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Soil Survey

Snohomish County Washington

By
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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Plant Industry, Soils, and Agricultural Engineering
In cooperation with the
WASHINGTON AGRICULTURAL EXPERIMENT STATION
and
WASHINGTON STATE PLANNING COUNCIL

HOW TO USE THE SOIL SURVEY REPORT

SOIL SURVEYS provide a foundation for all land use programs. The report on each survey and the map that accompanies the report present information both general and specific about the soils, the crops, and the agriculture of the area surveyed. The individual reader may be interested in the whole report or only in some particular part. Ordinarily he will be able to obtain the information he needs without reading the whole. Prepared for both general and detailed use, the report is designed to meet the needs of a wide variety of readers of three general groups: (1) Those interested in the county as whole; (2) those interested in specific areas; and (3) students and teachers of soil science and related agricultural subjects. Attempt has been made to meet the needs of all three groups by making the report comprehensive for purposes of reference.

Readers interested in the area as a whole include those concerned with general land use planning—the placement and development of highways, power lines, docks, urban and industrial sites, community cooperatives, resettlement projects, and areas for private or public forests, recreation, and wildlife management. The following sections are intended for such users: (a) General Nature of the County, in which physiography, vegetation, climate, water supply, population, and cultural development are discussed; (b) Agriculture, in which a brief history of the agriculture of the county is given and the present agriculture described; and (c) Productivity Ratings, in which the productivity of the soils is given and a grouping of soils presented according to their relative physical suitability for agricultural use.

Readers interested chiefly in specific areas—such as some particular locality, farm, or field—include farmers, agricultural technicians interested in planning operations in communities or on individual farms, and real-estate agents, land appraisers, prospective purchasers and tenants, and farm agencies. The reader's first step is to locate on the map the tract with which he is concerned. The second is to identify the soils on the tract by locating in the legend on the margin of the map the symbols and colors that represent them. The third step is to locate in the table of contents in the section on Soils and Crops, the page where each soil type is described in detail and information given as to its suitability for use and its relations to crops and agriculture. He will also find useful specific information relating to the soils in the section on Productivity Ratings.

Students and teachers of soil science and allied subjects, including crop production, forestry, animal husbandry, economics, rural sociology, geography, and geology, will be interested in the section on Morphology and Genesis of Soils. They will also find useful information in the section on Soils, the introduction of which presents the general scheme of classification and a discussion of the soils for the county as a whole, and the rest a detailed discussion of each type. For those not already familiar with the classification and mapping of soils, these subjects are discussed under Soil Survey Methods and Definitions. Teachers of other subjects will find the sections on General Nature of the County, Agriculture, Productivity Ratings, and the introduction under the heading Soils of particular value in determining the relations between their special subjects and the soils in the county. Soil scientists and students of soils as such will find their special interest in the section on Morphology and Genesis of Soils.

This report on the soil survey of Snohomish County, Wash., is a cooperative contribution from the—

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SOIL SURVEY OF SNOHOMISH COUNTY, WASHINGTON

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

Contents

[1] The field work for this survey was done while the Division was a part of the Bureau of Chemistry and Soils

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ON July 4, 1792, Capt. George Vancouver landed near the present site of Everett, Wash. Fur traders and trappers were the only white men in the territory when it was dominated by the Hudson's Bay Company. Shortly after the Treaty of 1846, which made this territory part of the United States and opened it to settlers, lumbering operations began on a small scale. The building of railroads led to an influx of settlers and started the exploitation of the timber resources. Lumbering is still the most important industry, although fishing ranks high. Dairying is the foremost agricultural activity, and poultry is next in value of products sold. Green peas and fruits are among important crops produced. To provide a basis for the best agricultural uses of the land a cooperative soil survey was begun in 1937 by the United States Department of Agriculture, the Washington Agricultural Experiment Station, and the Washington State Planning Council. The essential features may be summarized as follows.

SUMMARY OF THE SURVEY

Snohomish County is in the northwestern part of the State of Washington, extending from Puget Sound to the Cascade Mountains. This report covers all the county except areas of national forests in the eastern part.

The three main physiographic divisions of the county are (1) level areas of recent alluvial deposits along the larger streams and their deltas bordering Puget Sound, (2) undulating to rolling glacial ground and terminal moraines entrenched by broad to narrow valleys and stream headwater tributaries, also including extensive areas of fairly smooth outwash plains and terraces, and (3) the mountainous area in the eastern part of the county.

The soils of this county are mapped in two main groups—the well-drained soils and soils with restricted drainage.

The well-drained soils have brown surface soils and light yellowish-brown upper subsoil layers. Most of the upland soils range between coarse gravelly loam and gravelly sandy loam in texture. The gravel is an annoyance, but few areas contain enough of it to interfere materially with cultivation. Less than 5 percent of the well-drained soil is cultivated.

The well-drained soils fall into four subgroups based on parent materials and soil-profile characteristics. They are soils underlain by (1) consolidated bedrock material, (2) compact or cemented glacial till material, (3) fine-textured glacial lake sediments, and (4) loose porous glacial drift and postglacial outwash. The soils underlain by cemented material are of the Alderwood series. The Alderwood soils, by far the most extensive of the county, cover an area of 262.3 square miles. The most extensive soil type is Alderwood gravelly loam. The soils of the subgroup underlain by loose porous glacial drift and postglacial outwash are in the Everett, Skykomish, Lynden, and Indianola series and cover a total area of 246.9 square miles. The Everett soils rank in extent next to the Alderwood.

The soils with restricted drainage include three subgroups: (1) Gray and brown soils, (2) dark-colored soils, and (3) organic soils. The gray and brown soils include the Puget, Sultan, Puyallup, Pilchuck, and Snohomish series. They cover 97.3 square miles and include about 65 percent of the cultivated land in the county. Puget clay loam

is the most important for farming. The dark-colored soils rank next to the gray and brown soils in fertility, but are hard to drain. The organic soils include different kinds of peat, and though also difficult to drain, they are adapted to certain truck crops when well fertilized.

Several large areas of miscellaneous nonagricultural land types are mapped, including rough and stony land in the eastern part of the county and less extensive areas of riverwash and tidal marsh, chiefly in the western parts.

The agricultural uses of the various soils and their acre yields and productivity ratings are tabulated primarily on the basis of interviews with farmers and others who have had experience in the agriculture of the county.

Most of the soils of the county are podzolic. They have developed in a forested region of cool moist climate and include small areas of true Podzols in sandy areas and at the higher elevations. The whole area may be considered as transitional between the region of Podzols and that of Gray-Brown Podzolic soils.

GENERAL NATURE OF THE COUNTY

The soil survey of Snohomish County, Wash., covers 976 square miles (624,640 acres), extending from Puget Sound on the west, eastward into the foothills of the Cascade Mountains, and including all

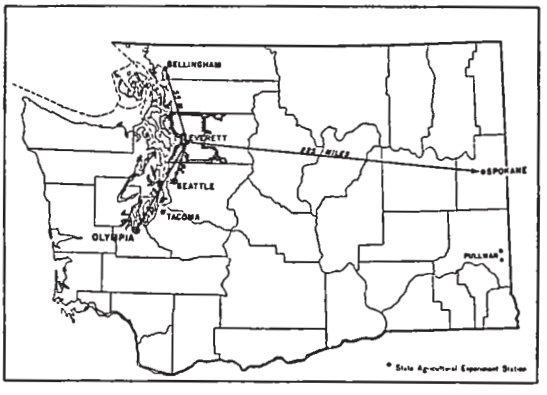


FIGURE 1.—Location of Snohomish County in Washington (eastern areas in national forests not covered in the soil survey).

the county except eastern areas in national forests (fig. 1). The area is covered in part by published reports on a much earlier soil survey of the Everett area,[2] and on a reconnaissance soil survey of the eastern part of the Puget Sound Basin.[3]

Snohomish County, the third county south of the Canadian boundary, is on the eastern border of the Puget Sound Basin and includes part of the great valley between the Cascade Mountains on the east and the Olympic Mountains on the west. Viewed from high elevations, the western part bordering Puget Sound has the appearance of a

[2] CARR, E. P., and MANGUM, A. W. SOIL SURVEY OF THE EVERETT AREA, WASHINGTON. U. S. Bur. Soils Field Oper. (1905) Rpt. 7: 1053–1079, illus. 1907.

[3] MANGUM, A. W., and party. RECONNAISSANCE SOIL SURVEY OF THE EASTERN PART OF THE PUGET SOUND BASIN, WASHINGTON. U. S. Bur. Soils Field Oper. (1909) Rpt. 11: 1517–1600, illus. 1912.

gently rolling plain traversed by broad smooth valleys that eastward merge sharply with the lower slopes of the Cascade Mountains. Everett, the county seat, is 25 miles north of Seattle.

The three main physiographic divisions in the county are (1) level areas of recent alluvial deposits along the streams, (2) benchlike or rolling areas of glacial ground moraine and outwash plains, and (3) mountainous areas.

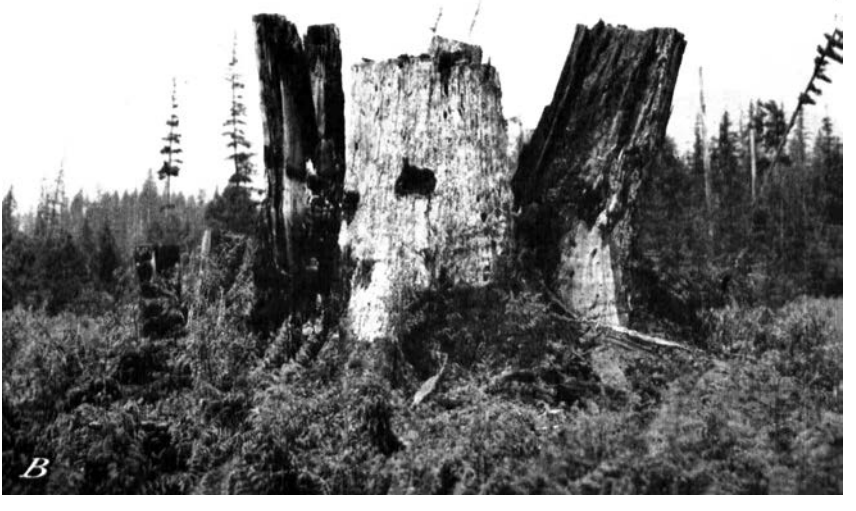
The level areas cover about 100 square miles along the bottoms of the larger streams and their deltas bordering Puget Sound.

The extensive benchlike areas, between 200 and 500 feet in elevation, have fairly gentle relief but break off sharply on the west to the level of Puget Sound and extend on the east, by slopes of 15 to 50 percent or more, into the streamways and ravines of the larger valleys. The ravines range in depth from a few feet at their heads to more than 100 feet where they emerge from the upland. The drainage system is fairly complete, although there are many small poorly drained kettle holes, lakes, and depressions. According to geologists who have studied the region, this division is covered with glacial material carried by the continental ice sheet from Canada by the Puget Sound glaciation. It occupies approximately 660 square miles, including about 100 square miles of glacial outwash plain of smooth relief. The largest outwash plain area extends from Marysville northeasterly past Arlington and up the North Fork Stillaguamish River and occupies a benchlike position 25 to 100 feet above the stream. A few small areas underlain by sandstone and shale are included with this physiographic division.

The mountainous area includes about 180 square miles, and except for some flat-topped ridges and narrow valleys, the relief is very steep and rugged, with large areas of exposed rock, and is distinctly alpine around Index and south of Darrington. The ground rock consists largely of hard granitelike metamorphics with smaller areas of lava rocks and granite (granodiorite). Outcrops of marblelike limestone are northeast of Granite Falls, southeast of Goldbar, and south of Whitehorse School.

The western border of the area is at sea level. According to topographic sheets of the United States Geological Survey the elevations are as follows: On the North Fork Stillaguamish River, 103 feet at Arlington, 163 at Cicero, 375 at Oso, and 500 feet at Darrington; on the South Fork Stillaguamish River, 387 feet at Granite Falls and about 900 feet at Verlot; and on the Skykomish River, 68 feet at Monroe, 141 at Sultan, 158 at Startup, and 532 feet at Index. Elevations range from about 200 to 500 feet at the foot of the mountains to about 3,000 feet on the ridges and 4,500 feet on the highest points in the area surveyed. Conspicuous higher landmarks near the eastern border but outside the area are Mount Pilchuck, 5,334 feet; White Horse Mountain, 6,820 feet; Three Fingers Mountain, 6,854 feet; and Mount Index, 5,639 feet.

Except for a few small peat bogs and some areas along the stream deltas, this region originally was covered with a dense forest, in which Douglas-fir was dominant (pl. 1, *A* and *B*). Virgin stands produced as much as 125,000 board feet an acre. A scattered growth of western redcedar still stands in some places. Western hemlock grew in variable



A, Large Douglas-fir stumps in logged area of Everett soils used for pasture. They do not burn readily and are difficult and expensive to move. *B*, Large Douglas-fir stump shattered by explosives in clearing a highway right-of-way. A heavy charge of dynamite broke it into several large sections and made a cavity several feet in diameter. Removal of the large stumps by explosives and heavy machinery leaves an irregular surface, which must be leveled for effective use for tilled crops.

A, Mukilteo peat bog near Alderwood Manor, showing marshland vegetation of sedges and trees encroaching around the margin. Where drained, this soil is used for truck crops, sugar beets, hay, and pasture. *B*, Bog of acid Greenwood peat near Alderwood Manor. It is occupied mainly by shrubs, principally Labrador-tea, and trees are encroaching around the margin.

quantities and dominated in many localities, especially in areas of heavy rainfall. Silver fir grows in the higher altitudes, red alder predominates in many poorly drained depressions, and cottonwoods are common in sandy stream bottoms. Except in the mountainous areas, most of the virgin timber has been cut, and more than half the uncut timber is hemlock. The first areas logged, which have been protected from fire, now support a good stand of young Douglas-fir, and larger areas are covered with a mixed growth of young alder, Douglas-fir, redcedar, and hemlock, together with a thick undergrowth difficult to penetrate.

Common trees and shrubs are cascara, vine maple, Oregon maple, dogwood, willow, red huckleberry, blackberry, evergreen blackberry, thimbleberry, gooseberry, snowberry, salal, Oregon-grape, rhododendron, yew, madrona, elderberry, and devilsclub. In newly cleared areas fireweed, goldenrod, and nettles are common. Large ferns (bracken) form a dense tangle in all openings, moss covers the ground in forested areas, and cattails and sedges are common in the marshy places (pl. 2, *A*). Velvet grass is the most widely distributed native grass. Kentucky bluegrass, timothy, redtop, and other pasture grasses are common in old fields. White clover and red clover grow in most of the partly cleared areas. The more common plants of the area are listed as follows:

FOREST PLANTS

Scientific name	*Common name*
Abies grandis Lindl	White fir
Acer circinatum Pursh	Vine maple.
Acer macrophyllum Pursh	Oregon maple
Alnus rubra Bong	Red alder.
Arbutus menziesii Pursh	Madrona.
Arctostaphylos tomentosa (Pursh) Lindl	Manzanita.
Berberis aquifolium Pursh	Oregon grape
Betula fontinalis Sarg (*Betula occidentalis*)	Western birch.
Ceanothus velutinus Dougl	Mountain balm
Gaultheria shallon Pursh	Salal.
Picea sitchensis (Bong.) Carr	Sitka spruce
Pinus contorta Dougl	Shore pine (lodgepole pine).
Pinus ponderosa Dougl	Yellow pine.
Populus trichocarpa Torr. & Gray	Cottonwood.
Pseudotsuga taxifolia (Poir.) Britton	Douglas-fir.
Pteridium aquilinum var *pubescens* Underw	Bracken fern.
Rhamnus purshiana DC	Cascara.
Rhododendron macrophyllum G. Don (*Rhododendron californicum*).	Rhododendron.
Thuja plicata Donn	Western redcedar
Tsuga heterophylla (Raf.) Sarg	Western hemlock.
Vaccinium ovatum Pursh	Huckleberry.

FRESH-WATER BOG PLANTS

Betula glandulosa Michx	Dwarf birch.
Brasenia schreberi Gmel	Watershield.
Drosera rotundifolia L	Sundew.
Kalmia polifolia Wangenh	Swamp laurel
Ledum groenlandicum Oed	Labrador-tea.
Lysichitum sp (*Lysichiton*)	Skunkcabbage.
Menyanthes trifoliata L	Buck bean
Nymphozanthus polysepalus (Engelm.) Fern. (*Nymphaea polysepala*).	Common waterlily.
Potamogeton sp	Pondweed.
Sagittaria latifolia Willd	Arrowgrass (wapato)

Scientific name	*Common name*
Scirpus validus Vahl (*Scirpus occidentalis*)	Tule.
Sphagnum sp	Peat moss.
Spiraea douglasii Hook	Hardhack.
Typha latifolia L	Cattail.
Utricularia sp	Bladderwort.
Vaccinium oxycoccus var. *intermedium* A. Gray (*Oxycoccus oxycoccus intermedius*).	Cranberry.

COMMON GRASSES

Anthoxanthum odoratum L	Sweet vernalgrass.
Deschampsia elongata (Hook.) Munro (*Aira elongatum*).	Slender hairgrass
Festuca myuros L	Rattail fescue.
Festuca sp	Perennial fescue.
Holcus lanatus L	Velvet grass
Lolium perenne L	English ryegrass
Poa pratensis L	Kentucky bluegrass.

Capt. George Vancouver landed near the present site of Everett on July 4, 1792. Fur traders and trappers were the only white men in the territory when it was dominated by the Hudson's Bay Company. Shortly after the Treaty of 1846, which made this territory part of the United States and opened it to settlers, lumbering operations began on a small scale. The first sawmill was established at Tulalip in 1853. Later, others were operated at Snohomish, Marysville, Stanwood, and Lowell. There were less than 40 white men in the county when it was organized, on July 14, 1861. The first county seat was at Mukilteo, but it was moved to Snohomish that summer and later to Everett, which was founded in 1892, and by 1940 had a population of 30,240.

Steamboats were operated on the Snohomish River in 1855, and regular service began shortly after the county was organized. Occasionally small steamboats went above Sultan,[4] and some also navigated the Stillaguamish River above Stanwood, where a Norwegian settlement sprang up in the decade after 1867.

The first railroad, now a part of the Northern Pacific Railway, was completed to Snohomish in July 1888 and was extended north the next year. Regular train service on the main line of the Great Northern Railway from Everett to the east began in 1893, but the line along the coast was completed earlier. A railroad from Everett past Granite Falls to Monte Cristo was completed in 1893 but is now abandoned. The Northern Pacific branch to Darrington was completed in 1900. The building of the railroads led to an influx of settlers and started the exploitation of the timber resources on a vast scale. A system of concrete highways connecting the larger towns in the western part of the county was built in 1916.

Railroad service in the county is good, and few agricultural areas are more than 10 miles from a shipping point. Everett is an important seaport, and ships call there from all parts of the world. Shipping service by smaller boats and barges is available at Edmonds, Mukilteo, Marysville, Stanwood, and Snohomish. Many logs, chained together in rafts, are transported to Everett. The roads are excellent in the settled areas. Most of the trunk roads are hard-surfaced, and

[4] WHITFIELD, W., ed. HISTORY OF SNOHOMISH COUNTY. 2 v., illus. Chicago and Seattle. 1926.

nearly all the other public roads are graveled, the latter being economical to build because of the abundance of gravel in the county. Large areas are undeveloped and have only secondary roads and trails.

The present population of Snohomish County, 88,754 (census of 1940), is largely concentrated along the valleys of the Snohomish, Stillaguamish, and Skykomish Rivers but is spreading rapidly to other parts. Nearly all the people are of western European descent, a large part being of old American or British stock. People of Scandinavian descent predominate in the northwestern part and are numerous in all others, and many settlers of German origin are in the Skykomish River Valley. There is a large settlement of people from North Carolina near Darrington, and many native Indians are on the Tulalip Reservation.

Everett is the principal trading point and manufacturing and shipping center. Snohomish, Monroe, Marysville, Arlington, and East Stanwood are important trading points with processing plants for farm products. Trading points in the northern part of the county are Stanwood, Silvana, Oso, Granite Falls, Fortson, and Darrington, and in the southern part, Edmonds, Mukilteo, Alderwood Manor, Hartford, Sultan, Startup, Goldbar, and Index. More or less isolated mining and lumbering centers in the eastern part are at Robe, Silverton, Big Four, and Monte Cristo (the last three towns outside the area surveyed). Several suburban districts surrounded Everett, and there are scattered settlements with one or more stores.

A large proportion of the farmers have electric current for light and power from transmission lines, and many have telephones. Free transportation is provided for children to excellent consolidated grade and high schools. There are schools and churches in all the larger towns and settlements. Most farmers have substantial well-kept houses and fairly good outbuildings. Pure soft well water of the best quality is available except in the areas of Custer soils north of Marysville.

Lumbering is by far the most important industry. Four large modern sawmills and three pulp and paper mills are operated near Everett, and many smaller mills, as well as a great number of small mills for cutting shingles from cedar, are scattered over the county. Everett has factories for making sawmill, logging, and other machinery, caskets, and a plant for processing salmon and other sea foods. Fishing in Puget Sound and in distant waters is an important industry. Oysters and clams are produced commercially on the tidal flats near Stanwood. Very little mining is done at present, although gold mining may be potentially as important as it is just east of that part of the county surveyed.

CLIMATE

The climate of Snohomish County is dominated by marine influences and characterized by mild moist winters and cool dry summers. The prevailing winds from the Pacific Ocean, from the southwest in winter and from the northwest in summer, have a significant modifying effect.

Most of the summer days are clear, but gentle rains lasting several days occur in winter. In the western part of the county the temperatures rarely exceed 80° F. and seldom fall much below freezing. There is a gradual increase in precipitation from the west to the Cascade Mountains in the east. These mountains act as a barrier and shut out the cold continental winds in winter and the hot winds from the interior in summer. The mean temperature decreases with increasing altitude to the east. The average frost-free period lasts from April 3 to November 4 at Everett. Owing to the possibility of frost in summer, an elevation of more than 1,000 feet is considered hazardous for farming.

The mean annual precipitation increases from 35.25 inches at Everett to 80.37 inches at Darrington, in the northern part of the county. About 75 percent of the rain falls at night. Thunderstorms are rare, and hail is unknown. Snow seldom falls in the western part, and when it does it lasts only for a few days, but deep snows cover mountains that exceed 2,000 feet in elevation. High rainfall and low evaporation keep the fields wet and soggy in winter, but they are usually dry enough to allow cultivation by the last of March. The mean rainfall for the three summer months at Everett is only 3.65 inches. This puts a premium on early maturing crops and on soil with good water-holding capacity.

The more important climatic data for the county are given in table 1, compiled from records of the United States Weather Bureau stations at Everett and Darrington.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at certain stations in Snohomish County, Wash.*[1]

EVERETT, ELEVATION, 127 FEET

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year	Total for the wettest year	Average snowfall
	°F	°F	°F	*Inches*	*Inches*	*Inches*	*Inches*
December	39.2	62	5	4.87	2.83	10.81	2.7
January	38.0	62	6	4.65	2.35	5.30	4.9
February	40.6	62	7	3.44	2.90	2.07	2.3
Winter	39.3	62	5	12.96	8.08	18.18	9.9
March	44.3	75	18	3.38	2.14	6.01	.5
April	48.8	79	23	2.46	1.87	.77	.3
May	53.4	88	30	2.28	2.70	3.30	0
Spring	48.8	88	18	8.12	6.71	10.08	.8
June	58.3	90	36	1.90	2.10	1.65	0
July	61.2	87	37	.75	.21	1.20	0
August	61.2	85	38	1.00	.03	1.72	0
Summer	60.2	90	36	3.65	2.34	4.57	0
September	56.4	83	30	2.38	1.68	2.32	0
October	50.6	78	22	3.39	3.06	3.24	0
November	44.4	68	16	4.75	1.99	2.45	1.0
Fall	50.5	83	16	10.52	6.73	8.01	1.0
Year	49.7	[2] 90	[3] 5	35.25	[4] 23.86	[5] 40.84	10.8

See footnotes at end of table

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at certain stations in Snohomish County, Wash.*[1]—Continued

DARRINGTON, ELEVATION, 550 FEET

Month	TEMPERATURE			PRECIPITATION			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year	Total for the wettest year	Average snowfall
	° F	*° F*	*° F*	*Inches*	*Inches*	*Inches*	*Inches*
December	35 0	58	−8	12 68	14 05	30 42	10 1
January	33 5	60	−11	11 58	6 30	15 37	7 9
February	36 7	64	−5	9 12	3 77	10 34	6 3
Winter	35 1	64	−11	33 38	24 12	56 13	24 3
March	41 8	82	11	8 13	8 49	10 13	6 7
April	48 4	87	21	4 96	4 92	.94	1 3
May	53 4	96	20	4 09	3 30	3 73	0
Spring	47 9	96	11	17 18	16 71	14 80	8 0
June	58 0	105	31	3 00	4 15	3 41	0
July	61 9	104	30	1 21	76	77	0
August	62. 4	97	33	1 60	70	1 25	0
Summer	60 8	105	30	5 81	5 61	5 43	0
September	56 6	95	24	3 97	51	8 53	0
October	49 0	82	16	7 50	3 39	10 88	0
November	41 0	71	10	12 53	1 11	7 16	1. 1
Fall	48 9	95	10	24 00	5 01	26 57	1 1
Year	48 1	[4] 105	[7] −11	80 37	[8] 51 45	[9] 102 93	33. 4

[1] Records from U S. Weather Bureau.
[2] In June 1925.
[3] In December 1919
[4] In 1930.
[5] In 1933.
[6] In June 1925
[7] In January 1916
[8] In 1929.
[9] In 1933

AGRICULTURE

The pioneer agricultural communities in the county were established at Snohomish in 1861, and at Stanwood 3 years later, but very little land was cleared until the early seventies. The 1880 United States census reports 2,483 acres in crops harvested the previous year. According to local records, about 930 acres of this was near Stanwood. By 1889 the acreage in crops harvested had increased to 6,980. Agricultural development was rapid after the advent of the railroads between 1888 and 1893, and the number of farms increased from 186 in 1880 to 6,231 in 1940. The cultivated acreage has not increased proportionately, because the area of improved land to the farm has decreased. Hay, grain, and pasture crops have commonly been grown on 80 to 90 percent of the cleared area, and the remaining 10 to 20 percent is planted to potatoes, peas, and other special crops. The acreage of important crops (from United States census reports, 1880 to 1940) is given in table 2 and the value of agricultural products by classes, in table 3.

