Apply in fall or spring, yearly.
	Small grains for hay or grain	200 pounds 5–20–20, or 6 to 8 tons manure and 200 pounds superphosphate. Apply at time of seeding.
	Blackberries, boysenberries, loganberries, youngberries.	500 to 800 pounds 5–20–20, or 800 to 1,000 pounds 3–10–10; or with manure, 400 to 500 pounds superphosphate. Spread manure early in spring; phosphate may be applied with manure or placed in furrow nearest berries when plowing away in spring. Other fertilizer applied in same manner in spring, yearly.
	Raspberries [7]	600 to 800 pounds 5–15–10, or 700 to 1,000 pounds 4–12–8; or with 8 to 12 tons manure, 400 to 500 pounds superphosphate.

TABLE 2.—*Soils arranged by management groups, and suitable uses and fertilization for each group—Continued*

Management groups and soils	Uses	Fertilizer [1]
Group 6.—Continued		
Sultan loam, 0 to 2 percent slopes		Fertilizer applied in a band 2 to 4 inches deep in a furrow 12 to 18 inches from base of plant about the time growth starts in the spring, yearly.
	Strawberries	10 to 15 tons manure or a cover crop plowed under before planting; 600 to 800 pounds 4–12–8 or 600 to 800 pounds 3–10–10. Apply in the same manner as for crop in group 1.
	Peas	With or without manure, 300 to 400 pounds 0–20–20. Place fertilizer 1 to 2 inches below seed or ½ inch to side and 1 inch below.
	Vegetables such as sweet corn, cucumbers, and broccoli.	Heavy applications of a complete fertilizer.[1]
Group 7.—Somewhat excessively to well drained soils underlain by coarse-textured materials of the bottom lands and alluvial fans:		
Camas clay loam, 0 to 3 percent slopes.	Grasses and grass-legume mixtures	400 pounds 4–12–8 or 150 pounds 11–48–0 and 45 to 65 pounds of potash (K_2O). Work fertilizer into surface just before seeding and apply yearly, early in spring, to old stands.
Camas gravelly loam, 0 to 3 percent slopes.	Clovers and vetches	300 pounds 5–20–10, or 300 pounds 5–20–20, or 400 to 600 pounds 3–10–10. On old stands, broadcast and work into soil before seeding, early in spring, yearly.
Eld gravelly loam, 0 to 2 percent slopes.	Alfalfa	*To establish stands:* 300 to 400 pounds 5–20–20, or 100 to 150 pounds 11–48–0 and 60 to 65 pounds of potash (K_2O). Apply at time of preparing seedbed.
Eld loam, 0 to 2 percent slopes		*To old stands:* 300 to 400 pounds 0–20–20 or 300 to 400 pounds 0–20–10. Apply in fall or spring, yearly.
Eld silty clay loam, 0 to 2 percent slopes.		
Newberg loam, 0 to 2 percent slopes		
Newberg sandy loam, 0 to 2 percent slopes.	Peas	With or without manure 300 to 400 pounds of 0–20–20. Place fertilizer 1 to 2 inches below seed or ½ inch to side and 1 inch below.
Pilchuck loamy fine sand, 0 to 3 percent slopes.[8]		
Pilchuck sand, 0 to 3 percent slopes.[8]	Raspberries	600 to 800 pounds 5–15–10, or 700 to 1,000 pounds 4–12–8; or with 8 to 12 tons of manure, 400 to 500 pounds superphosphate.
Puyallup fine sandy loam, 0 to 2 percent slopes.	Vegetables	Heavy applications of a complete fertilizer.[1]
Puyallup loam, 0 to 2 percent slopes.	Strawberries	10 to 15 tons manure or cover crop plowed under before planting; 600 to 800 pounds 4–12–8. Apply in same manner as in group 1.
Wadell loam, 2 to 5 percent slopes		
Wadell silty clay loam, 0 to 3 percent slopes.	Small grains for hay or grain	200 pounds 5–20–20 or 6 to 8 tons manure and 200 pounds superphosphate. Apply at time of seeding.
Group 8.—Poorly drained soils of bottom lands:		
Puget clay, 0 to 2 percent slopes	Grasses and grass-legume mixtures	400 pounds 4–12–8 or 150 pounds 11–48–0 and 45 to 65 pounds of potash (K_2O). Work fertilizer into surface just before seeding and apply yearly, early in spring, to old stands.
Puget silty clay loam, 0 to 2 percent slopes.		
Reed clay, 0 to 2 percent slopes	Oats for hay and grain	200 pounds 5–20–20 or 6 to 8 tons manure and 200 pounds superphosphate. Apply at time of seeding.
Reed silty clay loam, 0 to 2 percent slopes.	Limited vegetable production (peas and sweet corn) on better drained sites.	
Snohomish silt loam, 0 to 3 percent slopes.		
Wapato silty clay loam, 0 to 2 percent slopes.		
Group 9.—Undulating and rolling, gravelly and stony, coarse to moderately coarse textured soils underlain by loose glacial outwash materials (prairie):[9]		
Nisqually loamy sand, 2 to 5 percent slopes.[10]		
Nisqually loamy sand, 5 to 15 percent slopes.[10]	Cole crops [11]	Heavy applications of 10–10–10.[1]
Spanaway gravelly sandy loam, 0 to 3 percent slopes.[10] [12]	Strawberries [11]	1,000 to 1,500 pounds of 5–10–10; 10 to 15 tons of manure or cover crop plowed under before planting.
Spanaway gravelly sandy loam, 3 to 15 percent slopes.[10] [12]	Raspberries (red and black)[11]	800 to 1,150 pounds of 5–10–10, or 900 to 1,300 pounds of 4–12–8, or 10 to 15 tons of manure and 500 to 600 pounds of superphosphate or 250 pounds of treble superphosphate.
Spanaway gravelly sandy loam, mound phase, 2 to 10 percent slopes.[10] [12]	Grasses and grass-legume mixture [11]	500 pounds of 4–12–8.
Spanaway stony sandy loam, 0 to 3 percent slopes.[10] [12]	Small grains for hay or grain [11]	40 to 45 pounds of nitrogen and 250 pounds of superphosphate or 8 to 10 tons of manure and 250 pounds of superphosphate.
Spanaway stony sandy loam, 3 to 15 percent slopes.[10] [12]		

TABLE 2.—*Soils arranged by management groups, and suitable uses and fertilization for each group—Continued*

Management groups and soils	Uses	Fertilizer [1]
Group 10.—Undulating and rolling coarse and moderately coarse textured soils underlain by loose glacial outwash materials (forested):		
Greenwater loamy sand, 0 to 3 percent slopes.[13]	Grasses and grass-legume mixtures	400 pounds of 4–12–8. Work fertilizer into surface just before seeding.
Indianola loamy sand, 3 to 15 percent slopes.		
Indianola sandy loam, 3 to 15 percent slopes.		
Lynden loamy sand, 0 to 3 percent slopes.	Oats for hay	200 pounds sodium nitrate and 200 pounds superphosphate or 100 pounds of treble superphosphate. Broadcast fertilizer in spring; apply phosphate at time of seeding.
Lynden loamy sand, 3 to 15 percent slopes.	Strawberries	10 to 15 tons manure or cover crop plowed under before planting, 800 to 1,000 pounds 5–10–10. Apply in same manner as for crop in group 1.
Tumwater fine sandy loam, 0 to 3 percent slopes.		
Tumwater loamy fine sand, 0 to 3 percent slopes.		
Tumwater loamy fine sand, 3 to 15 percent slopes.		
Group 11.—Undulating and rolling, gravelly and stony, coarse and moderately coarse textured soils underlain by loose glacial drift (forested):		
Everett gravelly loamy sand, 0 to 3 percent slopes.	Forestry	None.
Everett gravelly loamy sand, 3 to 15 percent slopes.		
Everett gravelly sandy loam, 0 to 3 percent slopes.		
Everett gravelly sandy loam, 3 to 15 percent slopes.		
Everett stony sandy loam, 0 to 3 percent slopes.		
Everett stony sandy loam, 3 to 15 percent slopes.		
Fitch gravelly sandy loam, 0 to 3 percent slopes.		
Fitch gravelly sandy loam, 3 to 15 percent slopes.		
Grove gravelly sandy loam, 3 to 15 percent slopes.		
Tenino gravelly sandy loam, 4 to 15 percent slopes.		
Group 12.—Hilly and steep soils and miscellaneous land types, best used for forestry:[12]		
Alderwood gravelly sandy loam, 15 to 30 percent slopes.		
Alderwood gravelly sandy loam, 30 to 50 percent slopes.		
Bucoda silty clay loam, 15 to 30 percent slopes.		
Cathcart gravelly loam, 15 to 35 percent slopes.		
Delphi gravelly loam, 15 to 30 percent slopes.		
Everett gravelly loamy sand, 15 to 30 percent slopes.		
Everett gravelly sandy loam, 15 to 30 percent slopes.		
Everett gravelly sandy loam, 30 to 40 percent slopes.		
Everett stony sandy loam, 15 to 30 percent slopes.		
Everett stony sandy loam, 30 to 40 percent slopes.		
Giles fine sandy loam, 15 to 30 percent slopes.		
Grove gravelly sandy loam, 15 to 30 percent slopes.		
Indianola loamy sand, 15 to 30 percent slopes.		

TABLE 2.—*Soils arranged by management groups, and suitable uses and fertilization for each group—Continued*

Management groups and soils	Uses	Fertilizer [1]
Group 12.—Continued		
Kitsap silt loam, 15 to 30 percent slopes. Kitsap silt loam, 30 to 40 percent slopes. Lynden loamy sand, 15 to 30 percent slopes. Made land Melbourne silty clay loam, 15 to 30 percent slopes. Melbourne silty clay loam, 30 to 40 percent slopes. Melbourne stony loam, 15 to 30 percent slopes. Olympic silty clay loam, 15 to 30 percent slopes. Olympic silty clay loam, 30 to 40 percent slopes. Olympic stony clay loam, 15 to 30 percent slopes. Prather silty clay loam, 15 to 30 percent slopes. Prather silty clay loam, 30 to 40 percent slopes. Riverwash Rough mountainous land, Melbourne soil material. Rough mountainous land, Olympic soil material. Rough mountainous land, Wilkeson soil material. Salkum silty clay loam, 15 to 30 percent slopes. Spanaway gravelly sandy loam, 15 to 30 percent slopes. Tenino gravelly sandy loam, 15 to 35 percent slopes. Tidal marsh Tumwater loamy fine sand, 15 to 30 percent slopes.	Forestry	None.

[1] For more detailed information see FERTILIZERS FOR WESTERN WASHINGTON (7).
[2] Because of stones, suited primarily to forestry.
[3] Because of high elevation and inaccessibility, suited primarily to forestry.
[4] Well adapted to growing ornamental crops such as bulbs, nursery stock and holly.
[5] Generally suited only to cranberry beds and commercial uses.
[6] Suited to permanent pasture and some grass and oat hay crops; generally responds to lime.
[7] Suited to the better drained soils.
[8] Too droughty for most crops; subject to periodic overflow.
[9] Soils in group 9 should receive at least one-third more fertilizer than soils in the other management groups; there should be one application at time of planting and another during the growing season.
[10] Not suited to cultivation unless irrigated and under good management.
[11] For Nisqually soils only.
[12] Suited only to some forage crops and grains.
[13] Generally too droughty for crops.

Use, Management, and Productivity of Soils

Soil use and management

The diverse soils of Thurston County form an intricate pattern of distribution and require, therefore, different management. These soils have been put into 12 management groups according to their relief, texture, and drainage. Some of the general uses and management practices suited to these groups of soils are given in table 2.

Productivity of Soils

Table 3 gives average acre yields of important crops to be expected over a period of years for the soils of the county. Average yields under the level of management most commonly practiced are given in columns A. The yields in columns B are those to be expected under good management.

Capability Groups of Soils

The capability grouping is an arrangement of soils that shows relative suitability for crops, grazing, forestry, or wildlife and the difficulties and risks in using them. Soils that are nearly level, well drained, free from overflow, and fairly fertile are placed in class I. These soils have no serious limitation to crop growth, and they are good for many uses. The farmer can use class I soils safely without special practices. He can

TABLE 3.—*Average acre yields of principal crops to be expected over a period of years under two levels of management, and the pasture carrying capacity and suitability to forestry for each soil*

[In columns A, yields to be expected under prevailing, or common, management practices; in columns B, expected yields under good management. Dashed lines indicate crop not generally grown or no reliable yield data are available]

Soil	Oat Hay		Timothy and clover hay		Oats with legume or timothy		Oats		Straw-berries		Rasp-berries		Pasture	Forestry
	A	B	A	B	A	B	A	B	A	B	A	B		
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Cow-acre-months* [1]	
Alderwood gravelly sandy loam, 3 to 15 percent slopes	1¾	2	1½	2	-----	-----	20	30	-----	-----	1½	2½	3.3	Good.
Alderwood gravelly sandy loam, 0 to 3 percent slopes	1¼	2	1½	2	-----	-----	20	30	-----	-----	1½	2½	3.3	Good.
Alderwood gravelly sandy loam, 15 to 30 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Good.
Alderwood gravelly sandy loam, 30 to 50 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Alderwood gravelly loam, 3 to 8 percent slopes	1¾	2	1½	2	-----	-----	22	35	-----	-----	1½	2½	3.3	Good.
Bellingham silty clay loam, 0 to 2 percent slopes	2	2¼	2	3	-----	-----	25	40	(2)	(2)	(2)	(2)	4.4	Fair.
Bellingham silty clay loam, 2 to 8 percent slopes	2	2¼	2	3	-----	-----	25	40	(2)	(2)	(2)	(2)	4.4	Fair.
Bellingham silt loam, 0 to 2 percent slopes	2¼	2½	2	3	-----	-----	30	40	(2)	(2)	-----	-----	4.4	Fair.
Bucoda silty clay loam, 5 to 15 percent slopes	1¾	2	1½	2¼	-----	-----	-----	-----	-----	-----	(2)	(2)	3.3	Good.
Bucoda silty clay loam, 15 to 30 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Good.
Camas clay loam, 0 to 3 percent slopes	2	2½	1¾	3	2¼	3¾	35	50	-----	-----	-----	-----	3.9	Good.
Camas gravelly loam, 0 to 3 percent slopes	1¾	2	1½	2½	2	2¾	30	40	-----	-----	-----	-----	3.3	Good.
Cathcart gravelly loam, 3 to 15 percent slopes	1¾	2	1½	2¼	-----	-----	-----	-----	-----	-----	(2)	(2)	3.3	Good.
Cathcart gravelly loam, 15 to 35 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Good.
Chehalis silty clay loam, 0 to 2 percent slopes	2¼	3	2½	3½	2½	4	50	80	-----	-----	-----	-----	5.5	Excellent.
Chehalis loam, 0 to 2 percent slopes	2¼	3	2½	3½	2½	4	50	80	-----	-----	-----	-----	5.5	Excellent.
Delphi gravelly loam, 3 to 15 percent slopes	1¾	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	(2)	-----	Good.
Delphi gravelly loam, 15 to 30 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Good.
Edmonds fine sandy loam, 0 to 3 percent slopes	-----	-----	-----	-----	-----	-----	-----	-----	(2)	(2)	(2)	(2)	-----	Fair.
Eld silty clay loam, 0 to 2 percent slopes	2¼	3	2½	3½	2½	4	50	80	-----	-----	-----	-----	5.5	Excellent.
Eld loam, 0 to 2 percent slopes	2	2½	2¼	3	2¼	3¾	45	75	-----	-----	-----	-----	4.9	Excellent.
Eld gravelly loam, 0 to 2 percent slopes	1¾	2¼	1¾	2½	2	3	30	50	-----	-----	-----	-----	3.9	Good.
Elma loam, 0 to 2 percent slopes	1¾	2¼	1¾	3	2	3	30	50	-----	-----	-----	-----	3.9	Good.
Everett gravelly sandy loam, 0 to 3 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Good.
Everett gravelly sandy loam, 3 to 15 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Fair.
Everett gravelly sandy loam, 15 to 30 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Fair.
Everett gravelly sandy loam, 30 to 40 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Fair.
Everett gravelly loamy sand, 0 to. 3 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Fair.
Everett gravelly loamy sand, 3 to 15 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Fair.
Everett gravelly loamy sand, 15 to 30 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Fair.
Everett stony sandy loam, 0 to 3 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Good.
Everett stony sandy loam, 3 to 15 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Fair.
Everett stony sandy loam, 15 to 30 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Fair.
Everett stony sandy loam, 30 to 40 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Fair.
Everson clay loam, 0 to 3 percent slopes	2	2½	2	3	-----	-----	35	45	(2)	(2)	(2)	(2)	4.4	Fair.
Everson silt loam, 0 to 3 percent slopes	2	2½	2	3	-----	-----	35	45	(2)	(2)	(2)	(2)	4.4	Fair.
Everson fine sandy loam, 0 to 3 percent slopes	1¾	2¼	2	3	-----	-----	30	40	(2)	(2)	(2)	(2)	4.4	Fair.
Fitch gravelly sandy loam, 0 to 3 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Fair.

TABLE 3.—*Average acre yields of principal crops to be expected over a period of years under two levels of management, and the pasture carrying capacity and suitability to forestry for each soil—Continued*

Soil	Oat Hay		Timothy and clover hay		Oats with legume or timothy		Oats		Straw-berries		Rasp-berries		Pasture	Forestry
	A	B	A	B	A	B	A	B	A	B	A	B		
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Cow-acre-months* [1]	
Fitch gravelly sandy loam, 3 to 15 percent slopes	(2)												(2)	Fair.
Galvin silty clay loam, 0 to 5 percent slopes	2	2¾	2¼	3¼	2¼	3¾	45	70					4.9	Excellent.
Galvin silt loam, 0 to 5 percent slopes	2	2¾	2¼	3½	2¼	3¾	45	70					4.9	Excellent.
Galvin fine sandy loam, 0 to 3 percent slopes	1¾	2¼	1¾	2¾	2	3¼	25	40	2½	3¼	1¾	2⅓	3.8	Good.
Giles fine sandy loam, 3 to 15 percent slopes	1¾	2¼	1¾	2¾	2	3¼	25	40	2½	3¼	1¾	2⅓	3.8	Good.
Giles fine sandy loam, 15 to 30 percent slopes	(2)												(2)	Good.
Greenwater loamy sand, 0 to 3 percent slopes							(2)	(2)	(2)	(2)	(2)	(2)	(2)	Good.
Greenwood peat, 0 to 2 percent slopes	(2)												(2)	Poor.
Grove gravelly sandy loam, 3 to 15 percent slopes	(2)												(2)	Good.
Grove gravelly sandy loam, 15 to 30 percent slopes	(2)												(2)	Good.
Indianola loamy sand, 3 to 15 percent slopes	1¼	1½	1½	2					1¼	1¾	1½	2	3.3	Good.
Indianola loamy sand, 15 to 30 percent slopes	(2)												(2)	Good.
Indianola sandy loam, 3 to 15 percent slopes	1¾	2	1¾	2¼					1⅓	2	1½	2¼	3.8	Good.
Kapowsin gravelly loam, 0 to 3 percent slopes	1¾	2	1¾	2¼									3.8	Good.
Kapowsin gravelly loam, 3 to 15 percent slopes	1¾	2	1¾	2¼									3.8	Good.
Kitsap silt loam, 0 to 3 percent slopes	2	2½	1¾	3	2	3½	35	55					3.8	Good.
Kitsap silt loam, 3 to 15 percent slopes	2	2½	1¾	3	2	3½	35	55					3.8	Good.
Kitsap silt loam, 15 to 30 percent slopes	(2)												(2)	Good.
Kitsap silt loam, 30 to 40 percent slopes	(2)												(2)	Fair to poor.
Lynden loamy sand, 0 to 3 percent slopes	1¼	1½	1½	2	1½	2¼		(2)	1¼	1¾	(2)	(2)	3.3	Good.
Lynden loamy sand, 3 to 15 percent slopes	1¼	1½	1½	2	1½	2¼		(2)	1¼	1¾	(2)	(2)	3.3	Good.
Lynden loamy sand, 15 to 30 percent slopes	(2)													Good.
Made land	(2)													
Maytown silty clay loam, 0 to 2 percent slopes	2¼	3	2⅓	3¼	2½	3½	45	65			(2)	(2)	5.2	Good.
Maytown loam, 0 to 2 percent slopes	2¼	3	2⅓	3¼	2½	3½	35	60			(2)	(2)	5.2	Good.
McKenna gravelly loam, 0 to 3 percent slopes	1½	2			1¾	2¼			(2)	(2)	(2)	(2)	4.4	Fair.
McKenna gravelly clay loam, 0 to 3 percent slopes	1½	2			1¾	2½			(2)	(2)	(2)	(2)	4.4	Fair.
Melbourne silty clay loam, 3 to 15 percent slopes	1⅗	2	1⅗	2¼	1⅗	2½	25	40					3.1	Very good.
Melbourne silty clay loam, 15 to 30 percent slopes	(2)												(2)	Very good.
Melbourne silty clay loam, 30 to 40 percent slopes	(2)												(2)	Good.
Melbourne stony loam, 3 to 15 percent slopes													(2)	Good.
Melbourne stony loam, 15 to 30 percent slopes	(2)												(2)	Good.
Meskill silty clay loam, 3 to 15 percent slopes	1⅗		2	2½	2¼	2¾	40	50	(2)	(2)	(2)	(2)	4.4	Fair.
Meskill silt loam, 0 to 3 percent slopes	1⅗		2	2½	2¼	2¾	45	55	(2)	(2)	(2)	(2)	4.4	Fair.
Mukilteo peat, 0 to 2 percent slopes	2¼	3	2	3	2¼	3	(2)	(2)	(2)	(2)	(2)	(2)	4.4	Poor.
Mukilteo peat, shallow over dense clay, 0 to 2 percent slopes	2	2¾	1¾	2½	2	2½	(2)	(2)	(2)	(2)	(2)	(2)	3.8	Poor.
Newberg loam, 0 to 2 percent slopes	2	2¾	2¼	3½	2¼	3¾	45	65					4.9	Excellent.
Newberg sandy loam, 0 to 2 percent slopes	2	2¾	2	3	2¼	3½	40	60					4.4	Excellent.
Nisqually loamy sand, 2 to 5 percent slopes	1¼	1½	1¼	2¼	1¼	2¼	25	40	1¼	1¾			2.8	Poor.
Nisqually loamy sand, 5 to 15 percent slopes	1¼	1½	1¼	2¼	1¼	2¼	25	40	1¼	1¾			2.8	Poor.
Norma loam, 0 to 3 percent slopes	2¼	2½	2	3	2¼	3			(2)	(2)	(2)	(2)	4.4	Fair.
Norma clay loam, 0 to 3 percent slopes	2	2¼	1¾	2¾	2	2¾			(2)	(2)	(2)	(2)	2.8	Fair.

TABLE 3.—*Average acre yields of principal crops to be expected over a period of years under two levels of management, and the pasture carrying capacity and suitability to forestry for each soil—Continued*

Soil	Oat Hay		Timothy and clover hay		Oats with legume or timothy		Oats		Straw-berries		Rasp-berries		Pasture	Forestry
	A	B	A	B	A	B	A	B	A	B	A	B		
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Cow-acre-months* [1]	
Olympic silty clay loam, 6 to 15 percent slopes	1¾	2	1½	2¼	1¾	2¼	30	40	-----	-----	-----	-----	2.8	Very good.
Olympic silty clay loam, 15 to 30 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Very good.
Olympic silty clay loam, 30 to 40 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Good.
Olympic stony clay loam, 6 to 15 percent slopes	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Good.
Olympic stony clay loam, 15 to 30 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Good.
Pilchuck sand, 0 to 3 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Fair.
Pilchuck loamy fine sand, 0 to 3 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Fair.
Prather silty clay loam, 3 to 8 percent slopes	1¾	2	1½	2½	1¾	2½	35	45	1⅔	2¾	-----	-----	3.3	Very good.
Prather silty clay loam, 8 to 15 percent slopes	1¾	2	1½	2½	1¾	2½	35	45	1⅔	2¾	-----	-----	3.3	Very good.
Prather silty clay loam, 15 to 30 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Very good.
Prather silty clay loam, 30 to 40 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Good.
Puget silty clay loam, 0 to 2 percent slopes	2¼	3	2	3	2¼	3½	-----	-----	(2)	(2)	(2)	(2)	4.4	Good.
Puget clay, 0 to 2 percent slopes	2	2¾	1½	2¾	2	3¼	-----	-----	(2)	(2)	(2)	(2)	2.2	Good.
Puyallup fine sandy loam, 0 to 2 percent slopes	2¼	3	2¼	3¼	2½	4	40	70	-----	-----	-----	-----	4.9	Excellent.
Puyallup loam, 0 to 2 percent slopes	2⅓	3	2⅓	3¼	2½	4	45	75	-----	-----	-----	-----	5.2	Excellent.
Reed clay, 0 to 2 percent slopes	1½	2	2	3	2¼	3¼	30	40	(2)	(2)	(2)	(2)	4.4	Poor.
Reed silty clay loam, 0 to 2 percent slopes	2	3	2¼	3¼	2½	3½	40	60	(2)	(2)	(2)	(2)	4.9	Poor.
Rifle peat, 0 to 2 percent slopes	2½	3	2½	3½	2⅔	4	45	75	(2)	(2)	(2)	(2)	5.5	Fair.
Rifle peat, shallow over dense clay, 0 to 2 percent slopes	2¼	2¾	2	3	2¼	3¼	(2)	(2)	(2)	(2)	(2)	(2)	4.4	Poor.
Riverwash	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Poor.
Rough mountainous land, Melbourne soil material	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Very good.
Rough mountainous land, Olympic soil material	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Very good.
Rough mountainous land, Wilkeson soil material	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(2)	Very good.
Salkum silty clay loam, 3 to 8 percent slopes	1¾	2¼	1½	2¼	2	3	30	50	-----	-----	-----	-----	3.3	Good.
Salkum silty clay loam, 8 to 15 percent slopes	1¾	2¼	1½	2¼	2	3	30	50	-----	-----	-----	-----	3.3	Good.
Salkum silty clay loam, 15 to 30 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	Good.
Semiahmoo muck, 0 to 2 percent slopes	2⅓	3	2¼	3	2⅓	3¼	-----	-----	(2)	(2)	(2)	(2)	4.9	Poor.
Semiahmoo muck, shallow over dense clay, 0 to 2 percent slopes	2	2¾	1¾	2½	2	2¾	-----	-----	(2)	(2)	(2)	(2)	5.4	Poor.
Shuwah silty clay loam, 0 to 2 percent slopes	2¼	3	2½	3¼	2½	4	50	75	-----	-----	-----	-----	5.5	Very good.
Snohomish silt loam, 0 to 3 percent slopes	2¼	3¼	2½	3½	2⅓	4	45	75	(2)	(2)	(2)	(2)	5.5	Very good.
Spanaway gravelly sandy loam, 0 to 3 percent slopes	½	1¼	½	1¼	¾	1¾	20	35	¾	1¼	1⅓	2	1.1	Poor.
Spanaway gravelly sandy loam, mound phase, 2 to 10 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.1	Poor.
Spanaway gravelly sandy loam, 3 to 15 percent slopes	½	1¼	½	1¼	¾	1¾	20	35	¾	1¼	1⅓	2	1.1	Poor.
Spanaway gravelly sandy loam, 15 to 30 percent slopes	(2)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.1	Poor.
Spanaway stony sandy loam, 0 to 3 percent slopes	½	1¼	½	1¼	¾	1¾	20	35	¾	1¼	1⅓	2	1.1	Poor.
Spanaway stony sandy loam, 3 to 15 percent slopes	½	1¼	½	1¼	¾	1¾	20	35	-----	-----	-----	-----	1.1	Poor.
Sultan fine sandy loam, 0 to 2 percent slopes	2½	3	2¼	3¼	2⅔	4	50	75	-----	-----	-----	-----	4.9	Excellent.
Sultan loam, 0 to 2 percent slopes	2½	3	2½	3¼	2⅔	4	50	75	-----	-----	-----	-----	5.5	Excellent.
Tacoma muck, 0 to 2 percent slopes	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	-----	Poor.
Tenino gravelly sandy loam, 4 to 15 percent slopes	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	Good.

TABLE 3.—*Average acre yields of principal crops to be expected over a period of years under two levels of management, and the pasture carrying capacity and suitability to forestry for each soil—Continued*

Soil	Oat Hay		Timothy and clover hay		Oats with legume or timothy		Oats		Straw-berries		Rasp-berries		Pasture	Forestry
	A	B	A	B	A	B	A	B	A	B	A	B		
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Cow-acre-months* [1]	
Tenino gravelly sandy loam, 15 to 35 percent slopes	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	Fair.
Tidal marsh, 0 to 2 percent slopes	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Tisch loam, 0 to 3 percent slopes	2¼	2¾	2	3	2⅓	3	40	55	(2)	(2)	(2)	(2)	4.4	Fair.
Tromp fine sandy loam, 0 to 3 percent slopes	2¼	2½	2	2¾	2⅓	3	40	55	(2)	(2)	(2)	(2)	4.4	Fair.
Tromp-Tisch complex, 0 to 3 percent slopes	2¼	2½	2	2¾	2⅓	3	40	55	(2)	(2)	(2)	(2)	4.4	Fair.
Tumwater loamy fine sand, 0 to 3 percent slopes	1¼	1½	1¼	2¼	1¼	2¼	25	40	1¼	1¾	-----	-----	2.8	Good.
Tumwater loamy fine sand, 3 to 15 percent slopes	1¼	1½	1¼	2¼	1¼	2¼	25	40	1¼	1¾	-----	-----	2.8	Good.
Tumwater loamy fine sand, 15 to 30 percent slopes	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	----------	Good.
Tumwater fine sandy loam, 0 to 3 percent slopes	1⅓	2	1¼	2¾	1½	2½	25	40	-----	-----	-----	-----	3.3	Good.
Wadell loam, 2 to 5 percent slopes	2	2½	2¼	3	2¼	3¾	45	75	-----	-----	-----	-----	5.5	Very good.
Wadell silty clay loam, 0 to 3 percent slopes	2¼	3	2½	3½	2½	4	50	80	-----	-----	-----	-----	5.5	Very good.
Wapato silty clay loam, 0 to 2 percent slopes	2¼	3	2¼	3	2⅓	3⅓	45	65	(2)	(2)	(2)	(2)	5.5	Fair.
Wilkeson silt loam, 3 to 15 percent slopes	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----------	Very good.

[1] The term "cow-acre months" is the product of the number of animal units carried per acre multiplied by the number of months the animal can be grazed without injury to the pasture. For example, a soil that supports 1 animal unit per acre for 12 months rates 12; a soil that supports 1 animal unit on 2 acres for 6 months rates 3.

[2] Crop not suited to this soil.

choose one of several cropping systems, or he can use the soil for pasture or for some other purpose.

Class II soils have a range of capability that is slightly less wide than that of class I. Class II soils require some special practices. A gently sloping soil, for example, should be farmed on contour, kept under vegetation most of the time, or handled in some other way to control erosion. Other soils may be placed in class II because they are too droughty, too wet, or too shallow to be in class I.

Class III contains soils that are suitable for regular cropping. But these soils have a range of capability that is less wide than that of class II soils, and they need more stringent management.

Class IV soils have the narrowest range of capability of any soils that should be cultivated. They are more limited in their capability range than class III soils. Without special practices class IV soils can be cultivated part of the time, but special practices are required if they are cultivated all of the time.

Soils not suitable for cultivation, or soils on which cultivation is not advisable are in classes V, VI, VII, or VIII. Class V is not used in Thurston County. Soils of this class are not subject to erosion but are unsuitable for cultivation because of stones or of standing water or frequency of overflow.

Class VI contains soils that are steep or droughty or that have other serious limitations but will produce fair amounts of forage or forest products. As a rule class VI soils should not be cultivated. But some of them can be disturbed enough to prepare them for tree planting or for seeding extremely long-producing pastures.

Soils in class VII are more limited than those in class VI. They normally give only fair to poor yields of forage or wood products.

Class VIII soils are so severely limited that they produce little useful vegetation. They may provide attractive scenery or may be parts of useful watersheds. Some have value for wildlife.

Subclasses: Because the broad capability classes are based on total suitability of the soils for different uses, one class usually contains different kinds of soils. The management problems therefore differ because the soils differ. Class IV soils in this county, for example, include rolling soils subject to erosion, droughty soils, and poorly drained soils. Because of these different limitations, it is convenient to recognize, within the broad classes, capability subclasses based on the dominant kinds of limitation. The subclasses used in Thurston County are established according to dominant limitations or risks, as follows: Erosion, designated by the symbol (e); excess water (w); and shallowness or droughtiness (s). The subclass is denoted by a small letter following the class number, such as IIe, IIIw, or IIIs.

In the grouping that follows, the capability classes and subclasses of the soils of Thurston County are de-

fined. The brief description of each subclass gives the general nature of the soils in that subclass.

CLASS I.—Nearly level soils with medium to imperfect drainage and with no more than slight limitations to use. Class I soils are not placed in subclasses.

CLASS II.—Soils that can be used for tilled crops, but with slight risks because of wetness, low fertility, or droughtiness.

IIw: Medium to poorly drained soils and well-drained soils limited by overflow.

IIs: Nearly level bottom-land soils limited by lack of available moisture.

CLASS III.—Soils that can be used for tilled crops, but under moderate risks because of wetness, or because of some unfavorable soil characteristic such as droughtiness, stoniness, shallowness or low fertility.

IIIs.—Nearly level to rolling soils limited by lack of available moisture.

IIIw.—Nearly level to undulating soils limited by excess water.

CLASS IV.—Soils that have extreme limitations for cultivation and, when cultivated, require extreme care.

IVe: Undulating to rolling soils subject to erosion.

IVs: Gently undulating to rolling soils that have limited fertility or limited moisture-supplying capacity.

IVw: Mostly soils that are nearly level, low, and wet; but some are very poorly drained and organic, and others are sloping soils that are kept wet by seepage.

CLASS VI.—Soils too steep, too sandy, too stony, or too shallow for cultivation, except occasionally to seed long-producing pasture or forage or to plant trees.

VIe: Hilly, erodible soils.

VIs: Sandy, gravelly, and stony soils.

CLASS VII.—Soils too steep for cultivation.

VIIe: Steep soils and rough mountainous land.

CLASS VIII.—Soils not suitable for the commercial production of crops. In Thurston County they are Greenwood peat, Made land, Riverwash, and Tidal marsh.

The capability class and subclass for each soil of the county is given in the following list:

	Capability class and subclass
Alderwood gravelly loam, 3 to 8 percent slopes (Aa)	IVs.
Alderwood gravelly sandy loam, 0 to 3 percent slopes (Ab)	IVs.
Alderwood gravelly sandy loam, 3 to 15 percent slopes (Ac)	IVs.
Alderwood gravelly sandy loam, 15 to 30 percent slopes (Ad)	VIe.
Alderwood gravelly sandy loam, 30 to 50 percent slopes (Ae)	VIIe.
Bellingham silt loam, 0 to 2 percent slopes (Ba)	IIIw.
Bellingham silty clay loam, 0 to 2 percent slopes (Bb)	IVw.
Bellingham silty clay loam, 2 to 8 percent slopes (Bc)	IVw.
Bucoda silty clay loam, 5 to 15 percent slopes (Bd)	IVe.
Bucoda silty clay loam, 15 to 30 percent slopes (Be)	VIe.
Camas clay loam, 0 to 3 percent slopes (Ca)	IIs.
Camas gravelly loam, 0 to 3 percent slopes (Cb)	IIIs.
Cathcart gravelly loam, 3 to 15 percent slopes (Cc)	IIIs.
Cathcart gravelly loam, 15 to 35 percent slopes (Cd)	VIe.
Chehalis loam, 0 to 2 percent slopes (Ce)	I.
Chehalis silty clay loam, 0 to 2 percent slopes (Cf)	IIs.
Delphi gravelly loam, 3 to 15 percent slopes (Da)	IVs.
Delphi gravelly loam, 15 to 30 percent slopes (Db)	VIe.
Edmonds fine sandy loam, 0 to 3 percent slopes (Ea)	IIIw.
Eld gravelly loam, 0 to 2 percent slopes (Eb)	IIIs.
Eld loam, 0 to 2 percent slopes (Ec)	IIIs.
Eld silty clay loam, 0 to 2 percent slopes (Ed)	IIIs.
Elma loam, 0 to 3 percent slopes (Ee)	IIIs.
Everett gravelly loamy sand, 0 to 3 percent slopes (Ef)	VIs.
Everett gravelly loamy sand, 3 to 15 percent slopes (Eg)	VIs.
Everett gravelly loamy sand, 15 to 30 percent slopes (Eh)	VIs.
Everett gravelly sandy loam, 0 to 3 percent slopes (Ek)	VIs.
Everett gravelly sandy loam, 3 to 15 percent slopes (El)	VIs.
Everett gravelly sandy loam, 15 to 30 percent slopes (Em)	VIs.
Everett gravelly sandy loam, 30 to 40 percent slopes (En)	VIIe.
Everett stony sandy loam, 0 to 3 percent slopes (Eo)	VIs.
Everett stony sandy loam, 3 to 15 percent slopes (Ep)	VIs.
Everett stony sandy loam, 15 to 30 percent slopes (Er)	VIs.
Everett stony sandy loam, 30 to 40 percent slopes (Es)	VIIe.
Everson clay loam, 0 to 3 percent slopes (Et)	IIIw.
Everson fine sandy loam, 0 to 3 percent slopes (Eu)	IIIw.
Everson silt loam, 0 to 3 percent slopes (Ev)	IIIw.
Fitch gravelly sandy loam, 0 to 3 percent slopes (Fa)	VIs.
Fitch gravelly sandy loam, 3 to 15 percent slopes (Fb)	VIs.
Galvin silt loam, 0 to 5 percent slopes (Ga)	IIIw.
Galvin silty clay loam, 0 to 5 percent slopes (Gb)	IIIw.
Giles fine sandy loam, 0 to 3 percent slopes (Gc)	IIIs.
Giles fine sandy loam, 3 to 15 percent slopes (Gd)	IVs.
Giles fine sandy loam, 15 to 30 percent slopes (Ge)	VIe.
Greenwater loamy sand, 0 to 3 percent slopes (Gf)	VIs.
Greenwood peat, 0 to 2 percent slopes (Gg)	VIII.
Grove gravelly sandy loam, 3 to 15 percent slopes (Gh)	VIs.
Grove gravelly sandy loam, 15 to 30 percent slopes (Gk)	VIe.
Indianola loamy sand, 3 to 15 percent slopes (Ia)	VIs.
Indianola loamy sand, 15 to 30 percent slopes (Ib)	VIs.
Indianola sandy loam, 3 to 15 percent slopes (Ic)	IVs.
Kapowsin gravelly loam, 0 to 3 percent slopes (Ka)	IVs.
Kapowsin gravelly loam, 3 to 15 percent slopes (Kb)	IVs.
Kitsap silt loam, 0 to 3 percent slopes (Kc)	IIIs.
Kitsap silt loam, 3 to 15 percent slopes (Kd)	IVe.
Kitsap silt loam, 15 to 30 percent slopes (Ke)	VIe.
Kitsap silt loam, 30 to 40 percent slopes (Kf)	VIIe.
Lynden loamy sand, 0 to 3 percent slopes (La)	VIs.
Lynden loamy sand, 3 to 15 percent slopes (Lb)	VIs.
Lynden loamy sand, 15 to 30 percent slopes (Lc)	VIs.
Made land (Ma)	VIII.
Maytown loam, 0 to 2 percent slopes (Mb)	IIw.
Maytown silty clay loam, 0 to 2 percent slopes (Mc)	IIw.
McKenna gravelly clay loam, 0 to 3 percent slopes (Md)	IVw.
McKenna gravelly loam, 0 to 3 percent slopes (Me)	IIIw.
Melbourne silty clay loam, 3 to 15 percent slopes (Mf)	IVe.
Melbourne silty clay loam, 15 to 30 percent slopes (Mg)	VIe.
Melbourne silty clay loam, 30 to 40 percent slopes (Mh)	VIIe.
Melbourne stony loam, 3 to 15 percent slopes (Mk)	IVe.
Melbourne stony loam, 15 to 30 percent slopes (Ml)	VIe.
Meskill silt loam, 0 to 3 percent slopes (Mm)	IVw.
Meskill silty clay loam, 3 to 15 percent slopes (Mn)	IVw.
Mukilteo peat, 0 to 2 percent slopes (Mo)	IIw.
Mukilteo peat, shallow over dense clay, 0 to 2 percent slopes (Mp)	IVw.
Newberg loam, 0 to 2 percent slopes (Na)	IIs.
Newberg sandy loam, 0 to 2 percent slopes (Nb)	IIIs.
Nisqually loamy sand, 2 to 5 percent slopes (Nc)	IVs.
Nisqually loamy sand, 5 to 15 percent slopes (Nd)	IVs.
Norma clay loam, 0 to 3 percent slopes (Ne)	IIIw.
Norma loam, 0 to 3 percent slopes (Nf)	IIIw.
Olympic silty clay loam, 6 to 15 percent slopes (Oa)	IVs.
Olympic silty clay loam, 15 to 30 percent slopes (Ob)	VIe.
Olympic silty clay loam, 30 to 40 percent slopes (Oc)	VIIe.
Olympic stony clay loam, 6 to 15 percent slopes (Od)	VIs.
Olympic stony clay loam, 15 to 30 percent slopes (Oe)	VIe.
Pilchuck loamy fine sand, 0 to 3 percent slopes (Pa)	IVs.
Pilchuck sand, 0 to 3 percent slopes (Pb)	VIs.
Prather silty clay loam, 3 to 8 percent slopes (Pc)	IVs.
Prather silty clay loam, 8 to 15 percent slopes (Pd)	IVe.
Prather silty clay loam, 15 to 30 percent slopes (Pe)	VIe.

	Capability class and subclass
Prather silty clay loam, 30 to 40 percent slopes (Pf)	VIIe.
Puget clay, 0 to 2 percent slopes (Pg)	IVw.
Puget silty clay loam, 0 to 2 percent slopes (Ph)	IIw.
Puyallup fine sandy loam, 0 to 2 percent slopes (Pk)	IIIs.
Puyallup loam, 0 to 2 percent slopes (Pl)	IIIs.
Reed clay, 0 to 2 percent slopes (Ra)	IVw.
Reed silty clay loam, 0 to 2 percent slopes (Rb)	IVw.
Rifle peat, 0 to 2 percent slopes (Rc)	IIw.
Rifle peat, shallow over dense clay, 0 to 2 percent slopes (Rd)	IVw.
Riverwash (Re)	VIII.
Rough mountainous land, Melbourne soil material (Rf)	VIIe.
Rough mountainous land, Olympic soil material (Rg)	VIIe.
Rough mountainous land, Wilkeson soil material (Rh)	VIIe.
Salkum silty clay loam, 3 to 8 percent slopes (Sa)	IVs.
Salkum silty clay loam, 8 to 15 percent slopes (Sb)	IVe.
Salkum silty clay loam, 15 to 30 percent slopes (Sc)	VIe.
Semiahmoo muck, 0 to 2 percent slopes (Sd)	IIw.
Semiahmoo muck, shallow over dense clay, 0 to 2 percent slopes (Se)	IVw.
Shuwah silty clay loam, 0 to 2 percent slopes (Sf)	IIs.
Snohomish silt loam, 0 to 3 percent slopes (Sg)	IIw.
Spanaway gravelly sandy loam, 0 to 3 percent slopes (Sh)	VIs.
Spanaway gravelly sandy loam, 3 to 15 percent slopes (Sk)	VIs.
Spanaway gravelly sandy loam, 15 to 30 percent slopes (Sl)	VIe.
Spanaway gravelly sandy loam, mound phase, 2 to 10 percent slopes (Sm)	VIs.
Spanaway stony sandy loam, 0 to 3 percent slopes (Sn)	VIs.
Spanaway stony sandy loam, 3 to 15 percent slopes (So)	VIs.
Sultan fine sandy loam, 0 to 2 percent slopes (Sp)	IIs.
Sultan loam, 0 to 2 percent slopes (Sr)	I.
Tacoma muck, 0 to 2 percent slopes (Ta)	IVw.
Tenino gravelly sandy loam, 4 to 15 percent slopes (Tb)	IVs.
Tenino gravelly sandy loam, 15 to 35 percent slopes (Tc)	VIe.
Tidal marsh, 0 to 2 percent slopes (Td)	VIII.
Tisch loam, 0 to 3 percent slopes (Te)	IIIw.
Tromp fine sandy loam, 0 to 3 percent slopes (Tf)	IIIw.
Tromp-Tisch complex, 0 to 3 percent slopes (Tg)	IIIw.
Tumwater fine sandy loam, 0 to 3 percent slopes (Th)	IVs.
Tumwater loamy fine sand, 0 to 3 percent slopes (Tk)	IVs.
Tumwater loamy fine sand, 3 to 15 percent slopes (Tl)	IVs.
Tumwater loamy fine sand, 15 to 30 percent slopes (Tm)	VIe.
Wadell loam, 2 to 5 percent slopes (Wa)	IIIs.
Wadell silty clay loam, 0 to 3 percent slopes (Wb)	IIIs.
Wapato silty clay loam, 0 to 2 percent slopes (Wc)	IIIw.
Wilkeson silt loam, 3 to 15 percent slopes (Wd)	IVe.

