

SOIL SURVEY

Clallam County Washington

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WASHINGTON AGRICULTURAL EXPERIMENT STATION
and the
WASHINGTON STATE PLANNING COUNCIL

How to Use THE SOIL SURVEY REPORT

FARMERS who have lived in one locality for a long time come to know about the soil differences on their own farms and on those of their immediate neighbors. What they do not know, unless a soil survey has been made, is how nearly their soils are like those at experiment stations or in other localities from which higher yields are reported. They do not know whether these higher yields are from soils like their own or so different that they could not hope to get equally high returns, even if they adopted the practices followed in these other places. These similarities and differences among soils are known only after a map of the soils has been made. Knowing what kind of soil one has and comparing it with soils on which new developments have proved successful will remove some of the risk in trying new methods and varieties.

SOILS OF A PARTICULAR FARM

To find what soils are on any farm or other tract of land, locate it on the soil map, which is in the envelope inside the back cover. This is easily done by finding the township, section, and quarter section the farm is known to be in and locating its boundaries by such landmarks as roads, streams, villages, and other features.

Each kind of soil is marked with a symbol on the map; for example, all soils marked B1 are of the same kind. To find the name of the soils so marked, look at the legend printed near the margin of the map and find B1. The color where B1 appears in the legend will be the same as where it appears on the map. The E1 means Bellingham loam. A section of this report (see table of contents) tells what Bellingham loam is like, its principal uses, and some of the other uses to which it is suited.

How productive is Bellingham loam?

Find this soil name in the left-hand column of table 6, and note the yields of the different crops opposite it. Compare them with yields given for the other soils mapped and refer to table 7 where the agricultural soils of the county are rated in descending order according to their productivity for important crops. Read in the section on Soil Types and Phases to learn what are good uses and management practices for this soil.

SOILS OF THE COUNTY AS A WHOLE

If a general idea of the soils of the county is wanted, read the introductory part of the section on Soils. This tells where the principal kinds are found, what they are like, and how they are related to one another. Then study the soil map and notice how the different kinds of soils tend to be arranged in different localities. These patterns are likely to be associated with well-recognized differences in type of farming and land use.

A newcomer who considers purchasing a farm in the county will want to know about the climate as well as the soils; the types and sizes of farms; the principal farm products and how they are marketed; the kinds of farm tenure; value of farm buildings, land, and other farm property; availability of schools, highways, railroads, and public utilities; industries; and cities, villages, and population characteristics. This information will be found in the sections on General Nature of the Area and on Agriculture.

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

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

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SOIL SURVEY OF CLALLAM 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

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

LOCATED in the extreme northwestern corner of Washington, Clallam County is the most northwesterly county in the United States. Because of the Olympic Mountains the area has the widest local range in rainfall known in the United States—from about 16 to 115 inches annually. About half the county is included in the Olympic National Park. Much of it is a densely timbered wilderness and consequently its chief importance is in its timber, water, and recreational resources. Logging and the manufacture of timber products have provided the principal source of income since the time of the first settlement. The county is not, as a whole, an important agricultural area; dairying is the principal farm pursuit. To provide a basis for the best agricultural uses of the land a cooperative soil survey was made by the United States Department of Agriculture, the Washington Agricultural Experiment Station, and the Washington State Planning Council.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

Clallam County, the most northwesterly county in the United States, is in the extreme northwestern corner of the State of Washington (fig. 1). Long and narrow in shape, it stretches from the Pacific Ocean

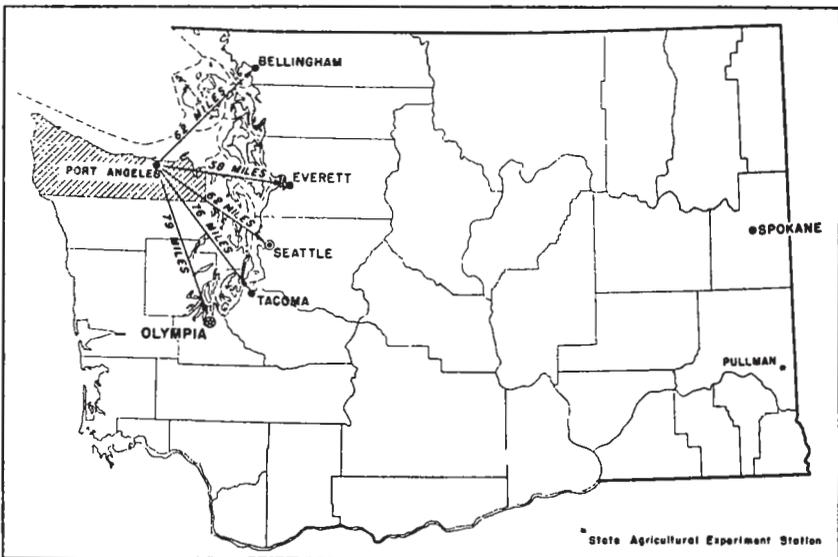


FIGURE 1.—Location of Clallam County in Washington.