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

Crop	1879	1889	1899	1909	1919	1929	1939
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Wheat	172	14	106	99	583	175	838
Corn for grain	------	1	19	4	36	33	34
Oats threshed	682	1,193	3,031	3,331	4,041	4,160	4,920
Oats cut and fed unthreshed	------	------	------	------	------	917	285
Barley threshed	183	59	31	58	196	145	119
Rye	------	------	1	2	23	2	40
Mixed grains	------	------	------	------	------	73	77
Sugar beets	------	------	------	59	------	27	96
Potatoes	163	321	588	1,625	1,772	1,206	1,126
All other vegetables	------	------	------	563	206	1,167	4,492
Ripe field peas	------	------	17	10	45	37	148
All hay	1,280	5,325	10,743	12,777	22,295	24,829	29,415
Timothy or clover, alone or mixed	------	------	------	9,486	15,171	15,018	17,208
Clover alone	------	------	66	476	978	962	[1] 222
Alfalfa	------	------	------	21	31	193	362
All other tame hay	------	------	10,390	190	1,027	2,796	3,436
Wild hay	------	------	------	194	305	745	618
Grains cut green	------	------	277	2,410	4,664	4,908	7,440
Annual legumes for hay	------	------	------	------	119	117	129
Corn silage	------	------	------	------	[2] 2,398	915	1,444
Corn forage	------	------	11	85	320	335	516
Root forage	------	------	------	------	480	140	14
Strawberries	------	------	11	42	125	576	412
Raspberries and loganberries	------	------	10	76	95	484	162
Blackberries and dewberries	------	------	3	28	68	112	81
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Apples, trees	------	4,589	37,596	41,983	59,542	38,827	36,496
Peaches, do	------	100	165	330	484	692	782
Pears, do	------	319	3,081	4,004	9,914	21,137	9,209
Plums and prunes, do	------	2,563	12,777	10,254	13,219	12,060	12,768
Cherries, do	------	569	3,033	4,920	10,162	30,932	29,091
Apricots, do	------	------	5	61	2	28	84
Grapes, vines	------	------	------	30	65	8,975	14,296

[1] Sweetclover

[2] All silage crops

TABLE 3.—*Value of agricultural products, by classes, in Snohomish County, Wash., in stated years*

Product	1899	1909	1919	1929	1939
Cereals	(1)	$145,040	$390,474	$194,566	$151,885
Other grains and seeds	(1)	423	[2] 7,835	5,581	6,705
Hay and forage	(1)	451,089	1,581,730	945,822	758,175
Vegetables	(1)	236,480	740,085	842,345	493,858
For sale [3]	(1)	(1)	(1)	347,744	197,956
For farm households' use [3]	(1)	(1)	(1)	197,505	169,295
Potatoes and sweetpotatoes	(1)	(1)	(1)	297,086	126,607
Fruits and nuts	[3] $36,107	103,774	368,345	557,920	190,624
Horticultural specialties sold	(1)	(1)	(1)	111,868	106,462
All other crops	(1)	364,451	------	8,279	6,908
Forest products sold	[4] 93,517	(1)	(1)	92,543	32,727
Dairy products sold	162,041	713,319	2,884,771	2,532,447	1,775,307
Poultry and eggs	[5] 18,104	180,409	688,380	3,567,282	1,350,231
Animals sold and slaughtered	93,284	208,015	(1)	(1)	401,548
Honey	(1)	[6] 1,635	[6] 14,955	11,422	2,110
Wool, mohair, and goat hair	(1)	1,459	[7] 899	2,615	[7] 653

[1] Not available.
[2] Excluding potatoes and sweetpotatoes.
[3] Fruits only.
[4] All forest products
[5] Poultry only.
[6] Includes wax.
[7] Wool only.

Dairying is an important activity. Much of the milk produced is used locally or shipped to nearby cities, and most of the remainder is processed into evaporated milk and other products at plants in Arlington and Snohomish. A large proportion of the eggs and other

poultry products is shipped to the far Eastern States. All the grain and hay produced is used locally, and in addition much is brought in from outside points. Truck crops are sold mostly to local processing plants, of which there are two at Snohomish and others at Stanwood, East Stanwood, Florence, Everett, Monroe, and Marysville. Most of the green peas, an important cash crop, are canned, but an increasing quantity is being handled by the frozen-pack process, and several carloads are sent east annually in refrigerator cars for the New York market. Much lettuce was once shipped east, but because of unfavorable prices little is now grown except for local markets (pl. 3). Potatoes and tree fruits are sold in local markets. Vegetables and small fruits are sold locally, many are processed, and some are shipped fresh to distant markets, but shipments for great distances are handicapped by high freight rates.

Very little commercial fertilizer is used except on truck crops. The census of 1940 reports that of 593 farms, each used on the average $42.40 worth of fertilizer in 1939. Most farmers use about 200 pounds an acre of superphosphate for green peas and about 600 pounds of concentrated mixed fertilizer on peat and muck soils planted to truck crops. On 4,735 farms the expenditures for feed averaged $307.52, according to the same census reports. The feed is largely returned to the soil in the form of manure, which is carefully preserved on most farms. The fertility of most of the land under cultivation is being built up every year. Many of the average yields given in this report for different soils, except the organic soils, were obtained with the liberal use of manure.

Efficient farm labor is plentiful except during the pea-harvesting season. Nearly all of it is white, and most of it is local, including home seekers who have moved into the county recently. The census reports show $312.03 as the average cost of labor on 1,695 farms in the county in 1939 and that the average size of farms has decreased steadily, from 131.5 acres in 1890 to 30.2 acres in 1940. At the same time the acreage of improved land on farms has decreased from an average of 38.2 acres to 13.4. The most important reason for the decrease is the large number of subsistence and chicken farms of 5 acres or less, most of which include only a little cleared land.

The first land cultivated in the county included the light-colored soils on the alluvial bottoms. This land was fertile and less difficult than the uplands to clear, and the farmers were able to convert large areas profitably. The soils of the uplands, which have been settled more recently, are expensive to clear. A large number of the recently established farms have only a few acres cleared. Near Stanwood there are many farms of 80 acres or more, but 40 acres is the common size with the exception of the small chicken and subsistence farms.

Census data of 1940 show that 86.5 percent of the farms are operated by owners, 13.2 percent by tenants, and 0.3 percent by managers. The number operated by tenants has been increasing slowly. Nearly all the tenants pay cash rent, commonly $8 to $10 an acre annually for cleared uplands and $10 to $12 for cleared bottom land. The trend in the number, size, tenure, and value of farms is shown in table 4.

TABLE 4.—*Selected farm data for farms in Snohomish County, Wash., in stated years*

Year	Farms	Land in farms	Average size of farm	Average improved land per farm	Farms operated by—			Land available for crops	Value of land and buildings—	
					Owners	Tenants	Managers		Per farm	Per acre
	Number	*Acres*	*Acres*	*Acres*	*Percent*	*Percent*	*Percent*	*Acres*	*Dollars*	*Dollars*
1880	186	30,147	162 1	23 7	94 6	5 4	0 0	4,417	1,821	11 24
1890	406	53,393	131 5	38 2	95 8	4 2	0	15,521	5,150	39 16
1900	1,024	97,507	95 2	22 8	88 1	11 0	9	23,371	2,716	28 52
1910	1,813	118,328	65 3	18 8	88 3	10 6	1 1	34,126	6,513	89 79
1920	3,095	151,584	49 0	17 3	87 5	11 5	1 0	53,410	7,422	151 55
1930	4,262	160,310	37 6	14 2	89 4	9 7	9	60,704	7,446	197 96
1940	6,231	188,304	30 2	13 4	86 5	13 2	.3	83,315	4,577	151 46

SOIL SURVEY METHODS AND DEFINITIONS

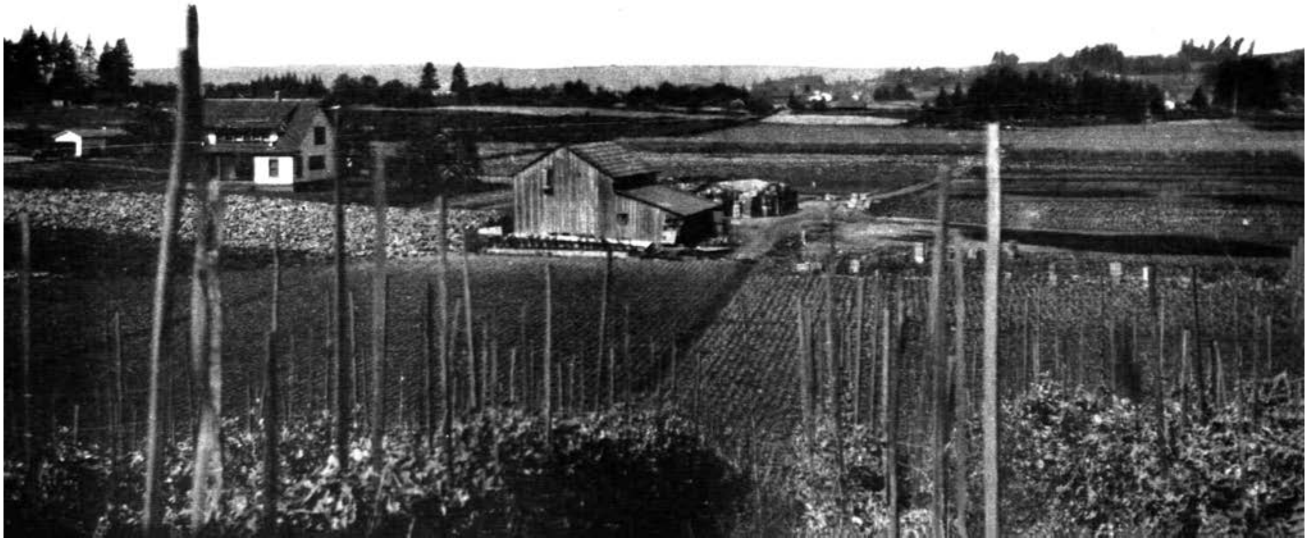
Soil surveying consists of the examination, classification, and mapping of soils in the field and the recording of their characteristics, particularly in regard to the growth of various crops, grasses, and trees.

The soils and the underlying formations are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road and railroad cuts, are studied. Each excavation exposes a series of distinct soil layers or horizons, called collectively the soil profile. Each horizon of the soil, as well as the underlying parent material, is studied in detail, and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The chemical reaction of the soil and its content of lime and salts are determined by simple tests.[5] The drainage, both internal and external, and other external features, as the relief or lay of the land, are taken into consideration, and the interrelation of the soil and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, with special emphasis upon the features that influence the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics the soils are grouped into classification units, the three principal of which are (1) series, (2) type, and (3) phase. In some places two or more of these principal units may be in such intimate or mixed pattern that they cannot be clearly shown separately on a small-scale map but must be mapped as (4) a complex. Some areas—as riverwash and rough stony land—that have no true soil are called (5) miscellaneous land types.

The series is a group of soils having the same genetic horizons, similar in their important characteristics and arrangement in the

[5] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. In this report determination of pH values given were made in the field by colorimetric methods, mainly Bromocresol green indicator, but with bromothymol blue, Soiltex, or LaMotte duplex indicators if above pH 5 6. In these determinations a pH rating of less than 5 is regarded as strongly acid, 5 to 6 moderately acid, and 6 to 7 slightly acid. The presence of lime in the soil is detected by the use of a dilute solution of hydrochloric acid.



Area of organic peat soils used for lettuce and other truck crops. Evergreen peas in foreground on sloping marginal Everett soils.

soil profile, and having similar parent material. Thus, the series comprises soils having essentially the same color, structure, natural drainage conditions, and other important internal characteristics, and the same range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The series are given geographic names taken from localities near which they were first identified. Everett, Alderwood, Custer, Puget, and Lynden are names of important soil series in this county.

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

A soil phase is a variation within the type, differing from it in some minor feature, generally external, that may be of special practical significance. For example, within the normal range of relief for a soil type some areas may be adapted to the use of machinery and the growth of cultivated crops, and others may not. Differences in relief, stoniness, and degree of accelerated erosion may be shown as phases. Even though no important differences may be apparent in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such instance the more sloping parts of the soil type may be segregated on the map as a sloping or a hilly phase. Similarly, some soils, having differences in stoniness may be mapped as phases even though these differences are not reflected in the character of the soil or in the growth of native plants. Examples in the Everett series are Everett gravelly loam, level phase, and Everett gravelly loamy sand, rolling phase.

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

SOILS

Soils are developed as the result of soil-forming forces acting on the parent material. The major forces concerned in soil formation are climate and vegetation, and it is of importance to consider the time that these forces have been acting.

The dominant soils of Snohomish County were developed under a heavy stand of timber in a mild, moist, nearly frost-free climate. The parent material consisted largely of glacial till and glacial outwash containing gravel and many glacial boulders. As a result many of the soils are gravelly. Along the eastern border extensive areas of soils are developed in place from consolidated rock, and smaller bodies

occur in the central part. Extensive bodies are developed from old lacustrine deposits, stream alluvium, and organic materials. The upland soils were formed under a forest of conifers, including Douglas-fir, hemlock, and redcedar. The needles and twigs fall on the surface, where they form a thin organic layer but add little to the soil. Because of slash burning, which follows lumbering operations, much of the forest organic matter is destroyed before the land comes under cultivation. Under the usual farm management, however, there is an increase in the organic matter. This is contrary to much of the experience in other parts of the United States.[6]

In the well-drained areas, the soils that are seldom frozen have been leached to considerable depth by winter rains. Calcium and other basic materials have been leached from the upper part of the soil, and marked soil acidity has developed.

Observation of a large number of profiles of well-drained soils in virgin areas indicate that they have the following common characteristics:

1. 0 to 1½ inches. A layer of brown forest litter grading into dark-brown leafmold containing a trace of mineral soil in the lower part and permeated by fine roots from shrubs and other plants.
2. 1½ to 2 inches. A thin ash-gray layer of irregular occurrence, best developed in sandy soils, distinct when dry, and inconspicuous when moist It is absent in heavy-textured soils.
3. 2 to 10 inches Brown or reddish-brown friable material containing many rust-brown pea-sized concretions, or cemented aggregates, locally known as "shot" The content of organic matter is moderately high in virgin condition.
4. 10 to 23 inches. A yellowish-brown layer that becomes more yellow with depth There are a few shothke aggregates in the upper part The material is rather hard when dry but breaks into small clods when crushed.
5. 23 to 30 inches. Light yellowish-brown, faintly compact material, slightly finer in texture than in the layer above It contains a trace of gray and rust-brown specks where underlain by compact glacial till
6. 30 inches +, the parent material, which may consist of gray cemented material, or compact gravelly till, yellowish-gray loose gravelly material, consolidated rock, or fine-textured lacustrine material.

There are many local variations from this generalized profile, resulting from differences in drainage, slope, and character of parent material. The thickness of each horizon is variable. Most of the soils consisting of recent alluvial deposits are gray or light grayish brown. Many of the poorly drained soils have dark-brown mottled subsurface layers and are underlain by grayish-blue substrata. The most poorly drained areas are occupied by peat and muck soils.

Dairying and chicken raising are the common types of farming, and considerable areas are planted to commercial trucking crops and potatoes. Timothy and clover and oats cover the greatest acreage. Green peas are grown as a cash crop in connection with dairying, the pea vines being used for silage. Fruits and vegetables are grown for home use by most farmers. There is a large number of subsistence farms mostly owned by men who have employment in the cities or have retired from active work. On most of these just enough land is cleared

[6] WHEETING, L. C. CHANGES IN ORGANIC MATTER IN WESTERN WASHINGTON SOILS AS A RESULT OF CROPPING. Soil Sci. 44 : 139–149. 1937.

for gardens and small orchards, but these have little influence on the agriculture of the area. There has been a large influx of home seekers in recent years, and much land is being cleared of stumps and brush.

Most of the fertile lowland soils, especially the Puget, Puyallup, and Sultan soils, have been under cultivation for years. Clearing and development of stump land is now confined mainly to the less productive uplands. The high cost of clearing is a great handicap in increasing the area under cultivation. This has emphasized the necessity of clearing the most productive land first, and the less productive land only when the demand for farm land becomes greater.

In this county there is no marked adaptation of individual crops to certain soil types, except that truck crops usually are grown on the more fertile alluvial and organic soils. Alfalfa does not do well on the stream flood plains, owing to a fluctuating water table, therefore it is grown largely on the upland soils. The large variety of soils in Snohomish County falls naturally into two distinct groups: (1) Soils with well-developed drainage and (2) soils with restricted drainage.

The well-drained soils are identified with the upland areas and though by far the most extensive and most representative, they are not the most productive. Based on the character of the underlying parent material from which developed, they are discussed in four subgroups, as follows: (1) Soils underlain by consolidated bedrock material—Oso and Cathcart series; (2) soils underlain by compact or cemented glacial till material—Alderwood series; (3) soils underlain by fine-textured glacial lake sediments—Kitsap series; and (4) soils underlain by loose porous glacial till and outwash materials—Everett, Skykomish, Lynden, and Indianola series.

The soils with restricted drainage are identified with the stream valley and lowland valley outwash plain and basin areas and are discussed in three subgroups, based on the degree of restricted drainage and on the character of the surface soils, as follows: (1) Imperfectly drained gray and brown soils—Puget, Sultan, Puyallup, Pilchuck, and Snohomish series; (2) poorly drained dark-colored soils—Bellingham, Norma, Edmonds, and Custer series; and (3) the organic soils—Carbondale muck, and Mukilteo, Rifle, and Greenwood peats.

In addition to these three groups, are a number of miscellaneous land types, as rough mountainous land and tidal marsh, which are mainly nonagricultural and do not fall naturally into a detailed classification of mature soils.

In the following pages the soils of Snohomish County are described in detail,[7] and their agricultural importance is discussed; their distribution is shown on the accompanying soil map; and their acreage and proportionate extent are given in table 5.

[7] Because of much greater detail in mapping in this survey, data accumulated in several years of field study and development in the science of soil classification since the date of the earlier surveys, which were of broader reconnaissance character, many changes have been made in soil names, resulting in apparent conflicts. The more important of these are noted in the text.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in Snohomish County, Wash.*

Type of soil	Acres	Per-cent	Type of soil	Acres	Per-cent
Oso loam	6,400	1.0	Puyallup fine sandy loam	5,696	0.9
Cathcart loam	3,136	.5	Sultan loam	3,136	.5
Cathcart clay loam	640	.1	Sultan silt loam	2,048	.3
Alderwood gravelly loam	86,592	13.7	Sultan clay loam	896	.1
Hilly phase	2,176	.3	Pilchuck fine sand	3,968	.6
Level phase	1,344	.2	Pilchuck gravelly sand	512	.1
Alderwood gravelly sandy loam	55,104	8.8	Snohomish silty clay	2,688	.4
Hilly phase	19,968	3.2	Snohomish silt loam	1,664	.3
Level phase	1,152	.2	Shallow phase	2,560	.4
Alderwood silt loam	1,536	.2	Snohomish loam	320	.1
Kitsap silt loam	9,280	1.5	Bellingham clay loam	3,072	.5
Steep phase	1,152	.2	Norma clay loam	8,320	1.3
Kitsap loam	4,608	.7	Norma loam	2,880	.5
Everett gravelly sandy loam	37,120	6.0	Norma fine sandy loam	192	(1)
Hilly phase	22,848	3.7	Edmonds sandy loam	2,048	.3
Level phase	4,416	.7	Edmonds loam	256	(1)
Everett stony sandy loam	2,240	.4	Custer fine sandy loam	5,312	.9
Everett gravelly loam	8,896	1.4	Carbondale muck	1,984	.3
Level phase	2,368	.4	Shallow phase	1,792	.3
Everett gravelly loamy sand	8,320	1.3	Sloping phase	896	.1
Hilly phase	2,752	.4	Mukilteo peat	7,360	1.2
Skykomish gravelly sandy loam	17,408	2.8	Shallow phase	384	.1
Skykomish gravelly loam	7,296	1.2	Rifle peat	3,712	.6
Skykomish stony loam	2,240	.4	Shallow phase	448	.1
Skykomish stony sand	4,160	.7	Greenwood peat	1,088	.2
Skykomish gravelly sand	1,920	.3	Rough mountainous land (Oso soil material)	91,200	14.6
Lynden loamy sand	11,584	1.9	Rough broken land	49,536	7.9
Lynden loam	10,880	1.8	Rough stony land (Oso soil material)	25,152	4.0
Lynden sandy loam	4,160	.7	Riverwash	2,880	.5
Indianola loamy sand	8,512	1.4	Tidal marsh	1,920	.3
Hilly phase	896	.1	Coastal beach	320	.1
Puget clay loam	18,496	3.0	Made land	512	.1
Puget silt loam	7,936	1.3			
Puget loam	5,120	.8			
Puget clay	832	.1	Total	624,640	100.0
Puyallup sandy loam	6,400	1.0			

[1] Less than 0.1 percent.

WELL-DRAINED SOILS UNDERLAIN BY CONSOLIDATED BEDROCK MATERIAL

The Oso and Cathcart series include soils developed mainly in place on consolidated rocks, which have been overridden and affected by glacial materials. The Oso soils, developed mainly from hard metamorphoric rocks that weather slowly, are shallow and rocky. The Cathcart soils are developed mainly from sandstones and shales that disintegrate readily.

OSO SERIES

Oso soils are covered with about 1½ inches of dark-brown organic material underlain by a thin gray layer that rests on light reddish-yellow or moderately yellowish-brown material containing some cemented aggregates of soil. At a depth of about 10 inches this layer passes into moderately yellowish-brown or yellowish-brown loam containing many angular fragments of rock. At an average depth of 30 inches the material is underlain by partly decomposed rock and at about 42 inches by hard rock. The depth to the bedrock ranges from 10 inches to more than 6 feet within short distances.

That Oso soils are developed at high elevations where the rainfall is high, and the cool temperature is reflected in the gray leached layer and the rust-brown horizon below it. These soils are developed in place from hard rocks somewhat overridden and affected by glaciation, although the material is dominantly of residual origin. As

mapped, the parent materials include a variety of rocks, but these are dominantly hard metamorphic rock, as argillite; and lava rocks, as andesite and basalt. The soils are nonagricultural, and no attempt was made to map them in detail on the basis of differences in geological origin or other characteristics.

The larger bodies occur on the lower mountain slopes, and areas near the main streams are at lower elevations. The relief is mainly gently to more steeply rolling and associated with mountainous relief. All the areas were formerly forested.

Oso loam is the only type of this series recognized in the county.

Oso loam.—This soil is covered with about 1½ inches of dark-brown organic material consisting of partly decayed forest litter. Beneath this is an ash-gray loam ½ to 1 inch thick, of irregular occurrence. This passes sharply into moderately yellowish-brown or rust-brown loam that contains some rust-brown weakly cemented aggregates of soil. It contains a variable quantity of angular rounded gravel.

At a depth of about 10 inches this material grades into light yellowish-brown loam. This contains angular weathered rock and gravel. At an average depth of 30 inches the material is underlain by weathered rock and at 42 inches by solid rock, but the depth to bedrock ranges from 6 inches to more than 6 feet within short distances. There are many rock outcrops on the surface. This soil is moderately or strongly acid. Areas that are more gravelly and sandy than typical occupy about one-third of a square mile and are indicated by gravel symbols.

Oso loam is a variable soil and might be considered a soil complex rather than a definite soil type. The parent material includes a number of hard rocks that are resistant to weathering. The relief is gently rolling or rolling, and some areas include some rocky breaks or steep slopes. The drainage ranges from good to excessive, owing to the fairly steep relief and to the friable condition of the subsoil.

All this soil was formerly covered with a heavy stand of hemlock, Douglas-fir, cedar, and other conifers. It occurs in the northeastern part of the county. About half the timber has been cut, and the rest is being logged rapidly. None of the land is under cultivation. It is of more value for the production of timber than for farming. Its total area is 10 square miles.

Areas of Oso loam in secs. 1 and 2, northwest of Whitehorse School; in sec. 30 southwest of Lake Roesiger; in sec. 32, T. 27 N., R. 7 E.; and near Olney Creek north of Startup have a deeper, finer textured soil than typical. They occur at somewhat lower elevations than typical Oso loam. Here the organic surface layer passes into yellowish-brown or reddish-brown heavy loam or clay loam, which contains numerous rock fragments. The parent rock consists largely of basalt, argillaceous metamorphic rocks, and granite. The parent bedrock outcrops in many places but generally occurs at a depth ranging from 24 inches to 6 feet or more. The total area of this included soil is about 1 square mile.

CATHCART SERIES

In virgin areas of the Cathcart soils there is a layer of partly decomposed organic material about 2 inches thick, which passes abruptly

into a rich-brown mineral soil of moderately high organic content about 8 inches thick. A small quantity of gravel and a few glacial boulders are on the surface.

The subsoil is yellowish brown, variegated or streaked with rust brown, gray, red, and yellow in the lower part and contains an abundance of small shotlike pellets. This layer is underlain by partly disintegrated shale and sandstone at an average depth of about 34 inches, the range being 24 to 60 inches. The Cathcart soils are permeable integrated shale and sandstone at an average depth of about 34 inches but ranging from 24 to 60 inches. The Cathcart soils are permeable and friable to the underlying bedrock. The surface soils are moderately acid, and the upper part of the substratum is slightly acid.