Descriptions of Soils

Most of the soils of Thurston County are similar to those of the counties in Puget Sound Basin to the north and northwest. Diverse parent materials, relief, drainage, and vegetation have produced exceedingly dissimilar soils in an intricate pattern of distribution.

The soils have developed under high rainfall. They are slightly to strongly acid in the surface soil and become less acid with depth. The coarser textured soils have been severely leached, but a fine-textured subsoil layer has not developed. Many firm or hard concretions, called shot, commonly occur in the surface layer of the well-drained soils on the uplands.

The soils range from light gray to almost black, but most of them are brown or yellowish brown. The color is greatly influenced by the type of vegetation and drainage under which the soils developed. Except on the prairies most of the well-drained soils are brown, but a few are grayish brown. Developed under grasses and ferns, the soils of the prairies have a dark surface soil. The soils of the poorly drained areas are darkest, normally being dark grayish brown.

Three-fourths of the soils developed from glacial drift. They are shallow, coarse textured, and low in fertility. The rest developed from weathered bedrock, old valley fillings, lake-laid sediments, recent alluvium, and organic accumulations.

Soils on glacial moraines are normally rolling to steep. Those on the glacial outwash plains, depressional areas, and alluvial flood plains are almost level, undulating, or rolling. Most of the soils that formed in place on weathered bedrock are hilly or steep.

The upland soils that developed on glacial till and outwash plains normally are gravelly, sandy, and porous. Soils from residual weathered rock, old valley filling, and glacial-lake or impounded-stream deposits generally are moderately fine textured in the subsoil. Their subsoil is slightly finer textured than their surface soil. Soils of the alluvial flood plains range from sandy loams to silty clay loams or clays.

Natural drainage in the county ranges from somewhat excessive to very poor.

Soil Series and Their Relations

In table 4 the soil series of the mineral soils of Thurston County are placed in seven groups according to their topographic position. An eighth group contains the organic soils. The parent material and drainage of these soil series are also given in this table.

Soils of residual uplands

The soils of the residual uplands have developed from parent materials derived from underlying sandstone, shale, basalt, and andesite. These soils are strongly and deeply weathered, medium acid, and fairly low in natural fertility, especially those derived from sandstone and shale. They occur in the southern and western parts of the county on the lower, less rugged terrain along the edges of mountains. The steeper, more rugged areas are classified as Rough mountainous lands. Acreage of these soils is small. The soils are used mainly for forestry, but a small part is in pasture, grain, or hay.

Soils of the residual uplands are well drained to poorly drained. The well-drained soils are of the Bucoda, Olympic, and Melbourne series. Olympic soils were developed from weathered underlying basalt. The surface soil is dark reddish brown and moderately fine textured. The subsoil is a lighter reddish brown; it is somewhat finer textured than the surface soil. At variable depths, the subsoil overlies weathered basalt. Olympic soils are granular and friable.

The Bucoda soils have developed from dark-gray, basic andesite lava. The surface soil is brown to dark grayish brown and overlies a subsoil that is iron-mottled in the upper part. The lower subsoil is mottled, olive to brownish-gray clay. Bucoda soils are slightly less friable than Olympic soils and drainage is not so good.

The surface soil of the Melbourne soils is dark

brown to dark grayish brown and medium to moderately fine textured. It overlies a dark yellowish-brown, somewhat finer textured subsoil that is slightly mottled in the lower part by yellow and reddish-brown stainings. The substratum is weathered stratified sandstone and shale. The Melbourne soils are granular and friable.

The Meskill soils are poorly drained. They occupy sedge-covered depressional areas or seepage slopes where saturation or high moisture content is common because of very slow internal drainage. The gray to dark grayish-brown surface soil overlies a fine-textured dense subsoil that is lighter gray than the surface soil and mottled. The substratum consists of gray clay shales. These soils are hard to work, and areas that are cleared are in pasture or forage crops.

TABLE 4.—*Position, parent material, and drainage of the soil series of Thurston County, Wash.*

Soil series	Parent materials	Drainage
Soils of Residual Uplands		
Olympic	Basic igneous, largely basalt	Good.
Bucoda	Basic igneous, andesite and basalt.	Good.
Melbourne	Shale and sandstone	Good.
Wilkeson	Mixed silty materials	Moderately good.
Meskill	Shale and sandstone	Poor.
Soils of Glacial Uplands		
Everett	Gravelly drift	Somewhat excessive.
Grove	Gravelly drift	Somewhat excessive.
Indianola	Sandy drift	Somewhat excessive.
Tenino	Gravelly semicemented till	Somewhat excessive.
Alderwood	Gravelly cemented till	Good.
Cathcart	Drift over shale or sandstone	Good.
Delphi	Gravelly cemented till over basic igneous material.	Good.
Kapowsin	Gravelly cemented till	Moderately good.
Kitsap	Silty lake-laid sediments	Moderately good.
Soils of Older Terraces		
Salkum	Weathered mixed gravelly materials.	Good.
Prather	Weathered mixed materials, dominantly shale and sandstone.	Good.
Soils of Younger Terraces		
Fitch	Gravelly outwash	Somewhat excessive.
Spanaway	Gravelly outwash	Somewhat excessive.
Lynden	Sandy outwash	Somewhat excessive.
Tumwater	Sandy outwash	Somewhat excessive.
Nisqually	Sandy outwash	Somewhat excessive.
Greenwater	Sandy mixed materials influenced by pumice.	Somewhat excessive.
Camas	Gravelly mixed basic igneous sedimentary material.	Somewhat excessive.
Elma	Sandy and silty outwash	Good.
Giles	Sandy and silty outwash	Good.
Soils of Depressions in Uplands and Terraces		
Tromp	Sandy glacial outwash	Imperfect.
Edmonds	Sandy glacial outwash	Poor.
Everson	Sandy glacial outwash	Poor.
Soils of Depressions in Uplands and Terraces—Continued		
Bellingham	Silty mantle over lake sediments or till.	Poor.
Norma	Medium-textured materials over till.	Poor.
McKenna	Gravelly and stony till	Poor.
Tisch	Silty diatomaceous material over till.	Poor.
Soils of Alluvial Flood Plains		
Pilchuck	Mixed basic igneous materials and glacial flour.	Somewhat excessive to excessive.
Newberg	Mixed basic igneous and sedimentary materials.	Good.
Chehalis	Same	Good.
Shuwah	Same	Good.
Puyallup	Mixed basic igneous materials and glacial flour.	Good.
Sultan	Same	Imperfect.
Maytown	Mixed basic igneous and sedimentary materials.	Imperfect.
Snohomish	Mineral soil over organic material.	Poor.
Wapato	Mixed basic igneous and sedimentary materials.	Poor.
Puget	Mixed basic igneous materials and glacial flour.	Poor.
Reed	Mixed basic igneous and sedimentary materials.	Poor.
Soils of Alluvial Fans		
Galvin	Shales and sandstones	Imperfect.
Wadell	Basaltic materials	Good.
Eld	Basaltic materials over glacial outwash.	Good.
Organic Soils		
Greenwood	Plant remains, mainly mosses	Very poor.
Mukilteo	Plant remains, mainly sedge peat.	Very poor.
Semiahmoo	Plant remains, mainly sedge muck.	Very poor.
Rifle	Plant remains, mainly woody material.	Very poor.
Tacoma	Mineral material mixed with organic accumulation from saltwater vegetation.	Very poor.

The Wilkeson soils, represented in this county by one soil type, are moderately well drained. They appear to have developed from material that is partly from the uplands and partly from old high terraces. The soils were derived from silty material, the origin of which has not been definitely determined. The material is probably weathered fine-grained pumice that was deposited by glaciers or wind. This material accumulated on terraces and upland hills. The Wilkeson soils have a brown to dark-brown granular friable surface soil that grades into a slightly finer textured and mottled subsoil. The subsoil grades at varying depths into basaltic fragments that were possibly influenced by Cascade glaciers. Only a small area of Wilkeson soil occurs in this county, but there are extensive areas in Pierce County.

Soils of glacial uplands

The soils of the glacial uplands occupy most of the county. Except for an extension of glacial outwash into Lewis County, the gravelly deposits of the continental glaciers of the Vashon period (*2*), and perhaps some of the Admiralty period, terminated in the southern part of the county. The glacial materials largely consist of granite and quartzite, but a wide variety of rocks is common. These materials are normally very deep, but some areas have a thin mantle that overlies shale, sandstone, or basic igneous rocks. Soils of the glacial uplands include those that have developed on till plains, terminal moraines, eskers, or kames. Most of them are coarse textured and porous. One soil series of this group—the Kitsap—has developed from silty lake-laid sediments.

The surface layers of the soils of the glacial uplands contain more shot than those of any other group. Natural drainage ranges from somewhat excessive to moderately good. The soils have developed under forest. They have brown, dark-brown, or grayish-brown surface soils and yellowish-brown or olive subsoils. Some of the less gravelly and finer textured soils are used for general crops, but most of them are in second-growth timber.

The soils of the glacial uplands are of the Everett, Grove, Indianola, Tenino, Alderwood, Delphi, Kitsap, Kapowsin, and Cathcart series.

Everett soils developed from poorly assorted or stratified glacial drift that is mainly porous coarse sand and gravel. These soils have a brown gravelly and stony surface soil that overlies a dark yellowish-brown subsoil.

Grove soils, to a minimum depth of 36 inches, contain more basic glacial material and slightly more fine material than the Everett soils. When moist, the surface soil is dark reddish brown to reddish brown and the subsoil is dark reddish brown. Grove soils occur in the northwestern corner of the county where the rainfall is higher than that under which Everett soils developed.

The Indianola soils have developed under forest and from sandy glacial drift. These soils have a brown surface soil, yellowish-brown subsoil, and gray and olive substratum. They are droughty, and crops are damaged by a scarcity of moisture during the dry season. These soils normally are rolling to hilly. They are limited in extent, and the principal areas are in the eastern part of the county near St. Clair.

Alderwood soils, at a depth of about 30 inches, overlie gray to dark-gray, strongly cemented gravelly till. This characteristic distinguishes these soils from many others. Alderwood soils are largely confined to the smoother till plains where they occur in association with Everett gravelly sandy loams and other soils of the glacial uplands. Alderwood soils are similar to Everett soils except for the cemented sandy and gravelly till.

The surface soil of the Alderwood soils is brown to dark brown, and it contains many shot. The gravelly subsoil is dark yellowish brown and frequently mottled in the lower part. Internal drainage is medium, but because of the cemented substratum the soil is saturated for long periods in winter.

In the Puget Sound Basin, Alderwood soils are among the most important soils of the uplands. Although not so extensive as in the counties to the northwest, in Thurston County they are important in the central part. These soils are used mostly for hay and pasture on the small subsistence farms.

Tenino soils occur on terminal and recessional moraines, which form a more strongly sloping, ridgy, and knoll-like terrain than that of the Alderwood soils. They have developed from weakly cemented gravelly and sandy till that is coarser than the till of Alderwood soils and not so dense, compact, and cemented. The Tenino surface soil is grayish brown to dark brown or brown. The gravelly or cobbly subsoil is yellowish brown or olive, mottled with gray and rust brown. The substratum is weakly cemented to loose, coarse, gravelly till. Tenino soils are more droughty than Alderwood and are of little value for farming.

Kapowsin soils, like Alderwood soils, have many shot in the surface soil, and their subsoil is mottled. The surface soil of the Kapowsin is dark grayish brown to dark brown, and the subsoil is grayish brown to brown. The Kapowsin soils are finer than the Alderwood, and their substratum is not so strongly cemented. They are moderately well drained. They occur on a more level ground moraine than the Alderwood. A large area of Kapowsin soils is located south of Yelm.

The Delphi and Cathcart soils are similar in that they consist of a thin glacial deposit over bedrock. Delphi soils were developed from gravelly cemented till that overlies basic igneous weathered material and rock. The basic materials have influenced the lower subsoils and substrata. Delphi soils occur in the northwestern part of the area in association with Grove and Olympic soils. They are very small in extent, rolling to hilly, and unimportant agriculturally. The Cathcart soils differ from the Delphi in that they overlie shale and sandstone. They occupy rolling to steep hills in the south-central part of the county. Some of the less strongly sloping areas are used for pasture and hay.

The Kitsap soils were developed from silty glacial lake or impounded stream deposits. The surface soil is dark grayish brown, shotty, and medium textured.

It overlies grayish-brown to olive stratified silty clay loam, silt loam, and very fine sandy loam. Kitsap soils are among the principal upland soils. They are used for many crops, but mainly for hay and pasture.

Soils of older terraces

The soils of the older terraces have developed on old deposits laid down by an ancient inland sea or lake. They are inextensive and occur in the southern part of the county on high remnants of ancient terraces. They are deeply weathered and fine textured. Leaching has been severe, and the soils are medium to slightly acid. Fertility is fairly low, but many soils of the old terraces are used for general farming.

This group consists of the Salkum and Prather soils. As a group they occupy undulating to steep relief that has entrenched drainage. The soils are developed from very old deposits, some of which are probably glacial in origin. The soils of both series have a dark-brown surface soil that is granular and friable and contains many shot. The reddish-brown subsoil is finer than the surface soil and firm.

The substratum of the Salkum soil is a highly colored clay and gravel matrix. This parent material is so strongly weathered that the gravel can be cut easily with a spade. Depths to the substratum range from 30 to 40 inches. The substratum of the Prather soils is highly colored, mixed silty and clayey materials. It differs from the Salkum substratum in that it contains no weathered gravel and is not so compact. The Salkum and Prather soils occur in the southwestern part of the county. The Prather soils are used extensively for general crops and strawberries. The Salkum soils are much less extensive and occur in isolated areas that are mostly in timber and brush.

Soils of younger terraces

The soils of the younger terraces have developed mainly from glacial outwash materials. Large glacial outwash plains extend in a broad belt from northeast to southwest across the central part of the county. These outwash plains are nearly level to slightly undulating and have steeper slopes between the more level areas. They consist mostly of exceedingly gravelly and sandy deposits. The deposits have not been appreciably altered by soil development below a depth of 2 feet.

The soils of the younger terraces developed under prairie grasses, forests, or both. Soils that developed under prairie grasses and ferns have a dark surface soil and a coarse-textured brownish lower subsoil.

Generally the soils of this group are too gravelly or sandy to be of agricultural importance. But some included fine sandy loams are used for farming, particularly near Olympia.

The soils of the younger terraces are of the Fitch, Giles, Elma, Greenwater, Lynden, Nisqually, Spanaway, Tumwater, and Camas series. The Nisqually and Spanaway soils developed under grasses and are dark colored. Fitch and Tumwater soils developed under conditions intermediate between forest and prairie. They have a dark-brown, grayish-brown, or brown surface soil. The Giles, Elma, Lynden, Greenwater, and Camas soils developed under forests and are brownish.

Spanaway soils are the most extensive soils of the younger terraces. The 12- to 24-inch surface soil is black, sooty, gravelly or stony sandy loam. Within depths of a few inches the sandy loam grades into a dark yellowish-brown, dark grayish-brown, gray, and olive loose porous mixture of gravel and sand. These soils are very droughty and low in fertility. They are used mainly for grazing.

The Fitch soils have developed from a very gravelly parent material similar to that of the Spanaway soils. But the Fitch soils developed under forests that have recently been removed. These soils, therefore, are lighter in color than the grassland soils. The surface soil, a dark grayish-brown gravelly sandy loam, grades into a brown very friable to loose subsoil. The subsoil, in turn, grades into a yellowish-gray to gray, loose, gravelly and sandy substratum. Drainage is somewhat excessive, and the soils are low in fertility.

The Nisqually soils developed under grasses and herbs. The surface soil is black, sooty, loamy sand that grades at depths between 18 to 24 inches into very dark grayish brown or very dark gray loamy sand. At depths of about 28 to 36 inches, the substratum is olive-colored fine sand or sand. These soils are similar to Spanaway soils but are more gravel free, less droughty, and more fertile. They are extensive south and southeast of Tumwater and in many areas near Mima, Grand Mound, and Tenino.

The Lynden soils have developed under forests from outwash sand deposits. The surface soil is brown, and the subsoil and substratum are gray, pepper-and-salt stratified sand. These soils are not drought resistant, and a scarcity of moisture damages crops in dry seasons. Lynden soils occur in many small bodies throughout the county; their total area is small.

The Giles soils have developed under forests from sandy outwash deposits. The surface soil is brown to dark brown and the subsoil yellowish brown. The subsoil, extending to a depth of 36 inches or more, has a fine sandy loam, or finer, texture. The substratum is transitional from fine sandy loam material, which is similar to that in the layer above, to material similar to the pepper-and-salt sands of the associated Lynden soils. Stratified layers of very fine sand, silt, and sand are common below 3 feet. These soils are moderately retentive of moisture but are low in natural fertility. Giles soils are leading agricultural soils. They are fairly extensive and occur in both large and small areas. Many of these areas have been cleared.

The Elma soil differs from the Giles soils mainly in its gravelly rather than sandy substratum. This soil occupies only a small acreage south of Rochester.

The Tumwater soils have developed from uniform sandy outwash materials similar to those of the Nisqually soils. Unlike the Nisqually soils they have developed under forest. The surface soil is brown to dark-brown loamy fine sand or fine sandy loam. The subsoil and substratum are dark yellowish-brown or

olive, stratified loamy fine sand, fine sandy loam, and very fine sandy loam. This stratified formation extends to depths of 4 to 6 feet or more. Tumwater soils are loose, porous, and low in water-holding capacity, but they are used to some extent for hay and berries and vegetables for home use. These soils resist drought less than the Giles, but they retain moisture better than Lynden and Spanaway soils. They resemble Nisqually soils except that they are lighter colored, more stratified, and less organic. Tumwater soils are considered the forested counterpart of the Nisqually soils.

The Greenwater soils occupy terraces along the upper Nisqually River. They were derived from highly andesitic and basaltic coarse sands deposited by stream action that was glacial or partly glacial. The surface soil is loose, brown to olive-gray loamy sand. The subsoil is a light- and dark-gray coarse sand that is very weakly cemented but breaks easily into single grains. Small yellowish pumice fragments are scattered throughout the surface soil and subsoil. The lower subsoil and substratum consist of coarse, angular, pepper-and-salt sands. The soil is somewhat excessively drained and droughty.

The Camas soils have a brown to dark-brown surface soil and a gravelly substratum. They occur on low alluvial terraces slightly above Chehalis and Newberg soils and are somewhat excessively drained.

Soils of depressions in the uplands and terraces

The soils of the depressions are associated with the well-drained soils of the terraces and uplands. They occur in depressions and low areas along drainageways and small streams and are imperfectly to poorly drained. Unless artificially drained, these soils are saturated and frequently covered with water during the rainy season. The surface soil is darker colored, thicker, and finer textured than that of the associated well-drained soils. The subsoil and substratum vary greatly. They consist of mottled sandy materials, gravelly cemented till, or fine-textured materials. Where adequately drained, these soils can grow hay and pasture.

The poorly drained soils of this group occur in depressions, kettles, and low flats. They are of the Bellingham, Norma, McKenna, Everson, Tisch, and Edmonds series. These soils are saturated most of the time. The surface soil of these poorly drained soils ranges from black to grayish brown or olive gray. It is high in organic matter.

The Norma and McKenna soils are associated with the Alderwood, Kapowsin, and Everett soils. The Norma soils are dark colored and, at a depth of about 2 feet, overlie a substratum of stratified gravel and sand or gravelly sandy loam. The McKenna soils are more shallow than the Norma. The McKenna surface soil grades into a compact gravelly till at depths between 18 to 24 inches.

The Bellingham soils are associated with the Kitsap soils and have compact fine-textured subsoils. The subsoil of Everson soils is gravel free and fine textured. It is underlain by a sandy substratum that differentiates Everson soils from Bellingham soils.

The Tisch soil is gravel free and contains variable amounts of light gray diatomaceous earth in the profile, normally within 3 feet of the surface. All of these poorly drained soils are slightly to medium acid throughout the profile. They are highly mottled in the subsoil.

The Norma soils occur in many small depressional areas throughout the glaciated regions. To a depth of 1 foot the surface layer is very dark grayish brown to very dark gray. This layer grades to a dark-gray and grayish-brown highly mottled subsoil that is finer textured than the surface soil. The subsoil overlies dark-gray or olive-gray stratified gravel and sand that is mottled with iron stains. The stratified layers grade into a compact gravelly till. Norma soils are generally associated with Alderwood, Everett, and Kapowsin soils. Drainage is normally necessary for pasture and hay.

The surface soil of McKenna soils is very dark gray to black. The subsoil is dark-gray to olive-gray, highly mottled with rust brown, gravelly loam to clay loam. The subsoil overlies compact stratified or gravelly and sandy glacial materials. McKenna soils differ from Norma soils in that they are shallower to the gravelly subsoil and more compact in the substratum. Drainage is usually necessary for pasture or hay. The most common use of McKenna soils is for pasture. Pasture grows better on these soils than on the well-drained soils because more moisture is available during summer.

The Everson soils have a very dark grayish brown to almost black, highly organic surface soil. The subsoil is olive, gravel-free sandy clay or clay loam. The substratum consists of stratified sands that distinguish Everson soils from Bellingham soils. Everson soils are highly mottled. The soils are used mainly for pasture and hay. They normally occur in depressions or along small streams of the glacial region as small irregular areas or narrow strips. In these places they are associated with sandy glacial outwash materials.

Bellingham soils occur in depressions and along low drainageways. They are poorly drained associates of Kitsap soils. The fine-textured surface soil is very dark gray or black and mottled. It is high in organic matter, and friable. The mottled clay subsoil overlies the substratum that consists of stratified, light olive-gray, fine-textured, lake-laid sediments or gravelly clay till.

The surface soil of the Tisch soil is dark grayish brown, and the subsoil contains variable amounts of diatomaceous earth. The diatomaceous layer normally is a foot or more thick. It occurs at depths between 12 and 36 inches and is normally silty. When this silty material is brought to the surface of a field by a plow or a burrowing animal, the field becomes spotty in appearance. The substratum is stratified, gray or olive, mottled sandy material. The Tisch soil occurs in local depressions and along minor drainageways in association with soils developed from glacial till or outwash plains.

The Edmonds soil consists of an olive-gray to dark-gray surface soil and a highly mottled rusty-brown sandy subsoil that is weakly cemented by iron oxides. The subsoil grades into stratified mottled sands. Most of the time, the soil is saturated by a high water table. The Edmonds soil is inextensive, and the narrow bodies along drainageways are mainly in brush and timber.

The imperfectly drained soils of this group are of the Tromp series. The surface layer of these soils, 12 inches or more thick, is very dark grayish brown and sandy. It grades into a mottled olive sandy subsoil. With mottles like those in layer above, the substratum consists of stratified sands that are pale olive, olive, and dark yellowish brown. The soils are saturated during the rainy season, and they retain moisture longer than the well-drained adjacent soils. A small part of these soils has been cleared and drained, and this part is used for pasture and hay.

Soils of alluvial flood plains

The soils of the alluvial flood plains are on the valley floors of principal streams and many tributary streams. Most of the soils are higher than the annual floodwaters, but they are flooded when the water is exceptionally high. The most fertile and productive soils of the county are in this group.

The well to excessively drained soils of this group are of the Chehalis, Shuwah, Newberg, Puyallup, and Pilchuck series. The Chehalis and Newberg soils occupy areas adjacent to large streams. They developed from alluvium that was derived from sandstone, shale, and basalt. The surface soil is usually dark brown, and the subsoil is light brown. The Newberg soils are normally lower and nearer the streams than the Chehalis soils. Their subsoil is sandier than the surface soil. Chehalis soils are normally uniform in texture throughout the surface soil and subsoil. They retain moisture and are very productive. The surface soil of the Shuwah soil is darker than that of the Chehalis soils.

Puyallup and Pilchuck soils occur along the larger streams of the glaciated region. They were developed from mixed materials. The Puyallup soils have a dark grayish-brown surface soil and olive-gray subsoil that becomes sandier with depth. The Pilchuck soils were developed from very recent alluvium. They have dark-gray to dark grayish-brown surface soils that overlie olive-gray subsoils of stratified sands and, in places, gravel of various grades.

The imperfectly drained soils of the alluvial flood plains are of the Maytown and Sultan series. The Maytown soils were derived from parent material similar to that of the Chehalis and Newberg soils. They occur inextensively in small valleys. The surface soil is brown to dark brown and friable. The lower subsoil and substratum are moderately mottled. These soils are slightly better drained than the Wapato soil.

The Sultan soils are associated with Puyallup and Puget soils. Soils of these three series were derived from similar materials. The texture of the surface soil and subsoil of Sultan soils is uniform, and the subsoil is mottled.

The Reed, Puget, Wapato, and Snohomish soils are poorly drained. Reed soils occupy swampy back bottoms in association with Wapato, Maytown, and Chehalis soils. The surface soil is very dark grayish brown or dark grayish brown. It is fine textured, granular, and slightly mottled. At depths of about 8 to 10 inches, the surface soil grades into a highly mottled, compact, very plastic clay that grades, in turn, into a gray or bluish-gray stiff clay.

Puget soils occupy back bottoms and are normally flooded in winter. The surface soil is gray or olive gray with some mottling. The subsoil and substratum are gray stratified silts and clays, highly mottled with reddish brown, yellow, and some bluish colors.

The poorly drained Wapato soils occupy back bottoms in large and small valleys. Drainage is more restricted in Wapato than in Maytown soils and the content of organic matter is higher. The surface soil of Wapato soils is very dark grayish brown and granular. The upper subsoil is olive gray to dark gray and slightly compact. It is highly mottled and finer textured than the surface soil. The lower subsoil is an olive gray. It is less highly mottled and finer textured than the upper subsoil. At a depth of 36 inches, the lower subsoil grades into the substratum, which is mottled and stratified and of a color similar to that of the lower subsoil.

The alluvial mineral surface soil of the Snohomish soil overlies a peat or muck. The depths to the organic material normally range from 18 to 24 inches.

Soils of alluvial fans

The soils of the alluvial fans occupy the sloping deposits at the mouth of local tributary streams. These streams rise in outlying low hills or in precipitous slopes of the higher mountains. The soils occur above the terraces along the major stream valleys or on the alluvial flood plains. In some places they grade almost imperceptibly into the soils of the valley floor. In other places they occupy slopes steep enough to have significant amounts of colluvial material. The texture of these soils largely depends on the slope, and texture changes with changes of slope. The use and productivity of the soils of this group vary within the soil series and within the group.

The soils of the alluvial fans are of the Galvin, Wadell, and Eld series. The Galvin soils differ from the Wadell soils in the origin of parent materials and in profile. Galvin soils were developed mainly from materials that were derived from sandstone and shales; Wadell soils were derived largely from basic igneous materials. The Galvin soils are imperfectly drained, and the Wadell soils are well drained.

Galvin soils occur in the southwestern part of the county on local alluvial fans that were formed from material washed from Melbourne soils. Seepage waters from the adjacent shale hills flood the low fans. Runoff and internal drainage are slow.

Galvin soils have a granular dark grayish-brown to

dark-brown surface soil that overlies a grayish-brown to dark yellowish-brown, firm, mottled subsoil. The subsoil grades into the grayish clay substratum that is mottled and stained and slightly compact.

The Wadell soils are dark reddish brown and friable in surface soil and subsoil. The subsoil overlies a stratified substratum that ranges from gravelly loam to sandy clay. The very small acreage of these soils is mainly on low terraces in the western part of the county.

The Eld soils were derived almost entirely from basaltic material. They have a dark reddish-brown surface soil and a lighter colored subsoil. The substratum is glacial gravel.

Organic soils

The organic soils consist mainly of plant material in various stages of decay. This material has accumulated in shallow lakes or in continually wet depressions. Fairly large acreages occur in this county, particularly along the Black River north and south of Black Lake.

These soils are characterized by a low bulk density, high water-holding capacity, and normally by a high nitrogen but low potassium content. The content of other nutrients varies, and the soils are medium to strongly acid. The water table is at or near the surface most of the time, and drainage is very poor. Organic soils are classed as peat or muck. In this county the small part that has been cleared is used mostly for pasture and hay crops.

The organic soils are Greenwood peat, Mukilteo peat, Rifle peat, Semiahmoo muck, and Tacoma muck. Greenwood peat consists of an accumulation of moss plants. In Thurston County it is of little agricultural value, but in other areas this peat is used for cranberry bogs.

Mukilteo peat consists of raw, partially decomposed sedges mixed with woody fragments. A large area occurs south of Black Lake. On deep adequately drained deposits, this soil produces fair crops.

Rifle peat consists of partially decomposed, acid woody plant remains mixed with some sedges. A large area occurs north of Black Lake, but drainage is very difficult because there is no adequate outlet in this area. Where this soil is deep and drained, it is superior to the Mukilteo peat.

Semiahmoo muck consists of well-decomposed sedge plant remains mixed with some woody plant remains. Where deep and adequately drained, this soil is productive.

Tacoma muck consists of fine tidal sediments and partially decomposed sedges, grasses, and other salt-tolerant plants. It occurs on tidal flats protected by dikes. The soil is valuable for pasture.

Miscellaneous land types

In addition to the soil series listed in table 4 there are nonarable miscellaneous land types that have varied soil profiles. These land types have little or no value for agriculture or grazing. In Thurston County they are Rough mountainous land, Made land, Riverwash, and Tidal marsh.

Soil Types and Phases

The soils of Thurston County are mapped and classified into 133 soil units that represent 51 series and 6 miscellaneous land types. In the following pages the soils are described in detail and their agricultural relations discussed. Their location and distribution are shown on the maps bound at the back of this report, and their acreage and proportionate extent are given in table 5. In the soil descriptions two different italicized subheads are used to set off the discussion of use and management. *Present use and management* is used if the discussion applies to the use and management that prevailed at the time of the survey. *Use and management* is used if both present use and management and suggested management are discussed.

Alderwood gravelly sandy loam, 3 to 15 percent slopes, (Ac; group 1)[3].—This soil normally occurs throughout the glaciated part of the county on rolling knolls or prominent moraines. It is generally associated with lower lying soils of smoother relief, such as those of the Everett, Lynden, Giles, and Kitsap series. The soil has developed from gravelly till materials derived from various rocks, chiefly granite, basalt, diabase, sandstone, shale, conglomerate, and quartzite.

Slopes of 6 to 12 percent are dominant. Runoff is slow to medium, and although the cemented substratum impedes the downward flow of water, internal drainage is medium. During winter and spring, the lower part of the subsoil above the cemented till is saturated for long periods. But this moisture is an asset during the growing season. The native vegetation is dominantly Douglas-fir, but there are a few hemlocks and cedars.

Profile description.—The 10- to 12-inch surface soil is brown[4] to dark-brown gravelly sandy loam, which becomes less brown and more yellow with depth. The upper 10 to 15 inches of this soil contains many iron and manganese concretions, locally called shot, that range from 1/100 to about ¼ inch in diameter (*8*).

The subsoil extends to depths of 28 to 32 inches. It is dark yellowish-brown gravelly sandy loam that is light yellowish brown to yellowish brown when dry. Below depths of 18 to 20 inches, very few shot occur. Above the substratum the soil is friable and has enough consistency to stand up in a cut bank. The material that overlies the substratum for 3 to 4 inches is frequently slightly mottled with yellowish brown and reddish brown and contains more fine material than any other part of the profile.

The substratum abruptly underlies the subsoil and is many feet thick. It is gray to dark-gray strongly cemented unassorted till. Although commonly called hardpan, this cemented till is not true hardpan, but it

[3] Letter symbol identifies soil on map; arabic number shows management group in which soil has been placed.

[4] Unless otherwise stated, the color terms used in this report are for moist soils.

TABLE 5.—*Approximate acreage and proportionate extent of soils mapped in Thurston County, Wash.*

Soil	Area	Extent
	Acres	*Percent*
Alderwood gravelly loam, 3 to 8 percent slopes	722	0.2
Alderwood gravelly sandy loam, 0 to 3 percent slopes	6,710	1.5
Alderwood gravelly sandy loam, 3 to 15 percent slopes	15,937	3.5
Alderwood gravelly sandy loam, 15 to 30 percent slopes	4,061	.9
Alderwood gravelly sandy loam, 30 to 50 percent slopes	673	.1
Bellingham silt loam, 0 to 2 percent slopes	196	(1)
Bellingham silty clay loam, 0 to 2 percent slopes	1,773	.4
Bellingham silty clay loam, 2 to 8 percent slopes	184	(1)
Bucoda silty clay loam, 5 to 15 percent slopes	87	(1)
Bucoda silty clay loam, 15 to 30 percent slopes	453	.1
Camas clay loam, 0 to 3 percent slopes	812	.2
Camas gravelly loam, 0 to 3 percent slopes	862	.2
Cathcart gravelly loam, 3 to 15 percent slopes	7,673	1.7
Cathcart gravelly loam, 15 to 35 percent slopes	4,660	1.0
Chehalis loam, 0 to 2 percent slopes	323	.1
Chehalis silty clay loam, 0 to 2 percent slopes	5,864	1.3
Delphi gravelly loam, 3 to 15 percent slopes	1,919	.4
Delphi gravelly loam, 15 to 30 percent slopes	1,621	.4
Edmonds fine sandy loam, 0 to 3 percent slopes	187	(1)
Eld gravelly loam, 0 to 2 percent slopes	499	.1
Eld loam, 0 to 2 percent slopes	212	(1)
Eld silty clay loam, 0 to 2 percent slopes	508	.1
Elma loam, 0 to 3 percent slopes	319	.1
Everett gravelly loamy sand, 0 to 3 percent slopes	1,301	.3
Everett gravelly loamy sand, 3 to 15 percent slopes	897	.2
Everett gravelly loamy sand, 15 to 30 percent slopes	504	.1
Everett gravelly sandy loam, 0 to 3 percent slopes	15,014	3.2
Everett gravelly sandy loam, 3 to 15 percent slopes	21,670	4.7
Everett gravelly sandy loam, 15 to 30 percent slopes	8,697	1.9
Everett gravelly sandy loam, 30 to 40 percent slopes	3,624	.8
Everett stony sandy loam, 0 to 3 percent slopes	3,226	.7
Everett stony sandy loam, 3 to 15 percent slopes	5,376	1.2
Everett stony sandy loam, 15 to 30 percent slopes	4,565	1.0
Everett stony sandy loam, 30 to 40 percent slopes	1,400	.3
Everson clay loam, 0 to 3 percent slopes	2,230	.5
Everson fine sandy loam, 0 to 3 percent slopes	1,811	.4
Everson silt loam, 0 to 3 percent slopes	1,977	.4
Fitch gravelly sandy loam, 0 to 3 percent slopes	4,549	1.0
Fitch gravelly sandy loam, 3 to 15 percent slopes	2,692	.6
Galvin silt loam, 0 to 5 percent slopes	222	.1
Galvin silty clay loam, 0 to 5 percent slopes	772	.2
Giles fine sandy loam, 0 to 3 percent slopes	11,103	2.4
Giles fine sandy loam, 3 to 15 percent slopes	7,272	1.6
Giles fine sandy loam, 15 to 30 percent slopes	1,239	.3
Greenwater loamy sand, 0 to 3 percent slopes	498	.1
Greenwood peat, 0 to 2 percent slopes	117	(1)
Grove gravelly sandy loam, 3 to 15 percent slopes	996	.2
Grove gravelly sandy loam, 15 to 30 percent slopes	1,461	.3
Indianola loamy sand, 3 to 15 percent slopes	2,485	.5
Indianola loamy sand, 15 to 30 percent slopes	1,332	.3
Indianola sandy loam, 3 to 15 percent slopes	216	.1
Kapowsin gravelly loam, 0 to 3 percent slopes	5,395	1.2
Kapowsin gravelly loam, 3 to 15 percent slopes	3,035	.7
Kitsap silt loam, 0 to 3 percent slopes	5,566	1.2
Kitsap silt loam 3 to 15 percent slopes	8,864	1.9
Kitsap silt loam, 15 to 30 percent slopes	2,281	.5
Kitsap silt loam, 30 to 40 percent slopes	507	.1
Lynden loamy sand, 0 to 3 percent slopes	2,925	.6
Lynden loamy sand, 3 to 15 percent slopes	1,006	.2
Lynden loamy sand, 15 to 30 percent slopes	149	(1)
Made land	398	.1
Maytown loam, 0 to 2 percent slopes	230	.1
Maytown silty clay loam, 0 to 2 percent slopes	1,274	.3
McKenna gravelly clay loam, 0 to 3 percent slopes	1,190	.3
McKenna gravelly loam, 0 to 3 percent slopes	1,824	.4
Melbourne silty clay loam, 3 to 15 percent slopes	4,862	1.1
Melbourne silty clay loam, 15 to 30 percent slopes	15,488	3.4
Melbourne silty clay loam, 30 to 40 percent slopes	2,889	.6
Melbourne stony loam, 3 to 15 percent slopes	230	.1
Melbourne stony loam, 15 to 30 percent slopes	851	.2
Meskill silt loam, 0 to 3 percent slopes	79	(1)
Meskill silty clay loam, 3 to 15 percent slopes	417	.1
Mukilteo peat, 0 to 2 percent slopes	6,532	1.4
Mukilteo peat, shallow over dense clay, 0 to 2 percent slopes	436	.1
Newberg loam, 0 to 2 percent slopes	1,592	.3
Newberg sandy loam, 0 to 2 percent slopes	1,307	.3
Nisqually loamy sand, 2 to 5 percent slopes	13,469	2.9
Nisqually loamy sand, 5 to 15 percent slopes	367	.1
Norma clay loam, 0 to 3 percent slopes	1,886	.4
Norma loam, 0 to 3 percent slopes	1,158	.3
Olympic silty clay loam, 6 to 15 percent slopes	1,739	.4
Olympic silty clay loam, 15 to 30 percent slopes	3,360	.7
Olympic silty clay loam, 30 to 40 percent slopes	1,130	.2
Olympic stony clay loam, 6 to 15 percent slopes	974	.2
Olympic stony clay loam, 15 to 30 percent slopes	1,738	.4
Pilchuck loamy fine sand, 0 to 3 percent slopes	634	.1
Pilchuck sand, 0 to 3 percent slopes	186	(1)
Prather silty clay loam, 3 to 8 percent slopes	4,044	.9
Prather silty clay loam, 8 to 15 percent slopes	1,833	.4
Prather silty clay loam, 15 to 30 percent slopes	1,307	.3
Prather silty clay loam, 30 to 40 percent slopes	727	.2
Puget clay, 0 to 2 percent slopes	17	(1)
Puget silty clay loam, 0 to 2 percent slopes	364	.1
Puyallup fine sandy loam, 0 to 2 percent slopes	2,882	.6
Puyallup loam, 0 to 2 percent slopes	96	(1)
Reed clay, 0 to 2 percent slopes	1,336	.3
Reed silty clay loam, 0 to 2 percent slopes	950	.2
Rifle peat, 0 to 2 percent slopes	1,204	.3
Rifle peat, shallow over dense clay, 0 to 2 percent slopes	127	(1)
Riverwash	562	.1
Rough mountainous land, Melbourne soil material	2,920	.6
Rough mountainous land, Olympic soil material	105,527	23.0
Rough mountainous land, Wilkeson soil material	518	.1
Salkum silty clay loam, 3 to 8 percent slopes	367	.1
Salkum silty clay loam, 8 to 15 percent slopes	144	(1)
Salkum silty clay loam, 15 to 30 percent slopes	112	(1)
Semiahmoo muck, 0 to 2 percent slopes	1,501	.3
Semiahmoo muck, shallow over dense clay, 0 to 2 percent slopes	819	.2
Shuwah silty clay loam, 0 to 2 percent slopes	45	(1)
Snohomish silt loam, 0 to 3 percent slopes	167	(1)
Spanaway gravelly sandy loam, 0 to 3 percent slopes	24,690	5.4
Spanaway gravelly sandy loam, 3 to 15 percent slopes	4,530	1.0
Spanaway gravelly sandy loam, 15 to 30 percent slopes	394	.1
Spanaway gravelly sandy loam, mound phase, 2 to 10 percent slopes	10,872	2.4
Spanaway stony sandy loam, 0 to 3 percent slopes	1,933	.4
Spanaway stony sandy loam, 3 to 15 percent slopes	1,124	.2
Sultan fine sandy loam, 0 to 2 percent slopes	448	.1
Sultan loam, 0 to 2 percent slopes	553	.1
Tacoma muck, 0 to 2 percent slopes	355	.1
Tenino gravelly sandy loam, 4 to 15 percent slopes	284	.1
Tenino gravelly sandy loam, 15 to 35 percent slopes	6,639	1.4
Tidal marsh, 0 to 2 percent slopes	440	.1
Tisch loam, 0 to 3 percent slopes	1,230	.3
Tromp fine sandy loam, 0 to 3 percent slopes	838	.2
Tromp-Tisch complex, 0 to 3 percent slopes	26	(1)
Tumwater fine sandy loam, 0 to 3 percent slopes	419	.1
Tumwater loamy fine sand, 0 to 3 percent slopes	8,617	1.9
Tumwater loamy fine sand, 3 to 15 percent slopes	2,127	.5
Tumwater loamy fine sand, 15 to 30 percent slopes	847	.2
Wadell loam, 2 to 5 percent slopes	259	.1
Wadell silty clay loam, 0 to 3 percent slopes	692	.1
Wapato silty clay loam, 0 to 2 percent slopes	4,309	.9
Wilkeson silt loam, 3 to 15 percent slopes	133	(1)
Gravel pits	83	(1)
Total	458,880	100.0

[1] Less than 0.1 percent.

is almost as hard as rock. Roots do not penetrate it; they form a root mat on top. Gravel and some boulders are scattered throughout the profile, but only a few widely dispersed areas contain enough to interfere with tillage.

Under virgin conditions, a fairly thick layer of organic litter and leaf mold overlies the surface soil. The surface soil is moderately high in organic matter. In cultivated areas it is paler and more brown and yellowish brown than it is in virgin areas.

This soil is more variable in Thurston County than in the counties to the north. In extreme instances, the depths to the cemented substratum range from 24 to 48 inches. The color of the surface soil ranges from dark grayish brown to dark yellowish brown. Areas of this soil associated with soils of the Kitsap, Kapowsin, and Cathcart series are usually more variable than others. Soils with semicemented substrata that, within small areas, vary greatly in hardness are included with this soil. In places, these included soils contain considerable fine material and are highly mottled with yellow and brown.

Present use and management.—Practically all areas of this soil have been logged, and about 20 percent of the acreage has been cleared for cultivation. Uncleared areas are in second- or third-growth timber of Douglas-fir and alder and have an undergrowth of vines, vine maple, and other shrubs. The rolling relief allows excess water to drain away, and the cemented substratum makes more moisture available for plants during the normally dry growing season.

These favorable features make this soil adaptable to most of the general crops of the region, especially hay, pasture, and fruit. However, this soil is not extensively cultivated. Generally farms are small. The chief crops are hay and pasture (fig. 2), and some fruit is grown for home use. Oats with legumes, timothy with clover, or oats alone are the common hay crops.

Barnyard manure is the most common amendment. Commercial fertilizers are becoming more important, but they are used chiefly on specialized crops. Occasionally superphosphate is applied with the barnyard manure.

***Figure 2.*—Wooded pasture on Alderwood soils provides some feed for the entire year, but this pasture is of low carrying capacity. It consists of the native grasses and weeds. Wooded pasture is the principal agricultural use of the glacial upland soils. Removing stumps and levelling are difficult and expensive.**

Alderwood gravelly sandy loam, 0 to 3 percent slopes (Ab; group 1).—This soil is similar to and occurs in small scattered areas closely associated with Alderwood gravelly sandy loam, 3 to 15 percent slopes. Runoff is very slow to slow. Although internal drainage is medium, it is slightly more restricted than in the more strongly sloping Alderwood soils. Furthermore, the lower part of the profile immediately above the "hardpan" is generally more mottled and finer textured.

This soil has about the same acreage cultivated as Alderwood gravelly sandy loam, 3 to 15 percent slopes. Use and management and crop yields are also about the same on these two soils.

Alderwood gravelly sandy loam, 15 to 30 percent slopes (Ad; group 12).—This soil is similar to other Alderwood soils except that it has a shallower profile. It occurs in scattered areas in close association with other Alderwood soils. The largest areas are northwest of Tenino. Little of this soil has been cleared of trees, brush, or stumps and used for farming. It is more valuable for growing timber than for farming.