eastward for about 90 miles along the Strait of Juan de Fuca, and is bounded on the east and south by Jefferson County. Its total land area is 1,143,040 acres. Port Angeles, the county seat and principal town, is 62 miles northwest of Seattle.

As a large part of the county is a densely timbered wilderness of steep mountain slopes and rugged foothills, its chief importance lies in its timber, water, and recreational resources. About half of it is within the Olympic National Park.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

The Olympic Mountains, an isolated northern extension of the Coast Range, extend into the county from the south and together with the outlying foothills occupy more than four-fifths of the area. The highest peaks reach elevations above 7,000 feet, rising abruptly from the stream canyons to sharp spires and knifelike ridges. The central massif of the mountain is flanked by steep foothill ridges, which in many places, particularly in the west, extend to the coast. Much of the shore line west of Freshwater Bay and along the ocean is rugged, being characterized by many cliffs, steep promontories, and offshore rocks and islets. The lower and more inhabitable parts of the county form a narrow belt of variable relief between the mountains and the shore.

A prominent feature of the surface relief is its apparent structural character. The beds of shale, sandstone, and conglomerate, masses of extruded basalt, and other formations underlying the region were greatly contorted by earth movements when the mountains were uplifted. The planes of visible rock formations are steeply inclined. In many places along the shore line, particularly on the ocean beaches, the originally horizontal sedimentary beds now stand on edge. Subsequent erosion and much canyon cutting have modified and in places deeply sculptured the higher land masses. The land forms at lower elevations also are largely the result of constructional and erosional processes. A mantle of glacial material consisting of gravelly drift and both coarse and fine outwash sediments covers much of the county below 1,500 feet. This material probably represents several periods of deposition of both continental and mountain, or Alpine, glaciation. The older formations are exposed chiefly in the shore-line bluffs, in the slopes along the entrenched streams, and in the steeper hills and mountains.

In the eastern part of the county a narrow, undulating, shelflike plain borders the shore of the strait, sloping gently from elevations of 1,800 feet or less in the foothills to bluffs of 50 to 200 feet along the beaches. The streams crossing this plain have for the most part cut courses through narrow valleys or canyons bordered by steep slopes or abrupt escarpments. Between the streams considerable areas retain an unaltered glacial-drift type of relief, characterized by small undrained depressions and low morainic hills and ridges.

In the western part, which is sparsely populated and still in a pioneer stage of development, the habitable lands are on the stream terraces and alluvial bottoms and along the shores near the few roads that penetrate the region. These alluvial bottom lands are widely scattered in small narrow strips and are of limited extent.

In the mountains are many small as well as several larger lakes. Lake Crescent, about 18 miles west of Port Angeles, is a summer resort noted for its scenic beauty. Lying in a deep narrow depression, it is surrounded by precipitous slopes that extend sharply downward to a depth of several hundred feet below sea level at the bottom of the lake. Ozette Lake, which has an area of about 12 square miles, is approximately 2 miles from the ocean. Soundings indicate that its bottom lies over 200 feet below sea level. Glacial drift around the lake shows that it is glacial in origin.

Many short swift-flowing streams drain the area. Except in the lower lands near the salt water, they are for the most part confined to canyons or narrow valleys (pl. 1, A). The runoff is considerable during the rainy winter season but greatly reduced in summer. Only the longer rivers fed by melting snow from higher mountains maintain an abundant flow in summer. In the eastern part of the county the Elwha and Dungeness Rivers are fed by glaciers, and their waters are turbid with gray rock flour when the glacial ice melts. The Dungeness River has built a fanlike delta across which it has changed its channel many times. The older and higher part of the delta, which adjoins the foothills, is a fan deposit of coarse gravel. Below this point the river has lowered its valley and subsequently laid down the largest areas of alluvium in the county.