The parent materials in this series consist of weathered shales and sandstones with thin or superficial glacial materials, as indicated by granitic gravel and occasional glacial boulders on the surface. The underlying rock is largely sandy shale or shaly sandstone, with some interstitial heavy claylike shale and, in places, thin beds of coal.

The relief is for the most part gently rolling, and in many places these soils are associated with steep slopes of rough broken land. Drainage is well developed.

The soils—Cathcart loam and Cathcart clay loam—are well drained, and in their virgin condition supported a heavy cover of Douglas-fir, cedar, hemlock, and associated trees and shrubs.

Cathcart loam.—In virgin areas this soil is covered with a 2-inch layer of dark-brown forest mull consisting of partly decomposed leaves, fir needles, litter, and considerable mineral soil, in the lower part bound together with fine rootlets. Between depths of 2 and 8 inches the surface soil is rich-brown loam of moderately high organic content. The upper part is faintly reddish brown when wet and contains a large number of rust-brown soil aggregates of iron cementation. The soil when plowed breaks to a faintly granular tilth and has a rich-brown color. This material grades into yellowish-brown rather heavy loam faintly variegated with rust-brown streaks. At a depth of about 28 inches it grades into yellowish-brown loam variegated with rust brown, rust yellow, and some gray. This is a gritty, rather heavy, moderately acid loam and breaks up to small clods. It is underlain by rust-brown and grayish-brown partly decomposed sandstone or sandy shale with streaks or mottling of rust yellow, gray, and a trace of black in the upper part. It becomes more gray with depth. The depth to the parent material ranges from 24 to 60 inches or more. The upper part of the parent material is rather soft. The substratum includes interbedded layers of sandstone, sandy shale, and shale, with occasional seams of coal. A few roots penetrate to a depth of 24 inches or more into the partly weathered sandstone and shale. A few granitic pebbles and glacial boulders and many fragments of sandstone and shale occur in the soil.

Cathcart loam covers a total area of 4.9 square miles. The land is gently rolling, with a moderately developed shallow dendritic drainage system. The largest areas are north of Cathcart and northeast of Snohomish.

Surface and internal drainage are very good. Closely spaced Douglas-fir stumps 6 feet or more in diameter indicate a former heavy stand of timber. The present uncleared areas are covered for

the most part with a thick stand of young hemlock, cedar, fir, alder, vine maple, Oregon maple, and other trees and shrubs, together with a thick growth of bracken in open areas. About 35 percent of the land is under cultivation, and considerable additional areas are being cleared, most of which also will probably soon be under cultivation.

This is one of the most desirable soils of the uplands. Forage crops for dairy cattle and timothy and clover are grown on most of the cultivated area. Timothy and clover, cut for hay the first year, yield about 2½ tons an acre, and may be cut for hay or pastured the second or third year. Oats are grown on about 25 percent of the cultivated land and are used as a nurse crop for timothy and clover. Most of the oats are cut green for hay, which yields about 2½ tons an acre; when cut for grain, the acre yield is about 60 bushels. Fruit trees and truck crops do well. Potatoes yield about 200 bushels, and strawberries 2,000 quarts. The yields mentioned are obtained with the use of fertilizer, mostly barnyard manure.

Cathcart loam is not especially susceptible to erosion, but owing to the occurrence of the parent rock at slight depths it should be carefully managed and farmed along the contour and not up and down the slopes.

As mapped, a few small areas of silt loam and of sandy loam texture are included. The sandy loam areas, covering somewhat less than half a square mile, are the more extensive. These are utilized as pasture and support a good growth of lespedeza and grass where not shaded and where bracken has not gained a foothold.

Cathcart clay loam.—In virgin areas this soil consists of a 2-inch covering of dark-brown well-decomposed organic material, underlain to a depth of about 6 inches by rich-brown clay loam. When plowed at the proper moisture content it breaks into angular pea-sized fragments. It is strongly to moderately acid (pH 4.8 to pH 5.3). Where cultivated, the organic surface layer is mixed with the surface soil and the material becomes rich brown. This layer passes into brownish-yellow heavy clay loam very faintly variegated with rust brown. It breaks into irregular large clods and small angular fragments. At a depth of about 24 inches this layer grades into dull yellowish-brown clay loam or silty clay stained with rust brown, and this, in turn, grades into brownish-yellow disintegrated shale.

The parent material, which is reached at depth of 34 to 60 inches, is brownish-yellow soft shale. It breaks along a horizontal plane to cubical or flat fragments with brownish-red stains. In some places there are interbedded layers of heavy sticky claylike shale. Where these outcrop the surface soil is finer in texture. The lower part of the subsoil and upper part of the shale substratum are moderately acid. The shale, into which roots penetrate to a depth of only a few inches, becomes less acid with depth.

The surface is gently rolling, with a somewhat hummocky microrelief. On the lower slopes this soil generally is associated with rough broken land. Surface drainage is good, and internal drainage is adequate. The total area mapped is 1.0 square mile. The largest area is near Cathcart.

There were more hardwoods in the native forest on Cathcart clay loam than on the other soils of the uplands in this county. The virgin timber has been cut, and the soil now supports much alder,

vine maple, Oregon maple, and a second growth of fir. About 40 percent of the land is under cultivation, and this is considered the best soil in the uplands for timothy and clover, which are grown on about 60 percent of the cultivated area and produce an average yield of 2½ tons of hay an acre. Oats are grown on about 20 percent of the cultivated land and produce about 2½ tons or more of oat hay or 60 bushels of grain. Strawberries yield more than 2,000 quarts. Many bush beans and telephone peas are grown. Some corn is grown for silage. Fruit trees do well.

WELL-DRAINED SOILS UNDERLAIN BY COMPACT OR CEMENTED GLACIAL TILL MATERIALS

The well-drained soils underlain by compact or cemented glacial till materials include several members of the Alderwood series. These soils are underlain by very compact or silica-cemented glacial till, locally known as hardpan. They are of average productiveness. Areas designated as the rolling phases are better adapted to timber production than to farming.

ALDERWOOD SERIES

In a virgin condition the Alderwood soils are covered with partly decomposed forest litter to an average depth of about 2 inches. In the more sandy areas and in areas of retarded drainage a very thin gray siliceous layer occurs in many places just below the organic material, but in general the organic layer passes abruptly into a weak-brown friable soil, which contains many small shotlike pellets,[8] or aggregates, and considerable gravel. At an average depth of about 6 inches this layer grades into more yellowish-brown material that becomes lighter colored with depth. The small pellets, or shot, as they are locally known, are one-tenth to one-quarter of an inch in diameter and of a uniform brown or rust-brown color. Much gravel and many glacial cobbles and boulders occur throughout the soil. The subsoil material is abruptly underlain by gray, dense, cemented, gravelly glacial till, which may continue to a depth of more than 40 feet.

In the earlier reconnaissance survey the Alderwood soils were included with soils of the Everett series, and Whatcom silt loam of the earlier survey, as now mapped, is included with the Alderwood soils.

The glacial till from which these soils have been developed consists of granite, quartzite, schist, slate, basalt, and other materials brought in from the north by glaciation.

Surface drainage is well developed in most places, but internal drainage is retarded by the cemented substratum, and the soils show the effects of drought somewhat less quickly during the dry summer season than do the more permeable soils of the Everett series, with which the Alderwood soils are associated.

Three soil types and four soil phases of the Alderwood series are recognized—Alderwood gravelly loam and Alderwood gravelly sandy loam, both with hilly and level phases, and Alderwood silt loam.

[8] WHELTING, L. C. SHOT SOILS OF WESTERN WASHINGTON. Soil Sci. 41 : 35–44, illus. 1936.

Alderwood gravelly loam.—In virgin areas this soil is characterized by a thin surface layer of dark-brown forest litter and partly decomposed leafmold from fir and hemlock needles, leaves, grass, moss, and twigs tightly bound together with fine roots. This organic mat ranges in thickness from 4 inches in areas of second-growth trees to less than 1 inch in pastured or burned-over stump land. Under cultivation the mat is mixed with the underlying soil. The organic layer passes abruptly into a brown, coarse, gritty, friable gravelly loam surface soil having a moderately high content of organic material. It has a reddish cast when moist and is more gray when dry. This layer contains many brown or rust-brown pea-sized cemented aggregates, or shot. A thin ash-gray layer about half an inch thick occurs in some places above this and just below the organic layer. It occurs irregularly as small spots in small depressions, where the drainage is slightly deficient, and on the more sandy areas.

The surface soil is strongly to moderately acid and ranges from pH 4.6 to pH 6.2, with an average of about pH 5.7 in virgin areas. In general it is slightly less acid in cultivated areas, because of the application of stable manure and commercial fertilizers. The most acid part is just below the leafmold, and the material becomes less acid with depth. It is slightly plastic when wet and without definite structure.

At an average depth of 6 inches the surface soil passes into a yellowish-brown coarse gravelly loam subsoil that is single-grained and friable. At a depth of about 12 inches the subsoil grades into a pale yellowish-brown or brownish-yellow gravelly loam lower subsoil, which has a faint green shade when moist but is more gray when dry. This layer is very faintly compact and breaks into small clods. It is usually less acid than the surface soil or the upper part of the subsoil and contains slightly more fine material.

Between the depths of about 24 and 38 inches is gravelly loam of slightly finer texture, ranging from brownish gray to yellowish brown faintly mottled with gray and rust brown. It is slightly compact and breaks into small clods and is rather hard to penetrate when dry. This layer contains much gravel and many glacial boulders. Plant roots are numerous and form a conspicuous horizontal mat of fine roots, the lower part of which is just above the gray cemented glacial material locally known as hardpan. This consists of unassorted glacial debris firmly cemented to a conglomerate rocklike mass. A heavy blow with a crowbar penetrates it only a fraction of an inch, but once broken the interstitial material between the gravel and rock is more easily loosened. Road cuts and wells indicate that it is of fairly uniform hardness to a depth ranging from 10 to 100 feet, with an average thickness of more than 40 feet. The cementing material appears to be mostly silica, with some iron. Where exposed to winter rains it disintegrates slowly. Road cuts with a 75 percent or steeper slope seem to stand up indefinitely. It is penetrated by moisture very slowly and by plant roots hardly at all. It is acid or neutral, ranging from pH 4.8 to pH 7.0, with an average of about pH 5.7, and, becoming less acid with depth, is neutral in places at a depth of 20 feet.

Gravel is scattered throughout the soil and on the surface, but there is seldom enough to prevent cultivation. The gravel consists mostly of granite, with some quartzite, schist, slate, basalt, and other rocks. The pieces of gravel are somewhat rounded and smooth with a little soil adhering to them. There are many glacial boulders on the surface and throughout the soil, in most places more than 20 tons an acre, which must be removed before the land can be properly cultivated.

Alderwood gravelly loam covers an area of 135.3 square miles and is one of the most extensive soils in the county. It is the predominating soil of the uplands in the western part. It is closely associated with Alderwood gravelly sandy loam and with the Everett soils.

The relief is that of a terracelike gently rolling or undulating ground moraine. This soil borders many steeper areas of the rolling phases of this and other soil types. The most typical areas are on benchlike positions between 200 and 400 feet elevation. Above the 400-foot elevation it is, in many places, bordered by a belt of the Kitsap soils. The average slope ranges from 2 to 13 percent. Areas with a slope of more than 13 percent are differentiated as the rolling phase, and nearly level areas are included with the level phase.

A fairly complete drainage system has developed. Most areas have good surface drainage. Underdrainage is somewhat deficient, because of the impermeable character of the substratum.

In its virgin state this soil was covered with a dense forest of Douglas-fir, some western hemlock, redcedar, alder, a few other trees, and underbrush, but because of easy accessibility was one of the first to be denuded. Much of the virgin timber was cut before 1910, and where protected from brush fires uncleared areas are now covered with a thick growth of alder, second-growth Douglas-fir, hemlock, and underbrush in various stages of maturity. A few areas support trees that will be large enough for merchantable timber in a few years, and much pulpwood is now being cut. Fallen logs, underbrush, and pitted ground conditions make uncleared areas difficult to traverse on foot. Trails and logging railroad grades quickly become overgrown with brush when abandoned. The land is costly to clear of the large stumps, but by using dynamite and heavy mechanized equipment much of this soil is being cleared (pl. 1, *B*).

About 5 percent of this soil is now under cultivation, and a little more is partly cleared for pasture. It is more productive than the average soil of the uplands but is less fertile than most soils in the valley bottom lands. Dairying and chicken raising are the most common types of farming practiced on this soil. More than 50 percent of the cultivated land is in clover and timothy for hay, which yields an average of 1½ to 2 tons an acre the first year, after which the land remains in pasture for 1 or 2 years. Oats, used as a nurse crop, average about 40 bushels an acre when cut for grain, but more than half the crop is cut green for hay, which averages about 2 tons an acre, and yields of 4 tons have been reported. Potatoes yield about 150 bushels. Potatoes and garden crops are grown for home use. The yields mentioned are obtained when liberal supplies of barnyard manure and some chicken manure are used. Most of the farmers buy considerable feed. This soil is not well adapted to fruit trees, because of the slight depth to hardpan, which interferes with deep-rooted crops. Some apples, cherries,

plums, and pears are grown for home use, and there are a few small commercial orchards near Edmonds. Loganberries and other bush fruits do well but are grown on a small scale. Most of the strawberries are grown on more sandy soils. Bracken dominates the pastures in cleared areas and tame-grass pastures about the fourth year.

A high content of gravel and fairly gentle slopes keep this soil from eroding readily, as also do the crops commonly grown. Any appreciable erosion would be destructive, owing to the shallowness of the soil above the hardpan, and steeply sloping areas should not be used for clean-cultivated crops. Owing to the slightly pitted surface the more level areas need good drainage through dead furrows and shallow-plowed ditches at the lower end of fields.

At present none of the farmed land is irrigated, but if water could be made available, limited supplemental irrigation would probably be profitable on garden crops during the dry months of July and August.

Alderwood gravelly loam, hilly phase.—This phase includes areas of the normal soil having slopes ranging from 13 to 25 percent. Areas with more than a 25-percent slope are classed as rough broken land. It occurs in small scattered areas closely associated with the typical soil and is similar in all respects except relief. The total area is 3.4 square miles. The dominant virgin timber of Douglas-fir has been cut, but less than 1 percent of the land is cleared of stumps and second-growth trees. It is used mostly for pasture and is more valuable for timber production than for farming.

Alderwood gravelly loam, level phase.—This level phase has a soil profile very similar to the typical soil, but the gray layer beneath the organic matter on the surface may be slightly better developed. The surface soil is mainly brown coarse gravelly loam, grading at a depth of 6 inches to yellowish brown and to a lighter color at a depth of 12 inches. It is underlain by a faintly mottled layer at a depth of about 24 inches, resting on a cemented substratum at a depth ranging from 24 to 48 inches or more. It occurs in small scattered areas in the eastern part of the county and is closely associated with typical soil. The total extent is 2.1 square miles, most of which is northeast of Lake Stevens, and is confined to nearly level terracelike areas having a slope of less than 2 percent. Surface drainage is slightly restricted but adequate. About 5 percent of the land is cleared. The crops grown and acre yields are similar to those on the typical soil.

Alderwood gravelly sandy loam.—In virgin areas a 2-inch cover of forest litter grades into dark leafmold. In most places this organic material is underlain by pale ash-gray gravelly sandy loam averaging about half an inch in thickness, but becoming as much as 2 inches thick in pockets and in the more sandy localities, or it may be lacking over considerable areas. This layer is spotted in occurrence, but it occurs much more consistently in this soil than in Alderwood gravelly loam. When wet, the gray layer is not very conspicuous. This horizon and the organic layer are distinctly acid, ranging from pH 4.6 to pH 5.0.

The surface soil between depths of 2½ and 10 inches is brown gravelly sandy loam. Most of it has a faint-red cast when moist, less red, however, than Alderwood gravelly loam, and it becomes somewhat gray when dry. Cultivated areas have a dull grayish-brown shade, owing to a mixing of the organic and the thin gray layer with the

underlying material. In most places this soil is of higher gravel content than Alderwood gravelly loam. Although the gravel is an annoyance, only a few areas contain sufficient quantities to preclude cultivation. Numerous glacial cobbles and small boulders also occur. Rust-brown pea-sized shot pellets are scattered through the soil and are concentrated in the lower part of this layer. The content of organic matter is low. This layer is strongly to medium acid, ranging from pH 4.7 to pH 6.0. The soil is loose and friable, with single-grain structure.

Below this layer the soil becomes yellower with depth. At about 10 inches it grades into yellowish-brown or light brownish-yellow gravelly sandy loam and continues to a depth of 26 inches or more. This material is slightly sticky when wet, and the walls of road cuts are firm and not easily broken down. When removed the material is fairly friable and porous. This layer is moderately acid and is low in organic matter.

At a depth of about 28 inches this material grades into brownish-yellow gravelly sandy loam, which may be of slightly finer texture than the soil above. The consistence is firm, and the material breaks into soft angular clods. It has a gray shade when dry and a green shade when moist. A trace of gray and rust-brown mottling occurs in the lower part of the layer. This material is without shot pellets, but gravel and cobbles to which soil adheres are conspicuous.

This layer rests abruptly on gray cemented glacial drift material locally called hardpan, which is 10 to 75 feet thick and consists of a mixture of roughly rounded cobbles, gravel, sand, and fine interstitial cementing material. The depth to the hardpan ranges from 24 to 48 inches. Where the hardpan is of greater depth, most of the areas are included with the Everett soils. In most places the top of the hardpan is covered with a mat of fine plant roots, which do not penetrate it, but water percolates through very slowly, and the reaction of the upper part of the hardpan is strongly acid, ranging from pH 4.8 to pH 5.0. The cemented material appears to conform to the slopes without great variation in thickness.

Alderwood gravelly sandy loam is one of the predominating soils of the uplands in the western part of the county. The total area is 86.1 square miles. The largest areas occur at elevations between 200 and 400 feet.

The relief in general is gently rolling but somewhat more strongly rolling than Alderwood gravelly loam, with slopes ranging from 2 to 13 percent. The microrelief in virgin areas is pitted with shallow depressions several feet in diameter as a result of overturned trees having shallow, widely spreading root systems. Surface drainage is good, but underdrainage is somewhat deficient. The soil material just above the cemented material is waterlogged during winter rains, but this is an advantage to many crops, as it conserves moisture for use in the dry summer months.

Most uncleared areas are now covered with a young growth of Douglas-fir, hemlock, alder, and other trees. Much pulpwood and cordwood is being cut in second-growth timber, and cordwood is also being cut from old fallen logs. Some of the oldest stands of second-growth timber are approaching sawlog size.

About 4 percent of this soil is under cultivation, in addition to small areas partly cleared for pasture. The main crops are clover and

timothy for hay and pasture, and oats, which are largely cut green for hay. Oat hay averages about 2 tons an acre and clover and timothy 1½ to 1¾ tons. Oats cut for grain yield about 35 bushels. Some potatoes, garden crops, and fruit are grown. Yields are comparable or slightly lower than on Alderwood gravelly loam.

The comparatively large area lying west of Lake Roesiger includes some undifferentiated areas of the rolling phase of this soil. These were not separated in the field, owing to difficult accessibility.

Alderwood gravelly sandy loam, hilly phase.—Separated from the typical soil on the basis of more steeply rolling relief, this soil includes areas having a slope between 13 and 25 percent. Nearly all of it is in virgin condition. The surface soil consists of a 2-inch layer of organic material, which passes into brown gravelly sandy loam. A thin ash-gray layer underlies this in some places, but it is not at all consistent. Below a depth of about 8 inches the material grades into yellowish-brown gravelly sandy loam, which, in turn, grades at a depth of about 26 inches into gray material underlain abruptly by cemented gravelly glacial drift at an average depth of 36 inches. The depth to the cemented layer, or hardpan, which outcrops on the steeper slopes, is more variable than in other Alderwood soils. As mapped, this soil includes small areas of Everett soils without the shallow hardpan layer. In some places adjacent to Cathcart soils the soil material is underlain by shaly sandstone.

This soil covers a total area of 31.2 square miles. It occurs mostly in scattered areas along breaks at the heads of stream channels in the western part of the county. Surface drainage is excessive, and drainage above the cemented substratum, which is impermeable to moisture, is good.

The relief is hilly. The slopes are not too steep to cultivate, but agricultural development is better deferred, where so much smooth land is available for clearing. This soil does not erode easily but is rather droughty and is more valuable at present for the production of timber than for cultivated crops. Less than 1 percent has been cleared, and much of this is in permanent pasture. Most of the virgin timber was cut more than 25 years ago, and while natural reforestation was delayed by brush fires, a young forest growth is taking place on much of this soil.

Alderwood gravelly sandy loam, level phase.—This is similar to the typical soil except that the relief is more level. It occurs in smooth benchlike areas having an average slope of less than 2 percent, the largest being in two bodies southeast of Lake Stevens. The total area is 1.8 square miles. Surface drainage is sluggish, but under cultivation adequate drainage is furnished by shallow furrows. About 5 percent of the land is cleared. The crops grown and the acre yields are similar to those on the typical soil.

Alderwood silt loam.—The surface soil in virgin areas is covered with a 1½-inch layer of brown, moderately acid, partly decomposed organic material containing many roots. Under cultivation this is mixed with the mineral soil below, which consists of reddish-brown smooth silt loam containing many small pea-sized soft rusty-red or rusty-yellow incipient concretions, or shotlike pellets. The material in this layer is weakly bound together with roots, is moderately high in

organic matter, slightly acid, and faintly granular. Some gravel and glacial boulders are scattered through the soil mass, although it is less gravelly than the other Alderwood soils.

Between depths of 7 and 18 inches, the subsoil is yellowish-brown silt loam with a red cast. It is friable and breaks into small clods and crumbles to small pea-sized fragments. This material passes into reddish- or yellowish-brown friable silt loam, which breaks into small clods. At a depth of about 30 inches it is underlain by light reddish-brown or yellowish-brown silt loam. This layer contains great numbers of roots that extend horizontally and in places form a mat over a brownish-gray dense hardpanlike substratum consisting of cemented glacial till. The average depth to the hardpan is about 36 inches but ranges from 24 to 50 inches. The hardpan is more than 40 feet thick in most places and is very hard to penetrate with a crowbar. Moisture permeates it very slowly and few plant roots penetrate it. It consists of water-worn gravel and glacial boulders embedded in interstitial material of fine sandy texture and appears to be cemented with silica and iron. The rock and gravel are largely basalt, with smaller quantities of granite, quartzites, schists, and other metamorphic rocks.

This soil occupies an area of 2.4 square miles in one locality northeast of Monroe, mostly in T. 28 N., R. 7 E. The relief is undulating or gently rolling, and the soil is not especially susceptible to erosion. Surface drainage is good, but underdrainage is somewhat deficient. The originally heavily timbered land has all been cut over, and uncleared areas are covered with a young growth of alder, Douglas-fir, redcedar, and hemlock, together with an undergrowth of bracken, red huckleberries, cascara, blackberries, and other shrubs and vines. About 30 percent of the land has been cleared.

Considered one of the best soils of the uplands, about 60 percent of the cultivated area is used for timothy and clover, 25 percent for oats, and the rest for miscellaneous crops. Timothy and clover produce an average yield of about 2 or 2¼ tons of hay an acre and potatoes 160 bushels. Cherries, apples, loganberries, and several small fruits do well. The content of organic matter of this soil is low, and the crop yields are obtained by use of a liberal supply of manure.

WELL-DRAINED SOILS UNDERLAIN BY FINE-TEXTURED GLACIAL LAKE SEDIMENTS

The soils of the Kitsap series are the only well-drained soils in the county developed from fine-textured sediments deposited in former glacial lake basins or ponded glacial waters. They are of average productivity.

KITSAP SERIES

The Kitsap series includes brown upland soils characterized by smooth fine texture and absence of gravel, coarse sand, or stone. The parent material consists of compact gray silty clay with thin interbedded layers of silt and very fine sandy loam, entirely free of coarse material and apparently originating in old glacial lake, alluvial, or marine deposits laid down in still waters. In uncleared areas the surface is covered with a thin dark-brown organic layer of partly decomposed forest litter.

These soils are developed on gently sloping or nearly level upland benches having a slight irregular microrelief. Surface drainage is somewhat restricted but adequate, and internal drainage is fair, but the silty clay substratum is slowly permeable to moisture. The soil materials are acid in reaction. A striking feature of all Kitsap soils not common in other soils of the region is the green color of ditch banks, caused by a growth of moss.

Before the land was cut over, these soils supported a heavy stand of Douglas-fir, western redcedar, and western hemlock. A young growth of alder, hemlock, redcedar, and fir is now coming in, together with a thick undergrowth of bracken, huckleberries, blackberries, salal, and other shrubs and vines. The soils are more productive of hay crops and grain than the Alderwood soils.

Two soil types and one soil phase of this series are recognized—Kitsap silt loam and its steep phase and Kitsap loam. These three were included mainly with the Whatcom soils of the earlier survey.

Kitsap silt loam.—In undisturbed virgin areas this soil is covered with a 1-inch layer of dark-brown partly decomposed organic material containing much fine silty mineral material in the lower part. The surface soil to a depth of about 6 inches is grayish-brown, yellowish-brown, or pale reddish-brown faintly granular smooth-textured silt loam. The organic-matter content is moderately high. Some small shotlike pellets adhere to the small roots. The ash-gray layer developed in many other soils of the county below the surface organic material is generally absent.

At a depth of about 6 and continuing to about 10 inches the subsurface soil is yellowish-brown heavy silt loam slightly mottled with gray and rust red and breaks to weakly developed clods. This layer and the one above are strongly acid (pH 5.2). Below, to a depth of about 20 inches, the material is brownish-yellow heavy silt loam mottled and streaked with rust brown and gray containing specks of black. It breaks into irregular clods that contain a few worm holes and many small roots and becomes grayer with depth, passing into light-gray or very pale-brown silty clay mottled with rust red and gray. This layer is moderately acid, rather tough, and hard to penetrate and breaks into large clods and blocks.