Alderwood gravelly sandy loam, 30 to 50 percent slopes (Ae; group 12).—This soil occupies areas of steep, irregular and often broken, relief considered impossible or extremely unfavorable for agriculture. The soil occurs on steep slopes adjacent to drainageways, on breaks between uplands and terraces, or on breaks along the Puget Sound coastline. The larger areas occur northwest of Tenino.

The soil profile resembles that of the other Alderwood soils but varies considerably more, especially in the depth to and hardness of the cemented substratum. In places the substratum is only very weakly cemented. This soil is used for forestry and for homesites along Puget Sound.

Alderwood gravelly loam, 3 to 8 percent slopes (Aa; group 1).—This soil is inextensive. It occurs largely northwest of Olympia in association with Alderwood gravelly sandy loam, 0 to 3 percent slopes, and Kitsap silt loam, 0 to 3 percent slopes. It differs from Alderwood gravelly sandy loam, 0 to 3 percent slopes, mainly in that it has a finer texture and contains more shot to a depth of 10 inches. Furthermore, it typically has less gravel in the profile and a larger proportion of fine material in the lower part of the subsoil. Runoff is slow to medium, and internal drainage is medium.

Use and management is similar to that on Alderwood gravelly sandy loam, 0 to 3 percent slopes, but this soil can be expected to give slightly higher yields of some crops. Because of its finer texture and the resulting higher capacity to hold water and plant nutrients, this soil is more desirable for farming than Alderwood gravelly sandy loam, 0 to 3 percent slopes. Only a small part is in cultivation, however, and it is used mainly for hay and pasture crops. The rest is in second-growth timber and brush.

Bellingham silty clay loam, 0 to 2 percent slopes (Bb; group 4).—This dark-colored soil occupies low-lying poorly drained basins or depressions. It is asso-

ciated with glacial lake deposits on which Kitsap soils are dominant. The soil occurs throughout the county except in the extreme western and southern parts. It generally occupies small areas, many of which are long and narrow along intermittent drainageways.

This soil is generally covered with water during the wet season of the year unless artificially drained. The native vegetation consists largely of alder, ash, Douglas-fir, and willow, with some shrubs and vines.

Profile description.—The surface soil to a depth of about 8 inches is friable very dark gray or black silty clay loam of coarse granular structure. When dry, the surface soil is dark grayish brown and is slightly mottled with yellow and brown in the lower part. It is medium acid and contains a high percentage of organic matter.

Gray firm clay or silty clay, highly mottled with yellow, reddish brown, and black, underlies the surface soil and continues to a depth of about 20 inches. This material grades to mottled olive-gray or gray firm silty clay that is less mottled than the layer above.

Olive-gray compact plastic silty clay occurs at a depth of about 36 inches and has only slight mottling for many feet. The subsoil and substratum are slowly permeable to water and plant roots.

Areas that are slightly better drained than normal and have grayish-brown to dark grayish-brown surface soils are included. These soils have lower than the normal organic-matter content. Some of the areas associated with soils of the Alderwood, Kapowsin, Cathcart, or Everett series are underlain by a gravelly clay till at a depth of about 3 feet.

Present use and management.—Without artificial drainage, this soil is not suited to cultivation. The areas that have been drained are used mainly for pasture; little is used for farm crops other than native grass for hay. The pastures have a high carrying capacity. They do not lack moisture during summer so much as the associated well-drained upland soils. Areas of this soil that are large enough are usually drained and used for hay crops. Most areas, however, are too small to make up a farming unit alone. These small acreages are generally used with the surrounding areas either for pasture or hay.

Bellingham silty clay loam, 2 to 8 percent slopes (Bc; group 4).—Areas of this soil occur below steeper, better drained upland soils. The soil is saturated most of the time by moisture from runoff and many small springs. It is associated with Kitsap silt loam, 0 to 3 percent slopes, and Kitsap silt loam, 3 to 15 percent slopes, and occurs on the peninsula in the northern part of the county. It differs from the Bellingham silty clay loam, 0 to 2 percent slopes, in relief and in having a shallower surface soil that is generally lighter colored where cultivated. This soil occupies only a few small areas. Use and management are similar to those for Bellingham silty clay loam, 0 to 2 percent slopes.

Bellingham silt loam, 0 to 2 percent slopes (Ba; group 4).—This soil differs from Bellingham silty clay loam, 0 to 2 percent slopes, mainly in texture of the surface horizon. The surface soil is dark gray to black, and the subsoil is olive gray with variable amounts of yellow and brown mottling. Generally this soil has a little lighter colored and more friable surface soil than Bellingham silty clay loams. The total acreage of this soil is small, and the areas are scattered. The largest area occurs south of Oyster Bay.

About half of this soil is cleared and in clover, grass, and vetch and oats used for hay and pasture. Crop yields are a little better than on Bellingham silty clay loam, 0 to 2 percent slopes. Artificial drainage is required for most cultivated crops.

Bucoda silty clay loam, 5 to 15 percent slopes (Bd; group 2).—This upland soil differs from Olympic silty clay loam, 6 to 15 percent slopes, mainly in that it has developed largely from andesitic igneous rock. The Olympic soils have developed largely from weathered basaltic materials. The profiles differ mainly in the color of the subsoils and substrata. The subsoil of this soil is brown or pale olive to olive, normally variegated with streaks of reddish brown and black. This coloring sharply contrasts with the strong brown or reddish brown in the Olympic soils. This soil occurs only in one area southwest of Tenino in association with the Melbourne and Olympic soils. It lies between the Olympic soils on the higher mountainous land and the Melbourne soils on the lower slopes. Soils with profiles similar to that of the Bucoda occur occasionally in areas of Rough mountainous land, Olympic soil material.

Runoff is medium, but medium to slow internal drainage causes iron discoloration in the subsoil. Native vegetation consisted chiefly of Douglas-fir, some hemlock and cedar, and the understory of shrubs and vines common to the region.

Profile description.—In heavily timbered areas the surface soil underlies a 1½- to 2-inch layer of organic litter that is partly decomposed in the lower part. The surface soil, 6 to 8 inches thick, is dark-brown to dark grayish-brown granular friable silty clay loam that is pale brown to brown when dry. A few iron concretions or shot occur in this layer.

The surface soil grades to a slightly lighter brown, firm to friable clay loam that contains a few streaks of reddish brown and purple in the lower part. This layer is granular. At depths that vary from 22 to 26 inches, the material is olive, firm clay that is highly streaked with yellow, brown, purple, and black. The clay is plastic when wet. Partly decomposed andesitic igneous rock fragments occur in the lower part.

This horizon grades to material largely of parent rock at depths of about 36 to 48 inches. The parent rock is chiefly andesite. In places, angular stones occur throughout the profile, and rock outcrops are fairly common.

Use and management.—Bucoda silty clay loam, 5 to 15 percent slopes, occupies a small acreage, and most of it is in second-growth timber. Some of the less timbered and brushy areas are used for wooded pasture along with cleared and seeded pastures. The areas in cultivation are used primarily for hay and pasture, and with moderate success. This soil is not so productive as the associated Olympic soils.

Bucoda silty clay loam, 15 to 30 percent slopes (Be; group 12).—This soil occurs only in one area southeast of Tenino and is closely associated with Bucoda silty clay loam, 5 to 15 percent slopes. Parent materials and vegetation are similar for the two soils. The

profiles differ only in depth to bedrock, which is normally more shallow and variable in this soil. Angular stones of andesite and basalt often occur in the surface soil. Runoff is rapid, and internal drainage is medium to slow.

This soil is mostly in brush and timber, and partially cleared areas are used for pasture. A small acreage is used for hay and pasture crops. The best use of this soil is for forestry.

Camas clay loam, 0 to 3 percent slopes (Ca; group 7).—This soil occurs on low alluvial terraces in the flood plains of the main streams that flow from the sandstone, shale, and basaltic hills. The principal areas are associated with Chehalis silty clay loam, 0 to 2 percent slopes, between the Chehalis and Black Rivers near the western county line. This soil occurs at elevations similar to those of the Chehalis soil, but the Camas soil may be more undulating and on slightly higher swells or ridges, which are surrounded by soils of the Chehalis and Newberg series. It differs from Chehalis silty clay loam, 0 to 2 percent slopes, in overlying glacial gravel at depths ranging from about 40 to 48 inches. The soil is above normal overflow and well drained. Internal drainage is medium, and runoff is slow.

Profile description.—The 14-inch surface soil is dark-brown to very dark grayish-brown friable clay loam of coarse granular structure. When dry it is brown to dark grayish brown. The organic-matter content is fairly high.

To a depth of 32 inches, the subsoil is a brown to dark-brown firm clay loam of blocky structure. Variegations of yellowish brown and brown occur in the lower part. Numerous plant roots penetrate the subsoil. Below 32 inches the subsoil material is yellowish-brown gravelly loam to gravelly clay loam that contains pebbles ⅛ to 2 inches in diameter that have come from various kinds of rock. At about 46 inches, there is an abrupt transition to loose porous single-grained gravelly sand. The profile is slightly acid.

The depth to the pebbles, or gravel, is variable, and in places gravelly material occurs within 12 inches of the surface. Included are areas that have a sandy substratum. The substratum is exceedingly variable within small areas.

Present use and management.—Less than half of this soil has been cleared and used for cultivated crops. The uncleared part is in stumps and second-growth timber and is used for grazing. The soil produces about the same kind of crops as Chehalis silty clay loam, 0 to 2 percent slopes. Yields are somewhat less than on the Chehalis soil, because the gravelly substratum reduces the water-holding capacity. Recently small acreages of blueberries, raspberries, and currants have been planted. Irrigation by sprinklers has become more important, and under irrigation yields are normally at least one-third higher than for crops not irrigated.

Camas gravelly loam, 0 to 3 percent slopes (Cb; group 7).—This soil is inextensive and occurs in close association with larger areas of Camas clay loam, 0 to 3 percent slopes, and Chehalis silty clay loam, 0 to 2 percent slopes. It differs from the Camas soil in having gravel throughout the profile, and the gravelly substratum is normally closer to the surface. Internal drainage is ordinarily medium, but in small areas it may be rapid. This somewhat excessively drained soil is droughty in summer.

Profile description.—The surface soil extends to a depth of 12 inches and is granular friable brown to dark-brown gravelly loam or loam. It has a moderate amount of organic matter.

The subsoil extends to a depth ranging from 20 to 30 inches. It is friable, dark yellowish-brown gravelly loam to gravelly fine sandy loam. The rounded pebbles make up 20 to 40 percent of the volume and are coated with fine material. This material changes abruptly to a loose porous single-grained gravelly sand, which extends for many feet.

Depths to the coarse-textured substratum range from 20 to 48 inches. Included are areas having a coarse sandy substratum. These extreme variations occur as small spots or narrow strips associated with the more typical soil. Narrow abandoned stream channels or intermittent drainageways that have variable soil characteristics are included.

Present use and management.—Most of this soil is used for wooded pasture or remains in brush and timber. It generally is cultivated only where it is associated with other cultivated soils. Under irrigation most crops will do very well.

Cathcart gravelly loam, 3 to 15 percent slopes (Cc; group 2).—This soil occupies rolling morainic knolls in the southern half of the county. It consists of a thin gravelly glacial deposit overlying relatively soft weathered shale and sandstone. The parent material is a mixture of glacial material derived largely from shale and sandstone. The surface soil has not been materially modified by the underlying sedimentary materials, but the lower subsoil definitely has been modified.

The soil occurs principally in the vicinity of Maytown and north and west of Tenino. Other smaller areas are on the lower slopes below the Melbourne soils in the southern part of the county. This soil is closely associated with Cathcart gravelly loam, 15 to 35 percent slopes, and with soils of the Alderwood, Everett, and Melbourne series.

Runoff is slow to medium, and internal drainage is medium. Because of its finer textured subsoil, the soil has a higher available moisture supply during the dry summer months than most well-drained glaciated upland soils. Root penetration is restricted in areas where the subsoil is very compact and plastic. The native vegetation consists largely of Douglas-fir, hemlock, cedar, and an understory of shrubs and vines.

Profile description.—To depths of 3 to 4 inches the surface soil is a dark grayish-brown granular gravelly loam that contains many rounded shot and small pebbles. This layer is highly organic and friable. It is underlain by 10 to 12 inches of brown friable gravelly loam that contains a few shot and is of moderate granular structure. The pebbles are heavily coated with fine material.

Below the gravelly loam and to a depth of 24 inches, the soil is brown or dark yellowish-brown gravelly clay loam. This layer is less friable than the layer above and has a subangular blocky structure and slight

yellow and reddish-brown mottling. It is light yellowish brown or very pale brown when dry. It grades to a more firm, highly mottled olive or yellowish-brown gravelly clay loam.

Between depths of 32 and 60 inches, the material is weakly cemented gravelly sandy clay, highly mottled with yellow and brown. Inclusions of weathered shale, sandstone, and gravel are common, especially in the lower part. This layer overlies soft disintegrated olive-colored shale or sandstone which has an angular blocky structure. The top of this layer is stained dark brown and black.

The profile of this soil is extremely variable within small areas, especially in the depth to the underlying sedimentary material. In extreme instances, these depths may range from 2 to 5 feet. In places, the subsoil is gray, highly mottled, dense, and plastic. These characteristics are especially common in areas having smoother relief. In areas where sandstone is the dominant parent material, the profile is more friable throughout. The weakly cemented gray or olive layer above the parent material is not always present. Areas having these variable characteristics are too spotty and small to be shown separately on the soil map.

Present use and management.—Much of this soil is in brush and stumps, but there has been a good restocking of second-growth timber, largely Douglas-fir. Pasturing of partly cleared areas is the principal agricultural use. Farms that have this soil are small, and only a few acres have been cleared on each farm.

Oats, legumes, and timothy are the chief crops. These crops are used for hay and pasture to feed dairy cattle. Yields are normally slightly higher than on comparable slopes of the Alderwood soils.

Cathcart gravelly loam, 15 to 35 percent slopes (Cd; group 12).—This soil is similar to and closely associated with Cathcart gravelly loam, 3 to 15 percent slopes. The depth to the sedimentary materials, however, is usually more variable and in most places this soil is shallower. Outcrops of shale and sandstone on the steeper slopes are common. The larger areas are northeast and west of Tenino.

Because of the steep relief, none of this soil is under cultivation. It is used mainly for timber, but a few areas are used for grazing. Most of the areas are in second-growth Douglas-fir, brush, and stumps. The best use is for forestry.

Chehalis silty clay loam, 0 to 2 percent slopes (Cf; group 6).—This soil occurs in the flood plains of the major streams and was derived from alluvium consisting mainly of shale, sandstone, basalt, and andesite rock. It is extensive in the valleys of the Deschutes, Skookumchuck, and Chehalis Rivers and their tributaries. Except for the areas in the Chehalis River valley, most of it occurs as discontinuous, narrow stringers along the Deschutes and Skookumchuck Rivers. Most of the areas are less than one-fourth mile wide. This soil is associated with the Newberg soils that are sandier and have developed from more recent deposits in areas adjacent to the stream.

The soil is subject to overflow only at extreme high water, which may occur for short periods during winter. Normally it is well drained. Short slopes ranging up to 6 percent are included in places.

Profile description.—The surface soil is dark-brown strongly granular friable silty clay loam. When dry, it is brown.

From depths of 10 to 15 inches, the material grades to slightly lighter brown firm to friable silty clay of granular or subangular blocky structure. The structural aggregates are strongly coated with colloidal material and are hard when dry but plastic when wet. At a depth of about 24 inches the silty clay is underlain by similar material that is slightly less firm, less granular, and brown in color.

Below depths of 36 to 44 inches, the soil is yellowish-brown or brown light clay or heavy silty clay loam, faintly mottled with yellow and reddish brown. It has an irregular interlocking structure. The entire profile is moderately permeable to water and plant roots.

Variations occur where the soil has been slightly modified by glacial material from surrounding uplands. Some of the areas in the Deschutes and Skookumchuck River valleys that pass through glaciated areas contain intermixed glacial material. This material has imparted lighter colored profiles that are gritty, less granular, and less friable than the typical soil.

Areas containing some gravel in the substratum below depths of 40 to 48 inches are included. Where this soil occurs adjacent to smaller streams or tributaries, it is more varied than the typical soil. In a few of these areas the soil is finer textured, more gritty, less friable, and more mottled in the substratum than the normal Chehalis soil. This deep soil is one of the most productive in the county.

Present use and management.—All the original forest has been removed, and the soil is in second-growth trees, brush, and stumps or in cultivation. Between 50 and 70 percent of the total area is under cultivation or in permanent pasture. The soil is fertile and highly productive of many crops (fig. 3).

The principal crops are small grains, mainly oats, and hay and pasture. The hay and pasture are used to feed dairy cattle. Legumes, timothy, oats, and vetch

Figure 3.—**Chehalis silty clay loam is well adapted to all crops of the region. Here it is in a winter cover crop that will be plowed under. The area will then be used either for a cash crop, such as green peas or small grain, or sown to legumes and grasses for hay and pasture. Rough mountainous land, Olympic soil material, is in the background. These areas are covered with second-growth timber consisting largely of Douglas-fir and hemlock.**

are the major hay crops, and they may be grown alone or in mixture. A small acreage is in alfalfa. Vegetables and fruit are grown largely for home consumption. Peas, grown for canning and for frozen pack, is an important cash crop that has increased considerably in recent years. Wheat and oats are important as grain crops for the area between the Chehalis and Black Rivers in the southwestern corner of the county.

Grain farming, dairying, and poultry raising are the principal types of farming in areas where this soil predominates. Grain crops are frequently grown in a rotation following clover and grass or other hay crops (fig. 3). All barnyard and chicken manure is applied to the soil, and occasionally superphosphate is used with the manure. Some farmers apply limestone. Many of the grain crops are harvested with a combine, and the straw is plowed under. Straw is also used for animal bedding and returned to the soil with the manure.

Although this soil has a moderately fine texture, the granular structure and friable surface soil allow tillage over a fairly wide range of moisture content. But the soil will puddle if cultivated when wet, and it is not nearly so easily tilled as the Puyallup soils. It retains adequate moisture for general crops, but late crops and pasture benefit during the dry summers by irrigation.

Chehalis loam, 0 to 2 percent slopes (Ce; group 6).—This soil is much less extensive than Chehalis silty clay loam, 0 to 2 percent slopes, and occurs in close association with it and Newberg loam, 0 to 2 percent slopes. It occupies smaller areas close to the stream channels than the Chehalis silty clay loam. This soil resembles Newberg loam, 0 to 2 percent slopes, except for having a finer textured substratum. In some places, it consists of silty material recently deposited over Chehalis silty clay loam, 0 to 2 percent slopes. Internal drainage is medium, and runoff is very slow. Because of its slightly lower position, this soil is flooded more frequently than Chehalis silty clay loam, 0 to 2 percent slopes. The original vegetation consisted of a heavy stand of Douglas-fir, hemlock, and cedar, with maples, alder, and a heavy undergrowth of brush and shrubs.

Profile description.—The surface soil to depths of about 10 to 12 inches is dark-brown to brown moderately granular friable loam. This is underlain by a pale-brown or dark yellowish-brown heavy loam or a light clay loam that is weakly granular and friable.

Beginning at about 24 to 28 inches is a brown slightly firm gritty clay loam. This layer is moderately permeable and continues to a depth of about 48 inches.

Below 48 inches, the soil is slightly firm, gritty, easily crushed loam to clay loam of massive structure. Thin layers of silt and fine sand occasionally occur below 3 feet.

Present use and management.—Because so many areas are small and isolated along the stream channels, probably less than 50 percent of this soil is cleared for cultivation. Like Chehalis silty clay loam, 0 to 2 percent slopes, it is used primarily for hay and pasture. The two soils have similar management and crop yields, but because this soil is coarser textured, tillage is easier, and the water-supplying capacity is only slightly lower. This soil is more suitable for truck crops than Chehalis silty clay loam, 0 to 2 percent slopes.

Delphi gravelly loam, 3 to 15 percent slopes (Da; group 1).—This soil occupies rolling areas on ancient terraces or lower foot slopes in mountain valleys. It is in the northwestern corner of the county south of Summit Lake. It is closely associated with steeper Delphi soils and is generally adjacent to and below steep and mountainous areas of Olympic soils. This soil, like other Delphi soils, has developed from glacial till of mixed origin, largely basalt. Frequently, significant amounts of Vashon, Admiralty, or older glacial gravels have been mixed into the till. The glacial deposit overlies or is mixed with weathered basaltic materials and basaltic rock. The profile has been materially modified by the underlying material, especially the color and texture of the lower subsoil. The soil is well drained, and native vegetation consisted largely of a heavy stand of Douglas-fir.

Profile description.—The 10- to 12-inch surface soil is dark reddish-brown granular friable gravelly loam that contains many small iron concretions, or shot, angular basaltic fragments, and rounded mixed glacial gravel. It is reddish brown when dry. The supply of organic matter is fairly high in the upper part.

The upper subsoil, extending to a depth of about 20 inches, is a weak granular, friable yellowish-brown gravelly clay loam that contains less shot than the layer above. The lower subsoil, which continues to depths of 27 to 32 inches, is a gravelly clay loam that is a lighter yellowish brown and more compact than the upper subsoil. This layer breaks into irregular structural aggregates that are easily crushed when dry.

The subsoil overlies a substratum of weakly to strongly cemented, olive, gravelly sandy clay till, highly stained with reddish brown. This till is dense and is cemented with siliceous materials and iron oxide. It has a high content of fine and medium sand and contains angular basalt fragments, and rounded pebbles and stones of various sizes and from different sources. Similar material normally continues downward many feet and rests on weathered basaltic materials or basalt bedrock.

Variations occur in areas transitional from this soil to Olympic soils. In places the glacial mantle over the Olympic soil material is very thin and in these the surface soil ranges from a gravelly loam to a stony clay loam. Included are areas in colluvial or fanlike positions that appear to be a mixture of glacial and basaltic materials. Cementation of the substratum is very slight in places, and the substratum consists mainly of a firm mixture of fine-textured weathered basaltic and gravelly glacial materials.

Present use and management.—The Delphi soil, originally densely covered with timber, has been allowed to remain in stumps and to restock with Douglas-fir and other trees and shrubs. Only a few small areas have been cleared for farm use. The soil is of minor importance for agriculture because the areas are small and scattered and they are associated with

steep and mountainous areas unsuited to farming. Areas adjacent to alluvial soils are used with them for pasture. Much of the cutover land on smoother slopes is used for grazing.

Delphi gravelly loam, 15 to 30 percent slopes (Db; group 12).—This soil differs from Delphi gravelly loam, 3 to 15 percent slopes, mainly in having stronger slopes. The profiles of the two soils are similar, but this soil is shallower in most places and contains more angular basaltic rock. Variations similar to those included in Delphi gravelly loam, 3 to 15 percent slopes, are included in this soil.

This soil was originally forested with Douglas-fir and some hemlock and cedar, but it is now mainly in brush and small trees. It is slowly restocking to Douglas-fir. Except for limited grazing, it has no agricultural use. It is best used for forestry. Along the shore of Summit Lake, summer homes occupy some areas.

Edmonds fine sandy loam, 0 to 3 percent slopes (Ea; group 4).—This soil has developed under poor drainage from sandy glacial outwash derived from many kinds of rocks. It occupies very nearly level depressional areas in glacial outwash plains and is generally associated with soils of the Lynden, Tumwater, and Everson series. It occurs only in a few small areas; the main one is east of Black Lake. This soil may be covered by standing water during the rainy winter season.

Profile description.—In timbered areas, a 1- to 2-inch layer of partly decomposed forest litter overlies the mineral soil. Under this litter is a 6-inch layer of olive-gray to dark-gray fine sandy loam mottled with reddish brown and yellow. This layer is underlain by a highly iron stained dark yellowish-brown loamy sand or sand weakly cemented by iron oxides. The cemented layer is about 6 to 8 inches thick and, in places, the cementation is spotty and in small pieces that can be crushed fairly easily.

Loose olive and gray coarse sand, slightly stained in the upper part, underlies the cemented layer. This material continues for many feet, but some thin layers of fine and coarse sand and gravel may occur below depths of 3 or 4 feet.

Present use and management.—Most of this soil is in second-growth timber, largely alder, cedar, vine maple, willow, salmonberry, elderberry, spirea, and other water-loving plants. A small acreage is used with the better drained adjacent soils, chiefly for pasture and hay crops. Artificial drainage is required before the soil can be used for general crops. If cleared and adequately drained, the soils would produce fair yields because crops and pasture would not be injured by drought so much as on the better drained soils.

Eld silty clay loam, 0 to 2 percent slopes (Ed; group 7).—Nearly level to gently sloping alluvial fans and alluvial flood plains are occupied by this soil. It was derived from material that originated from the basaltic hills. The recent deposit overlies mixed glacial gravel at depths ranging from 36 to 60 inches. The soil is associated with Eld gravelly loam, 0 to 2 percent slopes, and Eld loam, 0 to 2 percent slopes. It occurs in the western end of the county along the lower part of Wadell Creek. This soil is well drained. Native vegetation consisted of Douglas-fir, hemlock, cedar, alder, cottonwood, vine maple, hazel, and other trees and shrubs.

Profile description.—To a depth of about 12 inches, the surface layer is a dark reddish-brown friable granular silty clay loam underlain by slightly lighter colored friable weakly granular clay loam to loam. Thin layers, or strata, of very fine sandy loam, loam, and clay loam occur occasionally, but otherwise there is little change to a depth of about 36 inches. At this depth the material becomes slightly lighter reddish brown and consists of stratified loam, silt loam, and clay loam that contain some rounded gravel. Below depths of 48 to 60 inches, the material is highly stained and coated mixed glacial gravel.

Areas with small lenses of gravel in the upper part of the profile are included. In places angular basaltic fragments occur. In a few areas the lower subsoil contains slight yellow and reddish-brown mottling.

Present use and management.—This soil is fertile, productive, and retains moisture well. About 75 percent of the area is under cultivation and is used to produce clover, mixed grasses for hay and pasture, oaks, and corn for silage (fig. 4). It is widely used for growing feed for dairy cattle and poultry. Corn for silage yields 12 tons per acre. All available manure, an average of 6 tons per acre, is applied to the soil. Superphosphate is also applied as a supplement to balance the manure.

Eld loam, 0 to 2 percent slopes (Ec; group 7).—This soil differs from Eld silty clay loam, 0 to 2 percent slopes, chiefly in that it has a coarser textured surface soil. It is limited in area and occurs along McLean Creek south of Eld Inlet. It is closely associated with Eld gravelly loam, 0 to 2 percent slopes. The 8- to 12-inch surface soil is a dark reddish-brown granular friable loam. The subsoil is a dark reddish-brown to reddish-brown loam or light clay loam containing scattered gravel. It is more compact than the surface soil, and is usually somewhat stratified. Between depths of 30 and 48 inches, the soil changes to a gravelly sandy loam that becomes coarser and looser with depth. This layer overlies loose sand and gravel.

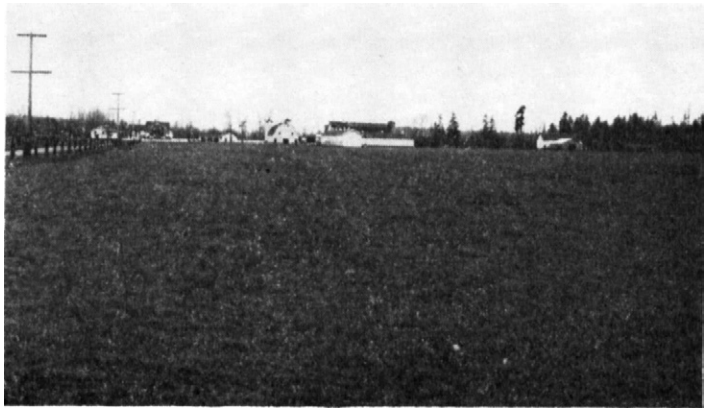

Figure 4.—Eld silty clay loam, one of the most fertile soils in the county, is used for pasture, hay, and small grains. Dairying is the principal industry.

This soil is moderately productive. However, because of its coarser texture, it is less productive and more subject to drought than Eld silty clay loam, 0 to 2 percent slopes. The soil is mostly covered by second-growth timber or brush and stumps. The main agricultural use is grazing.

Eld gravelly loam, 0 to 2 percent slopes (Eb; group 7).—This soil is similar to Eld loam, 0 to 2 percent slopes. The chief difference is that it is gravelly throughout the profile. The gravel consists of subangular basalt fragments and rounded glacial pebbles of mixed origin. Areas of this soil are small and occur northwest of Little Rock, along McLean Creek, and west of Summit Lake.

Profile descriptions.—The 8-inch surface layer is dark reddish-brown granular friable gravelly loam. Below this layer the color changes to dark yellowish brown to yellowish red and the gravelly loam becomes more compact. Structure is coarse and granular to a depth of 20 inches.

Between depths of 20 and 30 inches the subsoil is a yellowish-brown to strong-brown gravelly loam that has slight compaction. This material grades into a loose porous olive or olive-yellow gravelly sandy loam that becomes more sandy and gravelly with depth.

Small inclusions contain gravelly fine sandy loam. In places, the gravelly loam of the surface layer is only a few inches thick and is underlain with loose gravelly loamy sand similar to Everett soil material. This soil is more varied than the other Eld soils.

Present use and management.—This soil is moderately fertile and productive, but because of the gravel and the more open substratum, it is less valuable for crops than the Eld silty clay loam or Eld loam. From 50 to 60 percent has been cleared. Crops similar to those on Eld silty clay loam, 0 to 2 percent slopes, are grown, but yields are lower on this soil.

Elma loam, 0 to 3 percent slopes (Ee; group 3).—Except for the scattering of gravel on the surface soil and in the upper subsoil, this soil resembles Giles fine sandy loam, 0 to 3 percent slopes. It occurs only in one area southwest of Rochester, where it occupies a gently undulating terrace in association with Lynden loamy sand, 0 to 3 percent slopes. The area is south of and adjacent to a higher terrace occupied by Prather soils. The surface soil and upper subsoil of Elma loam appear to have been modified by materials washed from the Prather soils.

Profile description.—The surface soil to depths of 10 to 12 inches is brown to dark reddish-brown friable granular loam to light clay loam. This material contains a high proportion of shot and grades into dark yellowish-brown friable silt loam or silty clay loam that contains some shot and gravel.

Some stratification with gravel and sand occurs below a depth of 20 inches. At depths of about 30 to 36 inches the material is a poorly assorted but stratified gravel and sand with some admixture of the material above. The lower subsoil and substratum are gravelly or very gravelly.

The depth to the gravel and the amount of gravel scattered in the upper part of the profile vary within small areas. Included are areas that have a gravelly surface soil.

Use and management.—This soil is used for many crops, and yields compare favorably with yields on Giles fine sandy loam, 0 to 3 percent slopes. Crops are spotty in dry years, because the variable gravelly substratum does not supply enough moisture. Farms on this soil are small, and crops consist mainly of hay, small grains, and vegetables and fruits for home use.

Everett gravelly sandy loam, 3 to 15 percent slopes (El; group 11).—This soil is one of the most extensive. It occurs with the other glacial upland soils and has developed from loose, gravelly, poorly assorted glacial drift that originated mainly from granite and quartzite but also from many other rocks. In places, the parent materials are somewhat stratified.

This soil is commonly associated with Alderwood soils, where generally it occupies slightly lower positions than they do. It is distinguished from them by a loose gravelly substratum. Alderwood soils have a cemented substratum.

Areas of this soil were covered originally with Douglas-fir, some hemlock and cedar, alder and broadleaf maple, and an undergrowth of salal, blue and red huckleberries, and bracken fern. The original timber has been removed, and most of this soil is in second-growth Douglas-fir, alder, broadleaf maple, willow, hazel, madrona, salal, and bracken fern. This soil is somewhat excessively drained and droughty.

Profile description.—A 1½ inch very dark grayish-brown organic layer composed of partially decayed forest litter and some mineral material lies directly over the mineral soil, which is brown to dark-brown gravelly sandy loam to depths of 10 to 13 inches. This layer has a very weak very fine granular structure and readily crushes to single grains. It is porous, very friable, and of high gravel content.

The subsoil, to an average depth of 24 inches, is dark yellowish-brown gravelly loamy sand. It is very friable, porous and of very low water-holding capacity. This gravelly loamy sand grades to poorly assorted sand and gravel variously colored light yellowish brown, light grayish brown, or a gray or dark-gray pepper-and-salt combination. The surface soil and subsoil are strongly acid to medium acid. The substratum is extremely loose, porous, and excessively drained.

This soil is of varied depths and in places may have only a few inches of gravelly sandy loam. In other areas the gravelly sandy loam may extend to 3 or 4 feet and be slightly cemented below 3 feet. This characteristic is especially evident where the soil occurs in small areas associated with Alderwood and Cathcart soils.

Use and management.—Everett gravelly sandy loam, 3 to 15 percent slopes, is among the least suited to agriculture, and little is under cultivation. Most of it is covered with brush and stumps or with second-growth timber (fig. 5). Small areas are pastured, normally along with better soils, and smaller areas are used for growing vegetables and fruits for home use and for building sites. Several poultry farms are on this soil, but little or no grain is grown for poultry feed.

The soil dries out early, and lack of moisture prevents crops from maturing properly. Yields are usu-

Figure 5.—**Everett gravelly loamy sand, 3 to 15 percent slopes, one of the most droughty soils in the county, is best suited to forestry. It is not suited to agriculture. Trees grow slowly and are in close competition with ferns and brush. Originally Douglas-fir was the principal tree, and it is slowly restocking these areas.**

ally low. The droughtiness of the soil allows only a short grazing season and low production of pasture. In a few areas where the soil can be irrigated, productivity is increased, but large amounts of fertilizer are necessary for satisfactory crops.

This soil is best suited to forestry or building sites, and it should be allowed to restock to timber in most areas. Second-growth timber, however, grows slowly, and the soil is not so good as most other upland soils for timber.

Everett gravelly sandy loam, 0 to 3 percent slopes (Ek; group 11).—This soil occurs in association with other Everett soils. It is not so extensive as Everett gravelly sandy loam, 3 to 15 percent slopes, and differs from that steep soil mainly in relief. Furthermore, the underlying material is normally more stratified. In some areas it is deeper than Everett gravelly sandy loam, 3 to 15 percent slopes, and the gravelly sandy loam may extend to a depth of 4 feet. Consequently, in these places the soil has a higher water-holding capacity.

Only a small part of this soil is used for crops or pasture. The soil is better suited to forestry than to farm crops.

Everett gravelly sandy loam, 15 to 30 percent slopes (Em; group 12).—This soil differs from Everett gravelly sandy loam, 3 to 15 percent slopes, chiefly in slope. Its profile is similar except that the surface soil is normally not quite so thick. The soil is closely associated with the Alderwood, Cathcart, and Kitsap soils and with other Everett soils. This soil normally occupies narrow breaks between smoother slope phases of other soils. Low fertility, droughtiness, and hilly relief limit use of this soil to forestry.

Everett gravelly sandy loam, 30 to 40 percent slopes (En; group 12).—This soil occurs on a few small sites on irregular steep terrain. It is similar to Everett gravelly sandy loam, 3 to 15 percent slopes, except that it is normally shallower and more gravelly and stony. It occupies steep slopes between different benches or between the upland and the shore of Puget Sound. Runoff is medium and erosion is well controlled by the native cover. Like the other Everett soils, it has been logged and is now covered by second-growth Douglas-fir and other vegetation similar to that on Everett gravelly sandy loam, 3 to 15 percent slopes. Relief is unfavorable for agriculture, and the soil is best suited to forestry.

Everett gravelly loamy sand, 3 to 15 percent slopes (Eg; group 11).—This soil resembles Everett gravelly sandy loam, 3 to 15 percent slopes. It differs chiefly in having a sandier profile. Slopes of 6 to 12 percent are dominant. The entire profile is somewhat excessively drained, droughty, and of low water-supplying capacity. Runoff is very slow because water penetrates the soil very rapidly. The native vegetation is similar to that on other Everett soils, largely Douglas-fir, deciduous trees, and underbrush.

Under virgin conditions, a strongly acid, 1-inch, dark-brown organic layer overlies the mineral soil. The surface layer of the mineral soil is brown gravelly loamy sand that contains a few scattered shot. The structure is loose and single grained. Rounded water-worn pebbles from granite, quartzite, or glacial rock occur in this layer. The subsoil, to a depth of 24 inches, is dark yellowish-brown gravelly sand or gravelly loamy sand of single-grained structure. It is loose when wet or dry. This layer overlies poorly stratified layers of gray, yellowish-brown, and olive gravel, sand, and sandy gravel.

This soil is of low fertility. It has all been logged and is restocking slowly to second-growth Douglas-fir. Areas are small and occur mainly north of Hawks Prairie in the northeastern corner of the county.

Everett gravelly loamy sand, 0 to 3 percent slopes (Ef; group 11).—This soil differs from Everett gravelly loamy sand, 3 to 15 percent slopes, chiefly in its smoother relief. In addition to the normal vegetation, madrona is common in the cutover areas. In places the surface is covered with moss. The acreage of this soil is small, and it occurs only in a few parts of the county. A large area lies south of Hawks Prairie, and a smaller area to the northeast. This soil is extremely droughty and unsuited to agriculture. It should be allowed to restock to Douglas-fir.

Everett gravelly loamy sand, 15 to 30 percent slopes (Eh; group 12).—This soil differs from Everett gravelly loamy sand, 3 to 15 percent slopes, mainly in slope, but also in having a wider range in content of gravel and thickness of the surface soil. The total area of this soil is small; the largest bodies are 3 to 4 miles south of St. Clair. The vegetation is similar to that of other Everett soils. This soil has no agricultural value and is best suited to forestry.

Everett stony sandy loam, 0 to 3 percent slopes (Eo; group 11).—This soil occupies gently undulating areas of stony and gravelly glacial drift. The stones and pebbles are mainly granite and quartzite, but some came from basic rocks. This is one of the stoniest soils in Thurston County. The largest areas are east and west of Lake Lawrence, southwest of Rainier,

and east of Offutt Lake. The soil is chiefly associated with Kapowsin soils and other Everett soils.

This soil was originally covered with Douglas-fir and some hemlock and cedar, as well as with alder, broadleaf maple, and an undergrowth of salal, blue and red huckleberries, and bracken fern. The soil is somewhat excessively drained.

Profile description.—A dark-brown, slightly acid, 1-inch organic layer composed of partially decayed leaves and plant remains directly overlies the mineral soil. To depths of 10 to 12 inches the mineral soil is brown stony sandy loam. It has a very weak, very fine granular or crumb structure and readily crushes. This layer is very friable and porous, and the content of stones and gravel is high. The pebbles and stones range from ¼ inch to 24 inches or more in diameter.

The subsoil, to an average depth of 20 inches, is dark yellowish-brown stony sandy loam or stony loamy sand. This layer is very friable and porous and has low water-holding capacity. The surface soil and subsoil are slightly acid to medium acid.

At about 30 to 36 inches, the subsoil grades into poorly assorted sand, gravel, and stones. This material ranges from dark yellowish brown or olive to light and dark gray, or pepper-and-salt colored.

Boulders 12 to 24 inches and occasionally 3 to 4 feet in diameter are scattered over the surface and throughout the soil and substratum. Southeastward, toward the mountains, the size of the boulders increases. Adjacent to the foothills and mountainous areas of Melbourne and Olympic soils, the pebbles and sand have a fine colloidal coating. This coating slightly increases moisture-holding capacity. In many places, the subsoil and substratum near the foothills are brown stony sandy loam. In these places the soil produces better grass than other Everett soils, but early drying limits the grazing period to a short time in spring and early summer.

Use and management.—The original timber has been removed, and a large part of this soil is in second-growth Douglas-fir, alder, broadleaf maple, willow, hazel, madrona, huckleberry, salal, and bracken fern. The soil is best suited to forestry or wooded pasture. A larger portion of this soil than that of Everett stony sandy loam, 3 to 15 percent slopes, is used for pasture. Where it adjoins more productive land, the soil is probably suited to limited grazing.

Everett stony sandy loam, 3 to 15 percent slopes (Ep; group 11).—This soil differs from the Everett stony sandy loam, 0 to 3 percent slopes, mainly in greater slope. Profile features are similar except that this soil has a thinner surface soil. The soil is droughty and low in natural fertility. In places where it is closely associated with the Kapowsin soils, some areas of this soil are used for limited grazing. The soil is best suited to forestry and should be allowed to restock to timber.

Everett stony sandy loam, 15 to 30 percent slopes (Er; group 12).—This soil differs from Everett stony sandy loam, 0 to 3 percent slopes, chiefly in having steeper slopes. Profile characteristics are similar except that the surface soil of this soil is normally thinner. The soil occurs as hilly to knoll-like ridges, and between these ridges are depressions that occasionally contain small areas of poorly drained McKenna, Norma, or one of the peat soils.

This soil is closely associated with other Everett and Kapowsin soils and with Rough mountainous land, Olympic soil materials. The largest area lies east of Lacamas School and Clear Lake between the Nisqually River and the areas of rough mountainous land.

Almost all of this soil has been logged and is now in stumps or second-growth timber. A very small area is used for wooded pasture along with other less droughty and smoother soils. Low fertility, stones, and steepness limit this soil to forestry and grazing.

Everett stony sandy loam, 30 to 40 percent slopes (Es; group 12).—This soil occupies a few small or narrow areas on steeply sloping, irregular terrain. It lies between smoother areas, between the upland and river bottoms, on or between upland and rough mountainous land. The soil is similar to Everett stony sandy loam, 0 to 3 percent slopes, except that it is normally shallower and more gravelly and stony. Runoff is slow to medium and erosion is not a problem. This soil has been logged and is now covered by second-growth Douglas-fir and other plants similar to those on the other Everett soils. Relief is unfavorable for agriculture, and the principal and best use is for forestry.

Everson clay loam, 0 to 3 percent slopes (Et; group 4).—This soil occupies nearly level, depressional areas in the glaciated uplands. It was derived from sandy outwash of varied origin that has some gravelly material below depths of 3 to 4 feet.

This soil has impaired drainage and is a poorly drained close associate of Lynden and Giles soils. The content of organic matter and nitrogen is higher than that of the better drained glacial soils of the upland. Fertility is also higher. Native vegetation consisted largely of alder, ash, and cottonwood. Cedar, vine maple, willow, hawthorn, salmonberry, spirea, sedges, and other water-loving shrubs and grasses also occur.

Profile description.—Under virgin conditions a 1½-inch organic layer of strongly acid dark-brown partially decayed leaves and other organic material overlies the mineral soil. The mineral surface soil consists of 5 to 6 inches of very dark grayish-brown to nearly black clay loam or silty clay loam of a granular structure. Many tree and grass roots permeate this horizon.

The upper subsoil, to depths ranging from 20 to 24 inches, is firm olive silt loam highly mottled with reddish brown and yellow. The structure of this layer is blocky. To a depth of 35 inches the lower subsoil is gray to olive-gray sandy clay or clay loam also highly mottled with reddish brown and yellow. The color is grayer than in the upper subsoil, and it is more highly variegated and has mottlings in irregular clusters.

This layer changes abruptly to light-gray or olive-gray stratified fine sandy loam or loamy sand moderately mottled with reddish brown and yellow. The soil is firm in place but breaks out in single grains when dry. The profile is slightly to medium acid.

The color of the surface soil varies. Areas are included that have a surface soil that is gray to light gray when dry. Normally these areas are much darker when moist. In places where this soil is associated

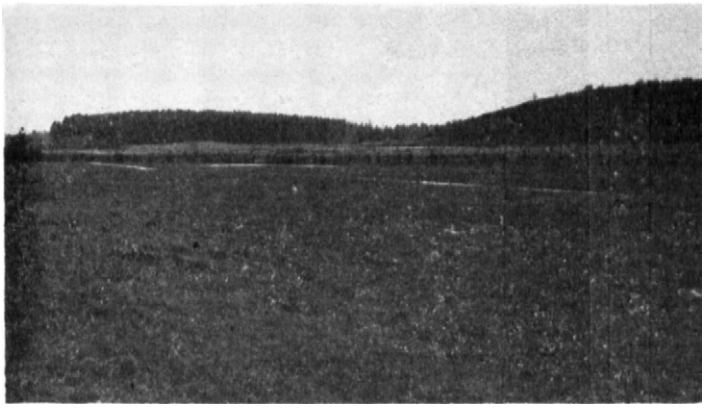

Figure 6.—**The Everson soils are well adapted to pasture and hay crops because of their high moisture-supplying capacity during the dry summer months. The upland soils become dry and during summer have a low carrying capacity. Everson soils require drainage for best results. The water table during the winter months is often at or near the surface. The soils in the background are of the Alderwood and Everett series.**

with McKenna soils or is in depressions of gravelly glaciated upland soils, gravel may occur below a depth of 3 feet.

Present use and management.—About half of this soil is similar to virgin soil and is used for wooded pasture or is idle. The rest has been drained and is now used for pasture and small hay crops. Many of the depressional areas are frost pockets that restrict use largely to pasture and hay crops. This is particularly apparent in the area south of Olympia. Drainage is normally accomplished with shallow open ditches that drain the excess water but keep the water table near the surface. Grass grows throughout most of the dry summers and supplies forage for cattle when upland pastures are dry (fig. 6). Crops are normally oats, alsike clover, and native grasses for hay.

Management of this soil is different from that of the associated upland soils because of the finer texture of the surface soil and drainage. The soil is more difficult to work and must be cultivated at a narrower range of moisture content. Much of it is under water at least part of every winter and spring because the drainage ditches are inadequate and may be clogged by silt or plants. The channels are normally narrow and shallow. Some ditches are maintained by the county. Maintenance costs are charged to the individual landowner in his taxes. These ditches are usually better maintained than those maintained through cooperative action.

Fields are normally plowed as early in spring as drainage conditions permit. Then oats are seeded. Oats are followed by grass or alsike clover, which is allowed to grow as long as it makes a good stand. Whenever the grass or clover becomes thin and weeds dominate, the soil is plowed. This may be done once every 3 or 4 years. Everson soils respond to applications of barnyard manure and superphosphate, but the latter is not used so consistently on this soil as it is on upland soils.

Because of small acreages in one locality, this soil forms only a part of any one farm. Therefore, the soil is usually in pasture or hay and provides late summer pasture after the upland soils have dried up.

Everson silt loam, 0 to 3 percent slopes (Ev; group 4).—This soil is similar to Everson clay loam, 0 to 3 percent slopes, but it usually occupies slightly better drained areas. Furthermore it occurs in small depressions and along intermittent drainageways throughout the county, generally in association with soils on sandy glacial outwash.

Profile description.—The surface layer consists of 6 to 8 inches of friable, fine granular, very dark gray silt loam high in organic matter. It is dark gray when dry. This layer changes abruptly to friable, gray to dark-gray silt loam 3 to 4 inches thick. Slight yellow and brown mottling and organic stains are apparent in this layer. The reaction is medium acid throughout the surface layers.

The upper subsoil, from 18 down to 24 inches, is an olive firm sandy clay loam or clay loam highly mottled with reddish brown and yellow. This layer is moderately compact and strongly acid. The lower subsoil is olive gray or olive and is more highly mottled with reddish brown than the upper subsoil. It varies in texture from loam to sandy clay loam and is also moderately compact.

At a depth of about 30 inches, there is a rather abrupt transition to the loose, porous, very slightly mottled, gray or olive-gray, or pepper-and-salt, coarse and fine sands. The lower subsoil and the substratum are medium acid throughout.

Variations occur in depth to the sandy substratum. In places this depth is 24 inches. Included are small areas that contain surface layers of loam. In places, subsoils are very prominently mottled with red and reddish stains, and a slight cementation is apparent when the material is dry. Gravel may occur below a depth of 36 inches.

Use and management.—About 50 to 60 percent of this soil has been cleared and seeded to pasture or other crops. The principal crops are Italian ryegrass, bentgrass, fescues, ryegrass and clover, alsike clover, oats, and vetch. Normally pastures consist of clovers and grasses, even where clover has been sown alone, because volunteer grasses invade the fields. Hay yields are similar to those on Everson clay loam, 0 to 3 percent slopes, but somewhat higher yields are expected on this soil because it has more favorable texture and better drainage. This is excellent pasture soil. Like other low-lying poorly drained soils, it can be pastured throughout the summer and fall when upland soils are dry. The same general farm practices are applied on this soil as on Everson clay loam, 0 to 3 percent slopes.

Everson fine sandy loam, 0 to 3 percent slopes (Eu; group 4).—This dark-colored soil is nearly level and has a high water table. It is coarser textured throughout than Everson silt loam, 0 to 3 percent slopes, or Everson clay loam, 0 to 3 percent slopes, and it has a shallower lighter colored surface soil. It is used mostly for hay, pasture, or grain and is well suited to these crops. This soil is used for the production of the same kinds of crops as other soils of the Everson series, and requires similar management. Yields, however, are slightly lower.

Fitch gravelly sandy loam, 0 to 3 percent slopes (Fa; group 11).—This soil occupies outwash plains very similar to those occupied by Spanaway soils. In organic matter and color it is intermediate between the very dark grayish brown grass-covered Spanaway soils and the brown heavily forested Everett soils. This color and organic-matter content is believed to result from the grass cover that was comparatively recently replaced by Douglas-fir. The size of the trees indicates that most of them are 35 to 100 years old. Occasionally there is a much older first-growth tree. The Fitch soils usually occur as small bodies around the edges of prairies of Spanaway soils. On the side away from the Spanaway soils Fitch soils are associated with the light-colored timbered soils of the Everett, Alderwood, and Tenino series.

Profile description.—A thin layer of moss and organic matters overlies the dark grayish-brown, very friable and porous, gravelly sandy loam surface soil. The surface soil varies from 6 to 10 inches in depth. It is moderately high in organic matter. Below 10 inches begins very friable to loose and porous grayish-brown or brown gravelly sandy loam to gravelly sand. Rounded stones 6 to 10 inches or more in diameter commonly occur throughout the subsoil and may extend to the surface. The subsoil becomes lighter brown with depth.

The substratum underlies the subsoil at depths of 25 to 30 inches. It consists of yellowish-gray to gray loose porous gravel and sand. The lower subsoil and substratum are very similar to those of the Spanaway and Everett soils.

In some areas, stones as much as 10 inches in diameter are common throughout the profile. Included are small areas having surface soils that are nearly black to a depth of about 3 inches.

Use and management.—This soil is very droughty and has low inherent fertility, because it is open and porous and of coarse texture. Little of the acreage is cultivated or used for pasture. Most of it is in timber, stumps, or brush. The cover consists largely of Douglas-fir and some lodgepole pine and oak and an undercover of shrubs and grass. Cleared areas are valuable for spring and early summer pasture. The best use of this soil is for forestry.

Fitch gravelly sandy loam, 3 to 15 percent slopes (Fb; group 11).—This soil differs from Fitch gravelly sandy loam, 0 to 3 percent slopes, mainly in relief. The dominant slopes range from 6 to 10 percent. They are single slopes between nearly level and hummocky areas. The profile is similar to that of Fitch gravelly sandy loam, 0 to 3 percent slopes, but there is more variation in the thickness of the horizons and the color of the surface layer. The small area of this soil is covered with stumps and brush and some second-growth Douglas-fir. The best use is for forestry.

Galvin silty clay loam, 0 to 5 percent slopes (Gb; group 6).—This soil is widely distributed throughout the southwestern part of the county. It occupies gently sloping alluvial fans and small fills in valleys. A few small areas have slopes of slightly more than 5 percent. The soil occurs as small bodies at the mouth of small canyons and along intermittent streams in the Melbourne hills. It is closely associated with the Melbourne soils, from which its parent material was largely derived.

Runoff is aided by the slope. Seepage and subsurface drainage from the hills and canyons keep the subsoil fairly well saturated and produce variable drainage and seepage areas in places.

The native timber is largely mixed coniferous and deciduous trees. Cedar, Douglas-fir, ash, maple, and alder are the most common. There is a heavy undergrowth of willow, hazel, and scattered salmonberry, wild rose, spirea, and sedges. Most of the forest has been logged, and the area that has not been cleared supports a heavy second growth of the original species.

Profile characteristics.—The 6- to 8-inch surface layer is granular dark grayish-brown to dark-brown friable silty clay loam slightly stained with rust brown and yellow. When dry, this layer is grayish brown to light grayish brown. The surface layer grades to grayish-brown to dark yellowish-brown heavy silty clay loam, which is highly mottled with rust brown and yellow. The silty clay layer is compact in place, contains some coarse sandy material, and has a subangular blocky structure.

Between depths of 16 and 30 inches the soil is more highly mottled firm silty clay loam that contains a small amount of weathered sandstone and shale fragments. The subsoil is highly mottled and splotched with rust brown, yellow, and gray.

The subsoil grades into a mottled gray to bluish-gray, massive substratum of silty clay or clay. The rust-brown and yellow mottling is highly developed, but is not so intense as in the layer above. The substratum becomes more friable, coarse, and less mottled with increasing depth. The subsoil and substratum are somewhat stratified and may contain lenses of fine sand.

Because of variable seepage and subdrainage, the color and degree of mottling in the subsoil vary. Cultivated fields normally have surface soils with spots or streaks of brown or dark grayish-brown. The darker colored or seep areas have more highly mottled and less permeable subsoils.

Use and management.—Although this soil is not extensive, much of it has been cleared or partly cleared for farming. Cultivated areas are usually farmed along with associated areas of Chehalis, Wapato, or Reed soils. Crops similar to those on the associated soils are generally grown. The principal crops—hay, small grains, and pasture—are used to feed dairy cattle. In many areas, the alluvial fans are used for buildings, homesites, and gardens. Drainage is greatly improved by running ditches or tile across the part of the fan adjacent to higher ground. The tile lines or ditches intercept hill seepage and excess runoff. When this soil is cultivated, organic matter and nitrogen should be maintained by adding barnyard manure and commercial fertilizer. The common practice is to add some superphosphate in addition to the manure. Pastures are greatly improved by this practice.

Galvin silt loam, 0 to 5 percent slopes (Ga; group 6).—This soil is widely distributed in the southwestern part of the county. It is similar to Galvin silty clay

loam, 0 to 5 percent slopes, except that the surface soil is more friable and coarse and the subsoil is slightly less mottled and compact. In crops grown, yields obtained, and management used, this soil is much like Galvin silty clay loam, 0 to 5 percent slopes.

Giles fine sandy loam, 0 to 3 percent slopes (Gc; group 3).—This soil normally occurs on relatively smooth plains in which there are many scattered closed basins or potholes. It has developed mainly from sandy outwash materials, but there are thin layers of silt and very fine sand in the lower subsoil and substratum. Thin layers of silty clay may also occur.

This soil occurs in association with Lynden and Tumwater soils, but it differs from them in having a less sandy subsoil and substratum. It also is associated with Kitsap soils on the peninsulas northeast and northwest of Olympia. It differs from the Kitsap soils in having a browner surface soil and a more friable and sandy subsoil and substratum. The principal areas of this soil occur southeast of Olympia and near East Olympia. The soil is closely associated with the other phases of Giles fine sandy loam.

Runoff is slow, and internal drainage is medium. Internal drainage is generally slightly retarded by the thin layers of finer textured materials that help retain moisture for late-maturing crops. These strata vary in thickness and in depth from the surface, but they normally occur slightly above a depth of 3 feet. The native vegetation consists of the same kinds of deciduous shrubs and trees as are common on other well-drained upland soils.

Profile description.—Under virgin conditions a 1- to 1½-inch layer of partially decayed leaves and other organic material overlies the mineral soil. To depths of 10 to 12 inches the surface soil is brown to dark-brown friable fine sandy loam to very fine sandy loam that contains many iron and manganese concretions or shot. The structure is granular.

The subsoil is yellowish-brown fine sandy loam to very fine sandy loam that contains a decreasing number of concretions and continues to depths of 24 to 30 inches. This layer is friable and breaks into fine granules under slight pressure. The lower subsoil, extending to depths of 40 to 50 inches, grades rather abruptly from yellowish-brown to olive friable fine sandy loam to very fine sandy loam. Normally there are no concretions in the lower subsoil, but frequently thin silt lenses occur. Slight yellow and brown mottling is common. The lower subsoil rests on variously stratified pepper-and-salt or olive-colored fine sand, sand, loamy sand, and silt. The soil profile is slightly to medium acid in reaction.

The material below 3 feet varies in texture. In places, silty material similar to that of the Kitsap soils occurs, particularly where this soil and Kitsap soils are closely associated. The subsoil of this Giles soil is more varied in texture where it is associated with Lynden soils. Areas of Giles fine sandy loam northeast of Olympia are the most varied. The substratum in the area southwest of East Olympia is finer textured than normal for Giles fine sandy loams. Areas of this soil that adjoin areas of Lynden or Tumwater soils have subsoils that are sandier than in the typical profile.

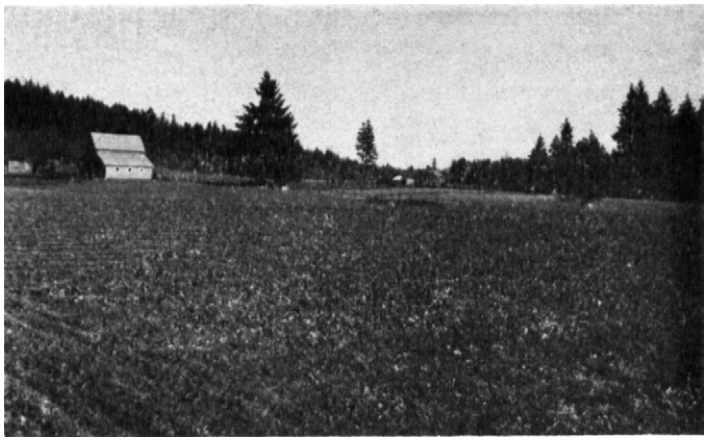

Figure 7.—**Strawberries and truck crops do well on Giles fine sandy loam. The soil is easily tilled and has a moderate moisture-supplying capacity.**

Present use and management.—Giles fine sandy loam, 0 to 3 percent slopes, is one of the most extensive and important agricultural soils in Thurston County. After it had been logged, alder, Douglas-fir, and undergrowth quickly returned, but about half this acreage has been cleared of brush, and much of it has had stumps removed as well. This is especially true near Olympia and East Olympia, where suburban dwellings and 5- to 10-acre part-time farms have been established and the occupants work elsewhere for most of their income.

The most common crops are clover-and-grass mixtures for pasture and hay. Oats are grown for grain or for hay. Some vetch is grown with oats for hay. Ryegrass or timothy are commonly grown with clover or alone. A little alfalfa is being successfully grown. Other crops are strawberries (fig. 7), raspberries, youngberries, blueberries, apples, pears, cherries, and grapes. Vegetables are grown mostly for home use. Holly trees are successfully grown for sale.

The average farm generally has a dairy herd, and all manure is normally returned to the land. Superphosphate is used as a supplement to the manure. Some farmers use ground limestone, especially for legumes.

Giles fine sandy loam, 3 to 15 percent slopes (Gd; group 3).—This soil occupies narrow slopes and is associated chiefly with Giles fine sandy loam, 0 to 3 percent slopes. It differs from the more nearly level soil chiefly in its more pronounced relief, slightly greater profile variability, and slightly thinner surface soil. Dominant slopes range from 6 to 10 percent.

This soil is farmed in association with Giles fine sandy loam, 0 to 3 percent slopes, and has the same proportion of land cleared for crops as the more nearly level soil. Yields, fertilization, and other management are also the same for the two soils.

Giles fine sandy loam, 15 to 30 percent slopes (Ge; group 12).—This soil occupies steep slopes adjacent to basinlike areas or steep slopes between more gently sloping areas. It is closely associated with the other phases of Giles fine sandy loam. Most of this soil occurs southeast of Olympia in an area characterized

by numerous closed basins, many of which contain lakes, ponds, or marshes. Runoff and internal drainage are medium. The total area of this soil is small. The profile is variable but, in general, resembles the profile of Giles fine sandy loam, 0 to 3 percent slopes. Normally, the surface soil is thinner, and the subsoil and substratum are more sandy.

This soil is largely in brush or second-growth timber. Cultivated areas are normally a part of larger areas of Giles fine sandy loam having smoother relief, and they are used primarily for pasture. This soil is best suited to forestry.

Greenwater loamy sand, 0 to 3 percent slopes (Gf; group 10).—This soil occurs on gently undulating stream terraces above present flood plains along the Nisqually River in the southeastern part of the county. Total area is small. The soil appears to have formed from glacial outwash or river deposits influenced by pumice. The deposits, apparently brought down from the flanks of Mount Rainier, consist of gray and dark-gray sands, dominantly from basalts and andesites. The few rounded boulders that occur in some places indicate the action of glaciers or swift turbulent water.

This soil is somewhat excessively drained. Runoff is very slow, and internal drainage is very rapid. The original vegetation was a light stand of Douglas-fir, and this is restocking with alder, maple, hazel, vine maple, willow, bracken, and grasses.

Profile description.—Beneath a 1-inch, dark-brown organic layer, the mineral surface soil is a brown to olive-gray loamy sand, 12 to 14 inches deep. This layer is loose and porous, and in some places about 25 percent of its volume is coarse yellowish-brown pumice particles. Many grass roots are present.

This material is transitional from light-gray to dark-gray, or pepper-and-salt, coarse sand that is very slightly cemented together but breaks easily into single grains. Rust staining and iron cementation occur in localized areas. Some yellow pumice fragments are present. The subsoil, very porous and droughty, extends to a depth of 32 inches. Below 32 inches is light-gray, gray, and dark-gray loose sand that may show brown mottling. The soil is medium to strongly acid throughout.

The subsoil varies considerably. In the area about 4 miles southeast of Yelm, it is a yellowish-brown loamy fine sand to loamy sand instead of the gray, pepper-and-salt sand. This subsoil contains many pumice fragments.

Use and management.—This soil is very droughty and of little agricultural value. Most areas are in stumps and brush, but a small acreage has been cleared. Douglas-fir, the original vegetation, is restocking along with other trees and grasses. The principal agricultural use is for grazing cattle, and the area 4 miles southeast of Yelm is largely used for alfalfa, oats, and hay crops of grass and clover or oats and vetch. In this locality, yields are similar to those for Lynden loamy sand, 0 to 3 percent slopes. This soil is best suited to forestry.

Greenwood peat, 0 to 2 percent slopes (Gg; group 5).—This soil was derived from sphagnum moss. It occurs in closed basinlike, low-lying, poorly drained areas that have few or no drainage outlets. The principal areas are south of Black Lake, in the hills north of Tenino, and west of Tumwater. Total acreage is very small.

The water table is high, and the areas are generally waterlogged during most of the year. The vegetation consists largely of Labrador-tea, but some areas have a scattering of white pine, hardhack, wild cranberry, swamp laurel, and sundew.

Profile description.—The surface layer to a depth of about 8 inches is brown to dark yellowish-brown, raw, fibrous, strongly acid peat that consists chiefly of undecomposed mosses. This is underlain by yellowish-brown or grayish-brown finely fibrous raw peat that consists of mosses and some sedges and plant roots. This material has undergone some decomposition, but the original fiber is still well preserved. The deposit continues for many feet and becomes lighter in color with increasing depth.

Use and management.—In this county Greenwood peat is not used for agriculture, but in some parts of the State it is used to grow cranberries. The areas north of Tenino have some value as a source of commercial packing material.

Grove gravelly sandy loam, 3 to 15 percent slopes (Gh; group 11).—This soil has developed from gravelly glacial drift similar to the parent materials of the Everett soils except that it contains more basic materials. It has a brighter, or redder, profile and slight staining on the gravel in the lower subsoil and substratum. The soil occurs in the western part of the county adjacent to the mountainous areas on which the Olympic soils are dominant. Most of the areas occur south and west of Summit Lake in association with the Olympic and Delphi soils.

Rainfall is higher in this mountainous section than in the area east of it where the Everett soils occur. This higher rainfall may be the dominant factor that produces the redder color in the somewhat excessively drained Grove soil. Extensive areas of reddish-colored glacial soils occur to the north in Mason County where the rainfall is more than 50 inches. The native vegetation consists of a dense stand of coniferous forest, mainly Douglas-fir with some hemlock and cedar. Vine maple, Pacific dogwood, alder, salal, and other trees and shrubs make up most of the undergrowth.

Profile description.—Beneath the strongly acid, partially decayed organic layer of leaves, twigs, and other organic material is the mineral surface layer, 8 to 18 inches of dark reddish-brown to reddish-brown gravelly sandy loam. This layer contains many iron concretions and is very friable and granular. The pebbles, ½ to 4 inches in diameter, are principally rounded quartzite and granite, but there is some basalt.

The subsoil is dark reddish-brown gravelly sandy loam to gravelly loam that normally has slight compaction to depths of 20 to 24 inches. This layer grades into a slightly lighter reddish brown gravelly sandy loam in which the pebbles are coated with fine materials.

Below depths of 32 to 36 inches is the substratum, which consists of yellowish-brown to gray poorly as-

sorted loose sand, gravel, and stones. The pebbles and stones are slightly coated with reddish-brown stains.

In some areas the color of the surface layer is yellowish brown to brown. In places the depth to the loose porous substratum is only 20 inches.

Present use and management.—Most of the virgin timber has been logged and replaced by alder, vine maple, dogwood, Douglas-fir, hemlock, and other trees and shrubs. Only a few acres are in farms, and they are used mainly for pasture. The best use of this soil is forestry.

Grove gravelly sandy loam, 15 to 30 percent slopes (Gk; group 12).—This soil is associated with Grove gravelly sandy loam, 3 to 15 percent slopes. A few areas having complex rolling to steep slopes are included. Most of the areas are northwest of Summit Lake, where they are closely associated with the Delphi and Olympic soils. Except for having greater variation in texture of the surface soil and in depth to the substratum, the hilly and the rolling areas of Grove gravelly sandy loam are similar. Where this soil borders the Delphi or Olympic soils, texture is finer and the profile more variable. Much of this soil has been recently deforested, but it is returning to timber, for which it is best suited.

Indianola loamy sand, 3 to 15 percent slopes (Ia; group 10).—This soil is widely distributed, generally in association with the Everett soils, but also with smaller areas of Indianola loamy sand, 15 to 30 percent slopes. The largest areas occur to the north of Lake St. Clair and in the southeastern corner southeast of Clear Lake. Dominant slopes range from 6 to 10 percent, though the total range is 3 to 15 percent. The soil was derived from sandy glacial drift of mixed origin.

This somewhat excessively drained soil has very slow runoff and very rapid internal drainage. The negative vegetation consisted largely of Douglas-fir and associated trees and shrubs common to the well-drained upland soils of the county.

Profile description.—In undisturbed timbered areas, a 1- to 2-inch layer of undecomposed organic litter overlies a brown, very friable, loamy sand surface soil that contains a few iron concretions or shot.

The surface soil is underlain at about 8 to 10 inches by dark yellowish-brown loamy sand or loamy fine sand. This layer is very friable to nearly loose. At depths of about 24 to 30 inches, the material is yellowish-brown, light-gray, and dark-gray loose sand, fine sand, or loamy sand that readily breaks into single grains when dug out. This material is sometimes irregularly stratified at depths of 3 to 4 feet. Some gravel may occur in the profile, especially where the soil merges with the Everett soils. In a few places, thin lenses or pockets of fine silts occur sporadically in the lower subsoil and substratum.

Present use and management.—All of this soil has been logged, and most of it now supports a second-growth stand of Douglas-fir and hemlock and many alder, hazel, and other trees and shrubs. Because of the coarse texture and low water-holding capacity, the soil has a limited use for agriculture. Only when the weather is favorable does it produce fair crops of hay. Yields for most crops are poor, compared to those on the Giles and Kitsap soils. Some of the most favorable sites are used with fair success for growing strawberries and raspberries.

Indianola loamy sand, 15 to 30 percent slopes (Ib; group 12).—This soil occurs on steep basinlike areas and on short steep slopes bordering Indianola loamy sand, 3 to 15 percent slopes. It is similar to the less sloping soil except for steepness of slope and variations in horizon thickness. It is in second-growth timber, stumps, and brush. The soil is not suitable for farming and is best suited to forestry.

Indianola sandy loam, 3 to 15 percent slopes (Ic; group 10).—From Indianola loamy sand, 3 to 15 percent slopes, this soil differs in having a slightly finer textured surface soil and a deeper profile. Furthermore it is less droughty and, consequently, slightly more productive. The total acreage is small and is made up principally of small areas northwest of Olympia.

Profile characteristics.—The 10- to 12-inch surface layer is brown, very friable sandy loam that contains a few small iron-cemented concretions or shot. Its structure is slightly granular. When dry, the surface soil is brown to light yellowish brown.

Below the surface layer is a dark yellowish-brown to yellowish-brown loamy fine sand to sandy loam that continues to depths of 18 to 24 inches. When moist, this layer is very friable to nearly loose. Underlying this material is a mixture of yellowish-brown, olive, light-gray, and dark-gray loamy sand, fine sand, and coarse sand. In places, this underlying material is stratified below depths of 3 to 4 feet.

Use and management.—This soil is largely in second-growth timber and brush. A few areas are used for early pasture and hay crops. Strawberries grow fairly well under the best moisture conditions and fertilization.

Kapowsin gravelly loam, 0 to 3 percent slopes (Ka; group 1).—This soil occupies nearly level undulating till plains that have many small depressions and intermittent drainageways. It occurs in the southeastern part of the county in the area between Yelm and Lake Lawrence. It is associated with the other glacial soils, such as those of the Everett and Alderwood series. It is similar to Alderwood soils, but differs mainly in having a grayer color when dry, a finer textured and less friable subsoil, and a higher proportion of shot in the surface soil. The soil has developed from compact cemented glacial till similar to that of the Alderwood soils.

Drainage is only moderately good, and the soil retains moisture better than the Alderwood soils, because it has smoother relief and finer texture tnroughout the profile. Runoff and internal drainage are slow. Native vegetation and growth on cutover areas consist of the same types of trees and shrubs as are common on the Alderwood soils.

Profile description.—In heavily timbered areas, dark-brown organic litter, 1 to 2 inches thick, overlies the mineral soil. The surface soil is dark grayish-brown to dark-brown, friable, granular gravelly loam

that contains many shot similar to those in the Alderwood soils. When dry this layer is light grayish brown to brown and becomes more gray with depth.

At average depths between 10 and 14 inches, the subsoil is grayish-brown to brown sandy clay loam to gravelly clay loam, slightly mottled and variegated with light gray and yellow. The material is firm in place and slightly hard when dry. When removed, it crumbles readily. The lower 3 or 4 inches of the subsoil is gray sandy clay loam or clay loam highly mottled with yellow and brown.

At depths ranging from 24 to 30 inches, the subsoil is underlain by dark-gray or olive-gray, semicemented to indurated, gravelly unassorted glacial till many feet in thickness. This substratum resembles the till underlying the Alderwood soils except that it contains a slightly higher proportion of fine material, not so strongly cemented, and, in the upper part, it has a platy structure and is usually mottled with yellow and reddish brown. Roots penetrate to this cemented layer and spread out as a mat on top of it. Water penetrates the cemented layer very slowly.

Minor variations occur in surface color, depth to the hardpan, and in the content of gravel and stones. Included are areas with subsoils that contain very much silt and very little gravel. Where Kapowsin soils are associated with Everett stony sandy loam, boulders may occur in small areas. Large boulders, or piles of boulders, called erratics, are on the surface. Normally they are not numerous enough to interfere with tillage. Areas having stones and boulders in numbers that may interfere with tillage are shown by stone symbols.

Use and management.—Only a small proportion of this soil is cleared for cultivation. The rest is mainly in stumps, brush, or second-growth timber. Much of the uncleared land is used for grazing dairy and beef cattle. Some farms use the associated poorly drained areas of McKenna, Norma, or Everson soils for late summer pasture or hay crops. The main crops grown are oats, clover, vetch, and various grasses for hay and pasture.

The profile above the cemented hardpan favors the absorption and retention of moisture for use during the growing season. The water-holding capacity and the fertility of this soil are better than average for growing all the adapted crops. In places, artificial drainage is needed for some crops. The kinds of crops grown on the Alderwood soils are grown on this soil, but yields are slightly greater, especially in dry years. This soil has been used mostly for hay and pasture probably because of distance to market.

Like the Alderwood soils, this soil is low in organic matter and nitrogen and, for adequate yields, requires frequent applications of manure and phosphorus or a complete fertilizer.

Kapowsin gravelly loam, 3 to 15 percent slopes (Kb; group 1).—This soil is similar to Kapowsin gravelly loam, 0 to 3 percent slopes. Dominant slopes range from 6 to 10 percent. Runoff is slow to medium, and internal drainage is slow. Included areas south of Lacamas School vary widely in content of stones and boulders. The total area of this soil is small.

Most of this soil is in second-growth timber or brush. Use and management, fertilizer practices, and yields are about the same as for Kapowsin gravelly loam, 0 to 3 percent slopes.

Kitsap silt loam, 0 to 3 percent slopes (Kc; group 3).—This soil occurs in the northern part of Thurston County adjacent to the several inlets of Puget Sound that divide the county into narrow peninsulas. Almost all of it is northeast and northwest of Olympia in association with Alderwood, Giles, Lynden, and Everett Soils. Elevations vary from slightly above sea level to not more than 150 feet above. The soil is gravel free and has developed from stratified, glacial, lake-laid sediments that originated from many kinds of rocks. It is one of the more extensive and more important soils of Thurston County.

Runoff is slow, and internal drainage is medium. The soil is moderately well drained, and areas that occur on the higher and narrower ridges are better drained than those on the flats. Generally the soil is highly saturated during winter and spring. Artificial drainage benefits some areas. This soil has developed under a dense coniferous forest dominated by Douglas-fir. Some cedar, alder, Oregon maple, madrona, and other trees and shrubs are in the stand.

Profile description.—Beneath a dark-brown medium acid organic layer 1-inch thick, the surface soil is a dark grayish-brown granular friable silt loam. This horizon averages between 10 and 12 inches in depth and contains many brown, round shotlike pellets. In dry cultivated fields, the surface soil is light gray.

The subsoil to depths of about 20 to 22 inches is a grayish-brown to olive silty clay loam or heavy silt loam, highly mottled with reddish brown, yellow, and orange. The structure is medium blocky. The subsoil is friable and breaks into angular aggregates under medium pressure. Only a few shot appear in the upper part. Roots penetrate this layer fairly readily. Reaction is medium acid.

Below 22 inches there is an abrupt change to light olive-gray to olive-gray, firm, massive silty clay loam, which is less highly mottled with grayish-brown and yellow than the horizon above. At an average depth of 30 inches, there is gray to light olive-gray firm silty clay loam that contains lenses of silt and fine sand. The reaction is neutral to mildly alkaline. The texture of the subsoil and substratum is somewhat variable. It ranges from heavy silt loam to clay in the subsoil and from a very fine sandy loam or silt loam to clay in the stratified substratum.

Included are areas that have an Alderwood-like cemented substratum below 3 feet. Areas of Kitsap soils that occur in the southeastern part of the county in association with the Kapowsin soils differ from Kitsap silt loam, 0 to 3 percent slopes, in having a slightly browner surface soil when moist and firmly cemented sandy clay glacial till at a depth of about 4 feet. Some gravel may also be scattered throughout the profile.

Present use and management.—High water-holding capacity and favorable relief make this one of the best agricultural soils of the uplands in the county. Because a large part is in stumps and second-growth timber, the acreage of this soil under cultivation can be expanded considerably. Much of this soil is used

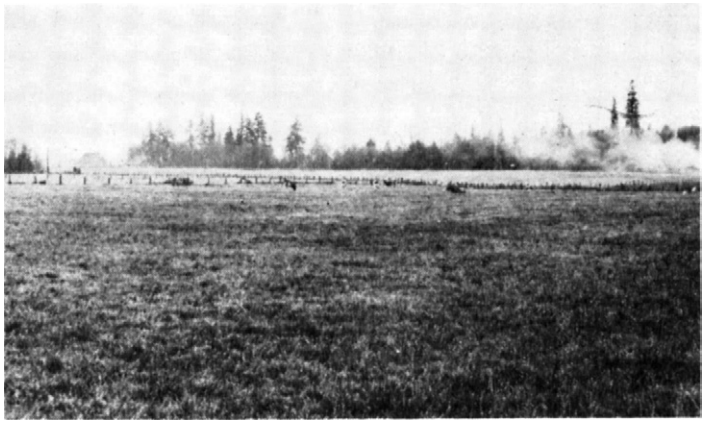

Figure 8.—**Pasture of mixed grasses and clover on Kitsap silt loam. This soil is one of the best agricultural soils of the uplands in Thurston county. It is used mainly for pasture and hay crops.**

for full-time farming, but there are some small or subsistence-type farms northwest of Olympia. Dairying is the most important type of agriculture.

The original timber has been logged, and second-growth timber and brush cover more than half of the area. The present vegetation consists of Douglas-fir, some cedar, alder, bigleaf maple, and madrona, and an undergrowth of oceanspray, elderberry, willow, blue and red huckleberry, cascara, salmonberry, salal, and bracken and sword ferns. About 25 to 35 percent of this soil is under cultivation and about an equal amount in stump pasture. Most of the cleared part is in clover and mixed grasses (fig. 8). The most important grasses are Italian ryegrass and mixed grasses without clover. Other important crops include oats and vetch for hay and oats for grain. Less important crops are wheat for grain, timothy for hay, and potatoes, apples, and pears. Cabbage is grown for seed. Apples were once widely grown in large home orchards and in several commercial orchards, but they have been neglected or abandoned during recent years. Lack of market is usually cited as the cause of orchard neglect and abandonment. Some strawberries and raspberries are grown on the areas associated with Giles fine sandy loam.

This soil is inherently low in organic matter and natural fertility, and to produce at the maximum it requires barnyard manure, crop residues, and fertilizers. All available manure is normally applied, and superphosphate is used occasionally.

Kitsap silt loam, 3 to 15 percent slopes (Kd; group 3).—This soil differs from the Kitsap silt loam, 0 to 3 percent slopes, chiefly in having a more pronounced relief. It also has a slightly thinner surface soil, and the lower subsoil and substratum are not so fine textured and mottled. Dominant slopes range from 6 to 10 percent, though the full range is 3 to 15 percent. This soil is associated with other Kitsap soils and occupies breaks between smoother areas of Kitsap soils north of Olympia. Use and management practices and yields are very similar to those on Kitsap silt loam, 0 to 3 percent slopes.

Kitsap silt loam, 15 to 30 percent slopes (Ke; group 12).—This soil differs from Kitsap silt loam, 3 to 15 percent slopes, chiefly in having a more pronounced relief. The profiles of the two soils are similar except that this soil has a more variable and a shallower surface soil. It is associated with the smoother Kitsap soils and occurs between these smoother areas and the waters of Puget Sound. The principal areas are near Young Cove. Small areas occur as narrow strips paralleling the inlets of Puget Sound.

Second-growth timber and brush occupy most of this soil. Cropland consists of small areas in grass and clover that are used for hay and pasture. Under native cover, this soil is not subject to erosion, but under cultivated crops it will probably erode during the wet season unless it is kept in a suitable cover crop during winter and early spring. The best use of this soil is forestry.

Kitsap silt loam, 30 to 40 percent slopes (Kf; group 12).—This soil occurs in a few small areas of steeply sloping irregular relief. It is shallower and more varied than Kitsap silt loam, 15 to 30 percent slopes, and occurs in narrow steep canyons, breaks, or cliffs along Puget Sound. Runoff is rapid, but erosion is well controlled by the native cover. Like the other Kitsap soils, this soil has been logged and is now largely covered by second-growth Douglas-fir. Relief is unfavorable for agriculture, and the main and best use is forestry.

Lynden loamy sand, 0 to 3 percent slopes (La; group 10).—This soil occupies nearly level to gently undulating glacial outwash terraces. It is associated with small, gently rolling to hilly areas. The soil is somewhat excessively drained and has developed under a dense stand of coniferous forest, largely Douglas-fir. Lynden soils occur throughout the county but generally in small areas associated with other glacial upland soils (fig. 9).

Profile description.—The surface layer to depths of 6 to 8 inches is brown to dark grayish-brown very friable weakly granular loamy sand that contains some iron concretions, or shot. When dry, the surface layer is brown. The organic-matter content is moderate.

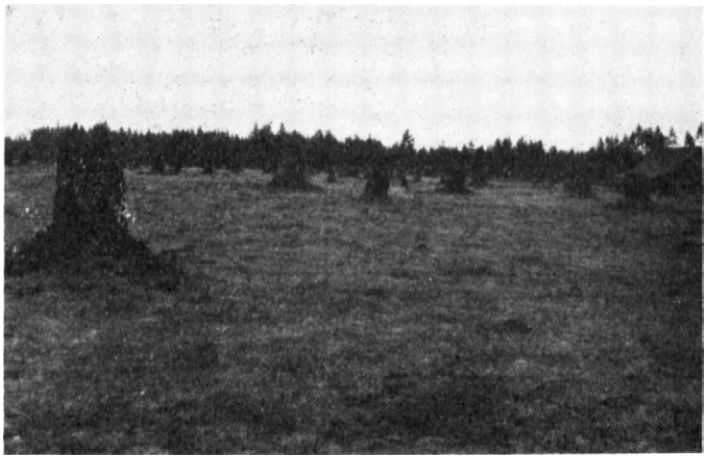

Figure 9.—**This logged area of Lynden and Everett soils furnishes a pasture of low carrying capacity. At present, removal of these Douglas-fir stumps would be uneconomical on this droughty and unfertile soil.**

The underlying material to a depth of about 17 inches is very friable to loose dark yellowish-brown and brown loamy sand. Between depths of 17 to 42 inches, the soil is olive or yellowish-brown loose loamy sand.

This layer is underlain by light-gray, gray, and olive sand that readily crumbles to a single-grain structure when removed. In places, yellow and brown stains occur. The soil is normally free of gravel and stones.

Included are small areas that have sandy loam and loamy fine sand surface soils. Where associated with the Giles soils, the Lynden soils may have slightly more mottling and sporadic lenses of fine sands and silts in the substratum.

Use and management.—Most of the areas have been deforested, and many of them are in farms. Areas in cultivation occur in association with other soils on the peninsulas north of Olympia. In other areas, this soil is used mostly for grazing or is left idle in brush or timber. Soils in cultivation are used for hay and pasture crops, strawberries, raspberries, and other crops commonly grown on associated soils. Yields are fair but not so good as on Giles and Kitsap soils. Crops lack moisture during the summer months, and yields vary with the season.

Lynden loamy sand, 3 to 15 percent slopes (Lb; group 10).—This soil is similar to and occurs in association with Lynden loamy sand, 0 to 3 percent slopes. Dominant slopes vary from 6 to 10 percent. Individual areas are small and not widely distributed; they generally occur between smoother areas.

Most of this soil is in brush and timber. Crop yields are about the same as for Lynden loamy sand, 0 to 3 percent slopes.

Lynden loamy sand, 15 to 30 percent slopes (Lc; group 12).—This inextensive soil resembles Lynden loamy sand, 0 to 3 percent slopes. but wider variation occurs in surface soil texture and depth to the sandy substratum, which is generally shallow. All of this soil is in brush and timber; it is best suited to forestry.

Made land (Ma; group 12).—Made land consists of areas that have been artificially built up from miscellaneous materials such as those from mine dumps, refuse at abandoned lumber mills, or dredgings from Puget Sound. The principal area, in the northern part of Olympia, is made up of dredgings from Budd Inlet. Made land has no agricultural value. The total area is very small and is used primarily for building sites.

Maytown silty clay loam, 0 to 2 percent slopes (Mc; group 6).—This soil occupies nearly level positions on recent alluvial flood plains. It is associated with Eld, Chehalis, and other soils that were derived from similar shale, sandstone, and basaltic materials. This soil is widely distributed in the western part of the county, especially near Little Rock and Mima. It is usually confined to small areas along the tributary streams.

Internal drainage is medium to slow; runoff is slow. The natural vegetation consisted of Douglas-fir, cedar, western hemlock, and dense growths of ash, alder, willow, and brush and shrubs, including vine maple, wild rose, snowberry, spirea, blackberry, and a few clumps of sedges and other water-loving grasses.

Profile description.—The surface layer, to depths of 10 to 12 inches, is brown to dark-brown silty clay loam that has a slight reddish cast and no mottling. It is granular and friable.

The subsoil to a 28-inch depth is dark yellowish-brown friable silty clay loam to clay. It is moderately mottled with yellow and reddish-brown iron stains and purplish manganese stains. This layer is more compact than the surface layer, and contains aggregates ⅛ to ½ inch in diameter. The structure is angular.

Below this layer, to depths of 40 inches and more, the substratum is lighter yellowish brown friable silty clay loam highly mottled with reddish brown, orange, and purplish colors. Structure is massive. The surface soil and subsoil are medium or strongly acid, and the substratum is medium acid.

The surface soil may range from dark grayish brown in small spots to dark reddish brown on the slightly higher elevations. The degree of mottling varies considerably, but strong mottling in the profile described normally occurs at a depth of 4 feet.

Use and management.—Most of this soil has been cleared of timber and brush and put under cultivation. The principal crops are oats, red and alsike clover, and grasses for hay and pasture. These crops are used mainly to feed dairy cattle. Some corn is also grown. Yields are slightly higher than those on Wapato soils. Because of somewhat better drainage, this soil, like other Maytown soils, can be worked earlier in spring, and it becomes waterlogged slower in the fall than other bottom-land soils.

The natural fertility of this soil is similar to that of Wapato soils, and application of manure and superphosphate is common. Some artificial drainage is advisable for most areas, but it is not essential. This soil is normally parallel to natural drainage channels that provide fair drainage.

Maytown loam, 0 to 2 percent slopes (Mb; group 6).—This soil occurs mainly along McLean Creek, southwest and west of Eld Inlet. It occurs in small bodies, frequently at slightly higher elevations above streams than the Eld and other associated soils that originate in areas of basaltic parent materials. Consequently, this soil has better drainage than they do. It differs from the less extensive Maytown silty clay loam, 0 to 2 percent slopes, mainly in having a coarser surface layer. In addition, the soil may contain some gravel in the substratum.

The small part of this soil that is cleared is in hay crops or pasture. The rest is in brush and second-growth timber or stumps and pasture. Under native conditions, the vegetation is similar to that of Maytown silty clay loam, 0 to 2 percent slopes.

McKenna gravelly loam, 0 to 3 percent slopes (Me; group 4).—This soil occupies nearly level basins and depressions adjacent to intermittent drainageways in the glaciated region. It commonly occurs in small scattered areas throughout the better drained soils of the glacial uplands. In some areas it is closely associated with Norma, Bellingham, or Everson soils, but it differs from them in having a gravelly surface soil overlying a gravelly and stony compact subsoil.

During winter, this poorly drained soil is saturated and often covered with water. The native vegetation

consists of a mixture of deciduous and coniferous trees, largely cedar, Douglas-fir, alder, maples, spirea, and sedges.

Profile description.—Below a 1- to 1½-inch organic layer the surface soil to depths of 6 to 8 inches is very dark gray to black gravelly loam. It is granular and high in organic matter. The surface soil grades into dark-gray to olive-gray or grayish-brown highly mottled friable gravelly loam to clay loam that contains a high proportion of gravel and stones. When dry, this layer is difficult to penetrate, but it is not cemented.

The olive-gray or grayish-brown layer is underlain at depths ranging from 18 to 24 inches by a gravelly and stony sandy clay till that is highly mottled with reddish brown. This layer is compact and impervious to water.

The surface texture and color vary considerably from area to area. In extreme instances, the texture ranges from a loam to gravelly sandy loam, and the color, when dry, from gray to dark gray. Included are areas with less compact substrata that usually have lighter colored surface soils.

Present use and management.—Much of this soil is under water at least part of the winter and spring, and most areas need artificial drainage for agricultural use. When the soil is cleared or partly cleared, drained, and seeded to grass, the carrying capacity is high. Most areas are used for pasture or for timber production. A few areas are used for hay crops and produce fair yields. This soil has a higher content of organic matter and nitrogen and a higher general fertility than the better drained upland soils. It produces good pasture during the dry season when pastures on the better drained soils produce little feed. Because most individual areas are too small to make up a farm, they are normally used with other depressional soils or with upland soils.

McKenna gravelly clay loam, 0 to 3 percent slopes (Md; group 4).—This soil occupies positions similar to those of McKenna gravelly loam, 0 to 3 percent slopes. It differs from the gravelly loam in having a finer surface texture and in having gravel throughout the profile. Most areas occur in association with Kapowsin soils.

The surface soil is granular, friable, very dark gray gravelly clay loam. In places it may be a silt loam or loam. This layer is underlain at a depth of about 10 inches by dark-gray to olive-gray compact gravelly clay loam that is highly mottled and plastic when wet. At a depth of about 20 inches, there is a gradual transition to a mottled, and gray, olive, reddish-brown gravelly and stony sandy clay till.

Use and management of this soil are very similar to those of McKenna gravelly loam, 0 to 3 percent slopes. Most areas are slightly more poorly drained than those of the gravelly loam, but, where cleared and drained, they make good pastures that have a high carrying capacity.

Melbourne silty clay loam, 15 to 30 percent slopes (Mg; group 12).—This soil occupies large areas of strongly sloping uplands. It has developed under forest from shale and sandstone and occurs in the southern and southwestern part of the county on elevations ranging from 200 to 1,000 feet. It surrounds seeped areas of Meskill soils that commonly occur on the lower slopes and along stream channels.