At an average depth of 26 inches, this is abruptly underlain by a parent material of compact light-olive or pale-olive clay shaded with brownish gray and yellow when moist but gray when dry. It has a faint horizontal fracture and breaks into angular fragments and blocks containing thin interbedded layers of silt and very fine sandy loam. A few small roots penetrate it to a depth of 60 inches or more. The upper part of the parent material varies in reaction from very strongly acid (pH 4.6) to slightly acid (pH 6.2) and it becomes less acid with depth.

The color of the soil varies considerably. In the better drained areas it is more yellow and in the more poorly drained areas it is grayer than typical. Pockets of gray and yellow material occur in the subsoil of all areas.

This soil is widely distributed in small bodies over the county. Much of the total area of 14.5 square miles is in an irregular belt slightly more than 400 feet in elevation. It is developed in flat terracelike areas

with a very gentle slope and has a faint irregular microrelief caused by the uprooting of huge trees that have been blown over. Surface drainage is somewhat restricted, but under cultivation shallow furrows carry off the water. Internal drainage is fairly good but takes place slowly. The soil is plastic when wet and becomes hard when dry.

Kitsap silt loam at one time was heavily forested with the common trees of the region. Practically all the original timber has been cut. A young growth of alder, redcedar, hemlock, fir, cascara, dogwood, and thick underbrush covers most of the cut-over area.

About 8 percent of the land is under cultivation, and on about 65 percent of this area timothy and clover are grown. The yields of hay are about 1¾ tons an acre the first year, somewhat less the second, and the hay land is pastured the third year and sometimes the second and fourth. Oats, grown as a nurse crop on about 20 percent of the cultivated land, produce an average yield of about 40 bushels an acre. Other general farm crops are grown on the rest of the land, but it seems to be poorly adapted to fruit trees and garden crops.

Kitsap silt loam, steep phase.—This steep phase includes eroded areas at the heads of ravines that extend into areas of the typical soil. A thin organic layer overlies the surface soil, which is grayish-brown heavy silt loam to a depth of about 6 inches. This is underlain by grayish-yellow silt loam or clay loam mixed with gray, brown, and rust-brown material that extends to an average depth of 16 inches, where it passes into compact greenish-gray silty clay with thin interbedded layers of silt and very fine sandy loam. The deeper underlying materials outcrop on the steeper eroded slopes. This soil erodes very easily and when wet it slides badly in road cuts. It has been logged but not cleared of stumps, and most of it is covered with a fair stand of young trees. Its greatest value is for the production of timber. Its 1.8 square miles occur in small scattered areas closely associated with other Kitsap soils.

Kitsap loam.—In undisturbed virgin areas this soil is covered with a 1½-inch layer of dark-brown or brown partly decomposed forest litter with fine mineral material in the lower part. The 6-inch surface soil is reddish-brown smooth fine-textured loam that grades into yellowish-brown material in the lower part and includes variations in texture ranging from smooth silty very fine sandy loam to light silt loam. This material contains a few shotlike pellets, many roots, and tiny dark streaks from decayed roots. In cultivated areas, where the soil is mixed with the layer of organic material, the surface soil becomes grayish brown. It passes into yellowish-brown fine-textured loam containing many pockets of light reddish-brown material that extend into it from the layer above. This layer of soil and the layer above are strongly acid (pH 5.4) in virgin areas and slightly less acid in well-fertilized cultivated areas. At a depth of about 15 inches the material grades into brownish-yellow silt loam variegated with rust brown, rust yellow, and gray. Matted roots lie horizontally in the lower part of this layer; associated in many places with the decayed roots is dark-colored decomposed organic material and the white mycelia of fungi. At an average depth of 32 inches the soil is abruptly underlain by the parent material of compact gray laminated silty clay containing very thin interbedded layers of silt and very fine sandy loam, together with specks of rust brown and

rust yellow. It has firm consistence and is rather hard to penetrate with a shovel and is not penetrated deeply by roots. This material is moderately acid in the upper part and becomes less acid with depth.

There is considerable variation in the color of the surface soil, which is brown, yellow, or gray according to differences in drainage. The included spots with deficient drainage are grayer, and the better drained areas are brown.

This soil occurs in small bodies scattered over the county at elevations of less than 500 feet. Many areas occur as high benches near places where small creeks join larger streams. The total area is 7.2 square miles.

The relief is smooth and benchlike, with very gentle slopes. Surface drainage is adequate. Underdrainage is somewhat restricted but is satisfactory for general farm crops.

Some of this soil, northwest and northeast of Sultan on benchlike areas slightly more than 400 feet in elevation, is of slightly lighter texture than typical, approaching fine sandy loam.

This soil originally supported a heavy stand of hemlock and Douglas-fir, but most of the large trees have been cut and the uncleared areas now are covered with a young growth of hemlock, alder, fir, vine maple, and cascara, and an undergrowth of willows, fireweed, devilsclub, bracken, huckleberries, and other shrubs and plants.

Kitsap loam is locally considered a desirable upland farming soil, somewhat superior to Kitsap silt loam. About 20 percent of it is under cultivation, and the cleared area is increasing rapidly. It has good water-holding capacity and is fairly easy to cultivate. Timothy and clover are grown on about 50 percent of the cultivated land and yield about 2 tons of hay an acre. Oats are grown on about 15 percent of the cultivated land and yield 40 to 45 bushels. Garden crops, potatoes, and fruit for home use are grown on the rest of the cultivated area.

WELL-DRAINED SOILS UNDERLAIN BY LOOSE POROUS GLACIAL TILL AND OUTWASH MATERIALS

The group of well-drained soils underlain by loose porous glacial till and outwash materials includes soils of the Everett, Skykomish, Lynden, and Indianola series. The Everett and Skykomish soils are underlain by gravel and sand and the Lynden and Indianola by sand or fine sand. The productivity of these soils depends mainly on the surface texture. The soils with loam surface soil are of average fertility. Those having coarse sandy surface soils are less fertile. Areas designated as loamy sand are of very low agricultural value. Areas designated as rolling are better adapted for timber production than for cultivated crops.

EVERETT SERIES

In virgin areas the Everett soils have a 2-inch cover of partly decomposed organic material, which passes sharply into brown or pale-brown soil with a high gravel content, but in many of the more sandy areas there is a thin gray layer beneath the organic layer. The gray layer is more distinct when the soil is dry and almost disappears when it is wet. Some rust-brown shotlike pellets are concentrated in the lower part of the surface soil. At a depth of about 10 inches the soil material passes into a more yellowish-brown gravelly subsoil. This

layer, in turn, grades into a more yellowish-brown or grayish-brown material with increase in depth and is rather loose and only slightly coherent. In most places it contains a large quantity of gravel. At an average depth of about 38 inches this layer passes into light grayish-brown or yellowish-brown gravelly glacial drift, which is more or less modified by glacial waters and is assorted or irregularly stratified, very slightly compact, porous, uncemented, and crumbles easily.

The water-holding capacity is rather low. The gravel consists of granite, quartzite, schists, and other metamorphics, shale, sandstone, basalt, and other rocks. In general the relief is gently rolling or rolling with some kamelike and morainic areas. Drainage is good or excessive, except in small spots subject to seepage. These soils originally were heavily forested but have been extensively logged, and are now occupied mainly by second-growth timber and shrubs. Comparatively small areas are used for pasture and farm crops (pl. 3). The Everett series is represented by four soil types and four phases, of which the gravelly sandy loam is by far the most extensive.

Everett gravelly sandy loam.—In virgin areas this soil is covered with a layer of dark-brown organic material consisting of partly decomposed fir needles, leaves, twigs, grasses, fern fronds, and moss, all grading into dark-brown well-decomposed leafmold that contains some fine sand and white fungi mycelia, and all firmly bound together by fine rootlets. The thickness ranges from a mere film on recently burned-over and pastured areas to 4 inches in heavy second-growth timberland. When cultivated the organic layer is mixed with the mineral soil below. A thin irregular ash-gray layer, developed beneath the organic layer in some areas, is more pronounced on the more sandy-textured areas at the higher elevations and in shaded localities. Generally the organic layer passes sharply into pale-brown gravelly moderately acid and friable sandy loam. The soil is very slightly plastic when wet and continues to a depth of about 10 inches. This material is low in organic matter. A red shade near the surface gives way to yellow with depth. Gravel constitutes about 10 percent of the material, and small glacial cobbles and boulders are scattered throughout. There are some rust-brown softly cemented shotlike pellets about one-tenth of an inch in diameter, which are more concentrated in the lower part of this layer. The soil grades into yellowish-brown friable gravelly sandy loam, which has many fine roots and becomes grayer with increasing depth. From a depth of about 38 inches downward to about 50 inches the subsoil generally is a very slightly compact grayish-brown or yellowish-brown gravelly sandy loam, but it may be replaced by irregularly stratified sand and gravel. The subsoil becomes less acid with depth. The reaction at a depth of 38 inches is slightly acid (about pH 6.0) and in places it approaches neutral (pH 7.0).

The substratum ranges from coarse glacial drift to glacial outwash material, with local inclusions, below a depth of 50 inches, of cemented materials such as underlie the Alderwood soils. The glacial till and outwash materials are derived largely from granitic and metamorphic rocks, with some basalt.

Glacial boulders and cobbles are scattered throughout the soil. Most of them are about 5 inches in diameter, and if the land is cleared of stone to plow depth, 15 to 40 tons an acre are generally removed.

Everett gravelly sandy loam covers an area of 58.0 square miles. It occurs in scattered bodies in the uplands over the western part of the county closely associated with the Alderwood soils, but generally at higher or lower elevations. The most extensive areas are northeast and southwest of Monroe and east of Stanwood.

The relief is gently rolling or rolling, and many low kamelike morainic mounds and intervening smooth areas give the surface a hummocky appearance. In many places the soil is bordered by steeper eroded areas of Everett gravelly sandy loam, rolling phase, and rough broken land. Surface drainage is good, except in local depressions; internal drainage is excessive, and only small seepage spots on slopes and local depressions have deficient drainage. This soil is inclined to be droughty, due to its porous character and deficient water-holding capacity.

The native vegetation was mostly a heavy stand of Douglas-fir, with some western redcedar and hemlock. Nearly all the forest has been cut over, and most of the land is now covered with second-growth alder, Douglas-fir, hemlock, and redcedar, some of which have a diameter of more than a foot. The timber restocks itself where protected from brush fires. Bracken covers all areas not densely shaded, and a thick growth of evergreen blackberry briers covers some of the moderately moist areas.

Less than 2 percent of the land is cultivated. The largest cultivated areas are south of Everett and east of Edmonds. Much of this soil is in isolated localities, remote from good roads and partly surrounded by areas of steep relief, which discourages clearing. Mixed clover and timothy is grown on about 60 percent of the cleared area and produces an average of 1½ to 2 tons of hay an acre, and oats cut for hay yield an average of a little more than 2 tons. The hay yields are slightly lower than on Alderwood gravelly loam. The Everett soil is rather porous for hay crops, but it is better than the Alderwood soils for fruit trees, owing to its greater depth and permeability. Apples, cherries, pears, and plums do well and give moderate yields where the trees are properly cared for, but sweet cherries often crack badly. Fruit growing is handicapped by competition with the irrigated region east of the mountains where the yields are higher and the markets better developed. Loganberries and other small fruits produce well, but few are grown commercially. Potatoes and vegetables are grown for home use. The yield of potatoes ranges from 50 to 250 bushels an acre, with an average of about 125 bushels.

Owing to its high content of gravel and rather porous character, this soil does not erode easily, although much of it has a slope of about 10 percent. At present the steeper areas are of greater value for forestry than for farming.

Everett gravelly sandy loam, hilly phase.—This hilly phase was separated from the typical soil on the basis of more rolling and steeper relief, although it is also more stony than average areas of the typical soil. It includes areas having a slope of more than 13 percent.

Many glacial boulders are scattered over the surface and throughout the soil. An average of about 30 tons of stone an acre would need to be removed before clearing the land for crops. The cost of removal is small compared with that of clearing the stumps, forest trash, and brush.

This soil occurs in scattered bodies closely associated with the other Everett soils over an area of 35.7 square miles. Most of the larger areas occupy eroded benches more than 400 feet in elevation bordering the mountains, and the most extensive are northeast of Monroe.

The relief is hilly, with slopes ranging from 13 to 25 percent. Areas having a slope of more than 25 percent are differentiated as rough broken land.

Practically none of the land is cultivated, though it could be cleared, and a few spots have been partly cleared for pasture. Its most profitable present use is for the production of timber.

Areas of somewhat finer or heavier texture and of lower stone content, aggregating about one-third of a square mile, are included. The larger of these are in sec. 8, T. 27 N., R. 8 E. This included soil does not differ materially from the typical soil in relief, profile, or land use and adaptability to cultivated crops.

Everett gravelly sandy loam, level phase.—This level phase consists of areas of the normal soil developed on nearly level terracelike relief with a slope of less than 2 percent. It occurs in small scattered areas closely associated with other Everett soils on a total of 6.9 square miles. In virgin areas there is a 2-inch layer of dark-brown leafmold on the surface, underlain in places by a film of ash-gray sandy loam over an 8-inch layer of brown or reddish-brown gravelly sandy loam containing many rust-brown shotlike pellets, all weakly bound together with roots. Underlying this is coarse gravelly sandy loam to a depth of about 20 inches, yellowish-brown, and becoming lighter gray with depth. This material is loose, porous, and of high gravel content. Between 20 and 30 inches the material becomes coarser and more gray, and below a depth of 30 inches imperfectly stratified layers of sand and gravel occur in many places. A few glacial cobbles and boulders are scattered through the surface soil and subsoil. Fine roots extend to a depth of 60 inches or more. Internal drainage is good to excessive, and surface drainage is adequate. In reaction, character of vegetation, land use, and acre yields, the level phase is similar to the typical. About 3 percent of the land is under cultivation.

Everett stony sandy loam.—Where not occupied by stone, the surface of this soil is covered with a 2-inch layer of forest litter, below which is a 1-inch layer of ash-gray sandy loam, hardly visible when moist. This material is strongly acid (pH 4.0 to 5.0) and is abruptly underlain by rust-brown or yellow-brown moderately acid gravelly sandy loam of light sandy texture, containing shotlike aggregates, or pellets. At an average depth of 18 inches is a grayish-brown or pale yellowish-brown layer of sand, gravel, and stone that is coherent or faintly compact to a depth of about 40 inches, below which it is loose and incoherent. Roots penetrate this layer to a depth of 40 inches or more. The gravel and stone are mostly granite, with some basalt, andesite, quartzite, and other hard metamorphic rocks. About 40 percent of the material consists of smooth round stones ranging from 4 to 12 inches in diameter. This soil, covering an area of 3.5 square miles, has developed on eroded terraces along swift streams emerging from the Cascade Mountains. It formerly supported a fair stand of Douglas-fir, which has been cut, but is now covered with a scattered growth of young alder,

Douglas-fir, hemlock, redcedar, and maple, and an undergrowth of bracken, red huckleberries, and salal, with some grass. The land is nonagricultural and is best suited to forestry.

Everett gravelly loam.—In uncleared areas this soil is covered with a dark-brown layer ½ to 4 inches thick of partly decomposed organic matter consisting of forest litter that grades into well-decomposed leafmold tightly bound together by fine roots. In places a half-inch ash-gray layer is developed beneath the organic layer, but it is not typical of this soil. The surface soil below the organic layer, to a depth of about 8 inches, is an acid (pH 4.8 to pH 6.2) brown or reddish-brown, single-grained loose friable, rather coarse gravelly loam, containing a few rust-brown soft shotlike pellets and here and there more firmly cemented rust-brown soil aggregates. Gravel constitutes 5 to 10 percent of the material. The gravel content is lower than in Everett gravelly sandy loam, and, although something of an annoyance, it is insufficient to interfere with cultivation. The organic matter content is fairly low, but there are many fine roots.

In cultivated areas the surface soil has a dull grayish-brown shade, owing to the mixing of the organic layer with the gravel and finer mineral soil material. This soil is slightly more reddish brown in the northern part of the county and is grayer at the higher elevations.

The surface soil is underlain to a depth of about 16 inches by brown or yellowish-brown coarse gravelly loam similar to the soil above in consistence. At a depth of about 16 and extending to about 36 inches the material becomes more yellow and grades into light yellowish-brown gravelly loam a little more sticky than the overlying material. At an average depth of about 36 inches it passes into more porous gravelly loam that continues to 50 inches or more. This material varies in color from grayish brown or yellowish brown to brownish yellow, becoming grayer with depth. The substratum, below a depth of 50 inches, consists of grayish-brown or gray glacial debris or outwash material, which may be cemented in places. This cemented material, or hardpan, is too deep to have much effect on plant adaptation. Where it occurs at less depth, the soil is classified with the Alderwood series.

Everett gravelly loam occurs on 13.9 square miles in small scattered bodies throughout the county. The surface is gently rolling or rolling, with somewhat irregular bench or kamelike relief. Surface drainage is good except in small depressions or glacial pot holes and in spots along slopes subject to seepage. Internal drainage is free, the water-holding capacity is low, and the soil subject to drought. In common with the other upland soils, the native vegetation consisted of Douglas-fir, hemlock, and redcedar, nearly all of which has been cut. This is now succeeded by young alder, Douglas-fir, hemlock, cedar, cascara, and other trees, together with a thick undergrowth of bracken, vines, and other plants.

About 3 percent of the land has been cleared. About 60 percent of the cultivated area is in timothy and clover, which yields an average of 1¾ to 2 tons of hay an acre. About 30 percent is used for oats, most of which are cut green for hay and yield about 2½ tons an acre. The yields are slightly higher than on Everett gravelly sandy loam. The rest of the cultivated land is planted to potatoes, gardens, and fruit trees.

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Potatoes average about 150 bushels an acre. Fruit trees do well and give yields comparable to those of the county as a whole.

A few comparatively inextensive areas are stony.

Everett gravelly loam, level phase.—This soil is covered with a 1½-inch layer of dark-brown partly decomposed organic material abruptly underlain by very light reddish-brown gravelly loam containing a few cemented shotlike pellets and a small quantity of organic materials. Between depths of 6 and 30 inches is light yellowish-brown gravelly loam, somewhat yellower in the lower part. Below a depth of about 30 inches the texture becomes coarser, and the material is grayish-brown or yellowish-brown gravelly sandy loam. The substratum, below a depth of 48 inches, consists largely of irregularly stratified glacial outwash and glacial debris. Small glacial boulders are scattered throughout the soil. Surface drainage is adequate, and underdrainage is good to excessive. The largest body in its 3.7 square miles is around Echo Lake in sec. 33, T. 27 N., R. 6 E. Less than 2 percent of the land is cultivated, and much of it is comparatively inaccessible to roads. In yields and relative acreages of crops grown, this soil is similar to the typical soil.

Everett gravelly loamy sand.—In uncleared areas this soil is covered with a 2-inch layer of brown forest litter consisting of leaves, moss, twigs, and fern fronds fairly well disintegrated and mixed with some mineral matter. It is abruptly underlain by an ash-gray layer of irregular occurrence and variable thickness but having an average thickness of about one-half inch. This layer is more conspicuous in this soil than in any other upland soil in the county and is strongly acid (pH between 4.0 and 5.0). Under the gray layer is a very light reddish-brown gravelly loamy sand or coarse sandy loam to a depth of about 8 inches, containing rust-brown weakly cemented layers in places and having low organic-matter content. This is underlain to a depth of about 14 inches by very light reddish-brown or yellowish-brown gravelly loamy sand somewhat coarser than in the layer above. This may contain aggregates of rust-brown weakly cemented material in places, is rather strongly acid, and passes into light yellowish-brown gravelly sand that in most places becomes coarser with depth. It is underlain at an average depth of about 30 inches by brownish-gray sand and gravel, irregularly assorted and stratified. The surface soil of most of this soil is variable in texture and as mapped includes small areas of gravelly sand, gravelly sandy loam, and sand. The soil material is penetrated by plant roots to a depth of 50 inches or more and includes small glacial boulders in various quantities.

In its total of 13 square miles, the most extensive areas are north and northeast of Monroe in T. 28 N., R. 7 E.; T. 28 N., R. 8 E.; and T. 29 N., R. 7 E., and one prominent area occurs west of Darrington in the northeastern part of the county. The relief in general is gently rolling or undulating, but some small nearly level areas are bordered by steep escarpments or rolling areas. The more rolling areas are differentiated as a rolling phase. Surface drainage is good and underdrainage is excessive.

This soil formerly supported a fairly heavy stand of Douglas-fir, much of which has been cut in recent years. Natural restocking has been slow, and much of the land is now bare of timber. Less than 1

percent has been cleared and is used for pasture. Crop yields would be low, because of the porous character of the soil and its low water-holding capacity. Its greatest value seems to be for the production of timber.

Everett gravelly loamy sand, hilly phase.—In virgin areas this soil has a thin layer of partly decomposed organic material overlying an 8-inch layer of reddish-brown gravelly loamy sand. This passes into light yellowish-brown gravelly sand, underlain by light-brown or gray sand and gravel glacial outwash material at an average depth of about 26 inches and continuing to a depth of more than 25 feet. In places a thin ash-gray layer occurs just beneath the organic layer. The texture of the surface soil and subsoil varies greatly, owing to outcrops of sand, gravel, and gravelly loam on the slopes. Small glacial boulders constitute 5 to 25 percent of the material. This soil covers a total area of 4.3 square miles and includes areas having an average slope ranging from 13 to 25 percent, with eroded areas, breaks or escarpment slopes, and kamelike morainic areas. It is most valuable for timber production. None of this land is cultivated, but the soil materials are used extensively as sources of sand and gravel for road and building materials.

SKYKOMISH SERIES

Virgin areas of the Skykomish soils are covered with a thin layer of forest duff and leafmold, which in most places is underlain by a brown gravelly sandy surface soil, but in some by an irregular ash-gray layer that ranges from ½ to 2 inches thick. This gray layer is not conspicuous when the soil is wet. The subsoils consist of yellowish-brown or grayish-brown gravelly sandy material underlain by stratified sand and gravel.

These soils are well drained and are developed on very gravelly terraces or benches lying 10 to 200 feet above the stream bottoms. All but the lowest apparently were deposited by swift streams as outwash material during the glacial period. They closely resemble the Everett soils, but differ in being underlain by stratified water-laid gravel rather than the less well-assorted glacial till and outwash material and in having a greater average depth to the gravelly substratum. They differ from the Lynden soils in being more gravelly and having a gravel rather than a sandy substratum.

The Skykomish soils were not recognized as representing a separate series in the earlier reconnaissance survey, in which they were included mainly with the Lynden and the Whatcom soils.

Skykomish gravelly sandy loam.—In uncultivated areas this soil is covered with a layer of dark-brown forest duff, mixed with some mineral soil in the lower part and ranging in thickness from a mere film in burned-over areas to 3 inches in heavy timberland. A thin irregular gray layer about half an inch thick occurs beneath the organic layer in places. Below this to a depth of about 7 inches is the characteristic surface soil, which consists of gravelly sandy loam of low organic-matter content and very weakly held together by roots. It is pale reddish brown or yellowish brown and contains many rust-brown shotlike pellets one-tenth to one-fourth inch in diameter.

This material grades into yellowish-brown gravelly sandy loam, which continues to an average depth of 22 inches. The upper part contains occasional aggregates or lenses of rust-brown weakly cemented

soil material, but the lower part is slightly more coherent. This layer rests on a brownish-gray stratified sand and gravel substratum. A number of water-worn cobbles and boulders 4 to 10 inches in diameter are scattered over the surface and throughout the soil. A few stones occur on the surface. The quantity of gravel in the surface soil varies considerably, owing to the stratified character of the parent material. Fine roots penetrate to a depth of 48 inches or more. The surface soil is strongly or moderately acid, the subsoil and upper part of the substratum somewhat less so.

The gray subsurface layer and rust-brown weakly cemented lenses are most strongly developed in the extreme northeastern part of the county. Areas along Squire Creek have a higher water table than those in other localities.

Skykomish gravelly sandy loam occupies 27.2 square miles, with largest areas along Skykomish River and the North and South Forks of the Stillaguamish River. It is developed on smooth gently sloping terraces, in many places bordered by steep escarpments of rough broken land. Although nearly level, drainage is adequate, owing to the porous character of the substratum and excessive underdrainage. The parent material is formed mostly from granite, basalt, andesite, and hard metamorphic rocks.

This soil formerly was covered with a heavy stand of Douglas-fir, redcedar, and hemlock. There is some virgin timber, with a stand of 50,000 feet or more an acre, southeast of Whitehorse School. As the land has only recently been logged, most of the cut-over areas have a rather sparse growth of young trees.

Possibly less than 1 percent of this soil is cultivated, though many spots have been partly cleared for pasture. Areas on the lower benches, which are less droughty, produce good crops of apples, cherries, pears, plums, and small fruits, when well fertilized. The rather sterile character of this soil makes good fertilization necessary for profitable crop production. A few plots are irrigated with water from the city. The soil responds well to irrigation but is too porous for hay and grain and is considered more valuable for timber production than for farming.

Skykomish gravelly loam.—Virgin areas of this soil are covered with a 1½-inch layer of brown material consisting of partly decomposed forest mulch held together by small roots and containing some fine sand in the lower part. The 6-inch surface soil is brown or pale reddish-brown friable single-grained gravelly loam, strongly acid (pH 4.7 to 5.5), low in organic matter, and with a trace of shotlike pellets. The subsoil is light yellowish-brown or brownish-yellow gravelly loam of slightly finer texture, becoming lighter colored with depth, and breaking into small clods. At an average depth of about 16 inches it grades into grayish-yellow or brownish-yellow gravelly loam, which becomes more gravelly with depth, is cohesive when moist, and firm when dry. The reaction is acid (pH 4.8 to 5.6). At an average depth of about 30 inches is pale yellowish-brown gravelly sandy loam underlain by stratified gravel and sand. The depth to the gravelly substratum ranges from 24 to 40 inches or more.