Runoff is medium. Internal drainage is medium but slightly retarded in places. Small seeped areas frequently occur. The native vegetation was largely Douglas-fir and some hemlock and cedar.

Profile description.—In virgin areas the mineral soil is covered by a 1- to 2-inch mat of partly decomposed organic matter. Abruptly under this organic mat is a 10- to 12-inch layer of medium to slightly acid, dark-brown to dark grayish-brown silty clay loam. When dry, this layer is brown to grayish brown. It is granular and friable and contains many iron concretions.

The upper subsoil is medium acid, dark yellowish-brown silty clay loam. It is firm and weakly blocky and contains a few round iron concretions. At depths of about 20 to 24 inches, this material grades into a firm lower subsoil of yellowish-brown or olive silty clay that breaks into colloid-coated blocky aggregates. This soil is variegated with gray, yellow, and reddish brown.

Between depths of 36 and 48 inches, there is a gradual transition to the parent material of yellowish-brown and reddish-brown silty decomposed shale and clayey sandstone. The shale fragments are highly coated with colloids and stained with yellow and reddish brown, but in their center they retain an olive-yellow color. At varying depths the substratum grades into less decomposed but strongly weathered fragmental shale and sandstone.

Areas of this soil that surround the seeped areas of Meskill soils have grayer surface soils and subsoils. The depth to underlying shale is fairly uniform, although this soil has a wide range in slope.

Use and management. — Originally this soil supported a heavy forest of Douglas-fir and some hemlock and cedar, but almost all has been logged. Only a small area is cleared and cultivated. Severe burning that followed logging particularly affected reseeding on some of this soil, and it is not restocking to merchantable timber.

Some of these areas have been used to a small extent for cattle grazing. Native wild vetches and clovers are common, but the acreage needed per head of stock is large. Competition of other vegetation with forage crops is severe, and the soil is largely in bracken fern, fireweed, alder, vine maple, salal, Oregon grape, and other brush and shrubs. This vegetation and fallen timber limit the growth of forage crops and hinder grazing. Unless diligently maintained, grass mixtures do not thrive. Repeated burning to improve grazing is not recommended because it would probably soon cause serious erosion on some of the steeper slopes.

Agriculture is limited mainly by the unfavorable relief that hinders farm machinery. Clean cultivation on these slopes is hazardous because returns to farmers are uncertain, and accelerated erosion may result. This soil is best suited to forestry, and any effort to reseed it and use it for forest is to be encouraged.

Melbourne silty clay loam, 3 to 15 percent slopes (Mf; group 2).—This soil differs from Melbourne silty clay loam, 15 to 30 percent slopes, principally in hav-

ing less strong slopes. Most areas are relatively small. They are associated with areas of the steeper Melbourne soils and occur as foot slopes along the small stream bottoms. This soil is farmed with the more fertile alluvial soils. Slow to medium runoff reduces erosion hazard. Internal drainage is medium. The structure of the surface soil and subsoil favor absorbing of water, and the fine texture allows much moisture to be held for crops. As on other upland soils, however, crops are damaged by lack of moisture late in summer. On the more gently sloping areas, moisture supplies are usually more favorable.

Less than half of this soil is cultivated, mainly to hay, small grains, and pasture. It is less fertile, and yields are normally lower than on Olympic soils. But this soil responds to fertilization and produces favorable yields under proper management. Greenmanure crops and farm manure are the most important sources of organic matter and nitrogen. Crops respond to phosphorus, and a complete fertilizer consisting of phosphorus, nitrogen, and some potassium is beneficial. Fertilization practices and yields are similar to those on the Olympic and Salkum soils.

Melbourne silty clay loam, 30 to 40 percent slopes (Mh; group 12).—This soil occupies the higher and steeper areas in the southern and southwestern part of the county. It is associated with other Melbourne soils and is similar to Melbourne silty clay loam, 15 to 30 percent slopes, except that it is shallower to the underlying weathered shale fragments. Runoff is rapid, but erosion is not severe because heavy vegetation and favorable structure allow moderate penetration of water.

Almost all of this soil has been logged, and it is slowly restocking. In many places severe burning that followed logging, as well as subsequent burning, have reduced the seed supply and destroyed much of the organic matter in the surface soil. Consequently favorable timber trees, mainly Douglas-fir, very slowly gain a foothold. The rapidly growing ferns, shrubs, and brush check erosion, but these plants also keenly compete with the Douglas-fir. Overgrazing or clearing of the steeper slopes might result in severe accelerated erosion. The best use of this soil is for forestry.

Melbourne stony loam, 15 to 30 percent slopes (Ml; group 12).—The acreage of this soil is small and occurs in scattered areas east of Tenino. The largest area is northwest of Lake McIntosh. This soil is similar to Melbourne silty clay loam, 15 to 30 percent slopes; it differs mainly in stone content and in having a shallower average depth to shale and sandstone. The depth is variable, however, and outcrops are common. Shale and sandstone fragments occur throughout the profile. This soil is associated with the Cathcart soils and frequently has some glacial gravel in the surface soil.

None of this soil is cultivated. Because of stoniness and the steep slopes, it is not suited to agriculture. Every effort should be made to keep it in forest or return it to that use.

Melbourne stony loam, 3 to 15 percent slopes (Mk; group 2).—Except for slope, this soil is similar to Melbourne stony loam, 15 to 30 percent slopes. It occurs as small areas east of Tenino and south of McIntosh Lake. The profile of this soil varies in the same way as that of Melbourne stony loam, 15 to 30 percent slopes, but this less sloping soil is slightly deeper to the bedrock of shale and sandstone.

None of this soil is cultivated as it is generally associated with and adjacent to steeper soils that are not suited to agriculture. The area south of McIntosh Lake is used for wooded pasture. Because of stones, this soil is best suited to forestry.

Meskill silty clay loam, 3 to 15 percent slopes (Mn; group 4).—In most places this soil occupies concave slopes or lower foot slopes below Melbourne soils, and seepage from those soils keeps it saturated. It has developed from shale and argillaceous sandstone under poor drainage conditions. It is limited in area and occurs mainly along Thompson Creek and adjacent to the upper Skookumchuck Valley. The vegetation consists largely of sedges, spirea, willows, alder, vine maple, and a few clumps of cedar and Douglas-fir. Included are areas associated with the Prather soils.

Profile description.—Underlying a 1- to 1½-inch layer of partially decomposed forest litter is 8 to 10 inches of mineral surface soil, which is friable, granular, gray to dark grayish-brown silty clay loam. Slight mottling usually occurs in the lower part. When dry, the soil is light gray.

The surface soil is underlain by a lighter gray silty clay layer, 6 to 8 inches thick, highly mottled with reddish brown. After a gradual transition this material is replaced by very firm strongly plastic gray or olive-gray dense clay. The clay has a blocky structure, and its smaller aggregates are coated with lighter colored colloidal material. Mottling occurs only along cleavage lines or fractures.

At depths ranging from 24 to 36 inches begins less dense, strongly plastic, olive-gray or olive clay that is mottled with reddish brown and yellow. This material grades into highly stained weathered shale.

Because of variations in drainage and soil color, the mottling in the subsoil varies greatly. Within small areas the surface soil varies from gray to dark grayish brown, and the subsoil is often dark gray or very highly mottled gray. The areas associated with the Prather soils have subsoils that are slightly less dense and plastic. The surface soil is generally darker in these areas.

Use and management.—The individual areas are small. Some of them were cleared for farming along with the adjacent better drained Melbourne soils or with the more productive soils of the alluvial flood plains. The soil is difficult to work, as it is sticky and plastic in the spring and dries out hard by late summer. It is moderately fertile for hay and pasture, however, mainly because it has a higher water supply than the better drained Melbourne soils. Reed canarygrass grows well and is one of the better pasture grasses. A few uncleared areas are used for grazing.

Meskill silt loam, 0 to 3 percent slopes (Mm; group 4).—This soil occurs on the remnants of low-lying ancient eroded terraces about 1¼ miles southeast of Grand Mound. It is associated with Melbourne and Prather soils and lies above Wapato, Reed, and Everson soils. It differs from Meskill silty clay loam, 3 to 15 percent slopes, principally in texture and slope.

The native timber of Douglas-fir and some cedar and hemlock has all been cut, but second-growth conifers of the same species and other trees, shrubs, and grasses have replaced it. Because this soil occupies narrow old terraces that rise above most of the adjoining terrain, drainage is improved.

Profile description.—The surface soil to a depth of 8 inches is granular, friable, dark grayish-brown silt loam containing a moderate amount of iron concretions. It is light brownish gray when dry.

The subsoil is blocky gray silty clay loam that is firm and contains less shot. Reddish-brown and yellow mottling occurs and increases in intensity with depth. At a depth of 18 inches there is an abrupt change to compact, variegated, olive and gray dense clay that has a blocky or irregular prismatic structure. The upper part of the aggregates in this layer are covered by an ashy gray material, which extends some distance down the sides. Reddish-brown and yellow mottling occurs in the lower part of this compact layer, which is slowly permeable to water and roots. The surface soil and subsoil are medium acid.

The substratum, which begins at a depth of 35 inches, is plastic, olive or olive-gray clay with rusty brown and yellow mottlings. The colloidal content is high, and colloids coat the fracture planes that form on drying. The substratum is more friable and coarser textured than the subsoil. The parent material is slightly acid. In places, highly disintegrated and decomposed shale occurs in the substratum.

Use and management.—This soil is comparatively fertile, but its compact, fine-textured subsoil makes it less productive than many other soils of the uplands and terraces. Only a small area is in mixed grasses and clover. Second-growth Douglas-fir and some cedar and hemlock, along with alder, maple, willow, vine maple, oceanspray, serviceberry, bracken, and native grasses, grow on areas not cleared for pasture or crops.

Mukilteo peat, 0 to 2 percent slopes (Mo; group 5).—This soil occurs throughout the county in areas that range from small depressions to large swamps. A typical location is the swamp along the Black River south of Black Lake. The soil occupies very poorly drained depressions where the water stands at or near the surface most of the time. It is the most extensive organic soil in the county. It consists of mineral material mixed with an organic accumulation from sedges and associated plants and some wood. This organic matter is in various stages of decomposition, but decay is nowhere so far advanced that the original fiber cannot be discerned. The original vegetation was mainly sedges and some tules. At present willow, spirea, alder, cedar, sedges, tules and other water-loving plants cover the areas.

Profile description.—The surface layer, to a depth of 3½ inches, consists of dark-brown or dark grayish-brown partially decayed roots and other plant remains derived mainly from sedges and other water-loving plants. At a depth of 10 or more inches begins raw, fibrous, dark-brown peat that contains partially weathered roots and other plant remains. In this layer the original plant fibers are more readily discernible than in the layer above.

From a depth of 10 inches to 4 to 7 feet or more, the material is brown or dark yellowish-brown finely fibrous peat. This layer is less decomposed than the surface layer, and contains more recognizable sedges and other aquatic plants.

A mixture of sedimentary mineral and finely fibrous organic materials normally occurs below a depth of 4 feet. In places there are occasional buried logs and a small amount of other woody material. The peat normally extends to depths of 4 or more feet and frequently to depths of 10 to 20 feet.

Use and management.—Because of very poor drainage and the lack of suitable outlets for artificial drainage, only a small part of this soil has been cleared for farming. Both cleared and uncleared, the soil is used mainly for grazing. The cleared areas are used for pasture and hay crops, some truck crops, blueberries, and strawberry plants. Where planted at intervals of 4 feet in rows 8 feet apart, blueberries yield an average of 6 tons per acre. Some corn is grown for silage along Vantine Road northeast of Tenino. Because of low-lying positions, most areas of this soil may have frost or freezing almost every month. Consequently, only frost-resistant crops can be safely grown.

Mukilteo peat, shallow over dense clay, 0 to 2 percent slopes (Mp; group 5).—This soil was mapped in areas where the depth of the sedge peat was less than 2 feet. The surface layer consists of dark-brown to dark grayish-brown partially decayed plant remains derived mainly from sedges and other water-loving plants. In nearly all areas this material is underlain at various depths down to 24 inches by stiff bluish-gray or gray clay similar to that under Reed soils. Although not so productive as Mukilteo peat, 0 to 2 percent slopes, this soil produces higher yields of hay than many other soils of the county. It is limited in area and is frequently farmed in association with poorly drained mineral soils and the deeper Mukilteo peat.

Newberg loam, 0 to 2 percent slopes (Na; group 7).—This soil occupies the first bottoms of recent alluvium that border the larger streams. It was derived from alluvium of sandstone, shale, and basaltic rock. It is associated with Chehalis soils but is composed of sandier, or coarser, more recently deposited sediments. The largest areas of this soil occupy flood plains of the Chehalis River. Other important areas occur along the Skookumchuck River. A few small bodies are on bottom lands along the upper part of the Deschutes River.

Periodic overflow during flood seasons adds small deposits of alluvium. This soil is lower in elevation and is flooded more frequently than most of the Chehalis soils. It is well drained and has medium internal drainage. It has undergone very little soil development.

Profile description.—The surface soil to depths of 8 to 10 inches is brown to dark-brown friable loam of granular structure. The upper few inches is darker and contains more organic matter than the lower part.

The subsoil is yellowish-brown stratified fine sandy loam and sandy loam of slightly granular structure. It is porous and friable to loose. Its reaction is slightly acid. Normally this layer becomes coarser with depth.

At depths between 24 and 36 inches, there is a gradual transition to grayish-brown porous sands, fine sands, and silts that are stratified and loose. The substratum is usually mottled with yellow and reddish brown.

Areas that have surface soils approaching silt loam in texture are included. Other small areas have loose sandy subsoils below a depth of 12 inches.

Use and management.—About 70 to 80 percent of this soil has been cleared for crops and pasture. The most important crops are sweet corn, oats for grain, ryegrass, clover and grass, vetch and oats, and alfalfa for hay. A small acreage of peas is grown for canning, and yields are about 2 tons per acre. This soil is one of the most prized for truck crops. Dairying and poultry raising are normally the principal farm enterprises.

Barnyard manure and occasionally superphosphate are applied to the soil. Limestone is also applied by some of the farmers, who report that clover yields are increased by its use. Shallow-rooted crops often lack moisture and are aided by irrigation.

Newberg sandy loam, 0 to 2 percent slopes (Nb; group 7).—This soil differs from Newberg loam, 0 to 2 percent slopes, chiefly in its coarser texture. It occurs most frequently along the Chehalis River in close association with Chehalis soils and Newberg loam, 0 to 2 percent slopes. Many areas occur as narrow strips along the Skookumchuck River, and a few small areas lie adjacent to the Deschutes River channel.

The 8- to 12-inch surface layer is friable brown to dark-brown sandy loam that grades to a very friable yellowish-brown sandy loam, fine sandy loam, or a loam. At a depth of about 2 feet, the material is stratified sediments consisting of yellowish-brown or olive sandy loam, loamy sand, and sand. Grayish-brown or olive sand is at depths of 3 to 4 feet.

Included with this soil are several areas in the Chehalis River flood plain along the Lewis County border that have a fine sandy loam surface soil. These areas are slightly more fertile and retentive of moisture than the typical soil. In localized areas near the Lewis County boundary line south of Grand Mound, a gravelly substratum is within 30 inches of the surface. These areas are droughty, and crops on them may fail during hot dry weather.

Crops similar to those on Newberg loam, 0 to 2 percent slopes, are grown on this soil. Yields are slightly less because of lower fertility and lower capacity to hold moisture for plants.

Nisqually loamy sand, 2 to 5 percent slopes (Nc; group 9).—This soil occurs on undulating glacial outwash plains in close association with the Spanaway soils. It differs from those soils mainly in being gravel free. Like the Spanaway soil, it has developed under grass and herbs. Around the border of this soil, small Douglas-fir trees are encroaching, and in some places clumps of Oregon oak are growing.

This extensive soil is mainly on Chambers and Bush Prairies south and southeast of Olympia. The principal areas cover a large part of Bush Prairie south of Tumwater, Chambers Prairie west of Patterson Lake, Little Chambers Prairie south of Lacey, and Neats Prairie southwest of Patterson Lake.

The soil borders areas of Tumwater, Giles, and Spanaway soils. Tumwater and Giles soils are forested brown soils, and Spanaway soils are the gravelly counterpart of the Nisqually soils. This somewhat excessively drained Nisqually soil is more fertile and less droughty than the Spanaway soils.

Profile description.—Under virgin conditions, a 1- to 1½-inch surface layer of well-decomposed organic matter, mixed with fibrous grass roots, leaves, and sand, overlies the mineral soil. The 12-inch surface soil is black loamy sand that contains much sooty organic matter. It is very friable and rather loose or only slightly compact. The structure is weakly granular to crumb, and the reaction is medium or slightly acid.

The soil continues downward as a very dark grayish brown or very dark gray loamy sand. Where the soil has been cultivated for a long period, this layer is darker than the soil near the surface. Below depths of 18 to 24 inches, the color is slightly lighter. This part of the soil is a uniform loamy sand that is very friable and very weakly granular.

At depths of about 28 to 36 inches begins the substratum, an olive, gray, or dark-gray sand that is slightly compact in place but very loose when removed. The colors give the appearance of a salt-and-pepper mixture. This material continues for many feet. In places, especially those closely associated with the Giles soils, it may be very fine sand that contains occasional lenses of silt.

Use and management.—Because it is treeless and easily tilled, this soil has been the most extensively farmed in the county. The soil, however, is one of the least productive, and only under irrigation and heavy fertilization are crops grown successfully. Under this management the soil is especially suited to cole crops and berries. Much of it has been farmed almost continuously since the first settlers located on Nisqually soils in the Bush Prairie about 100 years ago. Oats and wheat were the first crops grown, and

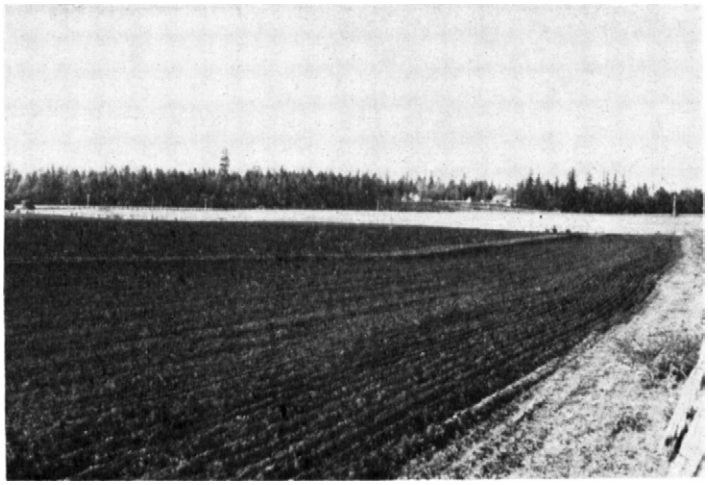

Figure 10.—Nisqually loamy sand being prepared for small grains under ordinary management.

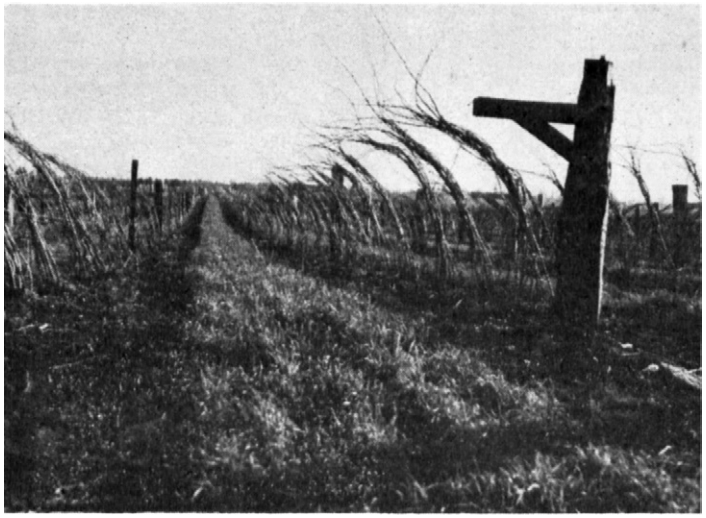

Figure 11.—**Raspberries are grown under irrigation and heavy fertilization on Nisqually loamy sand.**

oats still occupy a major part of the soil under cultivation.

The principal crops are oats for grain or hay (fig. 10), corn for silage or fodder, oats and vetch, and wheat, rye, and barley. There are also small acreages of strawberries, blackcap raspberries (fig. 11), peaches, and vegetables, which are grown mostly for home use.

Generally all available barnyard manure is used, but normally this is enough to cover only a small part of the cultivated soil. Little manure is available, because the farms on this soil mainly produce grain and support little livestock. Some farmers use limestone or limestone and manure with good results. For general crops, commercial fertilizers are considered less valuable than manure on this soil.

Because the soil is sandy and droughty, fall-sown grains or hay crops are considered best. Gray winter oats, Bluestem and Australian club wheat, and Rosen rye are the varieties most commonly grown. Strawberries may fail to produce because supplies of moisture and plant nutrients are too low. Peaches have been recently planted. Marshall strawberries and Pacific gold peaches are grown.

Crop adaptability is limited on this sandy, porous, loose soil. Perhaps the soil can be used most effectively for specialty crops. Lavender has been grown experimentally for many years around Puget Sound, and for a few years on the Nisqually soils of Chambers Prairie. It appears to be commercially successful. One field of several acres has produced 30 to 40 pounds of lavender oil annually. The oil is distilled from an average yield of 2½ tons of leaves and flowers per acre.

Lavender does well on a somewhat excessively drained, sandy, not too fertile soil like those of the Nisqually and Tumwater series. Some frost is essential, but too much is not desirable. A location closer to Puget Sound than Chambers Prairie would be more favorable. Harvesting consists of cutting with mowers or combines the upper leaves and flowers and immediately hauling them to the still where the oil is obtained by distillation. It is essential to process the leaves as soon as possible after cutting to prevent loss of the volatile oil. This requirement makes it necessary for the lavender fields to be within short distances of the processing still. It is most important to free the lavender crop of weeds, because weeds affect the grade of oil if they are distilled with the lavender. The only fertilizers considered necessary are those that contain phosphorus and potassium. Nitrogen fertilizers cause excessive leaf growth, which reduces the oil content.

In recent years a highly specialized system of agriculture has been started. Fairly large acreages that are irrigated and heavily fertilized are used mainly for strawberries, raspberries, cherries, bulbs, and various vegetables, particularly broccoli. Irrigation water, applied through overhead sprinkling systems, comes from deep wells or nearby lakes. Early observations indicate that at least some of these special crops will prove more profitable than the crops grown under general farm practices. More experimentation, however, is needed, particularly for vegetables and strawberries. Only with careful and intensive management can specialized crops be grown successfully.

Nisqually loamy sand, 5 to 15 percent slopes (Nd; group 9).—This soil occupies depressions and breaks between more nearly level areas and occurs as small bodies, normally in narrow strips, in association with Nisqually loamy sand, 2 to 5 percent slopes. The total acreage is small. The soil differs from Nisqually loamy sand, 2 to 5 percent slopes, chiefly in having a more pronounced relief. The profile of this soil is similar to that of the more nearly level Nisqually soil except that this soil is more variable and possibly has a thinner surface soil. This soil is used for pasture or crops along with the adjacent soils.

Norma clay loam, 0 to 3 percent slopes (Ne; group 4).—This soil occupies small poorly drained depressions in the glaciated uplands, and in places it is associated with McKenna and Bellingham soils. It differs from the McKenna soils in having a thicker surface soil and a less compact sandier subsoil that is generally nearly gravel free to depths of 3 to 4 feet. The original vegetation was largely alder, willow, and ash and some Douglas-fir, cedar, hemlock, spirea, and sedges.

Profile description.—The surface soil is very dark grayish brown to very dark gray friable clay loam, high in organic matter and of granular structure. At depths of 6 to 8 inches begins dark-gray or dark grayish-brown clay loam that is highly mottled with reddish brown and yellow. This material is somewhat compact in place but is moderately permeable to moisture.

At depths of about 18 to 24 inches there is a change to olive-gray sandy loam or loam, mottled with reddish brown. This layer continues to a depth of about 3 feet, where there is a change to dark-gray or olive-gray gravelly sandy till that is moderately compact. This compactness limits the penetration of water. The underlying material is quite varied.

Areas are included that, below a depth of 3 feet, contain only slightly compact sandy material. In many places, this soil is transitional to Bellingham or McKenna soils. Variations occur in the depth to and thickness of the sandy substratum. In some areas, the moderately fine textured surface soil may extend to the gravelly or sandy till substratum.

Present use and management.—The timber has largely been removed, and the soil is restocking to the same trees and brush. About 25 percent of this soil has been cleared and used for pasture or crops. The crops normally grown are oats for hay or grain, alsike clover, ryegrass, and native grasses for hay.

Because of the moderately fine textured surface soil and poor drainage, this soil can be tilled only when the soil is within a narrow range of moisture content. The soil is usually flooded during the wet winter, and most of the depressional areas need artificial drainage for successful crops.

Organic matter, nitrogen, and general fertility are higher in this soil than in the better drained upland glacial soils. Norma soils respond to applications of barnyard manure, crop residues, and superphosphate. These amendments need not be applied so frequently as on the less fertile upland soils. Plowing is normally carried on as early in the spring as moisture content permits. Oats are then seeded, followed by grass or alsike clover that is allowed to grow as long as a good stand is maintained. This soil is plowed again when the grass or clover becomes thin and weeds dominate the pasture, or once every 3 or 4 years. Because of the small acreage in any one locality, this soil forms only a small part of any farm. Therefore, it is usually in pasture or hay. It produces a good hay crop, and it may be used for late summer pasture after the uplands have become dry.

Norma loam, 0 to 3 percent slopes (Nf; group 4).—This soil is associated with Norma clay loam, 0 to 3 percent slopes, and the McKenna and Everson soils in poorly drained depressions on the glacial upland. Except for a coarse-textured, more friable surface soil, this soil is very similar to Norma clay loam, 0 to 3 percent slopes.

Profile description.—The surface soil is very dark grayish brown to very dark gray friable loam that has a granular structure. It contains much organic matter and is medium or strongly acid.

Below a depth of 6 inches and continuing to 20 to 24 inches, the subsoil is dark-gray to grayish-brown fine sandy loam or loam, very highly mottled with reddish brown and yellow. It is moderately compact and slightly to medium acid. This layer is underlain by olive-gray sandy loam that contains strata of light-gray silty clay loam or clay in places.

Below a depth of 3 feet, is the substratum, a moderately compact gravelly sandy loam till. It is slightly acid. The depth to the glacial till varies and in places may be 4 or more feet. Some gravel may occur throughout the profile.

Present use and management.—About half of this soil is in brush and second-growth alder, ash, and maple trees. The rest is used for pasture. Some of the areas have been artificially drained. Little if any of the soil has been cultivated. The soil is more workable under more varied moisture content than Norma clay loam, 0 to 3 percent slopes, but crops, yields, and fertilization practices on the two soils are similar.

Olympic silty clay loam, 15 to 30 percent slopes (Ob; group 12).—This soil has developed from weathered basic igneous rock, mainly basalt, with some andesite. It is closely associated with Rough mountainous land, Olympic soil material. Runoff and internal drainage are medium. The soil was originally heavily forested mainly with Douglas-fir. Some hemlock and cedar trees were in the stand. Yields of timber were exceptionally good.

Profile description.—In virgin condition, a partially decomposed dark-brown organic layer, 1 to 2 inches thick, overlies the mineral soil. Abruptly under this layer is a dark reddish-brown silty clay loam that contains some rounded concretions high in content of iron and manganese. This 6- to 10-inch horizon is friable, granular, and medium acid. It is reddish brown to brown when dry.

The upper subsoil is friable, granular, dark reddish-brown silty clay loam that is reddish brown to brown when dry. This medium-acid horizon contains a few soft shot and extends to depths of about 18 to 24 inches, where it grades into the lower subsoil. The lower subsoil, a yellowish-red or reddish-brown silty clay loam, or clay, contains small specks of purple and very small angular basalt fragments. It is slightly compact and has a blocky structure.

At depths ranging from 3 to 4 feet, the subsoil grades into the substratum, or parent material, of clay loam or clay. This material is yellowish red, variegated with yellow and purple. It contains concretions and is slightly compact but moderately permeable. It is strongly or medium acid.

Depth to solid basalt bedrock varies from 2 to 10 feet or more. Fragments of weathered basalt may appear throughout the profile. Because the slope varies, there are some variations in the soil profile. The sharper slopes commonly contain more stones, and the lower slopes often have a duller color. In some particularly well aerated spots, the soil is a distinct red.

Some areas in the southeastern corner of the county have a purplish-red or purplish-gray cast when dry. In these areas internal drainage appears to be slower than in the normal soil.

Present use and management.—Areas of this soil not cleared for farming are slowly restocking to the original species. Alder, maple, vine maple, hazel, oceanspray, salal, Oregon grape, bracken, fireweed, and other brush and shrubs quickly take over the logged areas. This vegetation aids in keeping erosion losses at a minimum, but these losses are not severe, even on clean-cultivated slopes, because the soil structure is excellent.

Agricultural use of this soil is handicapped, mainly by the difficulty of using farm machinery and the possibility of accelerated erosion. Furthermore this soil is normally shallower and contains more stones than Olympic silty clay loam, 6 to 15 percent slopes. This is particularly true of the surface soil on the steeper slopes or at the crests of ridges. In addition, the soil is droughty during the summer, especially on the

southern slopes. These unfavorable features also limit the use of the soil for forestry.

The original timber was excellent, and many of the logged areas are restocking well. Favorable areas that are not restocking should be reseeded or replanted. Some areas adjacent to farmland that have not restocked to merchantable timber could be partially cleared and grass seed sown for pasture. The best use of this soil, however, is for forestry.

Olympic silty clay loam, 6 to 15 percent slopes (Oa; group 2).—This soil occupies several small areas where basalt is the dominant underlying rock. It is similar to Olympic silty clay loam, 15 to 30 percent slopes, except that it varies less, especially in the depth to the rocky substratum and in stoniness.

Surface drainage is slow to medium, and internal drainage is medium. In places where the relief is more gentle, internal drainage is slower, and the lower subsoil is generally mottled with reddish brown and purple.

Present use and management.—Only a few isolated areas north of Gate are cultivated, and these are used in association with other soils for crops or grazing. Clearing costs are very high, but when cleared the soil is fairly productive. Farming is hindered by the rolling relief and small size of the areas. Because the soil is deficient in organic matter and nitrogen, a satisfactory yield requires application of barnyard manure and crop residues and use of a crop that includes a rotation legume.

The principal crops are hay, small grains, and pasture. Wheat and oats are the main grain crops. Oats, oats sown with a legume, or a mixture of grass with red clover are the common hay crops.

Most of this soil is located in the Black Hills of the Capitol State Forest. It is being reforested or used to grow seedling trees that will be used for reforesting.

Olympic silty clay loam, 30 to 40 percent slopes (Oc; group 12).—This soil is mainly on steep, broken, and irregular slopes, but it includes small areas that are less sloping. Rock outcrops and shallow areas are common. The soil closely resembles Olympic silty clay loam, 15 to 30 percent slopes, except for variation in thickness and in depth of horizons. This soil is mainly in the State Capitol Forest in the Black Hills. It is being reforested in places where natural reseeding has not provided an adequate cover of young trees. It is best suited to use for forestry, recreation sites, or game preserves.

Olympic stony clay loam, 6 to 15 percent slopes (Od; group 2).—The small area of this soil occurs in the northwestern part of the county along Perry and Kennedy Creeks. The soil is much shallower than Olympic silty clay loam, 6 to 15 percent slopes. In places, bedrock is less than a foot from the surface. The narrow strips adjoin Rough mountainous land, Olympic soil material. The many angular basaltic stones and pebbles on the surface and throughout the profile limit agricultural use. Some areas that have been logged and are slowly restocking to desirable timber could be used for grazing, but the soil is best suited to forestry.

Olympic stony clay loam, 15 to 30 percent slopes (Oe; group 12).—This soil occupies a small acreage and is closely associated with Olympic stony clay loam, 6 to 15 percent slopes, and Rough mountainous land, Olympic soil material. It is very similar to the former soil except for relief. Small areas with slopes greater than 30 percent are included. Because of stoniness and relief, this soil is best suited to forestry.

Pilchuck loamy fine sand, 0 to 3 percent slopes (Pa; group 7).—This soil occupies flood plains along the Nisqually River. It was derived from recently deposited sandy materials, which are mixed but are dominantly of glacial origin and have a high percentage of basalt. The soil is nearer the river channel than the Puyallup soils and frequently at lower elevations. It is flooded and reworked more often than the Puyallup soils. The soil is level to undulating because floodwaters flowing across the land have formed many ridges. During the summer, the surface is 10 to 25 feet above the river. The vegetation consists of cottonwood, alder, willow, vine maple, a few Douglas-fir and cedar trees, snowberry and blackberry bushes, and grasses.

Profile description.—The surface soil, extending to a depth of 12 inches, is a dark-gray to dark grayish-brown loamy fine sand. It is loose and porous and has a single-grained to weak granular structure.

The subsoil to a depth of 30 inches is somewhat stratified olive-gray loamy sand to fine sand. It contains cementing material that forms very weak aggregates easily crushed into single grains. The substratum consists of light-gray and dark-gray, or pepper-and-salt, sand and coarse sand. It is loose and porous and has a single-grained structure. The profile is slightly acid throughout.

In places gravel occurs at depths of 4 to 5 feet or more. Included are areas that have surface textures varying from loamy sand to loamy fine sand.

Use and management.—This soil is low in water-holding capacity and very droughty. Except for spring pasture, the only cultivated areas are home gardens in the Nisqually Indian Reservation northwest of Yelm. Pasture grasses grow well during the rainy season, but when the dry season starts the grass dries quickly.

Pilchuck sand, 0 to 3 percent slopes (Pb; group 7).—This soil occupies nearly level to undulating flood plains along the Nisqually River and is closely associated with Puyallup soils, Riverwash, and Pilchuck loamy fine sand, 0 to 3 percent slopes. It differs from the Pilchuck soil mainly in having a coarser and more porous profile.

The ill-defined profile contains dark-gray to dark grayish-brown sand to depths of 12 to 15 inches. To an average depth of 2 feet the subsoil is olive-gray sand similar to that of the surface layer. At about 2 feet begins dark-gray and light-gray sand. Gravel normally occurs at depths between 2 and 6 feet, but in places it is scattered throughout the profile.

The total area of this soil is small, and it is used largely for forestry and grazing. It is not suitable for cultivated crops.

Prather silty clay loam, 3 to 8 percent slopes (Pc; group 2).—This soil occurs in the Michigan Hills and in other smaller areas in the southwestern part of the county where the elevations range from 200 to

slightly more than 600 feet. In the Michigan Hills and low-lying foothills near Little Rock it occurs in close association with Melbourne and Salkum soils as high terraces or benches that are remnants of an ancient plain of obscure geologic origin. The parent materials, which overlie shale and sandstone, are probably of glacial origin similar to those of the Salkum soils. These materials are highly variegated, dense, clayey, and typically without gravel.

The original cover was a heavy growth of large Douglas-fir, with some hemlock and cedar and a dense undergrowth of deciduous trees and shrubs. Practically all the areas have been logged and are now in second-growth Douglas-fir, brush and stumps, or cultivated crops. Runoff is slow, and internal drainage is medium.

Profile description.—Under virgin conditions, a 1- to 2-inch organic layer of decaying twigs, leaves, and moss overlies the mineral soil. The mineral surface soil is dark-brown coarse silty clay loam that contains many small iron concretions. It varies from 6 to 12 inches in thickness but averages 10 inches. Both the organic layer and the surface soil are slightly to medium acid. Next in the profile and continuing to a depth of 18 to 22 inches, is yellowish-brown firm silty clay loam that has an irregular blocky to coarse granular structure and light-gray stains along the fracture planes. This layer, the upper part of the subsoil, is medium or slightly acid and has fewer iron concretions than the layer above.

At a depth of 35 inches the subsoil is reddish-brown compact silty clay loam to silty clay of a blocky structure. When excavated, this horizon comes out as angular irregular aggregates that are difficult to crush when dry. The angular fracture planes are coated with gray colloidal material. Variegations of yellow and red occur in the lower part. Some manganese stains also occur. From this layer there is a gradual transition to a yellowish-red to reddish-brown heavy silty clay loam to clay that has sharp angular fracture planes coated with colloidal material. Gray seams and variegations of red, yellow, and purple occur throughout the layer.

At about 45 inches begins the substratum, purple silty clay or clay, that is marly and highly variegated with yellow, red, and gray. Normally it is not so firm as the layer above. This layer is extremely variable; it ranges from a highly variegated clay to a yellowish-red silty clay loam that is only slightly streaked with gray and red seams. In some places, the substratum is similar to the parent materials of the Salkum soils, and in others it is similar to the highly variegated shale and sandstone that underlie the Prather soils at depths greater than 10 feet.

Most of this soil that occupies the undulating to rolling hills east of Rochester is deeper and more friable than is typical for Prather soils. Permeability of the subsoil also varies sporadically in areas on Michigan Hill. The areas about 1½ miles southeast of Grand Mound have a thinner surface soil than normal and a subsoil that is firmer when moist and more plastic when wet.

Present use and management.—The main cultivated areas of this soil are south of Rochester in the Michigan Hills. As dairying is the principal farm industry, most of the crops are grown for dairy feed. About half of this soil is in hay, grain, strawberries, and raspberries. The common hay crops are oats alone, oats and a legume, clover alone, and clover mixed with Italian ryegrass, timothy, or orchardgrass. Clover is commonly sown with oats as a nurse crop. Alfalfa has been grown successfully, but a good stand is somewhat difficult to obtain. This is one of the principal soils used for strawberries. Apples and pears are grown for home use. Because of its greater depth, this soil is much better suited to orchard crops than the Salkum soils. Filbert nut trees grow well.

Like all the timbered soils of the county, this soil is low in organic matter. Application of barnyard manure or crop residues or use of legumes in the crop rotation is essential to obtain maximum yields. Ground limestone normally increases yields, but it is less commonly used than phosphate fertilizer.

Prather silty clay loam, 8 to 15 percent slopes (Pd; group 2).—This soil differs from Prather silty clay loam, 3 to 8 percent slopes, chiefly in having a thinner surface soil. It is closely associated with other Prather soils. Runoff is medium and, although erosion is well controlled under native cover, it might be accelerated under improper cultivation. Use of this soil is the same as for Prather silty clay loam, 3 to 8 percent slopes. Nevertheless, because of its greater slope, more careful management is needed, especially for crops that require clean cultivation.

Prather silty clay loam, 15 to 30 percent slopes (Pe; group 12).—This soil occurs throughout the other Prather soils as small areas on short steep slopes or as large hilly areas. Frequently it adjoins and lies above the steeply sloping Melbourne soils. It differs from Prather silty clay loam, 8 to 15 percent slopes, mainly in having stronger slopes.

Some of this soil is used for pasture, but most of it is in brush, second-growth Douglas-fir, or deciduous growth that includes alder, maple, willow, vine maple, hazel, and other brush. Under proper management, some areas could be used for supplemental grazing. But this soil is better adapted to timber than to pasture or cultivated crops.

Prather silty clay loam, 30 to 40 percent slopes (Pf; group 12).—This soil occupies steep areas along well-incised stream channels. It occurs in a few large bodies in the Michigan Hills. It is similar to Prather silty clay loam, 3 to 8 percent slopes, except that it is commonly shallower. Runoff is rapid, but erosion is well controlled by vegetation. Relief is unfavorable for agriculture, and the principal and best use of this soil is forestry.

Puget silty clay loam, 0 to 2 percent slopes (Ph; group 8).—This soil occurs in small back-bottom locations in association with Puyallup and Sultan soils. It is inextensive and occurs principally around Eld Inlet, where it is adjacent to Puget Sound and in places is affected by high tide and a fluctuating water table. The parent materials consist of fairly recently deposited, slightly modified alluvium of fine texture that has accumulated under ponded or stagnated drainage. This alluvium has been slightly affected by materials from the surrounding glacial soils of the uplands.

The surface is generally level, and runoff and internal drainage are very slow. Surface drains or tiles are necessary before the soil can be cultivated. In some areas many springs at the base of the adjacent uplands keep the soil saturated and the color of the surface soil is darker than typical.

The soil originally had a dense growth of Douglas-fir, cedar, hemlock, alder, and maple, and an undercover of elderberry, willow, salmonberry, and bracken and sword ferns.

Profile description.—The upper part of the surface soil, 4 inches deep, is gray or olive-gray silty clay loam to silt loam that has rust-brown mottlings. Normally it is friable and has a coarse granular structure. The lower surface soil, to a depth of 10 inches, is gray or olive silty clay loam, highly mottled with yellow and brown.

The subsoil is gray plastic silty clay to clay, more highly mottled with yellow and reddish brown than the layer above. This clayey material contains some thin layers of silt and fine sand. The subsoil usually continues for many feet. In places, however, the material below depths of about 28 to 32 inches is pale-olive, gritty, stratified clay loam that has some reddish-brown and light-gray mottling to depths of 4 to 7 feet. This pale-olive material is massive and is very plastic when wet.

Present use and management.—Most of this soil has been cleared of brush and timber and put under cultivation. Mixed grasses, alsike clover, and oats—the principal crops—are used mainly to feed dairy cattle.

Puget clay, 0 to 2 percent slopes (Pg; group 8).—This soil occupies only about 100 acres and is closely associated with Puget silty clay loam, 0 to 2 percent slopes. It has a finer textured subsoil and is more difficult to drain and prepare for crops than the silty clay loam. It is used mostly for hay and pasture, for which it is best suited.

Puyallup fine sandy loam, 0 to 2 percent slopes (Pk; group 7).—This soil occupies nearly level to gently undulating alluvial flood plains along the Nisqually River. It covers more than 2 square miles, which is a greater area than that occupied by Puyallup loam, 0 to 2 percent slopes. Most of the soil occurs between the Olympia-Tacoma and the Yelm-McKenna highways. The soil is associated with the Sultan and Pilchuck soils but occupies slightly higher positions. It is developing from materials not so recently deposited as those from which the Pilchuck soils are developing. The parent materials are of mixed origin and were derived from glacial material and outlying mountainous areas of country rock. Typically this soil contains various amounts of glacial rock flour. It differs from the Sultan soils in having a sandier subsoil and substratum and in lying closer to the stream channel.

Runoff is very slow, and internal drainage is rapid. Crops normally lack moisture during the dry season. This soil is flooded only during years of extremely high water, and the floodwaters quickly flow off after the river subsides. Native vegetation was large cedar and Douglas-fir trees, bigleaf maple, vine maple, alder, hazel, grasses, and bracken fern.

Profile description.—The surface soil, extending to depths of 6 to 10 inches, is a dark grayish-brown friable fine sandy loam or sandy loam. This is underlain by an olive-gray very friable loamy fine sand or occasionally by loamy sand or fine sandy loam. Next in profile, at depths between 30 and 36 inches, is light-gray and dark-gray, or pepper-and-salt, loose sand. Slight mottling occurs below depths of 1 to 2 feet.

Immediately south of the Nisqually School, this soil has a typical fine sandy loam surface soil. At a depth of 12 inches the surface soil overlies dark-gray and light-gray, or pepper-and-salt, loose sand that is more droughty than typical for Puyallup soils. This inclusion extends southward to one-eighth mile from the crossroad to the east. It is in stumps and is not used, except possibly for spring pasture.

Present use and management.—The merchantable timber has all been logged, but, because many areas are small, scattered, and relatively inaccessible, only about 30 to 40 percent of this soil has been cleared of brush and stumps and cropped. Most of the cultivated area is near Nisqually. It is farmed to support dairying, and the crops are mainly small grains, hay, and pasture. Oats are grown alone for grain or with vetch for hay. Clover mixed with grasses is a commonly grown hay crop. Mixtures for seeding permanent pastures are made up of red and alsike clovers and Italian and English ryegrasses, orchardgrass, timothy, and Kentucky bluegrass.

The soil is moderately fertile but dries out during the warm dry summer. On areas near Puget Sound, subirrigation makes conditions ideal for pasturing dairy herds the year round. Some sprinkler irrigation is carried on to provide grazing through the year. Yields vary greatly. Field and sweet corn grow well if summers are not too dry. Small acreages of specialized vegetable crops grow well under irrigation. Northeast of Yelm, a small irrigated area of this soil is used to produce lilies and daffodils for the bulb market.

Puyallup loam, 0 to 2 percent slopes (Pl; group 7).—This soil is closely associated with Puyallup fine sandy loam, 0 to 2 percent slopes, and differs from it mainly in having a finer texture in the upper 10 to 14 inches. It occurs mainly south of Nisqually. The total area is small.

The surface soil is dark grayish-brown friable loam that has a granular structure. The subsoil is a grayish-brown friable loam or fine sandy loam, slightly mottled with yellow and brown. At depths of 30 to 36 inches there is a gradual transition to a light-gray and dark-gray sandy substratum that is loose and very porous.