The stratified sand and gravel substratum extends to a depth of 25 feet or more and includes layers of gravel, sand, cobbles, and boulders and thin lenses of finer textured material. The occurrence

of stone in the surface soil is variable—most areas have some, and a few small spots are almost covered with small boulders—and 10 to 20 tons an acre must be removed on clearing.

Skykomish gravelly loam is not so extensive as Skykomish gravelly sandy loam. Small areas of its total of 11.4 square miles are scattered on high terraces along the Skykomish and Stillaguamish Rivers. The soil occupies gently sloping benches of smooth relief, generally bordered by the Everett and Alderwood soils on the upper side and breaking off to narrow belts of rough broken land on the lower side along the larger stream bottoms. An incipient natural drainage system extends back into the smooth benches. Surface drainage is good, and internal drainage is excessive. The water-holding capacity is low, owing to the porous substratum. The native timber dominated by Douglas-fir has been cut, but a good stand of young trees is coming in on the uncleared areas.

The cleared acreage has increased rapidly in recent years, and about 5 percent of the soil is now under cultivation. About 60 percent of this is planted to timothy and clover, which is commonly cut for hay the first year, yielding about 2 tons an acre, and is usually used for pasture the second year and sometimes the third. Oats, grown on about 25 percent of the cultivated areas, average about 40 bushels of grain an acre, or about 2½ tons of hay, but these yields are obtained only with liberal applications of manure or fertilizer. Fruits common to the region do especially well on this upland soil, because of its fair depth, favorable relief, and good drainage. Crop yields are somewhat higher than on Alderwood or Everett gravelly loams.

Skykomish stony loam.—A 1½-inch layer of brown partly disintegrated fir needles, leaves, moss, grass, and twigs, held together with fine roots, covers this soil in virgin areas. A trace of gray leached material occurs in places below this layer, but generally it is underlain directly by pale reddish-brown friable coarse gravelly loam having a low content of organic matter and many soft shotlike pellets. It is very strongly acid (pH about 4.8), but becomes less so with depth and is somewhat sticky when wet and coherent when dry. At an average depth of 5 inches it grades into light yellowish-brown gravelly loam, which becomes more gravelly with depth. Layers of brownish-yellow gravel or gravelly sand are reached at an average depth of about 16 inches. The particles of gravel are rounded and above a depth of 30 inches are coated with a thin rust-brown film. Below this depth the material consists of stratified layers of gravel, sand, and water-worn cobbles. More cobbles and boulders are scattered through the surface soil and subsoil than in Skykomish gravelly loam. The soil material above a depth of 30 inches is firm enough to stand up well in cuts, but lower it is incoherent and loose. Most of this soil (3.5 square miles mapped) is in small scattered bodies along the Skykomish and Stillaguamish Rivers.

The relief, parent material, and drainage are similar to these features in Skykomish gravelly loam. Practically no Skykomish stony loam is cultivated, though a few spots have been partly cleared for pasture. It is too shallow, gravelly, and stony to be suitable for farming and is better adapted to timber production.

Skykomish stony sand.—In virgin areas this soil is covered with a 1-inch layer of brown forest litter, which grades into a dark-brown

layer ½ to 3 inches thick, consisting of decomposed fir needles and leaves mixed with a trace of sand. Below this layer is an ash-gray strongly acid sandy layer of irregular thickness, averaging about 1 inch but missing in many places. This is underlain by grayish-brown or yellowish-brown slightly acid gravelly material consisting of gravel, small cobbles, and stone embedded in sandy interstitial material. The lower part contains more fine material than the upper.

A layer of sand, gravel, boulders, and cobbles continues to a depth of about 48 inches, and roots penetrate to the lower part of it. The gravel is coated with a rust-yellow film, the color becoming grayer with depth. This material is underlain by irregularly stratified gravel and sand that generally is more sandy and not so stony as the soil above.

The relief is nearly level, but in many places the level areas break off to steep escarpments forming a narrow belt of rough broken land on the lower side. This soil is developed from coarse glacial outwash materials. The gravel and stone consist of granite, hard metamorphic rocks, and lava rocks. Surface drainage is good, and underdrainage is excessive. The area covered totals 6.5 square miles, mostly on high terraces along the Stillaguamish and Skykomish Rivers. One area southeast of Whitehorse School consists largely of recently deposited material and has a high water table.

Much of this soil formerly supported a fairly heavy stand of timber, but most of it is now covered with a young growth of Douglas-fir, alder, hemlock, redcedar, and other trees, huckleberries, bracken, fireweed, and other plants. None has been cleared except for building sites. Although too stony, gravelly, and porous to be of agricultural use, it has value for timber production.

Skykomish gravelly sand.—The 3.0 square miles of this soil is covered in virgin areas with a 1-inch layer of dark-brown forest duff mixed with some sand and is abruptly underlain by a mixture of rust-brown and gray gravelly sand having a pepper-and-salt appearance, a sprinkling of gravel, and very few stones on the surface. At a depth of about 10 inches this is underlain by a slightly compact mixture of gray and rust-yellow gravelly sand, in places containing aggregates of rust-brown partly cemented soil material. This passes at an average depth of 24 inches into gray and rust-yellow stratified gravelly sand and sand, which extends to more than 60 inches and is loose and incoherent and caves readily in road cuts. Small roots extend to a depth of about 24 inches.

This soil is formed from gravelly material deposited by swift glacial-fed streams. It is slightly or medium acid. The parent material is derived mainly from old metamorphic and sedimentary rocks, including some andesite, basalt, and granite.

The relief is smooth and nearly level. Surface drainage is good, and underdrainage is excessive. The soil occupies a few inextensive areas in the vicinity of Darrington on high terraces near the Sauk River and the North Fork of Stillaguamish River. Its original cover of Douglas-fir has been cut and most of the soil now appears rather barren, although there are small scattered fir, hemlock, willows, vine maple, ferns, grasses, and many wild strawberry plants. None of this soil is cultivated. It is not productive for farming but has value for timber and scanty pasture.

LYNDEN SERIES

The Lynden soils, like the other well-drained virgin forested soils, are covered with forest litter and leafmold. Beneath the 2-inch organic layer the soil is very dark brown or weak brown to a depth of 8 inches or more, where it passes into lighter reddish-brown and at a depth of about 24 inches into pale grayish-brown or yellowish-brown somewhat stratified sandy loam or sand. The deeper sandy materials are gray. These soils are young, with little development of a soil profile, and are fairly free of gravel and stone to a depth of 24 inches. They have little trace of a gray leached layer below the organic layer and have a few shotlike aggregates or pellets. Unlike the Skykomish soils, they are free from gravel and are underlain by sandy rather than by gravelly material.

The old alluvial or glacial outwash material now above normal overflow from which they are developed appears to be derived from a variety of rocks, mostly hard metamorphic and granitic, together with some basalt and andesite. They are closely associated with the Custer soil, though developed on the better drained parts of terraces rather than on slightly lower areas with deficient drainage.

The relief is smooth, nearly level, and terracelike. Surface drainage and underdrainage are adequate in most areas and somewhat excessive on loamy sand. Three soil types are recognized—Lynden loamy sand, loam, and sandy loam.

Lynden loamy sand.—The surface soil is covered with a 1½-inch layer of brown forest litter and well-disintegrated or decomposed leafmold, mixed with some sand in the lower part. To a depth of about 7 inches it is pale reddish-brown moderately acid loamy sand, which is slightly coherent when moist and loose and incoherent when dry. There are some reddish-brown faintly compact lumps in the upper part. The organic-matter content is low. A trace of a thin ash-gray layer occurs below the organic layer in places. At a depth of about 7 inches and continuing to about 24 inches the soil is brownish-yellow faintly coherent loamy sand, which becomes lighter colored with depth and in places contains a trace of fine granitic gravel. Below this and extending to a depth of about 60 inches is pale grayish-yellow or yellowish-brown sand. This is loose and incoherent when dry. This material in places contains a small quantity of gravel that may increase with depth. Below a depth of 60 inches this layer is underlain by pale grayish-brown or gray slightly acid sand with rust-yellow mottlings. This layer is stratified and of variable texture and color and includes layers of sand, fine sand, and gravelly sand.

This soil covers an area of 18.1 square miles, mainly in a large body west of Edgecomb. Smaller areas are scattered along the larger streams. In many places it is intimately associated with the Custer soil, and, although the boundary between them is fairly sharp, areas bordering the Custer soil have a darker surface soil than average.

The surface is nearly flat, sloping gently toward the larger streams. The soil is developed on old alluvial terraces, most of which are 25 feet or more above the adjacent river bottoms. The microrelief is faintly hummocky. Low knolls and hollows indicate that the material has been slightly disturbed by wind. Internal drainage is excessive, and excess moisture passes quickly into the porous subsoil, which is

of low water-holding capacity, although areas bordering the Custer soil may have a higher water table and are less droughty.

This soil formerly supported a heavy stand of Douglas-fir, and much of it is now covered with a good stand of young fir more than 6 inches in diameter.

About 4 percent of this soil has been cleared for cultivation, mostly in recent years. Strawberries are grown on about 20 percent of the cleared land and are its most important cash crop, the yield being about 1,500 to 2,000 quarts an acre. Home gardens, fruits, and berries do fairly well when the soil is well fertilized. A number of chicken farms on this soil help supply the needed fertilizer.

This soil is too sandy for the profitable growing of hay and grain crops. Supplemental irrigation from shallow wells is possible on much of this soil and might be successful on intensive truck crops during dry summers.

In the earlier reconnaissance survey this soil was included with Lynden sandy loam.

Lynden loam.—In uncleared areas this soil is covered with a 1½-inch layer of forest mull consisting of partly decomposed leaves, fir needles, grass, fern fronds, and moss, mixed with some mineral material and fine roots in the lower part. This material is abruptly underlain by the mineral soil of brown loam containing some very fine sand, which in most areas has a faint-red tint when moist. This layer is soft and friable and breaks into small irregular-shaped fragments. The organic content is moderately high, although roots are numerous. At an average depth of about 12 inches the surface soil passes into light yellowish-brown rather heavy loam, which breaks into small irregular aggregates. Below a depth of about 24 inches the texture becomes coarser and the varied material includes stratified layers of loam, fine sandy loam, silt loam, and gravelly sandy loam. In most places it is light grayish-brown or pale-yellow or gray fine sandy loam to a depth of about 32 inches, where it is underlain by brownish-yellow loamy fine sand to a depth of 60 inches. The substratum below 60 inches consists of stratified layers of sand, sandy loam, sandy clay, and gravel.

An occasional small water-worn boulder may occur in the surface soil, but both surface soil and subsoil generally are free of stone, and both are friable and permeable, though a somewhat compact layer that is strongly acid (as low as pH 4.6) may be present in any part of the soil profile. The surface soil is mostly medium acid (ranging from pH 5.0 to 6.2), and the lower part of the subsoil is less acid. Fine roots penetrate to a depth of more than 60 inches.

The total area of 17.0 square miles is largely in scattered bodies on terraces near the Stillaguamish and Skykomish Rivers, with smaller bodies along the smaller streams. In many places this soil is closely associated with the Skykomish and Sultan soils. It is developed on smooth nearly flat terraces mostly at low elevations, but some are more than 100 feet above the streams. Surface drainage is adequate, and underdrainage is somewhat excessive, although some local areas have a high water table.

This soil formerly was covered with a heavy stand of Douglas-fir, redcedar, and hemlock, nearly all of which has been cut. About 35 percent is under cultivation, and 20 percent is partly cleared for stumpland pasture. Clover and timothy are grown on about 65 percent and

oats on 25 percent of the cleared land. Clover and timothy hay yields about 2 tons an acre and oats about 50 bushels when the soil is well fertilized. Potatoes yield about 180 bushels. Fruit and truck crops do well when fertilizer is used.

The uncleared areas are covered mostly with young alder, Douglas-fir, hemlock, and redcedar, together with an undergrowth of cascara, vine maple, Oregon maple, dogwood, madrona, red huckleberry, blackberry, fireweed, and other plants. Much lespedeza grows on the partly cleared areas. Bracken soon covers the permanent pastures and uncultivated areas.

As mapped, a few small areas that have a slightly heavier or finer textured surface soil than the typical are included and some of these have a somewhat mottled subsoil with retarded drainage transitional to the Sultan soils. These heavier textured areas produce slightly higher yields.

Some areas recognized as Lynden loam in this county were included with the Puget and the Whatcom soils of the reconnaissance survey of 1909.

Lynden sandy loam.—In virgin areas this soil is covered with a 1½-inch layer of dark-brown forest mull lightly bound together with roots. The surface soil between depths of 1½ and 8 inches is dominantly pale reddish-brown sandy loam, but small areas of fine sandy loam and very fine sandy loam texture are included. This material is slightly sticky when moist and is coherent and slightly compact when dry. It has a low content of organic matter but contains many small roots and a trace of soft rust-brown shotlike accretions. Flat, softly cemented lumps with a rust-brown stain, which are strongly acid, sometimes occur in the upper part of this layer. The surface soil is fairly free of stone and gravel.

Beneath it, to a depth of about 18 inches is brown or yellowish-brown sandy loam, friable when moist and slightly compact when dry. In many places it is slightly finer textured than the surface soil. The reaction is strongly acid (about pH 5.5). This layer passes into grayish-brown or brownish-yellow sandy loam, which becomes lighter colored with depth. It includes some rust-brown and gray variations in color.

At an average depth of about 34 inches the subsoil in underlain by a pale yellowish-brown substratum consisting of stratified layers of loamy sand, sandy loam, and some gravel, which continues to a depth of 10 feet or more. The quantity of gravel increases where the soil is adjacent to the larger streams. The soil is slightly acid. Fine roots extend to a depth of 4 or more feet. The depth to the sandy substratum ranges from 24 to 48 inches or more.

This soil, with a total area of 6.5 square miles, occurs in many small areas, mostly on low benches in the valleys of the larger streams. It is developed along swift streams from water-laid material probably deposited, in part, during glacial times. The parent material is derived from a variety of rocks, mainly granitic, basaltic, and metamorphic.

The land is smooth or undulating, with a gentle slope toward the larger streams. A few areas are cut by abandoned meandering shallow old stream channels. The surface drainage is good, and the underdrainage somewhat excessive.

The numerous large stumps indicate a former heavy stand of virgin timber. About 35 percent of the land is under cultivation and is planted to the crops commonly grown. Timothy and clover hay yields an average of about 1½ tons an acre, and oat hay yields about 2 tons. Oats for grain yield about 35 bushels and potatoes 175 bushels when the land is well fertilized and properly managed.

INDIANOLA SERIES

The Indianola soils, formed in high somewhat eroded terracelike areas of smooth benchlike or undulating to gently rolling relief, are porous, droughty, and of rather low fertility. They are older than the Lynden soils and have more development of profile and duller colored surface soils. In virgin areas they are covered by a thin layer of partly decomposed organic material overlain in places by a thin ash-gray layer that rests on a 6-inch layer of brown sandy surface soil containing many shotlike pellets. These are rust brown and medium hard and occur to a depth of about 24 inches. In a few places rust-brown weakly cemented lumps occur at about this depth. The subsoil of light yellowish-brown sand becomes lighter colored with depth and grades at about 36 inches into brownish-yellow sand that has a faint olive-green shade when moist and is decidedly gray when dry. It shows some stratification, and this becomes more distinct with depth.

These soils were originally covered with a coniferous forest of Douglas-fir and associated trees and shrubs. Cut-over areas now support a growth of young fir, alder, hemlock, vines, and in places patches of grasses.

Indianola loamy sand and a hilly phase of this soil are now mapped. These soils had not been recognized as such at the time of the earlier and less detailed reconnaissance survey and were included with the Lynden soils.

Indianola loamy sand.—In this soil the ash-gray layer below the forest litter is more distinct and consistent than in most soils of the county. It is strongly acid (pH 5.0) and is abruptly underlain by light-brown loamy sand containing a larger number of small shotlike pellets than most of the other soils. These pellets are of uniform rust-brown color, not concentric in structure, and somewhat harder than in some other soils, but they can be cut easily with a knife. In many places they are clustered around the numerous small roots. Between depths of 8 and 18 inches the soil is yellowish-brown slightly loamy sand containing a large number of shotlike concretions. The material in this layer is underlain by light yellowish-brown loamy sand, which is slightly compact and breaks into weak angular aggregates. Flat rust-brown very coherent but not cemented lumps of soil occur in this layer and in the layer above. Light grayish-brown loose incoherent loamy sand or sand occurs at a depth of about 34 inches, the color becoming grayer with depth. This material is more or less stratified and includes layers of coarse sand and fine sand and a trace of gravel. The color ranges from brownish yellow to olive brown and may be streaked with rusty brown and gray. The substratum is medium or slightly acid (pH 5.6 to 6.7). Roots penetrate to a depth of 50 inches or more.

The aggregate area of 13.3 square miles is widely distributed, with the most extensive bodies near the Stillaguamish River Valley and east and northeast of Arlington. The relief is fairly smooth and benchlike. Sharp breaks to the drainageways give some areas a rolling appearance. The larger areas are at an elevation of slightly more than 250 feet above sea level. This soil seems to be developed largely from estuarine and beach deposits of old glacial streams.

This is an extremely porous and droughty soil, owing to excessive external and internal drainage. Stumps indicate that it formerly was covered with a heavy stand of Douglas-fir. It now supports a scattered growth of young alder, fir, and hemlock, together with some undergrowth of bracken, red huckleberry, and very little grass. About 7 percent of the soil is under cultivation. Strawberries ordinarily produce yields of 1,000 to 2,000 quarts an acre, with a maximum of 3,000, and gardens and small fruits are grown for home use. This soil is not very well suited to hay or grain crops, but timothy and clover hay are reported to yield 1 or 1¼ tons an acre and oat hay 1¾ tons when well fertilized. Potatoes and garden crops do fairly well on the less droughty areas.

The results of mechanical analyses on samples of this soil taken at several depths are shown in table 6.

TABLE 6.—*Mechanical analyses of Indianola loamy sand*

Sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
551730	½–1½	1 5	7 0	14 8	29 9	9 7	31 2	5 3
551731	1½– 7	4 2	14 6	21 0	32 0	5 6	17 0	4 7
551732	7 –23	2 9	10 4	20 6	38 8	6 5	17 3	3 5
551733	23 –34	3 1	11 8	22 4	44 3	6 5	9 1	2 8

Indianola loamy sand, hilly phase.—This hilly phase is of variable texture, caused by outcrops of stratified sandy materials on the slopes on which it occurs. The surface soil in average virgin areas is covered with a 1½-inch layer of partly decomposed organic material underlain in many places by a thin ash-gray layer about half an inch thick. The surface soil to a depth of about 7 inches is brown loamy sand containing many shotlike accretions or pellets. This material is underlain to a depth of about 18 inches by yellowish-brown sand or loamy sand, which contains many shotlike pellets and a few rust-brown seams of faintly cemented soil material. Between about 18 and about 30 inches the soil is light grayish-brown loamy sand, below which it passes into a brownish-gray sandy substratum of variable texture, which continues to a depth of more than 60 inches. The land is hilly with eroded slopes ranging from 13 to 25 percent. Both surface drainage and underdrainage are excessive. Its 1.4 square miles occurs in small scattered areas, mostly near the Stillaguamish and Snohomish Rivers. The original heavy stand of Douglas-fir has been cut. None of the land is under cultivation. It has low value for agriculture and is best utilized for forestry.

IMPERFECTLY DRAINED GRAY AND BROWN SOILS

The group of imperfectly drained gray and brown soils includes the Puget, Puyallup, Sultan, Pilchuck, and Snohomish series. Derived from recent alluvial stream-bottom deposits, they have undergone comparatively little development of soil profile. Though they occupy only 97.3 square miles; as a group they are the most fertile soils in the county and include about 65 percent of the cultivated land. The most productive are the clay loams and silt loams; the small areas classified as fine sand are of low value.

PUGET SERIES

The Puget soils have brownish-gray or gray faintly mottled surface soils to a depth of about 6 inches. The subsoils are light brownish gray mottled with gray and rust brown and yellow to a depth of about 40 inches, where they are underlain by stratified material consisting of sand, sandy loam, silt, and clay. Most of these soils are strongly to slightly acid (pH 5.0 to 6.5), their organic content is moderate to low, and they are free from gravel and stone. Near the mouths of the Stillaguamish and Snohomish Rivers the soils contain more organic material than others and have greater depth to the stratified substratum. They have been affected by tidal waters, and they are strongly acid.

These soils are of recent origin and have little development of profile. They occur in the first bottoms and deltas of the larger streams. The parent materials are derived from a variety of rocks and consist in part of glacial rock flour contributed by active glaciers of the Cascade Mountains. The surface is nearly level and is traversed by abandoned meandering stream channels. The forested areas originally supported a cover of hemlock and redcedar, with some Douglas-fir mixed with hardwoods. Although of comparatively small extent, the Puget soils are important for farming. The lower areas are subject to overflow where not protected by dikes or levees, and the low delta areas have a high water table and support a marsh vegetation dominantly of cattail, sedges, marsh grasses, and spirea.

The four types mapped in the Puget soil series are the clay loam, silt loam, loam, and clay.

Puget clay loam.—The surface soil is smooth light brownish-gray clay loam to a depth of about 6 inches and is faintly variegated with gray and rust brown. The texture is uniform, silty, and free from any coarse material. It is sticky when wet and breaks into small clods when dry. It can be worked readily if plowed at the optimum moisture content, but is inclined to puddle if cultivated when wet. The organic-matter content is moderately high. The upper subsoil layer, to a depth of about 20 inches, is a light brownish-gray laminated clay loam mottled with rust brown and gray. This layer has many fine capillary holes from root channels, and the material grades into bluish-gray silty clay loam or silty clay mottled with gray and rust brown. Thin seams of fine sand may occur at any depth. At an average depth of 40 inches the layer is underlain by gray or greenish-gray stratified layers of sandy loam, sand, silt, and clay. The depth to the stratified

substratum varies considerably. It is waterlogged in undrained areas and is always moist in drained areas.

The reaction is moderately or slightly acid in typical areas. Between Norman and the Skagit Bay and immediately northeast of Everett are slightly more poorly drained areas than the typical, and the soil is acid (pH 4.8 to 5.8). The soil profile shows the effect of the high-water table, as the mottled bluish-gray layer occurs at a depth of about 6 inches and continues to 40 inches. This layer in these areas has rust-colored peaty seams and pockets as well as thin seams of fine sand; it has a horizontal laminated structure and breaks into large clods. This passes into brownish-drab more silty clay loam and at a depth of about 55 inches into bluish-gray waterlogged silty clay loam or silty clay. This is underlain by blue-gray sandy material at a depth ranging from 60 to 90 inches or more.

This soil includes more cultivated land than any other soil type in the county. Most of it approaches silty clay loam in texture, especially in areas north of Stanwood. The total area, mainly in the first bottoms of the Snohomish, Stillaguamish, and Skykomish Rivers, is 28.9 square miles. The largest body is along the Stillaguamish River in the extreme northwestern part of the county.

The surface is nearly level, but there are many abandoned meanders from old stream channels and a few small areas of hummocky microrelief. All this soil is developed from recent alluvial material, a large part of which consists of glacial rock flour derived from a variety of rocks. Much of this soil formerly was covered with a stand of mixed conifers and hardwoods. Areas bordering the coast were partly covered with a marsh vegetation.

It is estimated that 75 percent of this clay loam is now under cultivation. Green peas, which are grown on nearly 15 percent of the cultivated area, are an important cash crop, 2 to 3 tons an acre being produced in average years. This soil ranks very high in yield of oats, which when cut for grain yield about 80 bushels an acre. Oats are grown on 15 to 20 percent of the cultivated area, and timothy and clover on about 50 percent. About 2½ or 3 tons of hay an acre are produced the first year and considerably less the second. It is often pastured the second year and generally the third. About 1½ or 2 acres are required for each cattle unit for 7 months of summer pasture. The land is too wet for profitable winter pasture, as the growth of grass is then very slow and becomes badly trampled, thereby damaging the summer pasture.

Small areas of sugar beets produce about 14 tons an acre. Much cabbage is grown, and the yields are good. A small acreage of alfalfa on the best drained areas yields about 3 tons an acre. Small areas are planted to canary grass and other hay crops, and some wheat is grown for chicken feed, producing 35 to 40 bushels an acre. Potatoes yield about 220 bushels. It is not considered a good soil for fruit, but a few apple and cherry trees are grown for home use, and some evergreen blackberries on undrained areas. Canada thistles are noxious weeds on this soil. As on other soils of the county, dairying and chicken raising are the principal types of farming. Liberal quantities of manure are used for all crops, and about 300 pounds of

superphosphate an acre are used on land planted to green peas and sugar beets.

Puget clay loam was included mainly with Puget silty clay of the earlier reconnaissance survey.

Puget silt loam.—The surface soil is brownish gray or gray smooth friable silt loam slightly mottled with gray and rust brown to a depth of about 6 inches. The organic-matter content is moderately high, and even in virgin areas there is little forest litter on the surface. The subsoil is a light-gray silt loam mottled with gray and rust brown. It has a distinct laminated structure with many fine capillary holes from decayed rootlets.

At a depth ranging from 20 to 40 inches the soil is brownish-gray or bluish-gray silty clay loam mottled with gray and specks of rust brown. It has a layered, or horizontal, structure and breaks into irregular clods, and is of slightly coarser texture in the lower part. This material is underlain by stratified layers of sand, fine sand, and sandy loam. The layers of sandy loam are grayish brown and yellowish brown, and the sand is a pepper-and-salt mixture having a greenish-gray cast. The surface soil in virgin areas is moderately acid, the subsoil slightly less so. Fine roots penetrate to a depth of 6 feet or more.

The total area of 12.4 square miles is in scattered areas on the first bottom of the larger streams. Surface drainage in most places is adequate. The most extensive areas are on natural stream-built levees and have a very gentle slope. Most of the flatter or depressed areas have been drained by shallow ditches, and many are protected from flooding by dikes.