Cropping practices are similar to those on Puyallup fine sandy loam, 0 to 2 percent slopes. But this soil is less droughty because it has a finer texture and is also slightly more productive.

Reed clay, 0 to 2 percent slopes (Ra; group 8).—This soil is associated with Chehalis and Wapato soils and occurs in the low swampy backbottoms on the valley floor. The principal areas occur east of Tono and along Prairie Creek.

The vegetation is a scattered stand of cedar, Doug-

las-fir and oak, and a dense stand of ash, alder, willow, vine maple, dogwood, and hazel. The dense undercover consists of spirea, wild rose, blackberry, sedges, and skunkcabbage. This soil is poorly drained.

Profile description.—The upper 1½ inches of the surface soil is very dark grayish brown friable silty clay that is granular and high in organic matter. The rest of the 8- to 10-inch surface layer is very dark grayish brown clay or silty clay, also high in organic matter. Some reddish-brown mottling occurs near the surface of this layer.

The upper subsoil, extending to depths of 14 to 18 inches, is grayish-brown, gray, olive-gray, or bluish-gray firm clay that has many yellow and rust-brown streaks throughout. It is hard when dry and very plastic and sticky when wet.

Next in profile is gray or bluish-gray dense stiff clay that contains some rust-brown and yellow mottling. Below depths of 32 to 40 inches, in the substratum, the material is a slightly less dense gray or olive-gray sandy clay or clay.

Present use and management.—Little of this soil is cultivated because poor drainage makes plowing impossible until late in the season. Yields are variable and depend upon the amount and distribution of rainfall and local drainage. Drainage is difficult and slow because the soil is in low places and has a tight, stiff clay subsoil.

The principal use is for grazing during the summer and fall when the water table falls. Some of the wetter areas are seeded to Reed canarygrass. This grass produces high yields of hay and has a fairly high carrying capacity when grazed.

Reed silty clay loam, 0 to 2 percent slopes (Rb; group 8).—This soil occurs in depressed backbottoms that are similar to those occupied by the closely associated Reed clay, 0 to 2 percent slopes. It differs from the Reed clay in having a dark grayish-brown silty clay loam or silty clay surface soil. The soil occupies slightly better drained positions than Reed clay and has a thicker surface soil overlying the tight, stiff clay subsoil. Along McLean Creek, there is a small included area that has a clay loam surface soil.

A larger percentage of this soil than Reed clay, 0 to 2 percent slopes, is cleared and in hay and pasture. Crops are of the same type, but yields are slightly higher on this soil. Tillage and fertilization are similar, but yields are less than on Wapato silty clay loam, 0 to 2 percent slopes.

Rifle peat, 0 to 2 percent slopes (Rc; group 5).—This soil occurs in low-lying depressions and flats that normally have very poor drainage. It was derived mainly from accumulations of woody vegetation, and the original material can still be recognized for a depth of 1 foot or more. The acreage is small, and the soil occurs principally in the northwestern part of the county.

Except during the summer months when they are fairly dry, virgin areas are water saturated and swampy. They support a few cedar, hemlock, and Douglas-fir, many alder, and some ash, vine maple, and dogwood. Willow, spirea, elderberry, wild rose, blackberry, snowberry, skunkcabbage, and sedges form a dense undergrowth.

Profile description.—The surface soil to a depth of 12 inches is very dark brown granular friable woody peat. The material contains grasses, leaves and twigs and other woody fragments that are partially decomposed but can be discerned. The surface layer is underlain by dark-brown, matted, raw sedge peat and woody peat that extends to depths of 2 to 4 feet or more and is somewhat massive in structure. This material usually consists of stratified layers of mixed sedge peat and woody peat, and the lower part is almost entirely raw sedges. Layers of mineral matter may be mixed with the peat layers, and partially decomposed logs and limbs frequently occur in the lower subsoil.

At various depths below 2 feet, the peat overlies a substratum of dark-gray to bluish-gray clay, silty clay, or silty clay loam.

Use and management.—This soil is very productive when properly managed. It is the best peat soil in the county, but it must be drained before it is cultivated. Under drainage and cultivation the peat decomposes and becomes more mucky, and this change improves the structure of the surface soil.

About 40 to 50 percent of this soil has been cleared, and much of it is used for pasture, hay, and other crops. One small area is in blueberries and truck crops. The average blueberry yield is 5 tons per acre. Yields of timothy, clover, and oat hay exceed those on Mukilteo peat.

Pasture mixtures suggested for this soil include Italian and English ryegrasses, orchardgrass, Kentucky bluegrass, common white clover, red clover, and alsike clover. On undrained areas, Reed canarygrass grows well.

Rifle peat, shallow over dense clay, 0 to 2 percent slopes (Rd; group 5).—This soil was mapped where the peat deposit over mineral soil is less than 2 feet deep. The few areas occur in the northern and northwestern parts of the county. The average depth of the peat is 12 to 20 inches. Frequently, in the shallower areas, the peat is entirely woody material.

The surface layer consists of partially decomposed very dark brown woody peat that contains some admixture of sedge peat and colloidal peat. Nearly all of this peat is underlain by stiff bluish-gray clay to silty clay loam that may contain some embedded stones. The native vegetation and cropping practices are similar to those on Rifle peat, 0 to 2 percent slopes. This soil is less desirable and less productive than the Rifle peat because it has a thin layer of peat. This soil, like other peat soils, tends to settle when drained and cultivated, and shallow deposits often lose their organic characteristics after several years of cropping.

Riverwash (Re; group 12).—This miscellaneous land type occupies narrow elongated areas that border river channels or recently abandoned riverbeds. These areas are either barren or support only a scattering of cottonwoods, willows, alders, and other trees and brush. They consist of stream deposits of sand, gravel, and stones that are frequently overflowed and altered by erosion and deposition. This miscellaneous land type has no value for crops and little or none for grazing. The greatest value is for road and fill material.

Rough mountainous land, Melbourne soil material

(Rf; group 12).—This miscellaneous land type occupies approximately 1 percent of the county. It occurs mainly on mountainous terrain and on outlying steep foothills that are considered nonagricultural. Some small inaccessible arable areas, however, may be included. The land type is not so mountainous and does not have so rough relief as Rough mountainous land, Olympic soil material. It normally occupies the lower elevations, or mountainous foot slopes, with the Olympic soils. It accounts for the main part of the rough mountainous land in the south-central part of the county southeast of Tenino and south of Vail. Elevations range from about 300 to about 1,500 feet.

The dominant country rock is sandstone and shale, but inclusions of other rocks in small local areas give rise to Olympic-like soils.

Douglas-fir was the dominant timber species. The vegetation was similar to that growing on Rough Mountainous land, Olympic soil material, but the size of trees and amount of timber were evidently less. Runoff is rapid on the steeper slopes, but the heavy cover protects the slopes from accelerated erosion.

Soil characteristics are not well developed. Frequently the soil is shallow and stony and has rock outcroppings. In general, the soil closely resembles those of the Melbourne series, but it is more variable in depth and in stoniness, and the subsoil is finer textured. The surface soil is dark grayish brown to dark brown, and the subsoil is dark yellowish brown. The depth to underlying bedrock varies from a few inches to 5 feet or more.

Present use and management.—Almost all areas have been logged and are restocking to trees and brush similar to those growing on other mountainous areas. Reforestation meets the same problems as those on Rough mountainous land, Olympic soil materials. Because the individual holdings are normally smaller and located nearer agricultural land, some of this soil may be used by nearby farmers for grazing.

Rough mountainous land, Olympic soil material (Rg; group 12).—This miscellaneous land type occupies about nine-tenths of the rough mountainous land, or about one-third of the total land area surveyed. It occurs mainly on the higher mountainous terrain and on outlying steep foothills that are considered nonagricultural (fig. 3). Small inaccessible areas of arable land, however, may be included. Some slopes are 70 to 80 percent. This miscellaneous land type includes soils of the Black Hills in the western part of the county and soils of the outlying spurs of the Cascade Range in the south-central part. Elevations range from about 200 to 2,667 feet in the Black Hills and are about 3,000 feet in the southeastern part of the county.

The dominant country rock is basalt and andesite, but inclusions of sandstones and shales occur. Along the Shookumchuck River canyon are outcroppings of granite. Considerable granite is believed to occur in places in the southeastern part of the county.

A large area along the headwaters of the Deschutes River is in virgin timber that is dominantly Douglas-fir, which thrives in this climate and grows to huge size. A few cedars and hemlocks grow with the Douglas-fir. The undercover is luxuriant. Alder and maple trees are scattered throughout the forest, especially in the wetter areas. Runoff is rapid on most of the steeper slopes, but the heavy cover protects the slopes from erosion.

Soil characteristics are not well developed. The soils are normally shallow and stony, and there are rock outcrops. In general, the soils mapped in this land type closely resemble those of the Olympic series, but they are more varied in depth and in stoniness, and the subsoils are finer textured. The surface soils are dark reddish brown to reddish brown, and the subsoils are dark reddish brown. The depth to underlying bedrock varies from a few inches to 10 feet or more.

In the southeastern part of the county where, in places, andesite is believed to be the dominant rock, the soil is more varied in color than the typical soil. This color ranges from purplish gray and purplish brown to reddish brown. The soils resemble the Bucoda soils more than the Olympic soils. Although the dominant rocks are basalt and andesite, there are inclusions of sandstones and shales that give rise to small areas of Melbourne-like soils.

Present use and management.—Practically all the area west of Clear Lake has been logged or was being logged while this survey was being made. Logged land is quickly invaded by fireweed, bracken, salal, Oregon grape, wild blackberry, and other brush or shrubs that produce a dense and luxuriant cover. This growth is closely followed by Douglas-fir, hemlock, alder, and maple.

In many instances reforestation has been slowed by severe and repeated burning that follows logging and by failure to leave adequate seed trees. The future of the lumber industry in the county largely depends on the careful reforestation of these mountainous areas.

Rough mountainous land, Wilkeson soil material (Rh; group 12).—This miscellaneous land type occupies about 0.4 percent of the mountainous land or about 0.1 percent of the area surveyed. It occurs in the southeastern corner of the county, where it adjoins much more extensive areas in Lewis County. The areas are at elevations of 1,000 to about 2,500 feet. At the higher elevations, the Wilkeson parent material is thin, and small areas of soil that developed from residual bedrock occur.

The underlying country rock is primarily basaltic. Before the Vashon glaciation, early glacial activity deposited a thin veneer of till, rubble, and fine soil material over most of the area. This deposit was similar to that from which the Wilkeson soils have developed. In these steeper and rougher areas soil development has been retarded and the soils resemble those of the Wilkeson only in their general characteristics. They are usually shallower and much more stony, and bare rock outcrops are common.

The surface soil, which underlies 1 or 2 inches of organic duff, is a friable granular dark-brown silt loam. This layer overlies the subsoil of friable to firm yellowish-brown silt loam or silty clay loam. The depth to the underlying bedrock is variable and largely depends on the relief.

The forest cover and the management practiced are

similar to those for Rough mountainous land, Olympic soil material. Some areas that have been slow in restocking to timber are used to a limited extent for grazing cattle.

Salkum silty clay loam, 3 to 8 percent slopes (Sa; group 2).—This soil occupies undulating high terraces or benches, remnants of a plain that was much more extensive during an earlier geologic epoch. The soil developed over a deep deposit of highly weathered gravel and cobbles and has a clay matrix.

In Lewis County this soil is widely distributed in large areas and is important agriculturally. But in this county it occupies only a few areas, mainly along the southern county line and in the Michigan Hills section that extends into Lewis County. The Salkum and associated soils occur in central Lewis County as an extensive plain that slopes gradually from east to west and northwest. This plain terminates in small remnants, the most northwesterly remnant being a large mound near Grand Mound in Thurston County.

In Thurston County, this soil is more varied than it is in Lewis County. It is closely associated with Prather and Melbourne soils and often, in part, resembles these soils. Southeast of Bucoda, the soil occupies the tops of hills and ridges and the Melbourne soils occupy the steep side slopes.

Runoff is slow, and internal drainage is slightly retarded by the compact substratum, which helps conserve moisture. The soil is well drained for early spring crops and winter grains.

Originally it was forested with Douglas-fir, scattered hemlock, and cedar. The forest has been logged and is now gradually restocking to second-growth trees of similar species. Logged areas are quickly reclaimed by alder, willow, hazel, salal, bracken fern, Oregon grape, and other brush and shrubs. Excessive burning has destroyed most of the second-growth timber in many places.

Profile description.—In virgin areas a partially decomposed 1- to 2-inch organic layer covers the mineral soil. Abruptly underlying this layer is friable dark-brown silty clay loam, which is brown when dry. This layer extends to depths of 10 to 12 inches. It is medium acid and very granular and contains many small rounded concretions high in iron or manganese. In cultivated fields, where the organic matter is largely destroyed, the surface soil is reddish or reddish brown.

The surface soil grades into the upper subsoil of dark yellowish-brown or slightly dark reddish-brown silty clay loam. The upper subsoil is granular and contains fewer iron concretions than the surface soil. It is medium to strongly acid and firm but moderately permeable. At depths of 22 to 26 inches, this material grades into the lower subsoil, a slightly more compact silty clay or clay that is moderately permeable to roots and water. The irregular crumb or granular structural units are highly coated with colloids. Under normal or low moisture content, this horizon is yellowish brown, but under some moisture conditions it is yellowish red. It is strongly to very strongly acid.

The substratum, or parent material, which occurs at depths of 34 to 40 inches, is composed of ancient very strongly weathered cobbles and clay of obscure origin. Probably this material consists of outwash-plain deposits left by alpine glaciers during a time much earlier than the Vashon or even the Admiralty glacial period. This substratum extends for many feet with little change. The embedded pebbles are easily cut through with a spade, and they break into highly colored clay. A fresh cut gives a striking picture of concentric weathering and exposes brilliant reds, yellows, purples, blues, and many other colors. The entire mass is compact and slowly permeable to water. Root penetration is almost entirely restricted. The pebbles and cobbles are from assorted andesites, basalts, granites, and various quartzites. Resistant quartzites of many colors are scattered through the profile and occasionally on the surface. Good collections of agates and, rarely, well-preserved pieces of petrified wood can be found.

Use and management.—As individual areas are small and generally associated with soils having steep relief, only a very small part of this soil has been cleared and cropped to hay or grain. Most crops are used to feed dairy cattle. They are hay, pasture, and small grains. Oats, for both hay and grain, are the most common crop.

The soil is deficient in organic matter and nitrogen. Under cultivation barnyard manure, crop residues, commercial nitrogen fertilizers, and proper rotation of soil-depleting crops with legumes, must be used to keep organic matter and nitrogen high enough for good crop production. Crops usually respond to manure or phosphate fertilizers applied alone or in combination. As most of the areas farmed are closely associated with the Prather soils, the same use and management practices are followed on this soil as on Prather soils.

Salkum silty clay loam, 8 to 15 percent slopes (Sb; group 2).—This soil is closely associated with Salkum silty clay loam, 3 to 8 percent slopes, and Melbourne and Prather soils. The profile is very similar to that of Salkum silty clay loam, 3 to 8 percent slopes, but it varies more in thickness of the surface soil. Runoff is medium, and on the steeper slopes some accelerated water erosion may occur in cultivated areas. The acreage is very small, and is entirely in timber and brush. If cultivated, the soil would have approximately the same use, management, and crop yields as Salkum silty clay loam, 3 to 8 percent slopes.

Salkum silty clay loam, 15 to 30 percent slopes (Sc; group 12).—This soil occurs as short, moderately steep, single slopes along drainageways or around isolated hills. Runoff is medium, and the subsoil does not become highly saturated during winter and spring. A few small seep areas occur adjacent to the stream channels or in occasional pockets on the slopes. The profile is more variable than that of Salkum silty clay loam, 3 to 8 percent slopes. Furthermore, higher and more exposed in position, it is usually shallower and commonly contains many scattered pebbles and stones from quartzite, strongly weathered but firm basalt, andesite, or occasionally granite. The soil in these exposed areas has stronger development of color and normally is redder. Where this soil is closely associated with soils of the Melbourne or Prather series, the profile is more varied and has some of the characteristics of either of these soils.

This Salkum soil occupies moderately steep, irregular areas considered unfavorable for cultivated crops. Areas are small, and farm machinery is difficult to handle. In the natural state this soil does not have an erosion problem, but under cultivation, erosion might become accelerated. The best use for this soil is forestry.

Semiahmoo muck, 0 to 2 percent slopes (Sd; group 5).—This soil occurs in low-lying depressions or flats that are very poorly drained and saturated with water most of the year. The largest areas are along the Black River and west of Scott Lake. Many small areas occur throughout the northern and western parts of the county. This soil may be associated with the other mucks or peats but more often occupies entire isolated depressions. The soil differs from Mukilteo peat in that the organic matter is more highly decomposed; the original fibers in the surface layer are no longer distinct. The soil was derived largely from sedges, but areas are included that have some admixture of wood and mineral material.

Many areas of this soil are flooded during late fall, winter, and spring. The native vegetation consists mostly of sedges, coarse grasses, spirea, and cattails, but many areas now have some willow, ash, alder, and cedar growing in clumps.

Profile description.—The 12-inch surface layer consists of very dark brown to dark grayish-brown remains of sedges and other water-loving plants that are highly decomposed. It is friable, granular, and medium acid.

The surface layer is underlain by a layer of very dark brown, medium acid, decomposed sedge muck in which sedge peat and some woody fragments are embedded. In places this layer is raw fibrous sedge peat. A layer of strongly acid sedimentary or colloidal peat begins at a depth of about 36 inches. In places, however, the layer at this depth is largely mineral soil mixed with organic matter. The total depth of the organic layers is greater than 2 feet and may be 4 feet or more.

Use and management.—This soil almost always requires artificial drainage before cultivation. It is mainly used with smaller areas planted to grass or clover for grazing. Farm practices are similar to those on Rifle peat and other organic soils. Only a small part of the muck has been cleared, and it is pastured in its natural state during the summer. Blueberry growers do not consider this soil so suitable for blueberries as Rifle peat, 0 to 2 percent slopes, but when properly drained and managed it is very productive for many crops. The late spring and early fall frosts that occur in the depressions, however, limit the use of these areas to grass and hay crops. When cut for marsh hay, the coarse grasses furnish a low-grade forage for cattle.

Semiahmoo muck, shallow over dense clay, 0 to 2 percent slopes (Se; group 5).—This soil has developed from a mixture of sedges and woody materials, mainly in areas southeast of Tenino and in Zenkner Valley near the Lewis–Thurston County line. Other scattered areas occur in the northern and western part of the county. The soil is poorly drained and swampy.

A granular, very dark brown, well-decomposed organic deposit, 6 inches to 2 feet thick, overlies dense, stiff blue or gray clay or silty clay loam. The muck is 12 to 20 inches thick.

The shallowness to the dense clay substratum makes this soil less easily drained and less desirable than Semiahmoo muck, 0 to 2 percent slopes. But the soil is moderately productive and, where drainage is favorable, excellent yields are obtained. Farm practices are similar to those used on Semiahmoo muck, 0 to 2 percent slopes, but yields are slightly less. Truck crops have been killed by the frost and abandoned. This soil is used mainly for grasses, oats cut for hay, and clover mixed with grasses.

Shuwah silty clay loam, 0 to 2 percent slopes (Sf; group 6).—This soil occupies a single area of about 50 acres located in an abandoned stream channel of the Skookumchuck River about 3½ miles southeast of Offutt Lake. It has developed from parent materials similar to those of Chehalis silty clay loam, 0 to 2 percent slopes. Apparently influenced by prairie conditions, it differs from the Chehalis soil in having a darker surface soil. The surrounding areas are dominantly Spanaway soils.

The surface soil is very dark grayish brown and ranges from 12 to 24 inches in thickness. It grades into dark yellowish-brown to brown material similar to that in the subsoils and substrata of the Chehalis soils.

This soil is all in cultivation and is used for hay, pasture, grain, and canning peas. Yields are similar to those of Chehalis silty clay loam, 0 to 2 percent slopes.

Snohomish silt loam, 0 to 3 percent slopes (Sg; group 8).—This soil occurs in small nearly level depressions along small streams. The total acreage is small. Runoff and internal drainage are very slow because of the high water table.

Profile description.—The surface soil to depths ranging from 6 to 12 inches is dark-gray to dark grayish-brown friable slit loam that contains some organic material grades into gray, dark-gray, or dark grayish-brown, friable silt loam that contains some organic material in layers and has a high content of diatomaceous earth. Some widely variable mottling occurs.

At depths ranging from 18 to 24 inches, the material is very dark brown sedge peat that normally contains some woody fragments, lenses of colloidal peat, or silty mineral material. The soil is quite variable. Depths to the peaty material may range from as little as 8 inches to as much as 30 inches. In places the subsoil, or the material immediately above the peat, is fine textured, mottled, and very plastic.

Artificial drainage is normally required for successful production, and when adequately drained this soil is very productive of grain, hay, pasture, and truck crops. Areas that have little artificial drainage are used chiefly for pasture and hay crops. More adequately drained areas are used for grain crops, mainly oats. Pasture has a high carrying capacity and does not dry out during the summer as it does on most soils.

Spanaway gravelly sandy loam, 0 to 3 percent slopes (Sh; group 9).—This soil has developed on smooth glacial outwash plains under a herbaceous and grass

cover. It is the most extensive soil on the outwash plain of the last continental, or Vashon, glaciation period. The soil is scattered throughout the county and occurs in fairly large areas in association with Nisqually and Fitch soils.

The principal grasses are ticklegrass and meadow fescue. Some Douglas-fir and Oregon-oak are encroaching around the outer margins of the prairies. Some areas contain open stands or scattered clumps of oak and fir. The scattered trees are usually short and limby and of poor quality for lumber. Runoff is very slow, and internal drainage is very rapid.

Profile description.—The surface soil, 16 to 20 inches deep, is black, sooty gravelly sandy loam. The extreme range in depths is from 12 to 24 inches. This layer is very friable, porous, and high in organic matter, but it contains no shot. The rounded pebbles vary from ¼ to 4 inches in diameter and make up about half of the total volume. The lower part of the surface soil is generally not so dark colored.

The surface soil overlies dark yellowish-brown, dark grayish-brown, gray- and olive-colored, loose, porous, poorly assorted gravel, sand, and stones. The stones are common and as large as 6 inches in diameter. They sometimes extend to the surface. The substratum extends to a depth of many feet. The soil profile is medium to strongly acid.

Use and management.—The soil is porous, droughty, and low in inherent fertility. It is one of the least productive upland soils of the county. The supply of organic matter is fairly high, but it appears to be largely inert material and not particularly beneficial to plant growth. For fair yields, it is essential to add barnyard manure, crop residues, fertilizers, and water.

This soil was among the first to be farmed during the pioneer era because crops could be grown easily. The early crops were mainly grains, which lowered fertility, and the soil was allowed to revert to pasture. Today this soil is used mainly for pasture. During the period following the First World War, there was a big boom in growing strawberries to can and barrel, and Spanaway gravelly sandy loam, 0 to 3 percent slopes, was the principal soil used in this region. The area adjacent to Grand Mound and Rochester was almost a solid block of strawberry fields, but it has been almost entirely abandoned because of insects, diseases, low prices, high production costs, and low yields. This area has been returned to pasture for cattle and sheep, but a few isolated fields are still in strawberries. Frost damage to the strawberry crop has occurred at intervals of 4 or 5 years. At the peak of production, 3,000 acres were in strawberries on Mound Prairie. The principal variety was Marshall. Some farmers consider it easier and cheaper to produce an acre of strawberries on the prairie than on the finer textured Prather soils of the Michigan Hills, but the yields are considerably less.

Other crops grown are Montmorency or Duke cherries, youngberries, oats for hay and grain, grass hay, corn for silage, and sweet corn for canning. When pastured, 10 to 15 acres will support a cow for 5 or 6 months. Some stockmen believe that 7 to 8 heavily fertilized acres are enough to support 1 beef animal. Most of the crops are grown by a small number of farmers.

Only under very careful management can the Spanaway soils be used profitably for agriculture. Barnyard manure is applied annually or less frequently on most farms. Some farmers use superphosphate, but few use other commercial fertilizers.

Spanaway gravelly sandy loam, 3 to 15 percent slopes (Sk; group 9).—This soil is very inextensive and occurs as single steeper slopes between two gently undulating areas. It occupies long narrow strips in association with Spanaway gravelly sandy loam, 0 to 3 percent slopes, north of Rochester, northeast of Delphi, west of Offcutt Lake, and on Mound Prairie. It differs from Spanaway gravelly sandy loam, 0 to 3 percent slopes, chiefly in having greater slope and a slightly thinner surface layer. The same type of vegetation covers these two soils.

Only a small area of this soil is farmed, and it is used for the same type of crops and produces about the same yields as the more nearly level Spanaway gravelly sandy loam, 0 to 3 percent slopes.

Spanaway gravelly sandy loam, 15 to 30 percent slopes (Sl; group 12).—This soil occurs west of Offcutt Lake; the total area is small. It is associated with, and in profile features is similar to, other Spanaway soils that have more gentle slopes. Included are a few slopes greater than 30 percent. This soil has a grass cover and scattered Douglas-fir trees. It is used for pasture.

Spanaway gravelly sandy loam, mound phase, 2 to 10 percent slopes (Sm; group 9).—This soil has a microrelief of mounds and slight depressions (fig. 12) or flats between the higher areas. The mounds are circular to elliptical horizontally, and they are 3 to 5 feet high in the center. They occupy about one-fourth to one-half or more of the surface area. Extensive areas of the soil are associated with Spanaway gravelly sandy loam, 0 to 3 percent slopes. A large area occurs west of Offutt Lake toward Maytown, and another large area is northeast and east of Mima. Smaller bodies are in Mound Prairie, south of Little Rock, and in Hawks Prairie. Vegetation on this soil is similar to that on Spanaway gravelly sandy loam, 0 to 3 percent slopes.

The surface soil is generally deeper on the mounds than in the areas between the mounds. In many

Figure 12.—**Mounds on Spanaway soils. These mounds are 2 to 5 feet in height. Spanaway soils are very droughty and have little or no agricultural value except for limited grazing in early spring.**

places on the mounds the very dark colored surface layer extends to a depth of 3 feet, but the surface soil between the mounds varies from only 4 to about 16 inches deep. There is no distinct difference between the mound phase and Spanaway gravelly sandy loam, 0 to 3 percent slopes, in distribution and amount of gravel, boulders, and sand. In some areas cobbles 4 to 10 inches in diameter occur on the surface between the mounds. Typically, the mounds are about equally spaced but occur in no distinct pattern. In some areas the mounds appear to be in rows and to be cut across by an occasional smooth trough.

This soil is mainly used for grazing (fig. 12); a few areas have been leveled for cultivation or used without leveling. Crops grown on the leveled areas are uneven or spotty, and yields are more variable and slightly less than on Spanaway gravelly sandy loam, 0 to 3 percent slopes.

Spanaway stony sandy loam, 0 to 3 percent slopes (Sn; group 9).—This soil occurs on glacial outwash plains adjacent to the Nisqually River in the eastern part of the county. It is similar to the other Spanaway soils—open, porous, and somewhat excessively drained. The soil contains a large amount of glacial gravel and stones of mixed origin. It has developed under a herbaceous and prairie vegetation. The principal grasses are ticklegrass and meadow fescue. Some Douglas-firs are encroaching around the outer margins of the prairie, and there are scattered clumps of scrub oaks. The Douglas-firs are usually short, limby, and of poor quality for lumber.

Profile description.—Under virgin conditions, the mineral soil is covered by a dark-brown organic layer composed of partially decayed plant remains. Unless they have been removed, stones 4 to 24 or more inches in diameter normally are scattered over the surface. The mineral surface soil, to average depths of 10 to 12 inches, is very dark grayish-brown, sooty stony sandy loam that has weak crumb or granular structure. It is very friable, porous, and very high in organic matter. Many rounded pebbles and stones, ¼ to 24 inches in diameter, occur throughout this horizon and constitute 25 to 50 percent of the volume. The lower surface soil is very friable, very dark brown, sooty stony sandy loam. The pebbles and stones range from ¼ to 24 inches or more in diameter and constitute 50 to 60 percent of the volume of this layer. The depth of the surface soil ranges from 20 to 26 inches but averages about 24 inches.

The subsoil, extending to depths of 30 to 36 inches, is dark grayish-brown or grayish-brown stony sandy loam or stony loamy sand.

The substratum consists of gray and olive unassorted sand, gravel, and stony materials. The pebbles and stones range from ½ to 24 inches in diameter and make up 50 to 75 percent of the volume of the substratum. This layer is loose, porous, and very low in moisture-retaining capacity. It extends to depths of many feet. The soil profile is medium to strongly acid in reaction.

Use and management.—This soil is porous, droughty, and low in inherent fertility. Stones and boulders must be removed before it can be cultivated. During the last few decades, a gravity irrigation system has been established on the prairie surrounding Yelm. A large acreage of this soil was cleared of boulders, irrigated, and planted to oats, various grasses and clover for hay and pasture, cane berries, and truck crops. In 1940, many truck and berry farms were abandoned, because shipyards and other war industries attracted farmers and because the cost of irrigation water rose. Dairying, poultry raising, and growing of blackcap raspberries and snap beans are now the principal agricultural pursuits on irrigated land in the Yelm area.

After being cleared of boulders, the surface soil resembles that of Spanaway gravelly sandy loam, 0 to 3 percent slopes, although the soil still has stones in the subsoil and substratum. This soil is considered better for grazing by some stockmen because it appears to retain moisture longer than the Spanaway gravelly sandy loam. Perhaps it is better because it has a slightly deeper profile. Most farmers who cultivate this soil have an outside source of income because many of the farms are too small to provide a living.

Spanaway stony sandy loam, 3 to 15 percent slopes (So; group 9).—This soil is inextensive and frequently occurs on a break between two gently undulating areas. It is associated with Spanaway stony sandy loam, 0 to 3 percent slopes, and occurs in long narrow strips north, northwest, and southeast of Yelm and west of Rainier along the Deschutes River. It is similar to Spanaway stony sandy loam, 0 to 3 percent slopes, except for the greater slope and thinner surface soil. The native vegetation is the same on these two soils. Only a limited area of this soil is farmed, and it is used for the same kinds of crops and produces about the same yields as Spanaway stony sandy loam, 0 to 3 percent slopes.

Sultan fine sandy loam, 0 to 2 percent slopes (Sn; group 6).—This soil is on flood plain of the Nisqually River in positions similar to those of the well-drained Puyallup soils. It was derived from medium-textured river sediments of origin similar to that of the Puyallup soils, but it is much less sandy than these soils. It occupies an area of less than a square mile, mostly near the Nisqually post office and in a few very small bodies east of Lacamas School. A few hummocky areas or swales occur.

The soil is imperfectly drained. During winter, the water table is high, and water may stand in places for short periods. Runoff is very slow, and internal drainage is medium. The native vegetation consisted of a heavy stand of conifers, but most areas have been cleared for cultivation.

Profile description.—The surface soil to depths of 10 to 12 inches is olive-gray or dark grayish-brown, very friable fine sandy loam that is grayish brown or olive gray when dry. The structure is granular, and the reaction is medium to slightly acid.

This layer grades into olive-gray to grayish-brown very fine sandy loam to fine sandy loam that is mottled and splotched with rust brown and yellow. It is very friable and rapidly permeable. Frequently it is stratified, and it may contain dark-gray sandy layers.

Below a depth of 30 inches begin thin layers of moderately permeable fine sandy loam, loam, and silt,

all of which are mottled with iron stains. These layers continue for many feet and vary considerably in texture and degree of mottling, particularly where the soil is adjacent to Tacoma muck.

Use and management.—In most places, artificial drainage is not needed for crop production, but where it is needed slopes are steep enough for open drains. In the lower part of the Nisqually River valley, this soil is protected by dikes which have drains back of them to protect the land from high tides. Formerly these tides flooded all of the area north of the new Tacoma-Olympia highway.

Most of this soil is used for hay, permanent pasture, or small-grain crops used to feed dairy cattle. The crops and farm practices are similar to those on the Puyallup fine sandy loam, 0 to 2 percent slopes. Because of the slower subdrainage and the resulting increase in moisture-holding capacity, however, yields on this soil are usually higher. Furthermore, permanent pastures are better throughout the dry season. The soil is inherently fertile and productive, but under cultivation organic matter should be added by the use of barnyard manures and legumes. Crops usually respond to nitrogen-phosphate fertilizers.

Sultan loam, 0 to 2 percent slopes (Sr; group 6).—This soil occurs along the Nisqually River, mainly north of the Tacoma highway. It adjoins areas of Tacoma muck. Near McAllister Creek and along tidal channels into Nisqually Beach, salts from sea water sometimes appear on the surface and reduce productivity. The soil differs from Sultan fine sandy loam, 0 to 2 percent slopes, chiefly in the finer surface texture.

The surface layer to depths of 12 to 15 inches is an olive-gray or dark grayish-brown friable loam that grades into stratified sediments of silt, loam, and very fine sand, mottled with rust brown, yellow, and gray. This material is friable and moderately permeable. Below a depth of 36 inches, the soil varies from a fine sandy loam to clay loam that extends to a depth of 5 feet or more.

This soil is similar to Sultan fine sandy loam, 0 to 2 percent slopes, in crop production.

Tacoma muck, 0 to 2 percent slopes (Ta; group 5).—This soil has developed from fine tidal sediments and partially decomposed sedges, grasses, and other salt-tolerant plants. It occupies coastal areas between the Sultan and Puyallup soils and the tidal marsh areas at the mouth of the Nisqually River. The topography is nearly flat with numerous microdepressions and tidal inlets. Before being diked, all of this soil was subject to floods during high tide. The native vegetation was water- and salt-tolerant grasses and sedges.

Profile description.—This surface soil, to depths that range from a few inches to 2 feet, is a dark-gray to dark grayish-brown mixture of medium-acid muck, peat, and silty materials mottled with rust brown and yellow. This material averages 12 inches in thickness and is normally underlain by fibrous peat or muck mixed with varying amounts of silty and sandy sediments. These different materials may occur in layers.

At depths of about 30 to 48 inches, this soil changes rather abruptly to very dark gray and bluish-gray stratified layers of silt, clay, fine loam, sand, and some finely fibrous peat. A little rust-brown staining occurs in places. Old root channels are filled with partially decayed roots, but few roots penetrate this material that extends to depths of 4 to 5 or more feet. The subsoil and substratum are strongly acid.

Use and management.—All this soil is in permanent pasture, hay crops, or oats and alsike clover. It is not so productive as the Sultan or Puyallup soils and satisfactorily produces only grasses and acid-tolerant clovers. Where this soil joins Tidal marsh, the outer margins show indications of salt infiltration. This whole area is drained by ditches along the dikes. It is best suited to pasture, because its low position insures enough moisture for plant growth during the hot dry season when most higher lying land is dry.

Tenino gravelly sandy loam, 15 to 35 percent slopes (Tc; group 12).—This soil occupies terminal and recessional glacial moraines that have ridgy, steep, knoll-like topography.

It occurs northwest of Little Rock on the edge of the Black Hills and 2 to 4 miles northwest of Yelm. It is similar to the Alderwood soils but has developed from coarser gravelly and cobbly sandy glacial till that lacks the compaction and cementation of the Alderwood soils. The soils differ from the Everett soils in having a less loose and porous substratum. Pebbles and cobbles in the subsoil and substratum are clay coated and iron stained. The vegetation is similar to that on the Alderwood and Everett soils. Runoff and internal drainage are medium.

Profile description.—To a depth of 12 inches, the surface soil is grayish-brown to dark grayish-brown or brown gravelly sandy loam that contains many iron concretions. This layer is very friable, porous, and very slightly granular.

The subsoil, to a depth of 24 to 28 inches, is yellowish-brown or olive gravelly and cobbly sandy loam, slightly mottled with rust-brown and grayish iron stains. Iron concretions decrease with depth.

Next in profile and continuing to a depth of 60 inches is the substratum, a yellowish-brown and gray softly cemented gravelly or cobbly loamy sand, mottled with rust brown. The pebbles and stones are coated with clay. The number and size of the stones are quite variable. Within small areas the cementation ranges from complete absence to strong cementation. Below a depth of 5 feet, the cementation decreases or is entirely absent, and the till becomes coarser and unassorted. The gravel consists mainly of quartzite and granite, though some of it is from mixed rocks. In most road cuts the material stands up firmly, but in places it is quite loose and incoherent.

Use and management.—This soil is all in timber and brush. Because it is rough, coarse textured, and droughty, the soil is not suitable for farming. Low-grade pasture might be obtained if the soil is cleared of brush. The soil is best suited to forestry. The large area northwest of Yelm is a training area for the Fort Lewis Military Reservation located in Pierce County.

Tenino gravelly sandy loam, 4 to 15 percent slopes (Tb; group 11).—This soil is closely associated with Tenino gravelly sandy loam, 15 to 35 percent slopes. Profiles of these soils are identical except that the sub-

stratum of this soil is more cemented and less varied. The soil covers a very small acreage. All of it is in timber and brush. Small areas west of Delphi are used for limited grazing. This soil is too coarse textured and droughty for most crops and is best suited to forestry.

Tidal marsh, 0 to 2 percent slopes (Td; group 12).—Tidal marsh consists of low-lying, wet, saline, marshy coastal areas that are crossed by many tidal sloughs or inlets. These areas are covered by saline waters during high tide. They occur at the mouth of the Nisqually River. The areas support a growth of salt-tolerant grasses and plants of little value for grazing. The soil is varied, but in most areas it consists of a mixture of mineral matter and sedge peat that contains roots of grasses and sedges, and below this, bluish-gray stratified clay, silt, and sand. The areas have no agricultural value unless diked.

Tisch loam, 0 to 3 percent slopes (Te; group 4).—This soil occupies nearly level poorly drained depressions or poorly drained areas along small streams. It is in positions similar to those of soils of the McKenna, Norma, and Everson series. Frequently it is associated with these soils. It also occurs in association with the better drained glacial upland soils. The original cover was a mixture of deciduous and coniferous trees and shrubs.

Profile description.—The surface soil to depths of 8 to 10 inches is dark grayish-brown loam that is slightly mottled with light gray when dry. This layer is high in organic matter, granular, and friable. It is underlain by light-gray to nearly white diatomaceous earth that ranges from 4 to 24 inches or more in thickness. The diatomaceous earth overlies gray or olive slightly mottled loamy fine sand to loamy sand. The entire profile is slightly to medium acid.

Included with this soil are areas of shallow Semiahmoo muck along Eaton Creek that are too small to map separately. In some areas diatomaceous earth is on or near the surface. The substratum ranges from sand and clay to peat.

Use and management.—About 30 to 40 percent of this soil is in crops of clover, alsike clover, oats for hay or grain, Italian ryegrass, and other grasses. All the cropland is drained by shallow open ditches. Yields are reported to be affected by the layer of diatomaceous earth, especially where it is near enough to the surface to be turned up by plowing. Because the subsoil and substratum are porous and sandy, shallow drains are more effective than deep ones. These drains keep the water table near enough to the surface to supply moisture to the subsoil during the dry season. Deep drains would lower the water table, and the subsoil would not retain enough moisture for crops. This soil has a fairly high inherent fertility, but barnyard manure, crop residues, and superphosphate are needed to maintain or increase fertility.

Tromp fine sandy loam, 0 to 3 percent slopes (Tf; group 4).—This soil occurs in the glacial outwash plains in association with soils of the Lynden, Tumwater, and Everson series. Total acreage is small. This soil occupies low-lying depressions and is imperfectly drained. During the rainy season, this soil is saturated most of the time, especially the subsoil. The native cover is principally spirea, willow, some Douglas-fir, cedar, lodgepole pine, sedges, and grasses.

Profile description.—The surface soil to a depth of 5 inches is very friable, dark grayish-brown fine sandy loam. This layer is granular and strongly acid. The lower part of the surface soil is very friable, dark yellowish-brown loamy fine sand that has low water-holding capacity and is slightly acid.

The subsoil is next in profile and continues to a depth of 30 inches or more. It is a slightly acid olive loamy sand moderately mottled with rust brown that has a massive structure that easily breaks into single grains. The lower subsoil is an olive loamy fine sand to loamy sand, more highly mottled with rust brown and yellow than the horizon above. Its consistence is firm, and coherence of particles is greater than in the horizon above. Reaction is strongly acid.

The material below a depth of 4 feet is stratified, pale-olive, olive, and dark yellowish-brown loamy fine sand to fine sandy loam, very highly mottled with rust-brown and orange stains. The structure is massive and reaction is medium acid.

Use and management.—Most of this soil remains in brush and timber, and only a small portion is cultivated. Cultivated crops normally need artificial drainage. The soil is best suited to pasture and hay crops and should be fertilized with barnyard manure, crop residues, and superphosphate to produce maximum yields. Expected yields are similar to those on Norma loam, 0 to 3 percent slopes.

Tromp-Tisch complex, 0 to 3 percent slopes (Tg; group 4).—This complex consists of small bodies of Tromp fine sandy loam and Tisch loam so intricately intermingled in small areas that separation on the map is impractical. It occurs in one area south of Tumwater. The Tromp portion of the complex consists of dark grayish-brown sandy loam and gravelly loam surface soils that overlie mottled dark yellowish-brown loamy fine sand or sandy loam subsoils. This portion occurs as low-lying rounded mounds.

The Tisch portion of the complex occurs as small flats or depressions between the small mounds. It consists of a dark-gray loam surface soil that contains diatomaceous earth and overlies a mottled sandy loam subsoil. This complex is used for growing truck crops, oats, vetch, and various grasses for hay or pasture. Yields are similar to those from either Tromp fine sandy loam, 0 to 3 percent slopes, or Tisch loam, 0 to 3 percent slopes.

Tumwater loamy fine sand, 0 to 3 percent slopes (Tk; group 10).—This soil occupies gently undulating sandy glacial outwash plains. It is very closely associated with the Nisqually soils but differs from them in being forested and in having a brown surface soil. The soil is not extensive and occurs south of Tumwater bordering the Bush Prairie on the south, and in other smaller scattered areas associated with Nisqually soils. This soil closely resembles Lynden loamy sand, 0 to 3 percent slopes. It differs in having a slightly darker surface soil and in being developed from finer sandy materials. Runoff is very slow, and internal drainage is very rapid.

Profile description.—The surface soil to depths of 10 to 12 inches is very friable, brown to dark-brown loamy fine sand. Structure is weakly granular.

This layer grades into a dark yellowish-brown or olive loamy fine sand that is very friable and breaks into small granules and single grains. When moist, the material stands up well in a cut bank. Many tongue-shaped, dark-colored organic stains penetrate this horizon from above. Slight reddish-brown mottling occurs in the lower part.

At a depth of about 30 inches, the materials grade into an olive loamy fine sand or loamy sand that is very friable and breaks into single grains and very weakly cemented granules. Some reddish-brown and dark-gray stains occur. The substratum is very rapidly permeable to moisture and plant roots. In places, it may be gray and dark-gray loose sand.

Use and management.—This soil is used largely for homesites of small acreages by people who work in Olympia or have other outside sources for most of their income. Hay and pasture, raspberries, and fruit and vegetables for home use are the principal crops. Crops grow fairly well but lack moisture during the summer months. This soil is fairly productive under irrigation, and yields are about equal to or slightly better than those expected from the associated Nisqually soils.

Tumwater loamy fine sand, 3 to 15 percent slopes (Tl; group 10).—This soil occupies small areas of gently undulating rolling relief or short steeper slopes between areas. It is distributed throughout the area of Tumwater soils. The soil is similar to Tumwater loamy fine sand, 0 to 3 percent slopes. Use and management of these two soils are similar.

Tumwater loamy fine sand, 15 to 30 percent slopes (Tm; group 12).—This soil is closely associated with the other Tumwater soils and occupies the hilly slopes between smoother areas. The soil differs from other Tumwater soils mainly in having a thinner and slightly lighter colored surface soil. The subsoil and substratum are more loose and coarsely textured than those of Tumwater loamy fine sand, 0 to 3 percent slopes. The small acreage of this soil is largely in second-growth timber and brush. The soil is too steep for cultivation and is best suited to forestry.

Tumwater fine sandy loam, 0 to 3 percent slopes (Th; group 10).—This soil occupies about 420 acres on Bush Prairie. The surface soil, about 16 inches thick, is very friable, granular, brown to dark-brown fine sandy loam. This layer grades into a slightly lighter colored subsoil that varies from a light fine sandy loam to a heavy loamy fine sand. The subsoil is very friable and easily penetrated by roots, water, and air. Below depths of 30 to 36 inches, the material is dark yellowish-brown loamy fine sand.

For the last 30 to 60 years this soil has been producing trees, but before this time it may have been in grass. Areas cleared of trees and cultivated should produce higher yields of truck crops and grain than Tumwater loamy fine sand, 0 to 3 percent slopes. The soil will respond to fertilization and irrigation and easily can be prepared for a good seedbed.