About 90 percent of the land is under cultivation, and the relative acreages of the different crops and the acre yields are about the same as on Puget clay loam, or very slightly lower. The oat yield is considerably less, averaging about 70 bushels an acre. This soil is easier to cultivate than the clay loam. It is earlier in spring and is resistant to drought. The soil is badly infested with Canada thistles, which materially reduce crop yields. This soil was, in part, included with Puget silty clay of the reconnaissance survey.

Puget loam.—The 7-inch surface soil is light brownish-gray loam having a high percentage of silt and very fine sand and a smooth uniform texture. In some virgin areas, gray and rust-brown spots are numerous. This layer is underlain to a depth of about 40 inches by drab or gray loam containing considerable gray and rust-brown mottling. It is grayer in the lower part and is distinctly laminated. Thin layers of fine sand may occur at any depth. Below a depth of 40 inches the material is light-gray very fine sandy loam, and at about 50 inches it is a gray fine sand or sand. The soil is free from stone and gravel and is moderately acid.

Areas east of Cathcart with better drainage and a browner surface soil than the average closely resemble the Sultan soils.

The total area of 8.0 square miles is scattered along stream bottoms at the lower elevations in all parts of the county. The relief is fairly level but is modified by old meandering stream channels. Some areas are flooded occasionally in winter. Drainage is good during the crop-growing season.

All this land was formerly timbered with mixed conifers and hardwoods, but as it is a warm, early, productive soil about 70 percent of it is now under cultivation. Timothy and clover is grown on more than half the cultivated area and yields about 2 tons of hay an acre. Oats average about 60 bushels an acre, and considerable corn is produced. About 1½ or 2 acres are required for each cattle unit for summer pasture.

Puget clay.—This clay is of silty texture to a depth of about 6 inches, brownish gray in a moist condition, sticky when wet, dull gray and refractory when dry, and breaks into small blocks. The surface soil grades into dull-gray or bluish-gray clay mottled with rust brown, which continues to a depth of about 40 inches and contains many pockets and streaks of rust-colored peaty material from decayed roots. Below a depth of 40 inches the soil is grayish-blue heavy plastic clay with a trace of rust-brown mottling. The total of 1.3 square miles occurs in scattered areas closely associated with Puget clay loam. The relief is flat and slightly depressed. Surface drainage is restricted, but water seldom stands on the surface. About 60 percent of the land is under cultivation. The crops grown and the yields produced are about the same as on Puget clay loam. The soil is productive but difficult to cultivate. It was included with Puget silty clay in the reconnaissance survey.

PUYALLUP SERIES

The Puyallup soils are characterized by a surface soil of sandy texture that ranges from light brown to light grayish brown. The subsoil consists of gray or light grayish-brown stratified layers of sandy loam, sand, and loam, with heavier textured layers in some places. Gravel occurs in but few places above a depth of 40 inches. These soils are very recent and have little profile development. They occur in the first bottoms of the smaller streams and on natural levees of the larger streams. The soil material consists of alluvial deposits derived mainly from granites, hard metamorphic rocks, andesite, and basalt. These soils are often flooded in winter. The native vegetation consists of mixed conifers, hardwoods, and brush. The Puyallup soil types mapped are the sandy loam and fine sandy loam.

These soils had not been recognized at the time of the earlier reconnaissance survey, in which they were included with the Puget soils.

Puyallup sandy loam.—The 10-inch surface soil in cultivated fields is light grayish-brown or brownish-gray sandy loam that contains some rootlets but in virgin condition has only a small or moderate content of organic matter. In most places this sandy loam passes into a light brownish-gray sandy loam subsoil about 20 inches thick and containing a few specks of rust brown. The texture is variable and includes stratified layers of fine sandy loam, silt loam, and fine sand that become coarser with depth. At a depth of about 30 inches it passes into pale-gray or yellowish-gray loamy fine sand, and at 50 inches this in turn is underlain by sand. The surface soil and subsoil are moderately acid. The soil is free from stone and rather free from gravel to a depth of 40 inches. Plant roots penetrate to a depth of 40 inches or more.

Puyallup sandy loam, with a total area of 10.0 square miles, occurs in small bodies along stream bottoms in all parts of the county. The surface is rather flat but hummocky because of old abandoned stream channels. Areas bordering the larger streams usually occupy natural stream-built levees and have a smooth surface. Most of this soil is flooded occasionally in winter and early in spring but seldom in summer. Natural drainage is fairly good along the larger streams, except when the land is flooded during periods of high water. Many areas on the small streams have poor surface drainage. Like all other Puyallup soils the sandy loam shows little profile development. It consists essentially of unaltered alluvial material, derived from basaltic lava and granitic, hard metamorphic, and similar rocks.

The original timber, which consisted of Douglas-fir, hemlock, redcedar, and some hardwoods, has been cut. The uncleared areas are now covered mostly with alder, other hardwoods, and brush. About 40 percent of the land is under cultivation, largely for timothy and other grasses and for semipermanent pasture, to which it is well adapted.

The results of mechanical analyses on sample of Puyallup sandy loam, taken at several depths, is shown in table 7.

TABLE 7.—*Mechanical analyses of Puyallup sandy loam.*

Sample No	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
5517245	0-11	1 0	8 6	17 4	25 2	12 1	28 2	7 5
5517246	11-18	0	2	4	9	2 0	79 6	16 9
5517247	18-32	0	2	6	11 2	32 5	48 1	7 4
5517248	32-48	0	1 0	10 8	53 3	16 9	14 4	3 6

Puyallup fine sandy loam.—The 8-inch surface soil is a light-brown or light grayish-brown fine sandy loam with about 3 percent organic-matter content and containing much very fine sand. This grades into brownish-gray laminated fine sandy loam containing specks of rust brown and including variations in texture from fine sandy loam to loam. At a depth of about 20 inches this layer grades into grayish-brown or bluish-brown material of finer texture than that above and includes stratified layers of fine sandy loam and clay loam. At an average depth of 40 inches and continuing to 60 inches or more the material is grayish-brown or bluish-brown fine sand that is stratified and includes some layers of coarser sand. The surface soil and subsoil are strongly acid (about pH 5.3).

The total area mapped in small scattered areas on the stream bottoms is 8.9 square miles. The relief is nearly level, with some irregular shallow depressions formed by old stream meanders. Some areas are subject to frequent overflows after heavy rains but seldom during the crop-growing season. About 640 acres occur on low benches bordering the Skykomish River between Monroe and Sultan.

This soil formerly was covered with mixed conifers and hardwoods. Most of the uncleared areas are now covered with alder, vine maple, Oregon maple, redcedar, cascara, dogwood, other trees, and brush.

About 60 percent of the land is cultivated to the crops common to the county. More than half the cultivated area is kept in timothy, clover, and other grasses as semipermanent pasture. Timothy and clover hay produces about 1¾ tons an acre, and other crops yield somewhat lower than on Puget clay loam.

SULTAN SERIES

The Sultan soils resemble the Puget soils in many respects, but differ in having browner, less mottled surface soils and subsoils and better drainage. The surface soil is smooth, friable, and free of stone or gravel and, at a depth of about 7 inches, passes into a grayish-brown fine-textured subsoil faintly mottled with gray and light brown, underlain at a depth of about 18 inches by brownish-gray faintly mottled gray and rust-brown material. This may continue to a depth of 50 inches, but in some places it becomes coarser in texture and includes layers of fine sand at different depths.

These soils consist of recent alluvial materials derived from a wide range of granitic, metamorphic, basic igneous, and other rocks and are developed on the better drained parts of first bottoms and low terraces of the larger streams. They are seldom if ever flooded, and natural drainage is adequate for most crops. Though formerly covered with Douglas-fir, hemlock, redcedar, alder, vine maple, Oregon maple, cascara, cottonwood, dogwood, other trees, and underbrush, practically all the timber has been cut, and most areas have been cleared.

Three soil types of the Sultan series are recognized—the loam, silt loam, and clay loam.

Sultan loam.—In cultivated fields the 7-inch surface soil is brown friable loam. In virgin areas a very thin layer of organic material covers the surface. The surface soil passes into pale brownish-gray smooth friable loam. At a depth of about 18 inches this grades into a pale grayish-brown or brownish-gray loam slightly mottled with gray and rust brown. This material may continue to a depth of 50 inches or more, but in most places it is underlain at a depth between 30 and 50 inches by pale brownish-gray loamy very fine sand with some gray and rust-red mottling. The material is pale yellowish brown when moist. The surface soil and subsoil are strongly acid (pH 4.8 to 5.5). The surface soil is free of gravel and stone. In typical areas the subsoil is fairly free of gravel to a depth of 50 inches or more. This soil is more variable than other soil types of the Sultan series, and along the Wallace River east of Sultan small areas having gravelly subsoil below a depth of 24 inches are included.

The total extent is 4.9 square miles, scattered in low benchlike or stream-bottom areas above normal overflow. The largest areas are east of Sultan. Drainage is adequate, and the subsoil provides moisture for crops during dry periods. The original cover of timber consisted of conifers and some hardwoods. About 60 percent of the land is under cultivation, and the rest is partly cleared for pasture. The general farm crops of the county are grown, and yields are slightly lower than on Sultan silt loam.

Sultan silt loam.—This soil is brown or grayish-brown smooth friable silt loam of low organic-matter content to a depth of about 7 inches and breaks into granular pea-sized aggregates. This mate-

rial passes into gray heavy silt loam. At a depth of about 18 inches is brownish-gray silt loam or silty clay loam faintly mottled with gray, which breaks into small clods and has a yellow cast when moist. This may continue to a depth of 50 inches, but below 36 inches the texture is variable and in many places at about 40 inches is a very fine sandy loam, which in turn at a depth of 50 inches grades into pale yellowish-gray very fine sand faintly mottled with gray. Small roots extend to a depth of 60 inches or more.

This soil is free of gravel and stone. The reaction of the surface soil and subsoil is moderately acid (pH 4.8 to 5.5). The largest bodies are northwest of Monroe, and the total area is 3.2 square miles scattered in the valleys of the larger streams.

This soil is developed from alluvial material on low terraces and high stream bottoms that are nearly flat or have only very gentle slopes. Surface drainage and underdrainage are somewhat restricted but adequate. All the original forest has been cut, and probably 80 percent of the land has been cleared. Green peas for canning are grown on 5 percent or more of the cultivated area and produce 2 to 3 tons an acre. Timothy and clover are grown on more than half the cultivated areas. About 2½ tons of hay an acre is produced the first year and 1¾ tons the second. Timothy and clover land is usually pastured the third year and sometimes the fourth. Oats, generally grown as a nurse crop, yield about 75 bushels an acre when cut for grain. A small acreage of alfalfa is grown and produces 2½ to 3 tons. Small fruits do well. A pressing problem is the extermination of the Canada thistle, which infests this soil.

Sultan clay loam.—Except for finer texture of the surface, this soil resembles Sultan silt loam. The relief, origin, crops grown, and acre yields are similar, but the clay loam is more difficult to cultivate. It occurs with a total area of 1.4 square miles in small areas along the Skykomish River, Woods Creek, and the Pilchuck River. The 6-inch surface layer is grayish-brown smooth clay loam and is underlain to a depth of 18 inches by pale grayish-brown heavy clay loam faintly mottled with gray. Between depths of 18 and 30 inches is pale yellowish-brown or grayish-brown silty clay loam faintly mottled with gray and rust brown. In places this layer continues to a depth of 50 inches, but the texture is variable below 30 inches and includes layers of brownish-yellow very fine sandy loam and fine sand. The surface soil and subsoil are free of gravel and stone.

PILCHUCK SERIES

The Pilchuck soils are the sandy and gravelly counterpart of the Puyallup soils. The surface soil is brownish gray or grayish brown, loose, and sandy or coarse-textured. With depth, this material gradually grades into coarser and sandier material. There is very little change between surface soil and subsoil. The Pilchuck soils are not so productive as the Puyallup, owing to the coarse texture. They also are more subject to overflow and occupy lower positions than the Puyallup. Pilchuck fine sand and gravelly sand are mapped in this area.

Pilchuck fine sand.—This soil consists of brownish-gray fine sand to a depth of about 8 inches and is covered by a thin layer of forest

litter in uncleared areas. The surface soil is loose and incoherent and contains a small quantity of organic material. It is underlain by stratified layers of loose, porous, and incoherent light brownish-gray fine sand and a pepper-and-salt mixture of greenish-brown, black, white, and yellowish-brown micaceous sand to a depth of about 50 inches. In most places this material is free of gravel to a depth of 24 inches. It is strongly acid (pH 5.0 to 5.5).

The total area of 6.2 square miles is widely scattered in stream bottoms where the gradient is high. Much of the land is flooded after heavy winter rains, but it is seldom inundated in summer. The uncleared areas are covered with alder, redcedar, vine maple, cottonwood, hemlock, Douglas-fir, Oregon maple, dogwood, cascara, birch, willow, huckleberry, snowberry, devilsclub, nettles, blackberry, and other trees and shrubs. About 40 percent of the land has been cleared and is used mostly for pasture. Small areas of this soil containing considerable gravel throughout the profile are slightly less desirable than the typical areas for most agricultural crops.

Pilchuck gravelly sand.—Most of this soil is covered with a thin layer of brown forest litter, which is underlain by stratified layers of gravelly sand and sand to a depth of about 30 inches, and these in turn by gravel, sand, and cobbles. The occurrence of the material and the thickness of the strata vary greatly. Sand covers the surface to a depth of 1 foot in many places, and water-worn cobblestones outcrop in some areas. This soil, differing from riverwash, is covered with a dense growth of trees of the same species as grow on Pilchuck fine sand. The total area of 0.8 square mile occurs along the Skykomish River above Sultan. The land is flooded at high-water periods. This soil is nonagricultural and none is cleared. It is of value only for the production of timber, which is used mostly for pulpwood.

SNOHOMISH SERIES

The Snohomish soils have gray or dark dull brownish-gray mineral surface soils, which pass into brownish-gray laminated mineral soil streaked with drab and rust brown and containing pockets and streaks of brown mucky material. The color is much darker and browner when moist than when dry. At an average depth of 24 inches this material is underlain by a layer of brown peat or peaty muck of variable thickness, resting on blue laminated clay and sandy loam at an average depth of about 4 feet, but in many places the soils have a series of interbedded organic and mineral soil layers throughout the profile. The depth to the organic layer varies greatly, and where it is less than 8 inches the areas are differentiated as a shallow phase.

These soils are moderately or strongly acid and are free from stone and gravel. They occur in the bottoms of the lower courses of the Snohomish and Stillaguamish Rivers and formerly were flooded by high water and in some localities by spring tides but now are protected by dikes. Some are drained by pumping and nearly all are cultivated. The surface soil materials are very similar to those of the Puget soils but average slightly darker. They have been superimposed on the organic materials by periods of overflow from the rivers carrying in suspension soil materials of the Puget and similar soils. The

four Snohomish soils mapped are the silty clay, silt loam and its shallow phase, and loam.

Snohomish silty clay.—The surface soil is brownish-gray or dark grayish-brown silty clay mottled with rust red and gray. The color is dominantly gray when dry and distinctly brown when moist. The material is uniformly smooth and fairly friable for a soil of such heavy texture. At an average depth of about 6 inches this material passes into brownish-gray silty clay finely mottled with rust brown and gray. It is faintly laminated and contains pockets and streaks of brown organic matter. At an average depth of about 32 inches this material is underlain by a layer of brown fibrous mucky sedge peat, which may extend to a depth of 60 inches or more but usually contains layers of laminated blue clay and brown muck at different levels. The peat and muck are derived mainly from sedges, but the different layers include some materials developed from wood, reeds, moss, and many fibrous roots. The woody material is largely from decayed roots and brush. Layers of blue clay and silt occur below a depth of 60 inches.

This is a recent soil, without a developed profile. In virgin areas it is strongly to medium acid (pH 5.0 to 6.0). It occurs only on the level bottoms of the Snohomish and Stillaguamish Rivers, the largest bodies are southeast of Everett. The total area is 4.2 square miles.

All this soil formerly was covered with water during floods and at the time of spring tides much of it was covered with salt water, but all is now protected from flooding by dikes. The thick subsoil is more or less waterlogged, but this provides subirrigation for the crops grown. The cultivated areas are ditched to remove the surface water. Uncleared areas are covered with alder, other hardwoods, some red-cedars, and hemlocks.

Probably 70 percent of the land is under cultivation. Green peas for canning or shipping (frozen or fresh) to eastern markets are grown on about 25 percent of the cultivated area and yield an average of about 3,000 pounds of shelled peas an acre, in addition to 5 tons of pea vines for silage. About 300 pounds of superphosphate an acre is used on land for peas. Timothy and clover, on about 50 percent of the cultivated area, produce an average of 2½ tons of hay an acre, but yields up to 4 tons are common. About 1½ or 1¾ acres are required for summer pasture for 1 animal unit. Oats are grown on about 15 percent of the cultivated areas and produce 80 to 90 bushels an acre. Potatoes average about 200 bushels an acre and produce as much as 330 bushels with the addition of 500 pounds of 3–10–20[9] commercial fertilizer. A few sugar beets are grown and yield about 15 tons an acre.

Snohomish silty clay is a heavy plastic soil and is rather difficult to cultivate. Most farmers consider it almost as productive as Puget clay loam, but it is slightly less desirable because of its wet and cold condition in spring.

Snohomish silt loam.—To a depth of about 6 inches the surface soil is gray or brownish-gray smooth friable silt loam, which passes into brownish-drab smooth heavy silt loam or silty clay loam mottled with

[9] Percentages, respectively, of nitrogen, phosphoric acid, and potash.

rust brown and having a laminated structure. It includes thin layers and pockets of brown peaty material. At an average depth of about 24 inches this material is underlain by brown peat. This is raw and fibrous, but includes considerable infiltrated silt and is derived mostly from sedges and reeds with many fine fibrous roots and a trace of moss peat and woody material, mostly from decayed roots and brush.

The depth to the peat layer ranges from 8 to 40 inches, and where it is less than 8 inches it is separated as a shallow phase. The thickness of the peat layer also is variable. In most places there are alternate layers of peat and clay to a depth of 60 inches, and beneath this is clay, which is pale blue when moist and bluish gray when dry. This soil is free of gravel or coarse material. The surface soil is very strongly to medium acid (pH 4.7 to 5.7), and the organic layers rather strongly acid.

The largest bodies are on the Snohomish River bottoms southeast of Everett, on the Skykomish River above Monroe, on the South Fork of the Stillaguamish River northwest of Granite falls. The total area is 2.6 square miles. The surface soil is of alluvial origin, and the subsoil is mixed alluvial and organic cumulose material accumulated for the most part where the stream current was affected by tidal waters. The relief is flat. Most areas were formerly flooded at high water. All the soil has now been drained by diking, ditching, and by some pumping.

The native vegetation consisted mostly of alder, other hardwoods, and brush, in addition to small areas of marsh grass and rushes. About 80 percent of the land is under cultivation or is cleared for pasture. The relative acreage of various crops and acre yields are the same as for Snohomish silty clay, but the soil is easier to cultivate.

Snohomish silt loam, shallow phase.—This shallow phase has a 2- to 8-inch surface layer of smooth gray silt loam overlying layers of peat or muck. In cultivated areas there is barely sufficient mineral material to make it a mineral soil. The organic material below the surface soil is brown sedge peat or peaty muck with a trace of woody material in places, but it contains considerable silty mineral material. At a depth of about 16 inches and continuing to 36 inches the material is mainly brown fibrous raw matted sedge-reed peat with a trace of woody material from roots, the proportion of reed peat increasing in the lower part. It contains considerable infiltrated mineral material. Between 36 and 60 inches are layers of brown sedge, reed peat, and moss peat, with a trace of woody material from roots or brush and with considerable mineral material. This, in turn, is underlain by blue silty clay at a depth ranging from 40 to 72 inches or more. Layers of drab silt loam may occur at any depth in different locations. This soil is moderately acid. It covers a total area of 4.0 square miles, with the largest bodies southeast of Everett and small bodies south of Monroe and southwest of Arlington.

This soil formerly was marshy but has been drained by diking and ditching. Probably 50 percent of the land at one time was covered with marsh grass, cattails, rushes, and some brush and the rest with hardwoods. Nearly all the land is cleared, and about 15 percent is planted to peas, 10 percent to oats, 35 percent to timothy and clover for hay

and pasture, and 5 percent to potatoes and minor truck crops. The rest is in semipermanent pasture of mixed timothy and native grasses. Yields are somewhat lower than on Snohomish silty clay. This is a cold late soil in spring.

Snohomish loam.—This soil is somewhat dark brownish-gray loam to a depth of about 6 inches, where it passes into somewhat stratified brownish-drab loam containing layers of sandy loam and streaks of rust brown. It is underlain by brown peat and muck at an average depth of 20 inches. The depth to the peat ranges from 3 inches on the lower slopes, where it borders the organic soils, to more than 40 inches on the upper slopes, where it borders the upland. This soil is darker than others of the Snohomish series. The total area is very small; 0.5 of a square mile was mapped. This soil occurs as a fringe on the outer borders of areas of peat, where mineral soil washed from the uplands has covered the peat. Surface drainage is deficient, owing to the runoff from the bordering higher land. Formerly the land was covered with hardwood, redcedar, and hemlock. About 40 percent is under cultivation, and the common crops are grown. Yields are lower than on Snohomish silty clay.

POORLY DRAINED DARK-COLORED SOILS

The poorly drained dark-colored soils are in the Bellingham, Norma, Edmonds, and Custer series. Most of them have been developed under conditions of poorly established drainage in flat glacial lake and similar depressions, although some occur on moderate to rather steep slopes that have been subject to seepage.

The Bellingham soils are underlain dominantly by highly mottled subsoils and fine-textured and relatively impermeable substrata through which subsoil waters move slowly. The Norma soils have similar surface soils and upper subsoil layers but are underlain by lighter textured and more permeable material. The Edmonds and Custer soils are Ground-Water Podzols.

All these soils require artificial drainage for effective utilization for purposes other than pasture. Drained Bellingham and Norma soils rank close to Puget soils in productivity. Edmonds and Custer soils are less productive and less important.

BELLINGHAM SERIES

The Bellingham series consists of dark surface soils to a depth of about 6 inches. In virgin areas there is, in many places, a dark highly organic mucky layer about 3 inches thick overlying a 3-inch layer of dark mineral soil. The subsoil, between depths of 6 and about 30 inches, is dark brown to dark gray, and is mottled with gray, rust brown, and yellow. It becomes grayer with depth. These soils are usually free of gravel and stone. Below a depth of about 30 inches there are many thin layers of bluish-gray fine sand and thicker layers of blue clay. In the larger areas the blue clay may extend to a depth of 10 feet or more. In the smaller areas grayish-brown gravelly glacial till may occur at a depth of 36 inches. The Bellingham soil is developed in poorly drained depressions, most of them in pondlike areas at the heads of small streams. The uncleared areas

are covered with alder and some vine maple, dogwood, willows, hemlock, cascara, and other hardwoods. They are locally known as "alder bottom." The series is represented by Bellingham clay loam.

Bellingham clay loam.—In cultivated fields the surface soil where typically developed is dark brownish-gray clay loam to a depth of about 10 inches, but in virgin areas a thin highly organic layer of variable thickness covers the surface. This soil is dark when moist but dries to a dark brownish gray finely mottled with rusty brown. Some areas of heavy silty clay loam texture are included. The subsoil is mottled brownish-gray and rust-brown plastic clay, the brownish gray predominating in most places. It becomes lighter colored with depth and at 12 to 24 inches passes into light bluish-gray or slightly bluish-gray waterlogged clay, which continues to 48 inches or more. Thin layers of muck or sandy material may be present at any depth.

The surface soil is medium acid (pH 5.5), and the lower subsoil layer is slightly less acid. It is widely distributed in small bodies in all parts of the county, but the total area is only 4.8 square miles. The relief, origin, and original vegetation are similar to these features in Norma loam. About 20 percent of the land is drained and cleared. More than half the cleared area is used for pasture, for which it is well adapted, and about 1¾ acres are required for one animal unit for summer pasture.

As mapped this soil includes a small area of about half a square mile 3 miles northeast of Stanwood, in which the lower part of the subsoil in places includes layers of loamy sand and gravel, generally waterlogged and acid in reaction. This included soil occupies the bottom of a broad flat and slightly depressed area that has the appearance of an abandoned stream valley. It is used mainly for timothy and clover for hay and pasture. When cut for hay, the yield is about 2 tons an acre.

NORMA SERIES

The Norma soils are dark brownish gray when dry, becoming dark gray or black when wet, high in organic-matter content, laminated or granular, and underlain by gray or drab upper subsoil layers highly mottled with iron stains, dominantly of fine texture, and slowly permeable. The subsoils rest on bluish-gray or gray sandy materials less highly mottled and of more permeable character. These soils are developed in flat depressions or ponded areas having poorly developed surface drainage and a high water table. Uncleared areas support a growth of alder, hemlock, vine maple, willows, and other shrubs. The soils are associated with and are closely related to the Bellingham soils, but are distinguished from them by lighter textured and more permeable lower subsoil layers and substrata. They are more readily drained by shallow ditches than the Bellingham soils and are adapted to a wider range of crops.

Norma clay loam.—The surface soil is dark grayish-brown or dark-gray moderately or slightly acid clay loam to a depth of about 6 inches. In many places there is a dark mucky layer about 3 inches thick on the surface, which grades into dark mineral soil about 3 inches thick. When wet the material may become nearly black. The surface

soil passes into dark-gray silt loam or clay loam mottled with gray and rust brown, becoming grayer with depth. At a depth of about 12 inches this material in turn grades into gray or drab material ranging in texture from loam to silty clay with occasional thin layers of fine sand, sandy clay, and muck and mottled with rust brown and yellow and breaking into angular aggregates when dry. Below a depth of about 36 inches the subsoil has a blue shade when moist and is of variable texture, stratified layers of fine sand, loam, and clay occurring in the larger areas. In the small areas drabbish-blue waterlogged glacial till may be reached at the 36-inch depth. The lower part of the subsoil is strongly to slightly acid (pH 5.0 to 6.5)

Because of slight differences in drainage there is much variation in the thickness of the dark surface layer. In the better drained areas this layer is very thin, and patches of muck occur on the surface of the wettest parts. It is much darker when moist than when dry, and most cultivated areas have a dark-gray cast. Its total of 13.0 square miles is in small bodies at the lower elevations, mainly in poorly drained basinlike areas. A few bodies along small streams are associated with old beaver ponds. The parent material consists of soil washed from bordering higher land. Natural drainage is poor, and the subsoil is waterlogged. In some places shallow water stands on the surface after heavy winter rains. Most of the land can be drained by shallow ditching.

In its natural condition this soil is covered with a nearly pure stand of alder, together with some cedar, vine maple, dogwood, hemlock, cascara, other hardwoods, and brush. The land is known locally as "alder bottom." Probably 20 percent is under cultivation, and some additional areas are partly cleared for pasture. More land is being drained and cleared annually. A larger acreage would be cultivated were it not for the cost of drainage.

About 60 percent of the cultivated area is in a mixture of timothy and clover, which produces about 2¼ tons an acre the first year, and 1¾ tons the second, after which it is usually pastured for 2 years or more. About 15 percent of the cultivated area is in oats, which yield about 65 bushels of grain or 2¼ tons when cut for hay. Potatoes yield about 200 bushels. Peas and miscellaneous truck and farm crops are grown on some of the cleared areas. This soil is productive when drained and produces good crops with the use of a small quantity of fertilizer.

Norma loam.—The surface soil is a dark dull-brown friable loam or silt loam to a depth ranging from 5 to 10 inches. In some places there is a thin, highly organic layer on the surface, but this becomes mixed with the mineral soil when cultivated. At an average depth of about 7 inches the surface soil passes into grayish-brown loam or silty clay loam, which, in turn, at a depth of 10 inches, grades into brownish-gray or brownish-drab compact gritty heavy loam, fine sandy clay, or clay loam. The material in this layer contains streaks of rust brown and yellow and breaks into angular clods. At an average depth of 20 inches this layer is abruptly underlain by a sandy substratum. The upper part commonly is grayish-brown or yellowish-brown loamy sand mottled and stained with rust brown and containing many rust-brown cemented angular aggregates or plates. The lower part is brownish gray loamy sand highly mottled with rust brown. Thin layers of mottled drab,

rust-brown, and yellow clay loam may occur at any depth in the substratum. In most places the material becomes coarser with depth and is underlain by bluish-gray sand at 30 to 40 inches. The substratum contains some gravel in places and much mica in others, and it is waterlogged in undrained areas.

The surface soil is strongly acid (pH 5.0 to 5.5) in virgin areas and slightly less so in cultivated areas that have been fertilized. The subsoil has about the same reaction as the surface soil, but in many places the sandy substratum is more distinctly acid. The surface soil is darker and thicker than typical where the soil borders areas of muck or peat. There is a belt of about 3 square miles southwest of Edgecomb near Kellogg Marsh, and small scattered areas occur elsewhere. It is developed in flat swalelike areas where natural drainage is deficient. Small areas occupy benchlike positions and have been affected by seepage from adjacent slopes. Most of the land has been drained by shallow ditches.

The original timber consisted largely of alder, other hardwoods, redcedar, and hemlock. The uncleared areas are now covered with alder, vine maple, willows, birch, cedar, blackberry vines, bracken, and other undergrowth.

About 75 percent of this soil is under cultivation. Most of it is near roads and markets and is not so expensive to clear as many other soils, owing to the smaller trees and stumps. Crops on this soil do not readily suffer from drought, owing to the supply of moisture in the lower part of the subsoil. About half the cultivated area is in a mixture of timothy and clover, which is cut for hay 1 or 2 years and yields about 2 or 2¼ tons an acre. It is then pastured for 1 or 2 years. About 2 acres are needed for each cow for summer pasture. About 17 percent of the cultivated areas is in oats, which are largely cut green for hay and yield 2 or more tons of hay an acre. From 10 to 15 percent of the land is used for the production of green peas, which average a little more than 2 tons an acre. Potatoes are grown on about 5 percent of the cultivated area and yield about 250 bushels. Most garden crops do well.

Norma fine sandy loam.—This soil consists of dark-brown fine sandy loam to a depth of about 7 inches. This layer is underlain by an 8-inch layer of grayish-brown sandy loam that rests on a 10-inch layer of light grayish-brown loamy sand or sand. This layer contains rust-brown stained lumps of soil in places and is underlain to a depth of about 50 inches by grayish-brown or gray sandy material that may include stratified layers of sand and finer material. The soil profile varies considerably within short distances. There is a trace of gravel in places but no stone. The soil is moderately acid and is penetrated by roots to a depth of 4 feet or more. About half of it has been cleared and is used mainly for permanent pasture, to which it is well adapted. Uncleared areas are covered mostly with alder and underbrush. The soil is developed in the slightly depressed parts of benchlike areas. The total area is 0.3 square mile.

EDMONDS SERIES

The Edmonds series has a dark surface soil and a somewhat dark grayish-brown subsurface soil underlain by a coffee-brown or rust-brown weakly cemented sandy hardpan of rather irregular or intermittent occurrence at a depth of about 14 inches and continuing to

about 26 inches. The underlying parent material is pale yellowish-brown loamy sand grading into bluish-drab sand at about 50 inches. These soils have developed in basinlike areas or on sloping terraces subject to seepage and are generally free of gravel and rock. They differ from the Custer soils in having dark surface soils without an ash-gray subsurface layer, but the two are similar in appearance when cultivated.

Edmonds sandy loam.—This soil to a depth of about 6 inches is dark-brown sandy loam with a thin surface layer of dark mucky material occurring in spots. It is underlain by loose, friable, and slightly coherent grayish-brown sandy loam or loamy sand, mottled with gray and rust brown. Where typically developed, this material, at an average depth of about 14 inches, passes abruptly into rust-brown softly cemented loamy sand representing a weakly cemented iron hardpan. The color is coffee brown variegated with yellow when the soil is moist. It is not easily penetrated with a shovel and offers considerable resistance to a crowbar. The hardpan and the soil above are medium to strongly acid (pH 5.5).

At an average depth of 26 inches the cemented layer is abruptly underlain by pale yellowish-brown loose loamy sand, which includes layers of fine sand and a trace of fine gravel. At an average depth of 50 inches it grades into pale bluish-drab moist sand, which on drying becomes pale gray.

Where the cemented hardpan material is lacking or only feebly developed the sandy upper subsoil layer may extend to a depth of about 30 inches, where it is generally underlain by light bluish-drab sandy material. In the vicinity of streams this may give way to stratified sandy loam, sand, and gravel, whereas in other areas gravelly glacial till is often present. Areas of this soil associated with areas of the shallow phase of Rifle peat may include gravel derived from shallow glacial till.

The small bodies scattered throughout the county aggregate 3.2 square miles. Most of these are developed in small depressions, but some occur along streams and in areas subject to seepage from higher lying soils. The surface soil and upper part of the subsoil are developed mostly from material washed in from bordering higher land. Natural drainage is poor. Water stands on the surface after heavy rains, and the lower part of the subsoil is waterlogged. Most of the land could be drained by shallow ditches.

Uncleared areas are covered with alder, a few redcedar, hemlock, spruce, yew, vine maple, and other hardwoods. Probably 20 percent of the soil has been drained and cleared. About 30 percent of the cleared area is planted to truck crops and the rest to timothy and clover (for hay) and oats, which produce average yields.

Edmonds loam.—The 6-inch surface layer of dark-brown coarse loam is underlain by brownish-gray loam mottled with rust brown and drab to a depth of about 20 inches, beneath which grayish-brown sand and gravel continue to a depth of 60 inches or more. A trace of gravel may occur in the surface soil. This soil is formed on low flat poorly drained benches affected by seepage or runoff from nearby slopes. Surface drainage is poor, and the water table is high. None of this soil is cultivated, but some has been partly cleared for pasture,

to which it is well adapted. It occupies 0.4 square mile. A small area is north of Darrington.

CUSTER SERIES

The Custer series is characterized by a dark thin surface layer high in organic matter overlying an ash-gray horizon about 2 inches thick, which rests on mottled rust-brown and drabbish-gray sandy material. This is underlain at a depth of about 15 inches and continuing to 25 inches by a reddish rust-brown weakly cemented hardpan layer, which grades into brownish-gray or greenish-gray sandy parent material that is more or less waterlogged. Only one soil in the Custer series is mapped—the fine sandy loam. It is free of stone and gravel, but plant roots do not easily penetrate the cemented layer. The total area is 8.3 square miles. The soil is developed on old glacial outwash deposits derived from a variety of rocks. The relief is flat, and natural drainage is poor, but most areas can be drained easily.

Custer fine sandy loam.—This soil to a depth ranging from 2 to 8 inches is dark grayish-brown fine sandy loam with a high organic-matter content, and is abruptly underlain by an acid ashy-gray fine sandy loam layer about 2 inches thick, the light gray of which is less conspicuous when moist and appears as a somewhat wavy seam when exposed. In cultivated areas the materials are mixed, giving the surface soil a dark-gray color. The texture is dominantly rather coarse fine sandy loam, coherent and slightly sticky when wet. It is underlain by rust-brown loamy sand, which grades into moist sand. This material passes abruptly into a reddish rust-brown weakly cemented sandy loam hardpan, which is variegated in color between reddish brown and a yellowish rust brown and contains many fine holes where roots have penetrated. At an average depth of 26 inches this layer, in turn, is underlain by rust-brown loamy sand, which grades into moist sand made up of yellow, gray, rust-brown, and black particles and has a somewhat green hue when moist. Below a depth of 36 inches the material is stratified and includes layers of fine sand, coarse sand, and thin layers of gravel. The water table closely approaches the hardpan layer in undrained areas. The surface soil is free of stone and gravel. The surface soil is very strongly acid (pH 4.6 to 5.0), and the underlying material to a depth of 6 feet is strongly or mildly acid (pH 4.8 to pH 6.5), becoming less acid with depth.

There is some variation in this soil associated with the drainage. Distinctly wet areas have a thicker dark layer at the immediate surface and a less conspicuous gray layer below. Areas with a high water table have the most distinct hardpan development.

Custer fine sandy loam is developed mainly in poorly drained areas bordering the Lynden soils. The total area mapped is 8.3 square miles, nearly all of it in one belt north of Marysville. The soil is developed in flat slightly depressed areas on high benches. Drainage is deficient, but most areas are drained easily by shallow ditches.

All the original timber has been cut. It apparently consisted of a mixed growth of hemlock, fir, alder, and redcedar. Uncleared areas are now covered with young alder, willows, aspen, fir, hemlock, redcedar, bracken, and salal, in addition to other trees, shrubs, and plants. Almost 40 percent of the soil is cleared. It is favorably located with

regard to nearness to good roads and markets and is adapted to diversified farming. About 10 percent of the cleared area is used for the production of timothy and clover hay, 20 percent for mixed timothy, clover, and other grasses for pasture, and 10 percent for oats. Strawberries are an important crop and yield about 2,000 quarts an acre. Potatoes and garden crops are grown for home use. There are many chicken farms and small dairy farms on this soil. With heavy manuring it produces yields slightly higher than the average for the county.

Most of this soil has some natural subirrigation from the high water table. This adds to its value, as crops do not suffer from drought in the dry summer months. The ground water is of poor quality for domestic use in places but may be suitable for irrigation from shallow wells.

A few small scattered areas are included that have a somewhat lighter textured sandy surface soil and a more pronounced development of cemented hardpan, which become waterlogged in spring. These areas are much less productive than the typical soil, and few if any are cultivated. The land is considered more valuable for wood and timber production than for agriculture.

ORGANIC SOILS

The organic soils are classified on the basis of character of profile, including arrangement of layers derived from different kinds of parent material, state of decomposition, content of mineral material, and thickness of the organic layer over the mineral soil. In Snohomish County they consist of Carbondale muck and Mukilteo, Rifle, and Greenwood peats. Areas in which the layer of organic matter is less than 24 inches thick are delineated as shallow phases.

These soils vary in usefulness for agriculture according to their degree of decomposition and acidity and in their possibility for improvement by artificial drainage. Some areas in small local pot-hole or glacial lake depressions have no natural outlets and can be drained only by pumping or by extensive ditching at costs out of proportion to the value of the land. Some of the less acid types, where improved by drainage and fertilized, are highly valued for truck crops (pl. 3).

Carbondale muck.—In uncleared areas the surface is covered with about 3 inches of forest litter. Between depths of 3 and 25 inches there is a dark-brown muck or peaty muck containing some mineral soil and a few fragments of rotted wood. Most of the material is very well decomposed. The soil has a granular structure and in cultivated areas is nearly black. In places the dark mucky layer reaches a depth of 48 inches or more. The soil is slightly to moderately acid. To a depth of 25 to 36 inches the material is generally brown or dark-brown mucky peat, derived from wood, with some sedges and many decayed logs and roots. Between 36 and 48 inches the material is a brown fibrous sedge and reed peat in most areas. A 1-inch layer of white diatomaceous earth may be found at any depth in the organic material. At an average depth of about 58 inches the soil passes sharply into a bluish-gray mineral soil. This is generally clay loam, but some areas are underlain by loam or fine sand. The depth to the mineral soil ranges from 24 to 60 inches or more, and there is a corresponding variation in the thickness of the layers above.

Carbondale muck is found in poorly drained depressions and along the outer borders of stream bottoms. Most areas are occasionally flooded in winter but are fairly dry in summer. The water table is always high in undrained areas. Uncleared areas are covered with hemlock, redcedar, alder, a few spruce and Douglas-firs, and an undergrowth of willow, cascara, dogwood, huckleberry, and other shrubs.

About 25 percent of this muck is under cultivation. The soil is used for the common crops of the region. Alsike clover and most vegetables do well. Green peas produce many vines but few pods. Potatoes yield about 200 bushels an acre and oats 50 bushels when well fertilized. A well-balanced fertilizer should be used. This soil is considered productive when drained. Drainage is the main problem, as the soil occurs in small areas that require individual drainage systems and aggregates 3.1 square miles. The largest bodies are below Snohomish near the Snohomish River, and there the surface soil contains more mineral soil than most of the type.

Carbondale muck, shallow phase.—A thin layer of forest debris covers the surface in uncleared areas. Below this is a dark-brown well-disintegrated muck to a depth of 4 to 24 inches, where it is underlain by mineral soil. A trace of partly decayed woody material is generally found in the lower part of the organic layer. The soil has a granular structure and is moderately to slightly acid. It is nearly black in cultivated areas. To a depth of 6 feet or more the lower subsoil is often bluish-gray clay loam in the central or lowest part of the areas and a loam containing much gravel on the outer borders. In many places this is a gradational soil between Carbondale muck and the Norma or Bellingham soils. This soil is found in small scattered areas aggregating 2.8 square miles. The relief, drainage, vegetation, and agricultural value is similar to the typical muck.

Carbondale muck, sloping phase.—This sloping phase is dark-brown well-decomposed granular muck to a depth of about 24 inches, where it passes into a brown mixed woody and sedge peat that is fibrous and matted and contains considerable mineral soil. At a depth ranging from 24 to 50 inches or more it is underlain by porous bluish-gray gravelly sandy loam or sandy loam. The total area is 1.4 square miles. The largest bodies are near North Creek in T. 27 N., R. 5 E.

This soil is developed on seepage areas on slopes and at the foot of hills and escarpments, the average slope being about 4 percent. It is fairly easy to drain by shallow ditches or by tiling. About 35 percent of the land is under cultivation and produces good yields of telephone peas, green beans, and other truck crops.

According to local farmers the soil settles 1 to 3 feet when drained and cultivated a few years. Where it is burned over and the organic matter is destroyed, the sandy gravelly mineral soil below is of low value. Some of the included areas have a thinner surface soil than typical and may be underlain by bluish-gray gravelly sandy loam or loam at a depth ranging from 4 to 24 inches. When the organic soil is destroyed by burning these shallow areas also are of lower value.

Mukilteo peat.—This brown fairly well-disintegrated mucky peat reaches an average depth of 16 inches and is derived mainly from sedges but includes much woody material, largely from decayed roots of trees and brush that have encroached on this soil in recent times.

A pure sedge peat is uncommon in this locality. The material is finely fibrous and somewhat matted in horizontal layers, and in uncleared areas a brown 2-inch layer of leaves, twigs, and moss covers the surface. In cultivated areas the plowed layer breaks to dark-brown peaty muck. At an average depth of 16 inches and extending to about 36, the material consists of definite horizontal layers of brown matted fibrous sedge peat and includes some woody material derived mostly from the roots of trees and brush. In general the color is yellower or somewhat straw-colored in the lower part. Below a depth of 36 inches the material is variable; it may pass abruptly into clay or sand and, in many places, into coarse matted sedge and reed peat, followed by a thin layer of moss peat, and then a brown spongy rather mucky mixed sedimentary peat over mineral soil. The mineral soil below is mostly pale-blue clay loam over blue fine sand. The thickness of the organic soil in most places is more than 4 feet and in places is reported to be as much as 15 feet. Layers of brown moss peat and dark-brown peaty muck may occur in any part of the profile. A small quantity of mineral soil is mixed with the organic material in most areas.

After being drained and cultivated a few years the land becomes more compact and the surface is reported to have become lowered 1 to 3 feet. The organic layer is moderately acid, and the mineral soil below is slightly or moderately acid.

On areas along the Snohomish River bottom the mineral content is rather high even when the material is raw and matted. All areas bordering the Snohomish soils contain more than the average quantity of mineral material. The total area of 11.5 square miles is widely distributed. It is developed in small bodies in all parts of the county.

This type of organic matter occurs mostly in basinlike areas, having an outlet in which water frequently covers the surface after heavy rains. All areas must be drained before they can be cultivated, for in all undrained areas water stands close to the surface. Most areas can be drained, except those bordering lakes. Areas on the map indicated by marsh symbols are marshy and are difficult to drain.

Uncleared areas are covered with hemlock, redcedar, alder, Sitka spruce, willows, spirea, leatherleaf, fireweed, bracken, and other trees and undergrowth. Areas contiguous to lakes are covered mostly with cattails, sedges, and other marsh vegetation (pl. 2, *A*). An area bordering Ebeys Slough southeast of Everett originally had a cover of Sitka spruce, which has been cut-over.

It is estimated that 10 percent of this organic soil is under cultivation, exclusive of the Frye Marsh near Monroe, nearly all of which is cultivated. The cost of removing stumps is much lower on peat and muck soils than on upland soils, and this has encouraged the clearing of these areas.

The Frye Marsh area, which is drained by pumping, is planted to sugar beets and truck crops, to which it is well adapted. It is fertilized with the equivalent of 200 pounds or more of 11–48–20 commercial fertilizer in addition to a small quantity of lime applied every year to help decompose the peat and thus produce muck. Much lettuce was grown at one time, but its production has been discontinued. In other parts of the county this soil is used for hay and pasture crops, but the yields are much lower than on Puget clay loam.

Mukilteo peat, shallow phase.—This shallow phase includes areas of the normal soil in which the peat layer is less than 24 inches thick over the mineral soil. It consists of a 4- to 24-inch layer of brown mucky sedge peat, containing some woody material, over bluish-gray loam. The small scattered patches and the borders of the deep peat areas aggregate 0.6 square mile. The relief, drainage, and vegetative cover are the same as for the typical soil. About 15 percent of the land is cleared and is used mostly for hay and pasture.

Rifle peat.—In representative virgin areas the surface material consists of a 2-inch layer of dark-brown forest litter bound together with small roots, resting on a 20-inch layer of dark-brown rather mucky woody peat. This material is rather well decomposed but contains many yellowish-brown fragments of rotted wood from logs and roots and in many places considerable sedge material. It is underlain by dark-brown or lighter brown fine fibrous matted sedge peat that is yellow when wet, resting on dark-brown coarse fibrous matted reed peat that contains many yellow fragments of reed stems, and continues to a depth of about 69 inches, where it grades into dark yellowish-brown mixed sedimentary and aquatic peat containing some fine roots but no other fibrous material. Below a depth of about 80 inches, layers of bright ocherous-yellow gritty material are intermixed with layers of mixed peaty materials derived from reeds, sedges, and other organic materials.

As mapped the profile is variable and there is little regularity in the thickness of the layers, but the sequence of the layers is characteristic. In many places a layer of woody peat overlies a like quantity of sedge peat, which passes directly into blue-gray clay loam underlain by fine sand. The depth to the mineral soil ranges from 24 inches to more than 8 feet, averaging about 4 feet in most places. This soil is slightly or medium acid.

Small moundlike patches of high moor occur here and there, covered with about a 1-foot layer of raw sphagnum moss peat over a mixture of woody and sedge peat.

This peat occurs in small bodies in all parts of the county. Its total area is 5.8 square miles. Most of it occupies flat depressions. The larger areas are on the outer border of stream valleys. Most areas are covered with water after heavy rains but can be drained by ditching. The uncleared areas are covered with hemlock, redcedar, alder, willows, spruce, vine maple, and other trees and such undergrowth as spirea, elderberry, dogwood, firewood, and bracken.

It is estimated that 20 percent of the land is under cultivation. The largest cultivated areas are at Kellogg Marsh. The cultivated part is mostly used for the production of timothy, alsike clover, and oats. It produces an average of about 1½ tons of hay an acre but is capable of much higher yields if well fertilized. This soil improves with tillage; as it becomes more compacted, its proportion of mineral material becomes greater and it breaks down to a more friable mucky soil. It needs to be properly drained, not overdrained, and protected from burning.

As mapped, a number of small widely scattered bodies, comprising nearly half the total area of this soil, consist of somewhat more completely decomposed organic materials of more mucky character. Most

of these are underlain by bluish-gray clay, loam, and fine sand. This land is a little more productive on the average than the less well-decomposed materials. Green peas produce many vines but few pods, potatoes about 200 bushels an acre, and oats 50 bushels.

Rifle peat, shallow phase.—This shallow phase consists of dark-brown well-disintegrated acid mucky peat to a depth ranging from about 4 to 24 inches, where it is underlain by bluish-gray acid mineral soil. In most places a trace of woody material is present in the lower part of the organic layer. In many places the lower subsoil is clay loam in the center of the areas and loam containing gravel along the borders. In places this phase is transitional between Rifle peat and the Bellingham soils. This soil occurs in small scattered areas aggregating 0.7 square mile. The relief, drainage, vegetation, and commercial value are similar to those of Rifle peat.

Greenwood peat.—This is a somewhat reddish-brown or yellowish-brown raw fibrous strongly acid moss peat to an average depth of 12 inches, below which it is brown fine fibrous felted raw peat developed from moss or sedge material. At an average depth of about 30 inches and continuing to about 50 inches the material is brown or reddish-brown fibrous felted or spongy raw peat of mixed sedge and sedimentary derivation. In places the moss peat continues to a depth of 40 inches or more. This material is very strongly acid (pH 3.0 to 5.0). This soil occurs in small scattered areas aggregating 1.7 square miles, the largest one northeast of Robe. It is most typically developed in deep basinlike areas having slow external drainage. Shallow water covers the surface during most of the winter, and the water table is near the surface in summer. It is not forested, but covered with thick brush consisting of Labrador-tea, spirea, a few cranberry bushes, salal, skunkcabbage, and a few scattered white pine, spruce, and redcedar trees (pl. 2, *B*). None of the land is cultivated, as it is very poor soil for farming. The surface layer of peat may prove to be of considerable value commercially for chicken bedding, nursery stock packing, and similar uses.

MISCELLANEOUS LAND TYPES

Miscellaneous land types consist of various types of nonagricultural material not included in the foregoing categories, with an aggregate area of 268 square miles, as follows: Rough mountainous land (Oso soil material), rough broken land, rough stony land (Oso soil material), riverwash, tidal marsh, coastal beach, and made land.

Rough mountainous land (Oso soil material).—Areas of pronounced rough mountainous relief occupied by shallow soil over parent bedrock are here included, together with extensive areas of nearly barren rock outcrops. The bedrock consists mainly of argillite, slates, schists, quartzite, and other hard metamorphic rocks and also basic lava and granitic rocks. The thin soil material is mainly representative of the Oso series. Most of the slopes range from 40 to more than 100 percent, but some less steeply sloping areas on the crests of ridges and in the valleys and areas of some less broken character are included, owing to difficulty of foot traverse and differentiation. The

total area of 142.5 square miles is marginal to the eastern border of the county. This type is of no agricultural value except for forestry. Douglas-fir, hemlock, and other conifers cover much of the land where the soil is of sufficient depth, and because of steepness and inaccessibility of the terrain most of the original timber still remains.

Where this land is associated with areas of rough stony land (Oso soil material), boundaries between the two are in some places indefinite and more or less arbitrarily established. It was included mainly with Everett stony loam of the earlier reconnaissance survey, at which time the Oso soils had not been recognized.

Rough broken land.—These areas are developed from glacial till material having steep relief, the slopes averaging more than 25 percent. The soil materials are predominantly Alderwood and Everett gravelly sandy loams, but they include some Indianola, Skykomish, and Cathcart soils of variable texture. The soil is covered in most areas with a ½-inch layer of organic material, below which is an 8-inch layer of pale-brown gravelly sandy loam, and between depths of 10 and 30 inches is yellowish-brown gravelly sandy loam. The most extensive areas are underlain at a depth of about 30 inches by gray cemented glacial till, which underlies the Alderwood soils. The underlying materials, however, are variable, owing to the range in kind of materials that outcrop on the steep slopes. Extensive areas occur in all parts of the county and include a total of 77.4 square miles. The most extensive are on deeply eroded gravelly terraces, near Stillaguamish River north of Wheeler Mountain. The typical relief is dominated by sharp breaks above the gullies and stream channels and by steep escarpments. The slopes are too steep to allow the use of wagons or farm machinery. A heavy stand of Douglas-fir, hemlock, and redcedar formerly covered this soil, most of which is now stocked with a growth of young trees. None is cultivated, but small areas have been partly cleared for pasture. The soil has little potential value for agriculture and is most valuable for the production of timber. It was included mainly with Everett stony loam of the earlier reconnaissance survey.