Wadell loam, 2 to 5 percent slopes (Wa; group 7).—This soil occupies alluvial fans adjacent to Olympic soils. It occurs in small areas, mainly south and west of Summit Lake in the northwestern corner of the county. It was derived almost entirely from basaltic materials, although a scattering of glacial gravel occurs in places. Runoff is slow, and internal drainage is medium. The native growth is a mixed stand of Douglas-fir, cedar, hemlock, alder, maple, willow, dogwood, and cascara.

Profile description.—The surface soil extends to a depth of 6 inches; it is a friable dark reddish-brown loam that contains some small rounded and subangular basaltic gravel. Its structure is medium granular. This layer grades into friable, granular, similar-colored material that contains more basaltic gravel.

At a depth of about 18 inches, there is friable reddish-brown or yellowish-red gravelly loam that contains a varying amount of gravel. Some yellow mottling occurs in this layer.

Below 36 inches, the material is stratified, gravelly loam, sandy loam, and sandy clay that has a subangular and angular structure. In some places part of the gravel is of glacial origin.

The soil varies in texture and in amount of gravel. Some areas have considerable gravel in the surface soil and subsoil; others have very little above depths of 4 feet. These variations occur in a spotty fashion. The gravelly areas are only a few feet in diameter.

Use and management.—Probably less than a third of this soil has been cleared for farming. It is productive for most crops and is similar to the Eld soils in use, crop yields, and management. Most of the areas are small and normally do not adjoin other soils suitable for agriculture.

Wadell silty clay loam, 0 to 3 percent slopes (Wb; group 7).—This soil occupies small alluvial stream bottoms and fans. It occurs mainly along Wadell Creek northwest of Little Rock. The creek has a narrow valley floor. The soil is similar to Wadell loam, 2 to 5 percent slopes, but differs in having less variation in the distribution and amount of gravel in the upper part of the profile.

Profile description.—For 10 to 12 inches the surface soil is friable dark reddish-brown silty clay loam that has medium granular structure. This layer grades into friable dark reddish-brown silty clay that has a slightly developed angular fine blocky structure.

Between depths of 36 to 48 inches, the material is slightly mottled yellowish-red silty clay that contains some angular basaltic gravel. Below a depth of 48 inches is the substratum of stratified gravelly sandy clay, loam, and sandy clay. In the substratum the amount of gravel ranges from very little to almost all of the material. The gravel is subangular and rounded basalt.

Included are small areas adjacent to the stream channel that consist of more recently deposited material. The soil in these areas has a more sandy subsoil and substratum than the typical soil. Most of the areas along Wadell Creek are narrow and small, and they vary considerably in the lower part of the profile. Also included are small seep areas.

Use and management.—Areas of this soil are small and scattered and not associated with those favorable for agriculture. Only a very small acreage is culti-

vated. This is mainly used for pasture and hay crops. The soil is productive, and yields correspond to those on Eld silty clay loam, 0 to 2 percent slopes.

Wapato silty clay loam, 0 to 2 percent slopes (Wc; group 8).—This soil occupies back bottoms or nearly level poorly drained areas. It is associated with the Chehalis soils and developed from shale, sandstone, and basaltic materials similar to those from which Chehalis soils were derived. The soil is widely distributed in valleys along streams and rivers in the southern, western, and central parts of the county.

Profile description.—The surface soil to depths of 8 to 10 inches is very dark grayish-brown silty clay loam that has some rust-brown mottling in the lower part. This layer has a coarse granular structure and is plastic when wet.

The surface soil grades into a subsoil of slightly compact olive-gray to dark olive-gray silty clay to clay, highly mottled with reddish brown and yellow. At depths of 22 to 26 inches, there is a tight, very plastic, olive-gray clay, less highly mottled than the layer above.

Below a depth of 36 inches, the material becomes slightly less plastic and is slightly grayish blue and highly variable in degree of mottling. The texture gradually becomes coarser as depth increases. Some stratification of materials occurs in the substratum. Purplish manganese stains appear in the subsoil and substratum. The profile is slightly acid.

In the main valleys, this soil occurs in rather large areas and is fairly uniform. In many of the smaller tributary valleys that contain mainly Wapato soils, some variation in color and other profile characteristics occur. In the smaller valleys, stratified materials and coarser textures are more common in the subsoil and occur closer to the surface. A more uniformly brown surface color also occurs in some places, but in these the highly mottled gray subsoil is just beneath the surface soil. Included are small areas having silt loam surface soils.

Use and management.—Nearly all of the timber has been cut, and a large part of the soil is used for cultivated crops and pasture. Uncleared areas support Douglas-fir, cedar, hemlock, and dense growths of ash, alder, maple, brush, and shrubs. The brushy growth includes vine maple, wild rose, serviceberries, snowberries, willow, spirea, blackberries, and some sedges.

The principal crops are oats, wheat, hay, and pasture. Permanent pasture does well and affords grazing through the summer in all but the driest years. Mixtures for pasture are normally similar to those for hay, but orchardgrass and Kentucky bluegrass are added. In the wetter areas, Reed canarygrass grows very well and is recommended.

The low position of this soil and its clay subsoil cause very slow runoff and internal drainage. Drainage of excess surface water is usually necessary before cultivated crops can be grown successfully. The soil stays wet and cold longer than the Chehalis soils. In the drier years the greater moisture in summer is beneficial, and crop yields in these years may be higher than on the Chehalis soils.

This soil is relatively fertile. Saturation during the winter months is the main disadvantage, and this causes late preparation of the seedbed and late maturing of the crops. Some areas are tile drained so that they may be worked earlier. Barnyard manure and superphosphate are the principal amendments used.

Wilkeson silt loam, 3 to 15 percent slopes (Wd; group 2).—This soil occupies rolling areas along the lower borders of the mountainous land in the southeastern part of the county. Only about 170 acres were mapped, and this occurs southwest of Elbe as an extension from much larger acreages in Lewis County.

In Thurston County this soil occurs at elevations of about 1,200 feet. It is older, more compact, more strongly acid, and has a yellower color than the associated Cinebar soil of Lewis County, which, in other respects, it closely resembles. The parent material appears to have been derived from fine-grained pumice that has been modified by glacial action. The pumice was deposited in a way similar to that of the Cinebar material, but at an earlier period.

Profile description.—Under virgin conditions an organic layer 1 to 2 inches thick overlies the mineral soil. The surface soil to depths of 15 to 18 inches is a friable brown to dark-brown silt loam that contains many small, soft, spherical shot. This layer is medium acid.

The upper subsoil, extending to depths of 30 to 36 inches, is dark yellowish-brown gritty loam or clay loam that contains many small shot. This part of the subsoil is firm but breaks into small irregular aggregates. The lower subsoil is a lighter yellowish-brown silty clay that has some faint mottling of yellow and spots of light gray. This material is slightly compact but easily breaks into irregular aggregates. Small pumice fragments give it a variegated appearance.

The subsoil grades into a substratum of yellowish-brown silty clay. In small areas remnants of a cemented gravelly till substratum may occur under this layer. Angular and subangular pebbles and stones and a few boulders are commonly scattered on the surface and throughout the soil profile. These fragments come mainly from basic igneous rocks but to a limited extent from granitic rocks.

Use and management.—None of this soil is farmed in Thurston County, and very little is farmed in Lewis County (*4*). The growing season is much shorter at the high elevations of this soil. As for the Cinebar soils of Lewis County, supplies of organic matter and nitrogen are deficient and these nutrients must be added for successful crop production. Crops respond well if phosphorus and manure or phosphorus and nitrogen fertilizer are applied. Despite the high acidity of the soil, response to lime is poor. This soil is best suited to forestry. It restocks well, principally to Douglas-fir and hemlock.

Additional Facts About Thurston County

Industries

For almost 100 years lumbering has been the chief activity in Thurston County. The manufacture of wood products is the leading industry. Factories that pro-

duce wood commodities and other important industries are centered at Olympia. Three plants manufacture plywood and veneer from Douglas-fir, most of which is imported from other Washington counties and from out of the State.

Because most of the virgin timber in the county has been cut, the number of sawmills has declined during the last 2 decades, and only 3 sawmills now operate. Two mills manufacture cedar shingles at Olympia. A small tie mill and several lumber mills are located in the timbered areas. The trend is from the operation of sawmills to the production of wood specialties. There is 1 furniture factory in the county. About 1,200 people are employed in the wood specialty industries.

Three canneries process fruits and berries in the Olympia area. Recently 1,200 people have been employed at these canneries during the peak season. Oysters are cultivated and exported. Two creameries manufacture dairy products, and the Washington Egg Producers Co-op Association collects eggs and sells them wholesale.

In 1944 about 50 people made metal specialties, tools, dies, and concrete products. A brewery at Tumwater employed 140 people.[5] Coal was mined near Tono, and near Bucoda other coal mines were being prepared for operation. Many people who work in Olympia have small subsistence farms. They grow fruits and vegetables; some raise a few cows and chickens.

Transportation and Markets

Thurston County is served by several railroads. The main line from Seattle to Portland, Oreg., runs north and south in the central part of the county through the towns of Bucoda, Tenino, and East Olympia. This line is used jointly by the Northern Pacific, the Great Northern, and the Union Pacific. Among the several branch lines are the Grays Harbor line of the Northern Pacific and the Grays Harbor line of the Chicago, Milwaukee, St. Paul, and Pacific Railroad. A logging railroad from the mountainous section southeast of Vail passes between Olympia and Lacey and ends at the log dump on Henderson Inlet. The county is served by water transportation through docks and harbor facilities at Olympia.

The Pacific Highway, United States No. 99, crosses the county through Nisqually, Olympia, Tenino, and Grand Mound and connects the area with the principal Pacific Coast cities. United States Highway No. 101 runs from Aberdeen around the Olympic Peninsula and enters the northwestern part of Thurston County to end at Olympia. Olympia is connected with Aberdeen by United States Highway No. 410. At Elma this highway intercepts State Highway No. 9 that runs northward from Grand Mound. Except for the mountainous areas, all sections have surfaced and graveled all-weather highways that are kept in good repair. Some county roads are being paved.

The principal farm products sold are milk, cream, eggs, livestock, poultry, fruit, and vegetables. These products are sent to Olympia and other local markets, and to Tacoma, Seattle, Centralia, and Portland. Milk and egg routes cover the main farming area, and collections are made as often as once a day. Farm products are processed in Olympia in creameries, ice-cream plants, slaughterhouses, canneries, and a brewery.

[5] The Olympia Chamber of Commerce furnished the statistical information for Olympia and Thurston Counties in 1944.

Cultural Development and Improvement

Grade and high schools serve the populous areas of Thurston County, and consolidated schools, the less populous sections. School buses serve outlying areas. St. Martin's College near Lacey is the only college in the county. The public library at Olympia extends its services throughout the county by a traveling bookmobile.

The dwellings range from unpainted log or lumber cabins to the most modern wood, brick, stone or cement-block houses. The outbuildings are often unpainted, but on the dairy and poultry farms they are generally well built, modern, painted, and in good repair. The farms normally are adequately fenced with woven or barbed wire, but there are a few rail fences. Most homes have electricity and running water. Telephone and power lines extend to all parts of the county, and in 1950 about 90 percent of the farms had electricity. Along the Nisqually River, hydroelectric plants produce power near Alder, La Grande, and Yelm. These plants supply power to Tacoma and Centralia and outlying districts. Modern conveniences are common on farms throughout the county.

Churches of various denominations are established in Olympia and other centers of population. Rural mail delivery is provided in all settled communities. Grange or other community halls occur throughout the rural sections. Various farm organizations and farm-cooperative associations operate in the county.

Puget Sound and many lakes throughout the county offer good fishing, boating, and swimming. Many summer homes and resorts occupy the shores of the lakes and Puget Sound. The most important lakes are Black, Chambers, Long, St. Clair, Patterson, Deep, Clear, Offutt, and Lawrence. South of Olympia on the north shore of Deep Lake, Millersylvania State Park offers camping and picnicking facilities.

Land Use and Farm Tenure

The number, acreage, and tenure of farms in Thurston County are given in table 6. Because of the high cost of clearing and the large proportion of poor agricultural soils, the total land in farms and the amount of improved land per farm are very small.

A rapid increase in the number of farms and land in farms continued until about 1935; the greatest increase was before 1900. Generally, the number of farms has increased more rapidly than the acreage of land in farms; the average size of farms therefore has decreased. But between 1945 and 1950 the trend was reversed. The acreage in farms increased, and the

TABLE 6.—*Number, acreage, and tenure of farms*

Year	Farms	Land in farms	Proportion of county in farms	Acreage per farm	Total improved land	Improved land per farm	Tenure			
							Full owners	All tenants	Part owners	Tenancy
	Number	*Acres*	*Percent*	*Acres*	*Acres*	*Acres*	*Number*	*Number*	*Number*	*Percent*
1930	2,082	143,378	31.6	69	[1] 45,784	22	1,772	188	105	9.0
1940	2,876	177,885	38.7	62	[2] 56,979	20	2,398	328	141	11.4
1950	2,022	170,640	37.2	84	[3] 57,361	28	1,746	94	177	4.6

[1] 1929. [2] 1939. [3] Cropland only for 1949.

number of farms sharply decreased. During this 5-year period, the average acreage per farm increased from 54.4 to 84.4 acres.

The acreage of improved land has slowly increased, but it is still a small part of the total land area. The acreage of improved land per farm is small because many subsistence farms near Olympia consist of less than 10 acres. The trend, particularly before 1945, was for city workers to move beyond the city limits and establish homes on small tracts, where they have gardens and a few cows or chickens.

The farms are classified by size in table 7. From 1920 until 1945 the number of farms operated by full owners steadily increased. Although the number of full owners decreased from 1945 to 1950, tenancy also decreased and fell to a low of 4.6 percent. During this 5-year period the number of part owners almost doubled.

In 1950 about 46 percent of the farms in Thurston County were smaller than 30 acres. These small farms are largely the part-time farms near Olympia on Giles, Kitsap, Lynden, and Alderwood soils and farms scattered throughout the county on gravelly glacial soils of low fertility. The farmers on these small farms depend upon some outside work for their principal source of income.

The large farms are on soils formed from sandy glacial outwash and on soils of the alluvial flood plains.

TABLE 7.—*Farms classified by size and number*

Size of farm	Number of farms	
	1940	1950
Under 10 acres	640	322
10 to 29 acres	976	610
30 to 49 acres	430	309
50 to 69 acres	140	144
70 to 99 acres	239	172
100 to 139 acres	124	116
140 to 179 acres	111	105
180 to 219 acres	61	57
220 to 259 acres	40	42
269 to 379 acres	57	[1] 94
380 to 499 acres	17	----
500 to 699 acres	25	[2] 39
700 to 999 acres	7	----
1,000 acres and over	9	12

[1] 260 to 499 acres. [2] 500 to 999 acres.

Some dairy farms on upland depressional soils that are associated with better drained glacial soils are much larger than the average farm. The farms with the largest acreage of improved land are on the Nisqually soils. On these farms the soil is used primarily for grain, but some is used for hay and pasture.

In 1949, about 12.5 percent of the total land area of 458,880 acres was cleared for crops or pasture. The rest of the land area remains in timber, brush and stumps, or wooded pasture, or it is wasteland. Since 1920, the acreage used for grain crops has decreased, and the acreage used for hay and pasture crops has increased. In 1949 about 45 percent of the land in farms, or about one-sixth of the total land area, was used for permanent pasture, both open and wooded. Approximately 33 percent of the farmland is cropland, including cropland used for pasture. The cropland is primarily used for hay crops, of which small grains cut green are the most important. About 18 percent of the farmland is woodland not pastured. The remaining 4 percent is occupied by farmsteads, roads, and other works of man.

Crops

The acreage and production of the principal crops in Thurston County in stated years are given in table 8.

The production of hay has increased consistently, and in 1949 hay occupied a larger acreage than any other crop in the county. The acreage in grains was second largest. Compared with that of other crops, the acreage of fruits and nuts is small.

Most of the hay consists of small grains cut green. Oats is the principal grain used for hay. The second most important hay crop is timothy and clover, grown either alone or together. Alfalfa and annual legumes became important after 1930, but they are now grown on only a small part of the land. Because of the cool and dry summers little corn for silage is produced.

Oats is by far the most important cereal crop, but the acreage in oats decreased about 20 percent from 1939 to 1949. Wheat, barley, and rye are of minor significance. More than half the wheat is winter wheat, which has much higher average yields than spring wheat. The cereal grains are grown on the prairie soils, mainly Nisqually loamy sand, other sandy glacial outwash soils, or alluvial soils.

TABLE 8.—*Acreages of principal crops in stated years*

Crop	1929	1939	1949
	Acres	*Acres*	*Acres*
All hay	14,662	18,982	15,206
Small grains cut for hay	4,958	8,504	4,360
Timothy and clover, alone or mixed	3,240	3,428	5,874
Alfalfa	31	284	337
Annual legumes	1,289	1,247	(1)
Other tame hay	4,005	4,463	2,121
Wild hay	1,149	1,056	2,543
Oats:			
Threshed	2,916	4,149	3,345
Unthreshed	447	224	660
Corn:			
For grain	54	12	16
For silage	127	327	51
For other purposes	156	252	26
Wheat threshed	1,045	547	1,238
Barley threshed	173	168	180
Rye threshed	619	656	227
Irish potatoes	369	167	54
Berries for sale:			
Strawberries	1,439	948	305
Raspberries	807	464	462
Blackberries and dewberries	47	15	22
Gooseberries	24	19	(1)
Loganberries	48	37	(1)
Youngberries	(1)	33	[2] 31
Tree fruits, nuts, and grapes[3]:	*Number* [4]	*Number* [4]	*Number* [4]
Apple trees	22,344	17,322	11,365
Cherry trees	23,656	20,228	8,404
Pear trees	6,019	3,874	2,146
Plum and prune trees	12,218	9,298	2,906
Grapevines	2,567	5,664	6,913
Filbert and hazelnut trees	341	5,239	7,827

[1] Not reported.
[2] Includes boysenberries and loganberries.
[3] Of bearing age.
[4] Number in census year, which is one year later than the crop year given at the head of column.

Formerly potatoes were an important crop but, because of diseases, insects, and low prices, few are now grown to be sold. A small acreage of potatoes is grown for home use.

Fruit orchards, vineyards, and planted nut trees occupied 1,223 acres in 1939, but this acreage fell to 898 in 1950. Low prices and lack of markets caused the sharp decline in the production of fruits. Cherries and apples are the principal tree fruits, and grapes and nuts are fairly important.

In 1939 Thurston ranked fifth among the counties of Washington in the production of strawberries, but from 1939 to 1949 production fell from 1,368,855 to 565,125 pounds. Recently the acreage of strawberries on the Nisqually soils has increased. The Prather, Lynden, and Giles soils also have significant acreages in strawberries. The second most important small fruit is raspberries, but from 1929 to 1949 the acreage of raspberries decreased about 40 percent.

Most of the cereal grains are used on the farms that grow them or are sold as feed to dairy and poultry farms. Hay is also used largely on the farms that produce it, but some is sold to local dairies. Strawberries, raspberries, and other small fruits are sold to the local canneries. Much orchard fruit is used at home, but some is sold to local markets and canneries.

Rotations and Fertilizers

Suggestions on fertilization of most soils and crops are available in the office of the county agricultural agent or in publications by the State College of Washington Experiment Stations.

Farmers in this county buy little fertilizer or lime. Manure is the most common fertilizer, and it is applied mainly to hay and pasture crops. The most common fertilization for pasture and hay is 6 to 15 tons of manure and 300 to 400 pounds of 18- or 29-percent superphosphate per acre.

Rotations are not practiced systematically. On the dairy farms, after pasture is grown for 2 or 3 years, part of the pasture land may be used for a cultivated crop such as corn or peas grown for canning. Frequently after 2 or 3 years, pastures are plowed and seeded to oats. No systematic rotations are used for the fruit and nut orchards. Commercial fertilizers should be used for vegetables and small fruits and for fruit and nut orchards.

Pastures and Hay Crops

Pastures in Thurston County occupy more farmland than all other crops combined. The plowable pastures are confined primarily to alluvial soils and organic soils of the depressions. The better drained upland soils generally are used only for early pasture, but the depressional soils have sufficient moisture for fair to good pasture throughout the summer. The soils derived from alluvium, such as the Sultan, Chehalis, Newberg, Eld, and Wapato, are excellent for pasture. Wooded pasture is used together with plowed pasture and is confined primarily to the glacial upland soils such as the Kapowsin, Alderwood, and Cathcart. The carrying capacity of these areas of wooded and plowed pasture varies greatly, and depends on the amount of brush and stumps that occur.

Land used for hay is closely associated with that used for plowable pasture. Normally hay is grown on the most fertile soils in the county. In 1949 about one-fourth of the cropland of the county was used for hay.

In preparation of a pasture, two or three cultivated crops should be grown to clear the land of weeds before it is seeded to pasture. Early spring seeding is suggested. Cultivated soils that are sufficiently drained should be seeded in March or April. The seeding of unplowed or partially cleared soils is safest in February. Depending on the soil, the amount of grass seed sown ranges from 20 to 24 pounds per acre.

The following grasses and legumes can be used for forage on alluvial soils and depressional soils of the upland: Alta fescue, Italian ryegrass, English ryegrass, orchardgrass, Kentucky bluegrass, whiteclover, red clover, and alsike clover. On the upland and terrace soils, the following species are satisfactory: Alta fescue, Italian ryegrass, English ryegrass, tall meadow ryegrass, orchardgrass, Kentucky bluegrass, red clover, whiteclover, alsike clover, and subterranean clover.

When grains are used as nurse crops for a pasture seeding, one-half or two-thirds of the normal seeding for the grain is used. Nurse crops are not desirable

for the droughty soils. For soils not suited to crops because they stay wet during much of winter and spring, Reed canarygrass is suggested. A mixture of meadow foxtail and big trefoil also has proved satisfactory for wet lands. Ten pounds of seed to the acre will produce a good stand and, when established, a pasture of high carrying capacity. Pastures should be fertilized regularly. A practical application consists of 6 to 8 loads of manure and 300 to 400 pounds of superphosphate per acre.

When grasses and legumes are used for hay and not for pasture, alsike clover mixed with Alta fescue or Italian ryegrass is suggested. Red clover may be substituted for alsike clover, but it is not so well suited to imperfectly drained soils. Timothy may replace Italian ryegrass, but the ryegrass makes better hay for dairy cattle. A popular grain-legume mixture for hay is gray winter oats and hairy or common vetch. Much of the hay is oats grown alone or in a mixture. Spring oats sown with field peas is suggested for the less droughty soils.

Livestock and Livestock Products

The number of livestock in Thurston County in stated years is given in table 9. The raising of livestock and the processing of livestock products are the most important enterprises related to farming. Dairy farming is the principal activity.

The dairy cattle are Guernsey, Holstein, and Jersey, or mixed breeds. Most of the dairy farms are south of Olympia and in the Yelm district, but some are scattered throughout the county. Generally they are in areas where the soils are suited to hay and pasture. Except for grain, most of the dairy farms grow their own feed. The dairy products have been sold largely as whole milk or butterfat, but recently because of a regular pickup service, most dairy farmers sell whole milk.

Poultry raising is the second most important farm activity. The location of poultry farms has no definite relation to the soils because most of the feed is bought from local stores or farmers. Many farmers raise poultry in conjunction with other activities. Most of the poultry products are sold locally. Formerly turkeys were unimportant, but since 1935, the number of turkeys has sharply increased.

TABLE 9.—*Number of livestock on farms in stated years*

[Livestock of all ages, unless otherwise indicated by footnote]

Livestock	1929	1939	1949
	Number	*Number*	*Number*
Horses and colts	[1] 1,704	[1] 2,053	[2] 1,203
Cattle and calves	[1] 12,592	[1] 14,905	15,765
Hogs and pigs	[1] 1,432	[3] 3,090	3,607
Sheep and lambs	[4] 3,153	[4] 1,570	1,263
Chickens	[1] 156,976	[3] 141,053	[3] 117,767
Turkeys	5,312	24,516	35,745

[1] Over 3 months old.
[2] Including ponies.
[3] Over 4 months old.
[4] Over 6 months old.

Types of Farms

In 1950 there were 1,349 miscellaneous and unclassified farms. The rest were classified by type as follows:

	Number of farms
Fruit-and-nut	39
Field crop other than vegetable and fruit and nut	10
Vegetable	14
Dairy	279
Poultry	183
Livestock other than dairy and poultry	77
General	71

The farmers on most of the farms listed as miscellaneous and unclassified produce primarily for their own use. These farmers depend chiefly upon nonfarm activities for cash income. Many of these small farms are near Olympia, and the land is used mainly as a place to live.

Farm Expenditures

The greatest farm expenditure is for feed for domestic animals and poultry. The next largest expenditure is for labor. Most of the laborers work on the dairy farms or the large diversified farms. Little money is spent for fertilizer.

Soil Survey Methods and Definitions

The scientist who makes a soil survey examines the soils in the field, classifies them in accordance with facts that he observes, and maps their boundaries on an aerial photograph or other map.

Field study.—The soil surveyor bores or digs many holes to see what the soils are like. The holes are not spaced in a regular pattern but are located according to the lay of the land. Usually they are not more than a quarter of a mile apart, and sometimes they are much closer. In most soils such a boring or hole reveals several distinct layers, called horizons, which collectively are known as the soil profile. Each layer is studied to see how its profile differs from others and to learn the things about the soil that influence its capacity to support plant growth.

Color is usually related to the nature of the parent material, the degree of oxidation, the content of organic matter, or to all three factors. The darker the surface soil, as a rule, the more organic matter it contains. Streaks and spots of gray, yellow, and brown in the lower layers generally indicate poor drainage and poor aeration.

Texture depends upon the amounts of sand, silt, and clay that a soil contains. In the field it is determined by the way the soil feels when rubbed between the fingers. Texture influences how well the soil retains moisture, plant nutrients, and fertilizer and whether the soil is easy or difficult to till.

Structure, or the arrangement of the individual soil particles in the larger grains and the amount of pore space between the grains, gives us clues as to the ease or difficulty with which the soil is penetrated by roots and moisture.

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

Classification.—On the basis of the characteristics observed by the survey team or determined by laboratory tests, soils are classified into phases, types, and series. The soil type is the basic classification unit. A soil type may consist of several phases. Types that resemble each other in most of their characteristics are grouped into a soil series.

As an example of soil classification, consider the Alderwood series. This series is made up of two soil types, which are placed in phases as follows:

Series	*Type*	*Phase*
Alderwood	gravelly loam	3 to 8 percent slopes.
	gravelly sandy loam	0 to 3 percent slopes.
		3 to 15 percent slopes.
		15 to 30 percent slopes.
		30 to 50 percent slopes.

The phase of most soils of Thurston County is determined by slope, but Mukilteo peat, shallow over dense clay, 0 to 2 percent slopes, is one of several exceptions.

Soil type.—Soils similar in kind, thickness, and arrangement of soil layers are classified as one soil type.

Soil phase.—Soil types may be divided into two or more phases to show significant differences in slope, stoniness, degree of erosion, depth to bedrock, or other features. Spanaway gravelly sandy loam, mound phase, 2 to 10 percent slopes, is a separate phase because of its characteristic mounds.

The soil phase (or soil type if it has not been subdivided) is the unit shown on the soil map. It is the unit that has the narrowest range of characteristics. Use and management practices therefore can be specified more easily for the soil phase than for the soil series or for yet broader groups that contain more variation.

Soil series.—Two or more soil types that differ in surface texture, but are otherwise similar in kind, thickness, and arrangement of soil layers, are normally designated as a soil series. In a given area, however, it frequently happens that a soil series is represented by only one soil type. Each series is named for a place near which the soil was first mapped.

Miscellaneous land types.—Fresh stream deposits, and rough, stony, and severely gullied land that have little true soil are not classified into types and series but are identified by descriptive names such as Riverwash or Rough mountainous land, Melbourne soil material.

Soil complex.—When two or more soils are so intricately associated in small areas that it is not feasible to show them separately on the soil map, they are mapped together and called a soil complex. This is true of the Tromp-Tisch complex, 0 to 3 percent slopes.

Morphology and Genesis of Soils

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

Except for the mountainous areas, the parent materials, although differing widely, are largely glacial deposits of various lithologic composition. Most of the soils of the county have been formed by dynamic forces of environment acting on these glacial deposits. Climate and vegetation are the chief environmental factors. The effects of these forces have been retarded or modified by impaired drainage and unfavorable relief. The soils have developed under the influence of forest vegetation and precipitation, which ranges from about 40 inches in the northeastern corner of the county to 70 inches in the mountainous areas. Most of the county receives 45 to 50 inches of precipitation a year. Little effective rain falls between mid-June and mid-September. At the lower elevations, the ground is only occasionally frozen and then only for short periods.

In most of the county the native vegetation consists of a dense growth of conifers with a ground cover of mosses, ferns, and shrubs. The conifers are largely Douglas-fir, hemlock, cedar, and some spruce; the deciduous trees are mainly alder and western maple. Deciduous trees and brush are common in the stream valleys and depressions. Several local areas in the county are prairies. The soils of these areas have developed under grasses instead of forest.

Geological outcroppings in Puget Sound Basin are of Tertiary age. In the past, land and water areas in the Puget Sound region constantly shifted and fresh and salt water frequently changed positions (*2*). In this region, the Pliocene period was primarily a time of uplifting movement and subsequent erosion.

In the succeeding Pleistocene period, three stages identified with glacial encroachment occurred.—Admiralty (glacial), Puyallup (interglacial), and Vashon (glacial). Good exposures of the Admiralty till are rare; and, where exposures are positively identified, they are not deeply weathered except in a few places where they have been stained by percolating water. A good exposure occurs in Cole Point on Anderson Island in Pierce County.

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

The latest glacier, the Vashon, advanced on Puget Sound from the north as did its predecessor, the Admiralty. The glacier extended at its maximum as far and farther south than the Admiralty; in no known instance did the Admiralty extend farther than the Vashon. The Vashon glacier extended to the south-

ern part of the county, and in many places the glacial deposits have only thinly mantled the glacier-scoured Miocene and Eocene sedimentary strata and Miocene extrusives, largely basalt and andesite. This condition occurs in the western part of the area and in several of the hilly and steep areas in the south-central part of the county. Vashon terminal moraines occur east of Delphi and northwest of Yelm. Glacial outwash covers many areas throughout the county and extends a few miles into Lewis County through the Chehalis River valley.

The parent materials of the Wilkeson, Salkum, and Prather soils, are believed to have resulted from local glaciation from Mt. Rainer (*2*) (*4*). The area covered by these materials is small but is much more extensive in Lewis and Pierce Counties (*1*) (*4*). These materials are old, and the weathering of the soil material has been severe and has occurred for a much longer time than on the Vashon glacial deposits.

Mountainous areas in the western and southeastern part of the county are composed of sedimentary and basic igneous rocks of Tertiary age. The sedimentary rocks consist of shales and sandstones; the igneous rocks consist of basalt and andesite.

A classification of all the soil series in Thurston County, according to orders and great soil groups, is shown in the following list:

Zonal soils:

- Zonal soils:
  - 1. Brown Podzolic:
    - Alderwood
    - Cathcart
    - Elma
    - Everett
    - Giles
    - Grove (*3*)*
    - Indianola
    - Kapowsin
    - Kitsap
    - Lynden
    - Tenino
    - Wilkeson
  - 2. Podzol:
    - Greenwater
  - 3. "Brown lateritic-like":
    - Bucoda
    - Delphi (*1*)
    - Melbourne
    - Olympic
    - Prather
    - Salkum
- Intrazonal soils:
  - 4. Humic Gley:
    - Bellingham
    - Everson (*5*)
    - Galvin
    - McKenna
    - Norma
    - Reed
    - Snohomish
    - Tisch
    - Wapato
  - 5. Ground-water Podzol:
    - Edmonds
    - Tromp (*1*)
  - 6. Planosols:
    - Meskill (*4*)
  - 7. Organic:
    - Greenwood
    - Mukilteo
    - Rifle
    - Semiahmoo
    - Tacoma
- Azonal soils:
  - 8. Alluvial (well to poorly drained):
    - Camas
    - Chehalis
    - Eld
    - Maytown
    - Newberg
    - Pilchuck
    - Puyallup
    - Puget (*4*)
    - Shuwah (*9*)
    - Sultan
    - Wadell (*3*)
  - 9. Regosol:
    - Fitch (*1*)
    - Nisqually
    - Spanaway
    - Tumwater (*1*)

* Arabic number in parentheses indicates great soil group in which some type, phase, or mapping inclusion of the series may also be classified or to which it is transitional.

Many of the soil series have not been sufficiently studied to indicate definitely that they are distinctly one great soil group and not another. It is possible that in time some of the soil series now listed under one great group may be changed to another group, or a new great soil group name may be given to them. Some of the great soil groups used in this report are only suggested names and are subject to change. These names are in quotation marks.

Zonal Soils

Zonal soils are any one of the great groups of soils having well-developed soil characteristics that reflect the influence of the active factors of soil genesis—climate and living organisms, chiefly vegetation.

Brown Podzolic

The Brown Podzolic soils are 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. These soils reflect chiefly the effects of climate and vegetation in their development. Both winter and summer temperature and the amount and distribution of the precipitation have had a marked influence on soil development.

The Brown Podzolic soil zone includes the Puget Sound Basin where the mean annual precipitation ranges from about 31 to 60 inches; the average January temperature ranges from about 33° to 38° F.; and the average July temperature ranges from about 60° to 63°. Summer is relatively dry; spring, fall, and winter are wet. Brown Podzolic soils in Thurston County receive slightly more rain than soils of the same great soil group in Pierce and King Counties.

Within this area, most of the soils have well-defined characteristics when developed under timber cover from open permeable materials on smooth relief and under adequate external and internal drainage. A very dark grayish brown (10YR 3/2)[6] or very dark brown (10YR 2/2) very friable, very strongly acid (pH 5) organic layer 2 or 3 inches thick abruptly overlies the mineral soil. An incipient gray layer of mineral soil grades into a brown (10YR 5/3) coarse granular layer about 10 inches thick. This granular layer consists of water-stable aggregates that are dark brown (7.5YR 3/2) when moist. Color changes as the moisture of the soil varies, but this layer does not expand or contract greatly at the extremes of moisture. Many brown iron shots that range in size from that of a small pea to sand grains are concentrated in this layer, especially in the upper part. The layer has a pH of about 5.5. Next in profile is pale-brown (10YR 6/3) faintly granular material that is similar in texture and acidity to the layer above. This material is 10 to 20 inches thick. It is underlain by light yellowish-brown (10YR 6/4) or light-gray (10YR 7/2) parent material, which is generally strongly acid (pH 5.1 to 5.5). In many series, this layer is semi-indurated or indurated. There seems to be little or no clay accumulation in any horizon, but iron, manganese, and phosphorus appear to have accumulated in the shot.

[6] Color of dry soil unless otherwise stated; symbols express Munsell notations.

The presence of shot pellets in the upland soils seems to be typical of the normal profile. Wheeting (*8*) explains the formation of these pellets by precipitation and dehydration of soluble iron and aluminum compounds around nuclei of sand grains or gravel or other materials. This formation occurs during dry summers, because dry periods inhibit a general downward movement of the compounds and the formation of a clear-cut textural B horizon. The shot soils formed under forest vegetation and are best developed where internal drainage is restricted. These shot are richer in sesquioxides and particularly in phosphorus than the soil matrix surrounding them. They are considered as parts of a diffused B horizon scattered throughout the weathered part of the profile, because of the similarity in composition of B horizons in normal podzolic soils and the shot in these soils. Soils in Thurston County having this kind of profile are of the following series: Alderwood, Cathcart, Elma, Everett, Giles, Grove, Indianola, Kapowsin, Kitsap, Lynden, Tenino, and Wilkeson. The Kitsap and Kapowsin soils have a grayer surface soil and more mottled subsoil than the other members of the Brown Podzolic great soil group.

Examination of the more typical profiles of these soils shows that the soil-forming processes have not had sufficient time to change the parent materials greatly. Under a coniferous forest, the litter is high in bases, compared with the mineral soil below. This litter decomposes slowly and mixes very little with the mineral soil. The soil is low in available nitrogen and brown in color. Except at higher elevations having a cool climate and higher rainfall, the distinctly developed thick, continuous, gray A_2 horizon common to Podzols is absent or only faintly developed. Although organic acids may form, they may not be sufficiently effective in leaching, because of the mild, rainy season and the especially dry summer. The pH of the organic matter is seldom much below 5.0.

Although all the series in the Brown Podzolic group have some characteristics in common, each of the series differs from the others in some morphological characteristics that can be detected when examined and mapped in the field. The Elma, Everett, Giles, Indianola, Lynden, and Tenino soils have developed from loose to nearly loose glacial materials and do not differ greatly in morphological characteristics. They differ principally in textural character of the drift, in topographic position, and in relief.

The Everett, Grove, and Tenino soils have developed from similar gravelly drift, but they are separated on the basis of color and compaction in the substratum. The Everett and Grove soils are loose and porous, whereas the Tenino soils are more stony or cobbly and have slight compaction in the substratum. In addition, the position and topography of the series differ. The Everett and Grove soils occupy smooth topography of ground moraine and outwash terraces; the Tenino soils have more pronounced relief on terminal and recessional moraines that are ridgy, knoll-like, hilly, and steep.

The following is a profile description of Everett gravely sandy loam on gently rolling relief under coniferous forest.

A_0 1½ to 0 inch, very dark grayish brown (10YR 3/2), organic layer of partially decomposed needles, leaves, small twigs, moss, and roots; very strongly acid; very friable; lower part contains some very dark gray mineral matter.

B_{21f} 0 to 12 inches, brown (10YR 5/3), soft, granular, strongly acid gravelly sandy loam; very friable and dark brown (10YR 4/3) when moist; granules remain hard and durable in water for several minutes; layer contains some reddish-brown iron shot concretions that can be cut with a knife but cannot be crushed between the fingers.

B_{31f} 12 to 24 inches, yellowish-brown (10YR 5/4), very friable, strongly acid, single-grained gravelly loamy sand; contains a few shot in the upper part; gravel pieces are only slightly coated and stained with manganese, colloidal clay, and silica.

C_1 24 to 34 inches, light olive-gray (5Y 6/2), loose, strongly acid, gravelly coarse sand; gravel pieces are clean and free from stains.

C_2 34 inches +, pale-yellow (5Y 7/3), gray, yellowish-brown and olive, porous, poorly assorted sands, gravel, cobbles, and stones; strongly acid.

The Indianola, Lynden, and Giles soils differ from the Everett soils in that they have developed from sandy glacial materials and are nearly free of gravel. The Indianola soils differ from the Lynden soils in that they occupy rolling uplands and have slightly more soil development. The Lynden soils have developed on smooth glacial outwash terraces consisting of stratified sands, whereas the Indianola soils occur on kamelike deposits and eskers.

The Giles soils are similar to the Lynden soils except that they have stratified layers of very fine sands and silts in the lower subsoil and substratum, which add materially to the capacity to hold water. The Elma soils are similar to the Giles soils except that they have a gravelly subsoil and substratum.

The Alderwood soils differ from the Everett soils in having a slightly finer textured subsoil and, at a depth of 30 inches, a gray semicemented or indurated layer. This material may extend to a depth of 60 feet or more. The Alderwood soils may also be slightly more acid than the Everett soils. Soils of these two series may often occur side by side.

The Cathcart soils have developed from shallow Vashon drift over old consolidated sandstone and shale. These soils have a profile fairly typical of the Brown Podzolic soils, but they also resemble the Gray-Brown Podzolic soils and the Gray Wooded soils of Canada.

Kitsap soils have developed from laminated silts and clays of glacial lake deposits. They occupy gently sloping or level upland terraces. The surface runoff is adequate, but internal drainage is more restricted than for the other soils of the Brown Podzolic great soil group. Because of this moderately good drainage the surface soil is darker gray and not so brown as the typical surface soil of the Brown Podzolic group, and the subsoil is distinctly mottled. The color ranges from a mottled rusty yellowish brown and gray to brownish gray and yellowish brown. The restricted internal drainage apparently has retarded soil development, and the Kitsap soils have relatively shallow profiles, in which oxidation has been limited. This series has characteristics very similar to those of the Gray-Brown Podzolic soils.

The Wilkeson soils differ from all other Brown Pod-

zolic soils in Thurston County in that they have developed from silty materials of older age and occur in regions of higher rainfall and slightly cooler temperatures. A gray, leached A_2 horizon is evident but discontinuous, and a finer textured, slightly mottled but friable B horizon is present.

"Brown lateritic-like"

"Brown lateritic-like" is a tentative name given to soils of parts of western Washington (*4*) that have developed on the well-drained uplands and terraces under forest cover.

Soils of this group have a thin, dark-brown organic layer that overlies a fairly thick, brown to weak reddish-brown surface soil that is slightly darker in the upper part. The surface soil is medium acid, friable, and granular. It grades to a yellowish-brown, moderately permeable, granular subsoil that is not appreciably compact or enriched in clay or sesquioxides. Many spheroidal shots that vary in size from that of a small pea to a marble occur in the surface soil and the subsoil. The highly weathered parent material was derived from shale, sandstone, basalt rock, a matrix of softened gravel and clay, or rocks of mixed origin. The reaction is about pH 5.5 throughout the profile, but possibly slightly more acid with depth.

These characteristics are most strongly developed in the older soils of the uplands and less strongly developed in the more recent soils on glacial deposits in the western part of the area. The soil series tentatively classified as "Brown lateritic-like" soils are the Bucoda, Delphi, Melbourne, Olympic, Prather, and Salkum.

The following is a profile description of Prather silty clay loam, which is considered typical of this great soil group:

A_0 1½ to 0 inch, dark grayish-brown (10YR 4/2) organic layer of partially decomposed needles, leaves, twigs, cones, and moss; medium to strongly acid.

A_1 0 to 10 inches, brown (10YR 5/3), strongly granular silty clay loam that is dark brown (7.5YR 3/2) and friable when moist; contains many shot, which cannot be crushed between the fingers.

B_1 10 to 22 inches, light yellowish-brown (10YR 6/4) silty clay loam of subangular blocky or strong coarse granular structure; contains less shot than the layer above; dark yellowish brown (10YR 4/4) with a slight reddish tinge and firm when moist; plastic when wet; light-gray staining along the fracture lines.

B_{21} 22 to 35 inches, yellowish-brown (10YR 5/6) silty clay loam or silty clay that is streaked with gray, yellowish red, and brown along fracture lines; blocky structure; hard when dry, plastic when wet; aggregates are coated with colloidal material; moderately permeable to moisture and plant roots; when moist, layer is reddish brown (5YR 4/4) and firm.

B_{22} 35 to 45 inches, yellowish-red (5YR 5/6) silty clay loam to silty clay having sharp angular fracture lines coated with colloidal material; gray seams and variegations of red, yellow, and dark purple radiate through this layer; very firm and reddish brown (5YR 4/4) when moist; very plastic when wet; moderately permeable; grades into the layer below.

C 45 inches +, yellowish-red (5YR 5/6), highly variegated yellow, red, brown, gray, and purple silty clay or clay; massive; very strongly plastic when wet and firm when moist.

Generally the profile characteristics of the other soils placed in this group are similar to those of the Prather silty clay loam. The Delphi soils differ more than the others in that they have developed from gravelly glacial materials. These soils resemble the Everett and Alderwood soils in the Brown Podzolic great soil group but differ in having reddish-brown A horizons and B horizons that are more stained with reddish brown and yellow. They occur in a higher rainfall belt in the western part of the county, where they are closely associated with the Olympic soils.

Podzols

Only one series, the Greenwater, has been classified as Podzol. The Greenwater soils were derived from mixed coarse-textured river and glacial deposits influenced by pumice. These soils in places have a good Podzol profile, but in this area the profile has been so badly mixed by man's activity that the distinct gray A_2 layer has been destroyed.

Intrazonal Soils

Intrazonal soils are any of the great groups of soils having more or less well-developed soil characteristics that reflect the dominating influence of some local factor of relief, parent material, or age over the effect of the climate and vegetation. Each group of these soils may be found in association with two or more of the zonal groups.

The intrazonal soils in Thurston County have developed largely under conditions of excessive moisture in depressions or low-lying land throughout the county. Most of these soils are hydromorphic. Unlike the well-drained brown soils formed under coniferous forest or the very dark grayish brown soils formed under grass vegetation, these soils have developed under a dense growth of deciduous trees, brush, grass, and water-tolerant vegetation. This cover has given the soil large quantities of organic residues of high base content. Intrazonal soils have a dark-colored surface horizon and rust-brown, gray, and orange-colored mottling throughout the profile. The mottling is caused by poor oxidation that results from poor drainage.

The intrazonal soils of Thurston County are Humic Gleys, Ground-Water Podzols, Planosols, and Organic soils.