Rough stony land (Oso soil material).—These areas of shallow stony soil and semimountainous relief differ from rough broken land in their pronounced stony character and in being developed predominantly from consolidated rocks rather than from unconsolidated material. Although prohibitive of agricultural development either by excessive stone content or by unfavorable relief, this land has a much less rugged and mountainous topography than rough mountainous land (Oso soil material) and is mapped in greater detail.

The surface is covered with a 2-inch layer of organic material resting on reddish-brown stony loam. Between depths of 10 and 30 inches the soil is predominantly yellowish-brown stony loam containing a high percentage of stone and is underlain at an average depth of 30 inches by yellowish-brown compact stony loam containing a large quantity of angular stones and gravel. Rock outcrops are not common, but in places many huge glacial boulders more than 4 feet in diameter are scattered over the surface. The stone and gravel content, as well as the depth to the underlying rock, varies considerably. The soil material appears to be most closely related to that of the Oso series.

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Andesite and basalt are the most common rocks, but considerable glacial material derived from other rocks is included. The total area is 39.3 square miles, with the largest bodies southeast and west of Monroe and east of Granite Falls.

Most of the original heavy stands of Douglas-fir, hemlock, redcedar, and other conifers have been cut in recent years, but none of this land is farmed. As mapped it includes small undifferentiated bodies of comparatively smooth land, which were impracticable to separate without unwarranted expense, owing to the difficulty of foot traverse. It has little if any present or future potential value for agriculture and is most useful for the production of timber. In the reconnaissance survey it was included mainly with Everett gravelly sandy loam.

Riverwash.—Riverwash consists of unassorted or stratified sand and gravel occupying stream beds adjacent to the channels of rivers and to the larger streams of intermittent or fluctuating flow. This material is of coarse texture and open leachy character, and is inundated during floods. Areas bordering the streams are barren, and those away from the streams are covered with a thin scrubby growth of willow and cottonwood. This land has no agricultural value. The surface is irregular, in many places eroded, and in places covered with logs and driftwood. Some excellent commercial sand and gravel are obtained on these areas, and placer mining has been carried on in some localities. The total area mapped is 4.5 square miles.

Tidal marsh.—The surface material of tidal marsh consists of a 5-inch layer of plant roots and mucky peat mixed with brownish-drab silty clay loam. This material passes into saturated brownish-drab silty clay loam containing a large quantity of roots and peaty material and overlying at an average depth of about 25 inches bluish-drab silty clay loam, which continues to a depth of 60 inches or more. Layers of fine sand may occur at any depth, especially on the seaward side, where the soil is more sandy. This material is strongly acid (the pH value ranging as low as 3.0).

Tidal marsh covers 3 square miles of low flat river delta estuaries and tidal flats adjacent to the coast. The surface is traversed by stream channels and in many places by a network of shallow meandering tidal sloughs, and is covered with salt water at recurrent high tides. The largest area of this land type is west of Stanwood. Small less typical bodies are west of Edmonds and north of Everett.

The seaward boundary is formed by the coast line and corresponds closely with the outer border of vegetation. It is somewhat indefinite, owing to the extreme high tides, and is changing continuously, because of the large quantity of sediment deposited in shallow bays by the Sauk and Stillaguamish Rivers. The soil material contains a large quantity of saline salts, and the vegetative cover consists of salt-tolerant and associated tidal-marsh plants. Much of the land can be drained by building dikes and floodgates to keep out salt water. When first drained this land has little value, owing to the high content of salt, but it furnishes some scant pasture, and after being exposed to rains for about 5 years it can be cultivated. The yields are low at first, but it is reported to produce good crops after a period of about 10 years.

Coastal beach.—This type consists of gray sand and gravel forming sloping beaches along the coast above mean tide. It is barren of vegetation and is subject to continual washing by waves during periods of storm or high tide. The area covered is very small—0.5 of a square mile—and its only value is for recreational purposes and for the production of clams, the latter of some real importance.

Made land.—The areas included are built artifically by filling in with debris, sawdust, and dredged material and cover a very small area near Everett that is used for docks and industrial sites.

PRODUCTIVITY RATINGS

The soils of Snohomish County are listed alphabetically in table 8, and estimated average acre yields and crop-productivity indexes, or ratings of the principal crops, are assigned for each soil under the prevailing farming practices.

TABLE 8.—*Estimated acre yields and productivity ratings of the more important crops on the soils of Snohomish County, Wash., under prevailing practices* [1]

Soil and condition	Oats (grain)		Oats (hay)		Timothy and clover hay		Potatoes		Strawberries		Pasture [2] (if cleared)	General productivity	Remarks on use
	Yield	Rating (100=50 bu.)	Yield	Rating (100=2 tons)	Yield	Rating (100=2 tons)	Yield	Rating (100=200 bu.)	Yield	Rating (100=2,000 qt.)			
	Bu		*Tons*		*Tons*		*Bu*		*Qt*				
Alderwood gravelly sandy loam.	35	70	2	100	1 5 -1. 75	80					Moderate	Moderate	About 4 percent cultivated, hay is the principal crop
Hilly phase											Fair	Low	Less than 1 percent cleared, most of it in permanent pasture
Level phase	35	70	2	100	1 5 -1 75	80					Moderate	Moderate	About the same as in Alderwood gravelly sandy loam
Alderwood gravelly loam	40	80	2	100	1 5 -2	85	150	75			do	Moderately high	About 5 percent cultivated, dairying and chicken raising are common
Hilly phase											Fair	Moderate	Less than 1 percent cleared of stumps and second growth, cleared areas used mostly for pasture
Level phase	40	80	2	100	1 5–2	85	150	75			Moderate	Moderately high	About the same as in Alderwood gravelly loam
Alderwood silt loam					2–2 25	105	160	80			Good	High	About 30 percent cleared, 60 percent of it for timothy and clover hay.
Bellingham clay loam.													
Drained					2	100					do	Moderate	About 20 percent cleared and drained, largely for pasture
Undrained											do	Low	Largely in timber.
Carbondale muck.													
Drained	50	100	2	100	2	100	200	100			do	High	About 25 percent cultivated
Undrained											Moderate	Very low	Largely in timber
Shallow phase, drained.	50	100	2	100	2	100	200	100			Good	High	About 25 percent cultivated
Shallow phase, undrained											Moderate	Very low	Largely in timber.
Sloping phase, drained.	50	100	2	100	2	100	200	100			Good	High	Produces good yields of peas, beans, and other truck crops, about 50 percent cleared
Sloping phase, undrained											Fair	Very low	Uncleared.
Cathcart loam	60	120	2 5	125	2 5	125	200	100	2,000	100	Good	High	About 35 percent cultivated, chiefly to hay and oats for hay, suited to fruit and truck crops
Cathcart clay loam	60	120	2 5	125	2 5	125			2,000	100	do	do	About 40 percent cultivated, one of the better soils of the uplands.
Coastal beach												Very low	Barren of vegetation, no agricultural value.

Custer fine sandy loam:													
Drained [4]									2,000	100	Moderate	Moderately high	About 40 percent cultivated; strawberries are important
Undrained											Fair	Low	Largely in timber.
Edmonds sandy loam													
Drained											Good	Moderately high	About 20 percent cleared and drained; vegetables are an important crop on the cleared areas.
Undrained											Moderate	Low	Largely in timber.
Edmonds loam:													
Drained											Good	Moderately high	Some partly cleared areas in pasture.
Undrained											Moderate	Low	Largely in timber
Everett gravelly loamy sand.											Poor	Very low	Poorly suited for farm crops.
Hilly phase											do	do	None cultivated; used for forestry and road materials
Everett gravelly sandy loam			2	100	1 25–1 75	85	125	60			Fair	Moderate	Less than 2 percent cultivated, hay, potatoes, vegetables, and fruits are the principal crops
Hilly phase											do	Low	A few small areas cleared for pasture.
Level phase			2	100	1 5 –2	85	125	60			Moderate	Moderate	About 3 percent cultivated.
Everett stony sandy loam											Poor	Very low	Best suited for forestry
Everett gravelly loam			2	100	1 5 –2	90	150	75			Moderate	Moderately high	About 3 percent used for the common cultivated crops, fruit trees do well
Level phase			2	100	1 5 –2	90	150	75			do	do	Do.
Greenwood peat, undrained.											Poor	Very low	None cultivated.
Indianola loamy sand [4]			1 75	85	1 25	60			1, 000–2, 000	75	do	Moderate	10 percent of cleared area in strawberries, other fruits and vegetables are grown for home use.
Hilly phase											do	Very low	None cultivated.
Kitsap loam	40–45	85			2	100					Moderate	Moderately high	50 percent of cultivated area in timothy and clover, truck grown for home use
Kitsap silt loam	40	80			1 75–2	90					do	do	65 percent of cultivated area in timothy and clover, poorly suited for fruit and truck crops
Steep phase											Fair	Low	Best suited for timber.
Lynden loamy sand									1, 500–2, 000	80	do	Moderate	20 percent of cleared area in strawberries, suited to truck and fruit crops
Lynden sandy loam	35	70	2	100	1 5	75	175	88			Moderate	do	35 percent used for the common farm crops.
Lynden loam	50	100			2	100	180	90			Good	High	About 35 percent used for cultivated crops, and about 20 percent more in partly cleared stumpland pasture
Made land												Very low	Industrial sites, docks, etc.
Mukilteo peat:													
Drained					1 5	75					Good	Moderately high	Sugar beets and truck crops grown on some areas.
Undrained											Fair	Very low	Uncleared
Shallow phase, drained.					1.5	75					Good	Moderately high	Principally for hay and pasture.
Shallow phase, undrained.											Fair	Low	Uncleared.
Norma fine sandy loam, undrained.											Good	Moderate	About 50 percent cleared, mostly for permanent pasture.

See footnotes at end of table.

TABLE 8.—*Estimated acre yields and productivity ratings of the more important crops on the soils of Snohomish County, Wash., under prevailing practices* [1]—Continued

Soil and condition	Oats (grain)		Oats (hay)		Timothy and clover hay		Potatoes		Strawberries		Pasture [2] (if cleared)	General productivity	Remarks on use
	Yield	Rating (100=50 bu.)	Yield	Rating (100=2 tons)	Yield	Rating (100=2 tons)	Yield	Rating (100=200 bu.)	Yield	Rating (100=2,000 qt.)			
Norma loam:	*Bu.*		*Tons*		*Tons*		*Bu.*		*Qt.*				
Drained			2	100	2-2.25	105	250	125			Good	Very high	75 percent used for timothy and clover hay, oats, peas, potatoes, and vegetables.
Undrained											do	Moderate	Largely in timber
Norma clay loam:													
Drained	65	130			2-2.25	105	200	100			do	Very high	About 20 percent cultivated, largely for hay.
Undrained											do	Moderate	Largely in timber.
Oso loam											Poor	Very low	None cultivated
Pilchuck gravelly sand											do	do	None cleared
Pilchuck fine sand											Moderate	Low	Principally for pasture
Puget loam	60	120			2	100					Good	High	About 70 percent cultivated, timothy and clover hay is the principal crop, some corn is grown
Puget silt loam	70	140			2.25-2.75	125	215	107			do	Very high	About 90 percent cultivated, for hay, oats, peas, and truck
Puget clay loam	80	160			2.5-3	135	220	110			do	do	About 75 percent cultivated, for hay, oats, peas, and truck
Puget clay	80	160			2.5-3	135	220	110			do	do	About 60 percent cultivated, for hay, oats, peas, and truck, but more difficult to cultivate than Puget clay loam.
Puyallup fine sandy loam	65	130			1.75-2.5	100					do	High	Principally for truck crops and corn
Puyallup sandy loam	50	100			1.75	90					do	Moderate	About 40 percent cultivated, largely kept in timothy and other grasses and used for semi-permanent pasture
Rifle peat:													
Drained	50	100			1.5	75	200	100			do	High	About 20 percent cultivated, largely for hay and oats
Undrained											Fair	Very low	Uncleared
Shallow phase, drained	50	100			1.5	75	200	100			Good	High	About the same adaptations as Rifle peat
Shallow phase, undrained											Fair	Very low	Uncleared
Riverwash											Very poor	do	No agricultural value

Rough broken land											Poor	do	None cultivated but small areas partly cleared for pasture
Rough mountainous land (Oso soil material)											do	do	No agricultural value other than for forestry
Rough stony land (Oso soil material)											do	do	Do
Skykomish gravelly sand											do	do	None cultivated.
Skykomish stony sand											Fair	do	Do
Skykomish gravelly sandy loam											do	do	Possibly 1 percent cultivated, some spots used for pasture, best use is forestry
Skykomish gravelly loam	40	80	2 5	125	2	100					Moderate	Moderately high	About 5 percent cultivated for common crops; well adapted to fruit
Skykomish stony loam											Fair	Very low	Practically none cultivated, a few spots in pasture
Snohomish loam.													
Drained	70	140			1. 75–2	90	175	88			Good	Very high	About 40 to 50 percent cultivated for common crops
Undrained											Fair	Low	Uncleared
Snohomish silt loam													
Drained	80–90	170			2 5 –3	150	200	100			Good	Very high	Largely for crops and pasture
Undrained											Moderate	Low	Uncleared
Shallow phase, drained.	75	150			2–3	125	175	88			Good	Very high	Nearly all for crops and pasture
Shallow phase, undrained											Fair	Low	Uncleared
Snohomish silty clay													
Drained	80–90	170			2. 5 –3	135	200	100			Good	Very high	Hay, peas, and oats the principal crops
Undrained											Moderate	Low	Uncleared
Sultan loam	70	140			1 5 –2. 25	90					Good	Very high	About 60 percent cultivated; the rest partly cleared for pasture
Sultan silt loam	75	150			1. 75–2. 75	110					do	do	Hay, oats, peas the principal crops, about 80 percent cleared
Sultan clay loam	75	150			1. 75–3	120					do	do	Uses similar to Sultan silt loam but more difficult to cultivate
Tidal marsh											Very poor	Very low	Little if any agricultural value

[1] Farming practices are built around dairying, poultry raising, and the growing of truck crops The principal feed crops are timothy and clover hay and oats The use of rather heavy applications of barnyard manure for nearly all crops is a common practice About 200 pounds of superphosphate are applied to green peas and 200 to 600 pounds of a complete mixed fertilizer are used on the peat and muck soils for truck crops.

[2] Only descriptive terms are used to give the relative productivity of the soils for pasture.

[3] Alsike clover is the principal hay on these soils.

[4] These yields and indexes apply to the better sites

NOTE – Leaders indicate that the crop is not commonly grown.

The estimates and ratings in table 8 are based primarily on interviews with farmers and others who have had experience in the agriculture of this county. They are presented as such to show the average production from the prevailing type of farming over a period of years. It is realized that these estimates may not apply directly to specific tracts of land for any particular year, inasmuch as the soils as shown on the map vary somewhat, the management practices differ slightly, and the climatic conditions fluctuate from year to year.

In addition to the estimated yields, crop productivity indexes, or ratings, are given in order that the yields may be compared directly with yields obtained in other parts of the county.

The rating compares the productivity of each of the soils for each crop to a standard—100. This standard index represents the approximate average acre yield obtained without the use of amendments on the more extensive and better soil types of the regions of the United States in which the crop is most widely grown. An index of 50 indicates that the soil is about half as productive for the specified crop as is the soil with the standard index. The standard yield for each crop is given at the head of its column in table 8. Some crops may have productivity indexes of more than 100 on soils given amendments, such as lime and commercial fertilizers, or special treatments, such as irrigation, and on unusually productive soils of small extent.

The principal farming practices are those associated with dairying, poultry raising, and the growing of truck crops. Most of the cleared acreage is used for timothy and clover hay and oats for hay. Heavy applications of barnyard manure on all crops is a common practice. About 200 pounds of superphosphate are rather commonly applied to green peas and 200 to 600 pounds of a complete mixed fertilizer to truck crops on the peat and muck soils. In the instance of the poorly drained soils, the crop indexes apply to the artificially drained condition.

The principal factors affecting the productivity of land are climate, soil (this includes the many physical, chemical, and biological characteristics), slope, drainage, and management, including the use of amendments. No one of these factors operates separately from the others although some one may dominate. In fact, the factors listed may be grouped simply as the soil factor and the management factor, since slope, drainage, and most of the aspects of climate may be considered as characteristics of a given soil type, and the soil type, as such, occupies specific geographical areas characterized by a given range of slope and climatic conditions. The best available summation of the associated factors is found in the crop yields over a long period of years, and these, therefore, are used where available.

In the column General Productivity the productivity of the soils, as measured by the relative productivity for the principal crops, is described in six classes—very high, high, moderately high, moderate, low, and very low, but no precise mathematical procedures were followed in assigning these terms. They were given arbitrarily by visual inspection of the indexes, particularly those for timothy and clover hay, oat hay, and potatoes. Since it is difficult to measure

mathematically or otherwise either the exact significance of a crop in the agriculture of an area or the importance or suitability of certain soils for particular crops, too much significance perhaps should not be given to the exact definition of general productivity. On the other hand such terms do give the general relations among the soil types in terms of their ability to produce the common crops of the county under prevailing farming practices.

The last column, Remarks on Use, gives information on use of land, including the relative proportion cleared for cultivated crops.

Because of the extent of soil types and the pattern of their distribution, productivity tables do not present the relative roles that they play in the agriculture of the county. The tables show the relative productivity of individual soils. They cannot picture in a given county the total quantitative production of crops by soil areas without the additional knowledge of the acreage of the individual soil types used for each of the specified crops.

Economic considerations have played no part in determining these productivity indexes. They cannot be interpreted, therefore, into land values except in a very general way. It is important to realize that productivity, as measured by yields, is not the only consideration that determines the relative worth of a soil for growing crops. Distance to market, relative prices of farm products, and other factors influence the value of land. The ease or difficulty of tillage and the ease or difficulty with which productivity is maintained are examples of other considerations than productivity that influence the general desirability of a soil for agricultural use. In turn, steepness of slope, presence or absence of stone, the resistance to tillage offered by the soil because of its consistence or structure, and the size and shape of areas are factors that influence the relative ease with which soils can be tilled. Likewise, inherent fertility and susceptibility to erosion are characteristics that influence the ease in maintaining soil productivity at a given level. Productivity, as measured by yields, is influenced to some degree by all these factors and by such other factors as the moisture-holding capacity of the soil and its permeability to roots and water. Therefore, they are not factors to be considered entirely separate from productivity, but on the other hand, schemes of land classification generally give them some separate recognition in designating the relative suitability of land for agricultural use.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of weathering and soil development acting on the soil materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point depend on (1) the physical and mineralogical composition of the parent soil material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life in and on the soil; (4) the relief or lay of the land; and (5) the length of time the forces of soil development have acted on the soil material. External climate is less important in its effects on soil development than internal soil climate, which depends not only on temperature, rainfall, and humidity, but on the physical characteristics of the soil or soil material

and the relief. The relief, in turn, strongly influences drainage, aeration, runoff, erosion, and exposure to sun and wind.

Most of the soils of Snohomish County are podzolic. They have developed in a forested region of cool moist climate and include small areas of true Podzols in sandy areas and at the higher elevations. The whole area may be considered as transitional between the region of Podzols and that of Brown Podzolic soils.

Exclusive of the mountainous areas developed on hard bedrock, the Cathcart soils developed on shales and sandstones, the alluvial soils of the stream bottoms, and the organic soils, the parent materials consist mainly of glacial drift and outwash materials brought in by the continental glacier from the north. Only a small part of the material comes from the Cascade glaciation to the east. The glacial drift was deposited mostly in the form of ground moraines, with occasional kamelike areas. Most of these areas are occupied by the Alderwood soils. There are many areas of terminal moraines in the eastern part of the county near the mountains, also extensive areas of glacial outwash material and gravelly Pleistocene terraces.

According to geologists two major ice flows have covered the region—the earlier one known as the Admiralty and the later one known as the Vashon. The Vashon drift has been considered as of the same age as the Wisconsin drift in the Middle States but it appears to have been more highly leached. This is partly due to the noncalcareous character of the original material and partly to the higher rainfall. The influence of old glacial lakes is noted in fine-textured lacustrine deposits on which the Kitsap soils have developed. Their largest areas are on the deltas of old glacial streams. These deposits occur below an altitude of 600 feet, which indicates that that was the highest level reached by the glacial lakes.

An unusual feature in the region is the gray silica-cemented glacial drift, locally known as hardpan. This consists of a mixture of small boulders, cobbles, and gravel firmly cemented with gray fine interstitial material. The cementing material appears to be mostly silica. The cemented layer is reached at a depth of about 3 feet and in some places continues to a depth of 75 feet or more. The Alderwood soils are developed on this material. In this county these soils are not well developed above an altitude of 600 feet, which may be significant as it coincides closely with the upper limits of the old glacial lakes.

The Everett, Skykomish, Indianola, and Lynden soils are formed from well-drained loose porous materials derived from modified glacial drift, outwash, and alluvial materials. Important factors other than parent materials that have influenced the development of the different soils are drainage and climate. Drainage has affected the development of intrazonal soils. Differences in climate have influenced variations of the zonal soils to such an extent that they range from weakly Podzolic to Podzols. The Podzols dominate in the eastern part where the elevation is higher, the temperatures lower, and the rainfall higher. The rather weakly podzolized soil development is well represented by Alderwood gravelly loam.

Following is a description of a profile of Alderwood gravelly loam as observed in a pit dug in the NE¼ sec. 19, T. 32 N., R. 5 E. The elevation is 300 feet, and the mean annual precipitation is probably about 35 inches.

A_0 and A_1. O to 2½ inches, rather dark-brown well-decomposed leafmold composed of fir needles, leaves, and grass bound together with fine roots containing considerable mineral material in the lower part. The pH value by the La Motte Duplex indicator is 4.6. This organic layer is thicker than average.

A_2. 2½ to 5 inches, brown gravelly loam containing some pockets and streaks of dark material. The upper contact is irregular. There are many small rust-brown accretionary shotlike pellets from $\frac{1}{16}$ to ¼ inch in diameter. The surfaces of the shot are slightly rough and coated with soil. The soil material has a soft fine crumb structure. The pH value is 4.6 according to the La Motte Duplex Indicator.

A_3. 5 to 10 inches, deep yellowish-brown or light-brown gravelly loam containing some shotlike pellets. The structure is soft fine-crumbed. This material contains many rootlets, but the organic-matter content is moderately low. The pH value is 4 8.

B_1. 10 to 20 inches, brownish-yellow heavy gravelly loam containing no shotlike pellets. The material breaks to small clods and is very faintly compact. It contains many small roots and some small cobbles. The stone and gravel are faintly coated with soil.

B_2. 20 to 32 inches, yellowish-brown heavy gravelly loam faintly mottled with gray and rust brown. It breaks into small clods and contains some small stones A mat of small roots lies horizontally at the bottom of this horizon on top of the hardpan.

C. 32 to 80 inches, light-gray, mottled with rust brown, cemented glacial drift, or hardpan. It is difficult to penetrate in place with a crowbar, but when broken apart the fragments break into gravelly loam. The reaction is medium acid (pH 5 9).

There are many small boulders on the surface and throughout the soil. The stone and gravel are largely of granitic origin. This soil is developed on a well-drained undulating glacial-drift plain. The original Douglas-fir timber has been logged, and the land is now covered with second-growth Douglas-fir, hemlock, alder, redcedar, vine maple, and undergrowth.

The most strongly developed Podzols are coarse sandy soils at a somewhat higher altitude in the belt of higher rainfall. Following is a description of a profile of Everett gravelly loamy sand, as observed in a deep pit in the southwest corner of sec. 14, T. 28 N., R. 8 E., half a mile northeast of Kellogg Lake at an approximate elevation of 675 feet. This represents a somewhat more strongly developed podzolic profile than the average for this soil type. The mean annual precipitation is probably 60 inches.

A_0 and A_1. 0 to 3 inches, brown partly decayed moss, needles, leaves, wood, twigs, and bark, containing some mineral material in the lower part.

A_2. 3 to 3½ inches, ash-gray sandy loam of irregular thickness and single-grained. The reaction is very strongly acid (pH 4 0).

B_1. 3½ to 9 inches, rust-red weakly cemented coarse sandy loam containing many small rootlets. This is an ortstein horizon, and the material breaks into angular fragments.

B_2. 9 to 14 inches, rusty reddish-brown compact gravelly loamy sand, very weakly cemented and containing many rootlets.

B_3. 14 to 25 inches, rusty yellowish-brown gravelly loamy sand, somewhat coherent when moist and containing some small roots. The reaction is strongly acid (pH 5 0).

C_1. 25 to 60 inches, yellowish-olive coarse sand containing a trace of gravel. It is strongly acid (pH 5.2).

The land is undulating or gently rolling, and surface drainage is good. The virgin Douglas-fir timber has been logged recently, and the land is covered with fireweed, ferns, huckleberries, blackberries, and young alder, hemlock, vine maple, and other trees. There is much moss on the surface of the soil. This profile illustrates the most

pronounced podzolic development in the county. In this respect it is not a typical profile of Everett gravelly loamy sand. Other soils having similar profiles in spots are Indianola loamy sand and Skykomish gravelly sand. The soils with restricted drainage are intrazonal and fall into three groups, as follows: (1) Gray and brown soils, (2) dark-colored soils, and (3) organic soils. The gray and brown soils with imperfect drainage are of recent origin and have little development of soil profile. The Bellingham soils in the group of dark-colored soils are distinctly hydromorphic or glei soils and have blue or bluish-gray subsoils. The Custer soils are regarded as representative of Ground-Water Podzols, with profiles similar to the Saugatuck soils in the North Central States.

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