Humic Gley

The Humic Gley soils have developed in depressions, adjacent to seeped areas, or in areas with a high water table. They are water saturated in winter and spring and often throughout the summer. The soils have formed under forest cover from materials laid down as glacial till, outwash, or lake-laid sediments and alluvium. Excessive moisture has prevented develop-

ment of a zonal profile, and the soils are hydromorphic. They are dark colored, and the surface horizon of high organic-matter accumulation is a distinct feature. The substratum ranges from clay till and gravelly drift to glacial or postglacial outwash, lake-laid sediments, or alluvial sediments. The surface horizon is dominantly thick and dark grayish brown, very dark grayish brown, or dark gray; the underlying layers are iron stained or mottled with orange, rusty brown, yellow, or blue. These colors result from changes in moisture conditions, which promote alternate reduction, oxidation, and hydration.

The Humic Gley soils of Thurston County are of the Bellingham, Everson, Galvin, McKenna, Norma, Reed, Snohomish, and Tisch. All of these soils are somewhat similar in profile but the origin and characteristics of their parent material differ.

McKenna gravelly loam is representative of the Humic Gley great soil group. Following is a profile description of McKenna gravelly loam under grass and trees:

A_1 0 to 7 inches, very dark gray (10YR 3/1), very strongly acid, granular gravelly loam; nearly black and friable when moist and very slightly plastic when wet; slightly mottled with reddish brown and yellow; very highly organic.

B_{2g} 7 to 18 inches, light olive-gray (5Y 6/2), highly mottled gravelly loam or gravelly clay loam; olive gray (5Y 4/2) when moist; friable when moist and slightly plastic when wet; hard and difficult to penetrate when dry because of the slight cementing of the gravel and fine material.

C_g 18 inches +, gray (5Y 6/1), gravelly and stony sandy clay till; compact, mottled, and fairly resistant to penetration by water.

The Bellingham and Norma soils have a profile very similar to that of the McKenna soils except that the Norma soils have a medium-textured B horizon in contrast to the gravelly, stony texture of the McKenna B horizon. The B horizon of the Bellingham soils is finer textured and is more stratified than that of either the Norma or McKenna soils. Most of the Bellingham soils are stone-free and contain a very small amount of gravel.

The Everson soils have developed from sandy glacial outwash. They are hydromorphic associates of the Lynden and Giles soils. They resemble the other members of the Humic Gley great soil group and in places are associated with them, but the gleyed horizon is less pronounced. The soils of this series have some characteristics of Ground-Water Podzols.

The Galvin soils occur on alluvial fans and have developed from alluvial sedimentary materials, chiefly shales and sandstones. These soils are above flood stage and have developed a B horizon that is finer textured than the McKenna B horizon. This horizon is mottled and plastic.

The Tisch soil differs from the Bellingham soils in that it has a layer of diatomaceous earth that ranges from 4 to 24 inches thick and occurs in the upper 3 feet of the profile. In a few places the diatomaceous earth is many feet thick. The percentage of silica in this material ranges from 90 to 95 percent.

Ground-Water Podzols

The Ground-Water Podzols in Thurston County are of the Edmonds and Tromp series. These soils are not good examples of the Ground-Water Podzols, but their characteristics approach those of Ground-Water Podzols. The process of podzolization has not yet reached the stage of producing the true Ground-Water Podzol. These soils are more or less wet, and the excessive moisture has had a strong influence in determining the soil profile. They are closely related to the Custer soils, which are Ground-Water Podzols that occur in some other counties in Washington.

The Edmonds soil has developed from sandy glacial outwash material. It has a high water table. Generally its vegetation is luxuriant and includes grasses and sedges. This soil has a dark grayish-brown, highly organic, granular surface soil that distinctly overlies the ortstein layer. A podzolized A_2 horizon has not developed. In some places the ortstein layer is very well developed and hardened, but in other places it is less well developed; and fragmental pieces are highly dispersed throughout the very friable mottled sandy layers below.

The Tromp soil has developed from sandy glacial outwash materials in imperfectly drained depressions. The water table is high. The subsoil is softly cemented and iron stained to locally firmly cemented. The Tromp soil lacks the A_2 horizon of the Ground-Water Podzols and is similar to Brown Podzolic soils.

Planosols

In Thurston County only soils of the Meskill series are Planosols. These soils have a gray surface horizon over a distinct claypan and a thin, gray leached layer above the claypan. The soils of this series have some characteristics of the Humic Gley soils, such as a dark surface soil and a gray gleylike layer. There is, however, an abrupt claypan layer, which is characteristic of the Planosols.

The Meskill soils, hydromorphic associates of the Melbourne soils, developed from sedimentary materials, dominantly shale and sandstone. The soils occupy concave slopes or lower foot slopes below areas of Melbourne soils where seepage keeps the soil saturated. These soils have gray, granular, slightly mottled surface layers that overlie a thinner, lighter colored, more highly mottled layer. This highly mottled layer is abruptly transitional to a light olive-gray or light-gray, very plastic, dense clay of blocky structure. The aggregates are coated with lighter gray material. The claypan is underlain at variable depths by highly weathered shale or sandstone.

Organic soils

The Organic soils are intrazonal. They have a mucky or peaty surface horizon underlain by peat; they developed under swamp or marsh vegetation, mostly in a humid or subhumid climate. They occupy a considerable area and are important. These soils

were derived from organic remains of plants in various stages of decomposition. The type of plants and their stage of decomposition are important in determining the identification and classification of these soils. The soils have formed in low basins or shallow depressions where standing water or seepage results from a continuously high water table.

In the development of Organic soils, generally different kinds of plants succeed each other, and different kinds of soils are formed in the following order: (1) Aquatic vegetation in open water forms sedimentary peat; (2) sedges and reeds in open marshes form sedge peat; (3) brush, shrubs, trees, and water-tolerant vegetation of swamps and forest form the woody peat. The latter stages may be followed by sphagnum, hyphum, and other mosses after the bases become exhausted and the acid condition cannot be tolerated by the other plants.

Peats are organic soils in which the remains may be identified as partially decomposed fibers and matted materials. In Thurston County, there are woody (Rifle), sedge (Mukilteo), and moss (Greenwood) peats. The Greenwood peat is a highly acid, well preserved, sphagnum peat moss that is sold commercially but not farmed.

Mucks consist of well-decomposed, finely divided organic remains that are normally mixed with more or less mineral material. The fibers of the organic material cannot be readily discerned. The mucks mapped in Thurston County include the sedge muck, classified as Semiahmoo muck, and the Tacoma muck, which developed under salt-tolerant vegetation.

Azonal Soils

Alluvial soils

Because of their recent origin the soils of the alluvial flood plains do not have the developed profiles of the older soils. They are classified as Azonal soils. They were derived from relatively recent alluvium, and their character is determined largely by the nature of the parent materials and the manner in which these materials have been sorted and deposited.

The Alluvial soils of Thurston County are of the Camas, Chehalis, Eld, Maytown, Newberg, Pilchuck, Puyallup, Shuwah, Sultan, and Wadell series.

According to origin of the parent materials, these soils may be placed in two principal groups. The Camas, Chehalis, Eld, Maytown, Newberg, and Shuwah soils are derived from mixed basalt, sandstone, and shale rock materials. The Chehalis soils have a brown, very granular and friable surface soil and a brown, firm, and moderately permeable substratum. The Camas soils are similar to the Chehalis except they have a gravelly substratum. The Shuwah soil is darker colored than the Chehalis and has been influenced by prairie conditions. The Newberg soils are distinguished by a coarser textured surface soil and a sandy substratum and by occupying a more recent position adjacent to the stream channel.

The Puyallup, Pilchuck, Puget, and Sultan soils were derived from mixed materials. These materials are largely not of sandstone, shale, and basalt rock origin, but they commonly contain various amounts of glacial rock flour. The Puyallup soils are well drained. They have a grayish-brown, friable surface soil over a pale yellowish-brown upper substratum and a stratified olive-gray, pepper-and-salt lower substratum. The Pilchuck soils are more recent and more sandy. The Sultan soils occur under slightly restricted drainage and are mottled in the lower subsoil. The Puget soils are poorly drained and mottled throughout.

Regosols

In Thurston County these soils are in the grass-and-fern covered areas. These areas have a dark grayish-brown to black (moist), very friable granular, sootlike deep A_1 horizon over a brown, loose to very friable horizon that becomes more yellowish gray with depth. These soils have a pH of about 5.5 to 6 and do not have a horizon of clay accumulation. The outstanding difference between these soils and the soils of the Brown Podzolic group is in the color and feel of the upper 20 or 30 inches of the profile. The color is typical of soils with grass or fern vegetation. These areas may never have been forested. It is also possible that they were once forested, but that fires destroyed the trees and grass became established. Trees could not become reestablished on these droughty soils until recently, when the grass had been destroyed by overgrazing or by cultivation. There are clear indications that forests are encroaching on these prairies. In fact, one of the series in this group, the Fitch, is mostly under forest cover now, but it has only recently been forested.

According to Nikiforoff (*6*), this group of soils is referred to as the "black-brown" soils. He states that they may be regarded as a transitional link between the true Chernozems and the most weakly podzolized meadow soils of the forested belt. He also states that in spite of their very dark (often black) color, these soils do not belong to the group of true Chernozems but are classed as an independent group of soils.

In this group are the Spanaway, Nisqually, Fitch, and Tumwater soil series. The Spanaway soils have developed on a comparatively level glacial outwash of the Vashon glacier. This material is exceedingly porous and has 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 horizon is seldom thinner than 12 inches and in slight depressions may be more than 24 inches.

The following description of Spanaway gravelly sandy loam on a gently undulating site is representative:

A_1 0 to 14 inches, very dark grayish brown (10YR 3/2, black; 10YR 2/1, moist) gravelly sandy loam; high organic-matter content; finer material is very friable and has a sooty feel; structure is very fragile and not definite; surface inch or more is well-decomposed, black, sooty organic matter consisting largely of grass roots and moss.

AC 14 to 18 inches, very dark grayish brown (10YR 3/2) to dark brown (10YR 4/3) very friable gravelly sandy loam; very gravelly and stony.

C 18 inches +, porous, loose, poorly assorted light grayish-brown or light yellowish-gray gravelly sand and gravel; many stones as large as 6 inches in diameter.

Nisqually soils differ from the Spanaway soils in being free from gravel and stones. They generally occupy large areas associated with areas of Lynden and Tumwater soils or are in old channel courses within Spanaway areas. They rarely have hogwallow mounds, which are characteristic of the Spanaway soils. The name "Mima" mounds was first used for the mounds on the Spanaway soils, as Mima Prairies in Thurston County.

The Fitch soils usually occupy higher positions than those of Spanaway soils and are forested. They resemble Spanaway soils in being exceedingly gravelly and stony, but the surface color is dark grayish brown instead of the very dark grayish brown of the Spanaway soils. The Fitch soils are intermediate in color between the Spanaway and Everett series but resemble the Spanaway more closely. The dark grayish-brown surface layer is underlain by a loose, porous, gravelly substratum. Fitch soils occupy level to gently rolling positions. The series is believed to have been developed under the influence of grass vegetation, but the forest invaded the areas many years ago, and the soil developed a lighter color.

The Tumwater soils resemble the Nisqually soils in having developed from sandy glacial outwash but have been forested for an indefinite period, as have the Fitch soils, and have brown surface soils. Both the Fitch and Tumwater are intermediate between Regosol and Brown Podzolic soils.

Literature Cited

(1) ANDERSON, W. W., NESS, A. O., AND ANDERSON, A. C.
1955. SOIL SURVEY OF PIERCE COUNTY, WASHINGTON. U. S. Dept. Agr. Soil Survey Rpt., Ser. 1939, No. 27, 88 pp., illus.

(2) BRETZ, H. J.
1913. GLACIATION OF THE PUGET SOUND REGION. Wash. Geol. Sur. Bul. 8, 244 pp., illus.

(3) FENNEMAN, N. M.
1931. PHYSIOGRAPHY OF WESTERN UNITED STATES. 534 pp., illus., New York and London.

(4) FOWLER, R. H. AND NESS, A. O.
1954. SOIL SURVEY OF LEWIS COUNTY, WASHINGTON. U. S. Dept. Agr. Soil Survey Rpt., Series 1941, No. 10, 130 pp., illus.

(5) MANGUM, A. W., AND PARTY.
1912. RECONNAISSANCE OF SOIL SURVEY OF THE WESTERN PART OF THE PUGET SOUND BASIN, WASHINGTON. U. S. Dept. Agr. Bur. Soils Field Oper., 1910, pp. 1491–1600, illus.

(6) NIKIFOROFF, C. C.
1937. INVASION OF THE GREAT SOIL ZONES IN WESTERN WASHINGTON. Geog. Rev. 27 (2): 200–213, illus.

(7) STATE COLLEGE OF WASHINGTON.
1950. FERTILIZERS FOR WESTERN WASHINGTON. Wash. State Col. Ext. Bul. 386 [n. p.] Pullman, Wash.

(8) WHEETING, L. C.
1936. SHOT SOILS OF WESTERN WASHINGTON. Soil Sci. 41:35–44, illus.

Soils of Thurston County, Washington:

Soil	Map symbol	Topographic position	Parent materials	Color of surface soil (moist)
Alderwood gravelly sandy loam, 3 to 15 percent slopes	Ac	Glacial uplands	Cemented gravelly till	Brown to dark brown.
Alderwood gravelly sandy loam, 0 to 3 percent slopes	Ab	Glacial uplands	Cemented gravelly till	Same
Alderwood gravelly sandy loam, 15 to 30 percent slopes	Ad	Glacial uplands	Cemented gravelly till	Same
Alderwood gravelly sandy loam, 30 to 50 percent slopes	Ae	Glacial uplands	Cemented gravelly till	Same
Alderwood gravelly loam, 3 to 8 percent slopes	Aa	Glacial uplands	Cemented gravelly till	Same
Bellingham silty clay loam, 0 to 2 percent slopes	Bb	Depressions in glacial uplands.	Silty mantle over lake sediments or till.	Very dark grayish brown or black.
Bellingham silty clay loam, 2 to 8 percent slopes	Bc	Same	Same	Same
Bellingham silt loam, 0 to 2 percent slopes	Ba	Same	Same	Dark gray to black
Bucoda silty clay loam, 5 to 15 percent slopes	Bd	Residual uplands	Andesitic igneous rock	Dark brown to dark grayish brown.
Bucoda silty clay loam, 15 to 30 percent slopes	Be	Residual uplands	Andesitic igneous rock	Same
Camas clay loam, 0 to 3 percent slopes	Ca	Recent alluvial terraces.	Mixed sedimentary and basic igneous alluvium over glacial gravel.	Dark brown to very dark grayish brown.
Camas gravelly loam, 0 to 3 percent slopes	Cb	Recent alluvial terraces.	Same	Brown to dark brown.
Cathcart gravelly loam, 3 to 15 percent slopes	Cc	Residual uplands	Glacial till over sedimentary material, shale, and sandstone.	Dark grayish brown
Cathcart gravelly loam, 15 to 35 percent slopes	Cd	Residual uplands	Same	Dark grayish brown
Chehalis silty clay loam, 0 to 2 percent slopes	Cf	Flood plains	Alluvium from mixed sedimentary and basic igneous material.	Dark brown
Chehalis loam, 0 to 2 percent slopes	Ce	Flood plains	Same	Dark brown to brown.
Delphi gravelly loam, 3 to 15 percent slopes	Da	Glacial uplands	Gravelly cemented till over basic igneous material.	Dark reddish brown
Delphi gravelly loam, 15 to 30 percent slopes	Db	Glacial uplands	Same	Dark reddish brown
Edmonds fine sandy loam, 0 to 3 percent slopes	Ea	Depressions in uplands.	Sandy glacial outwash	Olive gray to dark gray.
Eld silty clay loam, 0 to 2 percent slopes	Ed	Flood plains and alluvial fans.	Basaltic alluvium over glacial gravel.	Dark reddish brown
Eld loam, 0 to 2 percent slopes	Ec	Same	Same	Dark reddish brown
Eld gravelly loam, 0 to 2 percent slopes	Eb	Same	Same	Dark reddish brown
Elma loam, 0 to 3 percent slopes	Ee	Outwash terraces	Sandy glacial outwash over glacial gravel.	Brown to dark reddish brown.
Everett gravelly sandy loam, 0 to 3 percent slopes	Ek	Glacial uplands	Gravelly drift	Brown to dark brown.
Everett gravelly sandy loam, 3 to 15 percent slopes	El	Glacial uplands	Gravelly drift	Same
Everett gravelly sandy loam, 15 to 30 percent slopes	Em	Glacial uplands	Gravelly drift	Same
Everett gravelly sandy loam, 30 to 40 percent slopes	En	Glacial uplands	Gravelly drift	Same
Everett gravelly loamy sand, 0 to 3 percent slopes	Ef	Glacial uplands	Gravelly drift	Brown
Everett gravelly loamy sand, 3 to 15 percent slopes	Eg	Glacial uplands	Gravelly drift	Brown
Everett gravelly loamy sand, 15 to 30 percent slopes	Eh	Glacial uplands	Gravelly drift	Brown
Everett stony sandy loam, 0 to 3 percent slopes	Eo	Glacial uplands	Gravelly drift	Brown
Everett stony sandy loam, 3 to 15 percent slopes	Ep	Glacial uplands	Gravelly drift	Brown
Everett stony sandy loam, 15 to 30 percent slopes	Er	Glacial uplands	Gravelly drift	Brown
Everett stony sandy loam, 30 to 40 percent slopes	Es	Glacial uplands	Gravelly drift	Brown
Everson clay loam, 0 to 3 percent slopes	Et	Depressions in glacial uplands.	Sandy outwash	Very dark grayish brown to nearly black.
Everson silt loam, 0 to 3 percent slopes	Ev	Same	Sandy outwash	Very dark gray
Everson fine sandy loam, 0 to 3 percent slopes	Eu	Same	Sandy outwash	Very dark gray
Fitch gravelly sandy loam, 0 to 3 percent slopes	Fa	Glacial outwash terraces.	Gravelly outwash	Dark grayish brown
Fitch gravelly sandy loam, 3 to 15 percent slopes	Fb	Glacial outwash terraces.	Gravelly outwash	Dark grayish brown
Galvin silty clay loam, 0 to 5 percent slopes	Gb	Alluvial fans	Alluvial material from sandstone and shale.	Dark grayish brown to dark brown.
Galvin silt loam, 0 to 5 percent slopes	Ga	Alluvial fans	Same	Same
Giles fine sandy loam, 0 to 3 percent slopes	Gc	Glacial outwash terraces.	Fine sandy loam, medium silty outwash.	Brown to dark brown.
Giles fine sandy loam, 3 to 15 percent slopes	Gd	Glacial outwash terraces.	Same	Same
Giles fine sandy loam, 15 to 30 percent slopes	Ge	Glacial outwash terraces.	Same	Same
Greenwater loamy sand, 0 to 3 percent slopes	Gf	River terraces	Sandy mixed material and pumice.	Brown to olive gray
Greenwood peat, 0 to 2 percent slopes	Gg	Depressions in uplands.	Organic moss accumulation	Brown to dark yellowish brown.

Summary of important characteristics

Consistence of subsoil (moist)	Moisture-supplying capacity [1]	Internal drainage [2]	Depth of root penetration [3]	Factor limiting root penetration	Surface runoff [4]	Natural drainage [5]
Friable	Moderate	Medium	Moderately shallow	Cemented substratum	Slow to medium	Good.
Friable	Moderate	Medium	Moderately shallow	Cemented substratum	Very slow to slow.	Good.
Friable	Low	Medium	Moderately shallow	Cemented substratum	Medium	Good.
Friable	Low	Medium	Moderately shallow	Cemented substratum	Rapid	Somewhat excessive.
Friable	Moderate	Medium	Moderately shallow	Cemented substratum	Slow to medium	Good.
Firm	High	Very slow (slow if drained).	Moderately shallow	Clay subsoil and high water table.	Very slow	Poor.
Firm	High	Same	Moderately shallow	Same	Very slow	Poor.
Firm	High	Same	Moderately shallow	Same	Very slow	Poor.
Friable to firm	Moderate	Medium	Moderately deep	Bedrock	Medium	Good.
Friable to firm	Moderate	Medium	Moderately deep	Bedrock	Rapid	Good.
Firm	Moderate	Medium	Moderately deep	Coarse substratum materials.	Slow	Good.
Friable	Moderate	Medium to rapid.	Moderately deep	Coarse substratum materials.	Slow	Somewhat excessive.
Friable	Moderate	Medium	Moderately shallow	Cemented substratum or bedrock.	Slow to medium	Good.
Friable	Low	Medium	Moderately shallow	Same	Rapid to very rapid.	Good.
Firm to friable	High	Medium	Moderately shallow	None	Very slow	Good.
Friable	Moderate	Medium	Moderately shallow	None	Very slow	Good.
Friable	Moderate	Medium	Moderately shallow	Cemented substratum	Slow to medium	Good.
Friable	Moderate	Medium	Moderately shallow	Cemented substratum	Medium to rapid	Good.
Weakly cemented	High	Slow	Shallow	High water table	Very slow	Poor.
Friable	Moderate	Medium	Moderately deep	Coarse substratum materials.	Very slow	Good.
Friable	Moderate	Medium	Moderately deep	Coarse materials	Very slow	Good.
Friable	Moderate	Medium	Moderately deep	Coarse materials	Very slow	Good.
Friable	Moderate	Medium	Moderately shallow	Loose coarse substratum materials.	Very slow	Good.
Very friable	Low	Very rapid	Moderately shallow	Same	Very slow	Somewhat excessive.
Very friable	Low	Very rapid	Moderately shallow	Same	Very slow	Somewhat excessive.
Very friable	Low	Very rapid	Moderately shallow	Same	Slow	Somewhat excessive.
Very friable	Low	Very rapid	Moderately shallow	Same	Medium	Somewhat excessive.
Loose	Low	Very rapid	Moderately shallow	Same	Very slow	Somewhat excessive.
Loose	Low	Very rapid	Moderately shallow	Same	Very slow	Somewhat excessive.
Loose	Low	Very rapid	Moderately shallow	Same	Slow	Somewhat excessive.
Very friable	Low	Very rapid	Moderately shallow	Same	Very slow	Somewhat excessive.
Very friable	Low	Very rapid	Moderately shallow	Same	Very slow	Somewhat excessive.
Very friable	Low	Very rapid	Moderately shallow	Same	Slow	Somewhat excessive.
Very friable	Low	Very rapid	Moderately shallow	Same	Slow to medium	Somewhat excessive.
Firm	High	Very slow (medium if drained).	Shallow	Clay subsoil and high water table.	Very slow	Poor.
Firm	High	Same	Shallow	High water table	Very slow	Poor.
Firm	High	Same	Shallow	High water table	Very slow	Poor.
Very friable to loose.	Low	Very rapid	Shallow	Loose coarse subsoil materials.	Very slow	Somewhat excessive.
Same	Low	Very rapid	Shallow	Same	Very slow	Somewhat excessive.
Firm	High	Slow (medium if drained).	Moderately shallow	Clay substratum and seepage.	Slow	Imperfect.
Friable	High	Same	Moderately shallow	Same	Slow	Imperfect.
Friable	Moderate	Medium	Moderately deep	Coarse-textured substratum.	Slow	Good.
Friable	Moderate	Medium	Moderately deep	Coarse-textured substratum.	Slow to medium	Good.
Friable	Moderate	Medium	Moderately deep	Coarse-textured substratum.	Medium	Good.
Loose	Low	Very rapid	Shallow	Loose coarse subsoil materials.	Very slow	Somewhat excessive.
Fibrous	High	Very slow to none.	Shallow	High water table	Ponded	Very poor.

Soils of Thurston County, Washington:

Soil	Map symbol	Topographic position	Parent materials	Color of surface soil (moist)
Grove gravelly sandy loam, 3 to 15 percent slopes	Gh	Glacial uplands	Gravelly drift	Dark reddish brown to reddish brown.
Grove gravelly sandy loam, 15 to 30 percent slopes	Gk	Glacial uplands	Gravelly drift	Same
Indianola loamy sand, 3 to 15 percent slopes	Ia	Glacial uplands	Sandy drift	Brown
Indianola loamy sand, 15 to 30 percent slopes	Ib	Glacial uplands	Sandy drift	Brown
Indianola sandy loam, 3 to 15 percent slopes	Ic	Glacial uplands	Sandy drift	Brown
Kapowsin gravelly loam, 0 to 3 percent slopes	Ka	Glacial uplands	Gravelly cemented till	Dark grayish brown to dark brown.
Kapowsin gravelly loam, 3 to 15 percent slopes	Kb	Glacial uplands	Gravelly cemented till	Same
Kitsap silt loam, 0 to 3 percent slopes	Kc	Glacial uplands	Silty lake-laid sediments	Dark grayish brown.
Kitsap silt loam, 3 to 15 percent slopes	Kd	Glacial uplands	Same	Dark grayish brown.
Kitsap silt loam, 15 to 30 percent slopes	Ke	Glacial uplands	Same	Dark grayish brown.
Kitsap silt loam, 30 to 40 percent slopes	Kf	Glacial uplands	Same	Dark grayish brown.
Lynden loamy sand, 0 to 3 percent slopes	La	Glacial outwash terraces.	Sandy outwash	Brown to dark grayish brown.
Lynden loamy sand, 3 to 15 percent slopes	Lb	Glacial outwash terraces.	Sandy outwash	Same
Lynden loamy sand, 15 to 30 percent slopes	Lc	Glacial outwash terraces.	Sandy outwash	Same
Made land	Ma	Variable	Mixed materials	
Maytown silty clay loam, 0 to 2 percent slopes	Mc	Alluvial flood plains.	Alluvium from mixed sedimentary and basic igneous material.	Brown to dark brown.
Maytown loam, 0 to 2 percent slopes	Mb	Alluvial flood plains.	Same	Same
McKenna gravelly loam, 0 to 3 percent slopes	Me	Depressions in glacial uplands.	Gravelly till	Very dark gray
McKenna gravelly clay loam, 0 to 3 percent slopes	Md	Same	Gravelly till	Very dark gray
Melbourne silty clay loam, 3 to 15 percent slopes	Mf	Residual uplands	Sandstone and shale	Dark brown to dark grayish brown.
Melbourne silty clay loam, 15 to 30 percent slopes	Mg	Residual uplands	Sandstone and shale	Same
Melbourne silty clay loam, 30 to 40 percent slopes	Mh	Residual uplands	Sandstone and shale	Same
Melbourne stony loam, 3 to 15 percent slopes	Mk	Residual uplands	Sandstone and shale	Same
Melbourne stony loam, 15 to 30 percent slopes	Ml	Residual uplands	Sandstone and shale	Same
Meskill silty clay loam, 3 to 15 percent slopes	Mn	Residual uplands	Sandstone and shale	Gray to dark grayish brown.
Meskill silt loam, 0 to 3 percent slopes	Mm	Residual uplands	Sandstone and shale	Dark grayish brown.
Mukilteo peat, 0 to 2 percent slopes	Mo	Depressions and bottom lands.	Organic sedge accumulation	Dark brown to dark grayish brown.
Mukilteo peat, shallow over dense clay, 0 to 2 percent slopes.	Mp	Same	Organic sedge accumulation	Same
Newberg loam, 0 to 2 percent slopes	Na	Alluvial flood plains.	Alluvium from mixed sedimentary and basic igneous material.	Brown to dark brown.
Newberg sandy loam, 0 to 2 percent slopes	Nb	Alluvial flood plains.	Same	Same
Nisqually loamy sand, 2 to 5 percent slopes	Nc	Glacial outwash terraces.	Sandy outwash	Black
Nisqually loamy sand, 5 to 15 percent slopes	Nd	Glacial outwash terraces.	Sandy outwash	Black
Norma loam, 0 to 3 percent slopes	Nf	Depressions in glacial uplands.	Medium-textured material over gravelly sandy till.	Very dark grayish brown to very dark gray.
Norma clay loam, 0 to 3 percent slopes	Ne	Same	Moderately fine textured material over gravelly sandy till.	Same
Olympic silty clay loam, 6 to 15 percent slopes	Oa	Residual uplands	Basic igneous rock	Dark reddish brown.
Olympic silty clay loam, 15 to 30 percent slopes	Ob	Residual uplands	Basic igneous rock	Dark reddish brown.
Olympic silty clay loam, 30 to 40 percent slopes	Oc	Residual uplands	Basic igneous rock	Dark reddish brown.
Olympic stony clay loam, 6 to 15 percent slopes	Od	Residual uplands	Basic igneous rock	Dark reddish brown.
Olympic stony clay loam, 15 to 30 percent slopes	Oe	Residual uplands	Basic igneous rock	Dark reddish brown.
Pilchuck sand, 0 to 3 percent slopes	Pb	Alluvial flood plains.	Mixed basic igneous material and glacial flour.	Dark gray to dark grayish brown.
Pilchuck loamy fine sand, 0 to 3 percent slopes	Pa	Alluvial flood plains.	Same	Same

Summary of important characteristics—Continued

Consistence of subsoil (moist)	Moisture-supplying capacity [1]	Internal drainage [2]	Depth of root penetration [3]	Factor limiting root penetration	Surface runoff [4]	Natural drainage [5]
Very friable	Low	Rapid	Moderately shallow	Loose coarse substratum materials.	Very slow	Somewhat excessive.
Very friable	Low	Rapid	Moderately shallow	Same	Slow	Somewhat excessive.
Very friable to loose.	Low	Very rapid	Moderately shallow	Same	Very slow	Somewhat excessive.
Same	Low	Very rapid	Moderately shallow	Same	Slow	Somewhat excessive.
Same	Low	Rapid	Moderately shallow	Same	Very slow	Somewhat excessive.
Firm	Moderate	Slow	Moderately shallow	Cemented substratum layer.	Slow	Moderately good.
Firm	Moderate	Slow	Moderately shallow	Cemented substratum layer.	Slow to medium	Moderately good.
Friable	High	Medium	Moderately deep	Fine-textured substratum.	Slow	Moderately good.
Friable	Moderate	Slow to medium.	Moderately deep	Fine-textured substratum.	Slow to medium	Moderately good.
Friable	Moderate	Slow to medium.	Moderately deep	Fine-textured substratum.	Medium	Moderately good.
Friable	Low	Medium	Moderately deep	Fine-textured substratum.	Rapid	Good.
Very friable to loose.	Low	Very rapid	Moderately shallow	Loose coarse substratum materials.	Very slow	Somewhat excessive.
Same	Low	Very rapid	Moderately shallow	Same	Very slow	Somewhat excessive.
Same	Low	Very rapid	Moderately shallow	Same	Slow	Somewhat excessive.
Friable	Moderate	Medium to slow.	Deep	None	Slow	Imperfect.
Friable	Moderate	Medium to slow.	Deep	None	Slow	Imperfect.
Friable	High	Very slow (medium if drained).	Shallow	Cemented substratum layer.	Very slow	Poor.
Friable	High	Same	Shallow	Cemented substratum layer.	Very slow	Poor.
Firm	Moderate	Medium	Moderately deep	Bedrock	Slow to medium	Good.
Firm	Moderate	Medium	Moderately deep	Bedrock	Medium	Good.
Firm	Moderate	Medium	Moderately deep	Bedrock	Rapid	Good.
Firm	Moderate	Medium	Moderately shallow	Bedrock	Slow to medium	Good.
Firm	Moderate	Medium	Moderately shallow	Bedrock	Medium	Good.
Very firm	High	Very slow	Moderately shallow	Claypan subsoil	Slow to medium	Poor.
Firm	High	Very slow	Moderately shallow	Claypan subsoil	Slow	Poor.
Fibrous	High	Very slow to none (medium if drained).	Moderately deep	High water table	Ponded	Very poor.
Fibrous	High	Same	Shallow	High water table, fine-textured substratum.	Ponded	Very poor.
Friable to very friable.	Moderate	Medium	Moderately deep	Coarse-textured substratum.	Very slow	Good.
Very friable	Moderate	Rapid	Moderately deep	Coarse-textured substratum.	Very slow	Good.
Very friable	Low	Very rapid	Moderately shallow	Coarse-textured substratum.	Very slow	Somewhat excessive.
Very friable	Low	Very rapid	Moderately shallow	Coarse-textured substratum.	Very slow	Somewhat excessive.
Firm	High	Very slow (medium if drained).	Moderately shallow	Compact substratum and high water table.	Very slow	Poor.
Firm	High	Same	Moderately shallow	Same	Very slow	Poor.
Friable to firm	Moderate	Medium	Moderately deep	Bedrock	Slow to medium	Good.
Friable to firm	Moderate	Medium	Moderately deep	Bedrock	Medium	Good.
Friable to firm	Moderate	Medium	Moderately deep	Bedrock	Rapid	Good.
Friable to firm	Moderate	Medium	Moderately deep	Bedrock	Slow to medium	Good.
Friable to firm	Moderate	Medium	Moderately shallow and shallow.	Bedrock	Medium	Good.
Loose	Low	Very rapid	Shallow	Coarse materials	Very slow	Excessive.
Loose	Low	Very rapid	Moderately shallow	Coarse substratum materials.	Very slow	Somewhat excessive.

Soils of Thurston County, Washington:

Soil	Map symbol	Topographic position	Parent materials	Color of surface soil (moist)
Prather silty clay loam, 3 to 8 percent slopes	Pc	Old terraces	Mixed weathered transported material.	Dark brown
Prather silty clay loam, 8 to 15 percent slopes	Pd	Old terraces	Same	Dark brown
Prather silty clay loam, 15 to 30 percent slopes	Pe	Old terraces	Same	Dark brown
Prather silty clay loam, 30 to 40 percent slopes	Pf	Old terraces	Same	Dark brown
Puget silty clay loam, 0 to 2 percent slopes	Ph	Alluvial flood plains.	Mixed basic igneous material and glacial flour.	Gray or olive gray
Puget clay, 0 to 2 percent slopes	Pg	Alluvial flood plains.	Same	Same
Puyallup fine sandy loam, 0 to 2 percent slopes	Pk	Alluvial flood plains.	Same	Dark grayish brown
Puyallup loam, 0 to 2 percent slopes	Pl	Alluvial flood plains.	Same	Dark grayish brown
Reed clay, 0 to 2 percent slopes	Ra	Alluvial flood plains.	Sedimentary and basic igneous alluvium.	Very dark grayish brown.
Reed silty clay loam, 0 to 2 percent slopes	Rb	Alluvial flood plains.	Same	Dark grayish brown
Rifle peat, 0 to 2 percent slopes	Rc	Depressions	Organic woody accumulation	Very dark brown
Rifle peat, shallow over dense clay, 0 to 2 percent slopes.	Rd	Depressions	Organic woody accumulation	Very dark brown
Riverwash	Re	Alluvial flood plains.	Coarse-textured alluvium	Variable
Rough mountainous land, Melbourne soil material	Rf	Residual uplands	Shale and sandstone rock	Variable
Rough mountainous land, Olympic soil material	Rg	Residual uplands	Basic igneous rock	
Rough mountainous land, Wilkeson soil material	Rh	Residual uplands	Mixed silty material over basic igneous rock.	
Salkum silty clay loam, 3 to 8 percent slopes	Sa	Terraces	Mixed gravelly valley-filling material.	Dark brown
Salkum silty clay loam, 8 to 15 percent slopes	Sb	Terraces	Same	Dark brown
Salkum silty clay loam, 15 to 30 percent slopes	Sc	Terraces	Same	Dark brown
Semiahmoo muck, 0 to 2 percent slopes	Sd	Depressions	Organic sedge accumulation	Very dark brown
Semiahmoo muck, shallow over dense clay, 0 to 2 percent slopes.	Se	Depressions	Organic sedge accumulation	Very dark brown
Shuwah silty clay loam, 0 to 2 percent slopes	Sf	Alluvial flood plains.	Sedimentary and basic igneous material.	Very dark grayish brown.
Snohomish silt loam, 0 to 3 percent slopes	Sg	Alluvial flood plains.	Mixed mineral material over organic accumulation.	Dark gray to dark grayish brown.
Spanaway gravelly sandy loam, 0 to 3 percent slopes	Sh	Glacial outwash terraces.	Gravelly outwash	Black
Spanaway gravelly sandy loam, mound phase, 2 to 10 percent slopes.	Sm	Glacial outwash terraces.	Gravelly outwash	Black
Spanaway gravelly sandy loam, 3 to 15 percent slopes	Sk	Glacial outwash terraces.	Gravelly outwash	Black
Spanaway gravelly sandy loam, 15 to 30 percent slopes	Sl	Glacial outwash terraces.	Gravelly outwash	Black
Spanaway stony sandy loam, 0 to 3 percent slopes	Sn	Glacial outwash terraces.	Gravelly outwash	Black
Spanaway stony sandy loam, 3 to 15 percent slopes	So	Glacial outwash terraces.	Gravelly outwash	Black
Sultan fine sandy loam, 0 to 2 percent slopes	Sp	Alluvial flood plains.	Mixed basic igneous and glacial flour.	Olive gray or dark grayish brown.
Sultan loam, 0 to 2 percent slopes	Sr	Alluvial flood plains.	Same	Same
Tacoma muck, 0 to 2 percent slopes	Ta	Alluvial flood plains.	Mixed mineral and organic salt water vegetation accumulation.	Dark gray to dark grayish brown.
Tenino gravelly sandy loam, 4 to 15 percent slopes	Tb	Glacial uplands	Gravelly semicemented till	Grayish brown to dark grayish brown or brown.

Summary of important characteristics—Continued

Consistence of subsoil (moist)	Moisture supplying capacity [1]	Internal drainage [2]	Depth of root penetration [3]	Factor limiting root penetration	Surface runoff [4]	Natural drainage [5]
Firm	Moderate	Medium	Moderately deep	Fine-textured substratum.	Slow	Good.
Firm	Moderate	Medium	Moderately deep	Fine-textured substratum.	Medium	Good.
Firm	Moderate	Medium	Moderately deep	Fine-textured substratum.	Medium	Good.
Firm	Moderate	Medium	Moderately deep	Fine-textured substratum.	Rapid	Good.
Firm	High	Very slow (slow if drained).	Moderately shallow	Fine-textured subsoil	Very slow	Very poor.
Firm	High	Same	Shallow	Fine-textured subsoil	Very slow	Very poor.
Very friable	Low	Rapid	Moderately shallow	Coarse-textured substratum.	Very slow	Good.
Friable	Moderate	Medium	Moderately shallow	Coarse-textured substratum.	Very slow	Good.
Firm	High	Very slow (slow if drained).	Shallow	Fine-textured subsoil and high water table.	Very slow	Poor.
Firm	High	Same	Moderately shallow	Same	Very slow	Poor.
Matted	High	Very slow to none (medium if drained).	Moderately deep	High water table	Ponded	Very poor.
Matted	High	Same	Shallow	High water table; fine-textured substratum.	Ponded	Very poor.
Loose	Very low	Variable	Very shallow	Coarse materials	Very slow	Variable.
Variable	Variable	Variable	Variable	Bedrock	Variable	Good.
Variable	Variable	Variable	Variable	Bedrock	Variable	Good.
Variable	Variable	Variable	Variable	Bedrock	Variable	Good.
Firm	Moderate	Medium	Moderately deep	Fine-textured substratum.	Slow	Good.
Firm	Moderate	Medium	Moderately deep	Fine-textured substratum.	Medium	Good.
Firm	Moderate	Medium	Moderately shallow	Fine-textured substratum.	Medium	Good.
Friable	High	Very slow to none (medium if drained).	Moderately deep	High water table	Ponded	Very poor.
Friable	High	Same	Shallow	High water table; fine-textured substratum.	Ponded	Good.
Friable to firm	High	Medium	Deep	None	Very slow	Good.
Friable	High	Very slow	Shallow	High water table	Very slow	Poor.
Very friable	Low	Very rapid	Shallow	Loose coarse materials	Very slow	Somewhat excessive.
Very friable	Low	Very rapid	Shallow	Loose coarse materials	Very slow	Somewhat excessive.
Very friable	Low	Very rapid	Shallow	Loose coarse materials	Very slow	Somewhat excessive.
Very friable	Low	Very rapid	Shallow	Loose coarse materials	Slow	Somewhat excessive.
Very friable	Low	Very rapid	Shallow	Loose coarse materials	Very slow	Somewhat excessive.
Very friable	Low	Very rapid	Shallow	Loose coarse materials	Very slow	Somewhat excessive.
Very friable	Moderate	Medium	Deep	None	Very slow	Imperfect.
Friable	Moderate	Medium	Deep	None	Very slow	Imperfect.
Friable	High	Very slow to none (medium if drained).	Moderately deep	High water table	Ponded	Very poor.
Very friable	Low	Medium	Moderately shallow	Weakly cemented substratum.	Slow	Somewhat excessive.

Soils of Thurston County, Washington:

Soil	Map symbol	Topographic position	Parent materials	Color of surface soil (moist)
Tenino gravelly sandy loam, 15 to 35 percent slopes	Tc	Glacial uplands	Gravelly semicemented till	Same
Tidal marsh, 0 to 2 percent slopes	Td	Delta flats	Mixed material	Variable
Tisch loam, 0 to 3 percent slopes	Te	Depressions in uplands.	Diatomaceous earth over glacial drift.	Dark grayish brown.
Tromp fine sandy loam, 0 to 3 percent slopes	Tf	Depressions in glacial uplands.	Sandy outwash	Very dark grayish brown.
Tromp-Tisch complex, 0 to 3 percent slopes	Tg	Depressions	Diatomaceous earth and sandy glacial outwash.	Variable
Tumwater loamy fine sand, 0 to 3 percent slopes	Tk	Glacial outwash terraces.	Sandy outwash	Brown to dark brown.
Tumwater loamy fine sand, 3 to 15 percent slopes	Tl	Glacial outwash terraces.	Sandy outwash	Same
Tumwater loamy fine sand, 15 to 30 percent slopes	Tm	Glacial outwash terraces.	Sandy outwash	Same
Tumwater fine sandy loam, 0 to 3 percent slopes	Th	Glacial outwash terraces.	Sandy outwash	Same
Wadell loam, 2 to 5 percent slopes	Wa	Alluvial fans	Basaltic material	Dark reddish brown.
Wadell silty clay loam, 0 to 3 percent slopes	Wb	Alluvial fans	Basaltic material	Dark reddish brown.
Wapato silty clay loam, 0 to 2 percent slopes	Wc	Alluvial flood plains.	Sedimentary and basic igneous alluvium.	Very dark grayish brown.
Wilkeson silt loam, 3 to 15 percent slopes	Wd	Uplands	Mixed silty fine-grained pumicy materials.	Brown to dark brown.

[1] The amount of water held available to plants during the growing season to the depth readily penetrated by roots. Generally soils with moderate moisture-supplying capacity are those with a medium-textured subsoil and deep, friable profiles; soils with high moisture-supplying capacity are those with a high water table or a perched water table caused by a claypan or hardpan, and they generally require artificial drainage for minimum production; soils with low moisture-supplying capacity have coarse-textured subsoils and are droughty.

[2] The rate of downward movement of water through the soil.

Summary of important characteristics—Continued

Consistence of subsoil (moist)	Moisture-supplying capacity [1]	Internal drainage [2]	Depth of root penetration [3]	Factor limiting root penetration	Surface runoff [4]	Natural drainage [5]
Very friable	Low	Medium	Moderately shallow	Weakly cemented substratum.	Medium	Somewhat excessive.
Variable	High	Very slow to none (medium if drained).	Variable	High water table and salts.	Ponded	Very poor.
Firm	High	Very slow (medium if drained).	Shallow	Diatomaceous layer	Very slow	Poor.
Firm	High	Slow (medium if drained).	Moderately deep	High water table, weak cementation.	Very slow	Imperfect.
Firm	High	Variable	Variable	Diatomaceous layer; high water table, weak cementation.	Very slow	Imperfect to poor.
Very friable	Low	Very rapid	Moderately shallow	Coarse substratum materials.	Very slow	Good.
Very friable	Low	Very rapid	Moderately shallow	Coarse substratum materials.	Very slow	Good.
Very friable	Low	Very rapid	Moderately shallow	Coarse substratum materials.	Slow	Good.
Very friable	Low	Very rapid	Moderately shallow	Coarse substratum materials.	Very slow	Good.
Friable	Moderate	Medium	Deep	None	Slow	Good.
Friable	Moderate	Medium	Deep	None	Very slow	Good.
Firm	High	Very slow (slow if drained).	Moderately shallow	High water table; fine-textured subsoil.	Very slow	Poor.
Firm	Moderate	Medium	Moderately deep	Fine-textured substratum.	Slow to medium	Good.

[3] Depths that roots readily penetrate under adequate drainage. The depths for the various terms are: Very shallow, less than 10 inches; shallow, 10 to 20 inches; moderately shallow, 20 to 36 inches; moderately deep, 36 to 60 inches; deep, more than 60 inches.

[4] Rate at which water flows over the surface of the soil.

[5] Conditions of drainage that existed during the development of of the soil.

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