The Soleduck, Calawah, and Bogachiel Rivers head well back in the mountains but are not fed by glaciers. Their present courses are for the most part entrenched in terraces of old coarse-gravel outwash, evidently derived from mountain glaciations. The three unite to form the Quillayute River, the largest stream in the county. The tidal estuary of the Quillayute River at the Indian village of La Push affords the only harbor for fishing boats and other small craft for many miles along the coast.

CLIMATE

The climate of Clallam County, which is distinctly oceanic, is characterized by cool summers, mild winters, and the usual wet and dry seasons of the Pacific coast. About 75 percent of the annual precipitation falls during the 6-month period from October to March. Although there usually are no effective rains during summer, the air remains humid, especially at night, and fogs are of common occurrence on the ocean and strait. Occasional periods of dry weather, however, cause the forests to become dry and subject to destructive fires. Irrigation is practiced in the eastern part of the area where the porous soils, unable to retain the winter moisture, become so dry that crops suffer.

The Olympic Mountains cause the widest local range in rainfall known in the United States. The moisture-laden wind from the ocean must pass over the mountains before reaching the inland valleys. As the rising and expanding air is cooled, large quantities of moisture are precipitated, either as rain on the coast and lower lands or as heavy snows on the mountains. By the time the air passes down the opposite side of the mountains it has been compressed and warmed and can take up moisture again.

Forks, on the western windward side of the mountains, has an average annual precipitation of 115 inches; Quinault, farther south in another county, has 122 inches. The precipitation on the mountain slopes is probably even greater. At Sequim, on the northeastern side of the mountains, an air-line distance of about 60 miles from Forks, the annual average precipitation is slightly above 16 inches. Although there are no records, the rainfall at the lighthouse on Dungeness Spit is even less, probably about 11 inches, or equal to that of the semiarid sagebrush regions in central Washington, where irrigation is necessary to insure full crop production.

The wide range in effective precipitation is largely a matter of intensity and duration rather than frequency. The average number

of days in which there is a measurable quantity of rain is about 190 in the western part, 139 at Port Angeles, and only 95 at Sequim; there are many cloudy or partly cloudy days at both Port Angeles and Sequim when the rainfall is too light to measure.

In the lower lying settled lands of the area, extremes of temperature are of rare occurrence and of short duration. Daily changes are usually slight, and the nights are always cool. Severe thunderstorms, hail, or torrential rains are virtually unknown. Destructive blow-downs occur in the heavy timber at rare intervals, but strong winds are uncommon except along the ocean coast. A snowfall heavy enough to break down small timber and telephone lines sometimes occurs, but many winters pass with little or no snow. At higher elevations in the adjacent mountains the climate is more severe, and the snow remains on the highest peaks until late in summer.

Except for extended periods of rain and cloudy weather in winter, the climate of the eastern part of the county is pleasant and invigorating. It is favorable for the growth of cool-climate crops and vegetables, but other crops do not do so well. The frost-free period ranges from 166 to 218 days, but cool nights and insufficient sunshine limit alfalfa production and prevent corn, tomatoes, and other warm-weather plants from maturing properly. On the more droughty upland soils where irrigation is unavailable all late crops suffer from lack of summer rainfall. In the western part of the county, however, the excessive rainfall not only leaches the soil and interferes with the growth and harvesting of crops but also discourages settlement and nonagricultural development.

Temperature and precipitation records for Port Angeles, elevation 98 feet; and precipitation records for Forks, near the ocean, at an elevation of 375 feet, and at Sequim, in the eastern part of the area, elevation 200 feet, are given in table 1.

VEGETATION

The natural vegetation of the county includes nearly all the plants common to the northern Pacific coast. Throughout the eastern less humid part of the county conifers are numerous, with Douglas-fir the dominant species. Cedar, hemlock, and deciduous trees, mainly alders with a few maples and willows, are confined largely to bottom lands or wet slopes and to less pervious soils where moisture is most abundant in summer. In the western part a belt of Douglas-fir extends down the droughty gravel terraces of the large rivers, but the dominant tree elsewhere is the Western hemlock, with large Sitka spruce and Western redcedar in swamps and bottom lands. These four dominant conifers grow to great size under optimum conditions; trees scaling 10,000 board feet are not uncommon.

Dense forest originally covered all the area except the high mountaintops and several small prairies. More than 95 percent of the area still remains uncleared, for clearing land is both difficult and expensive and consequently proves a major obstacle to settlement and agricultural development. The merchantable timber has been logged from a large part of the county outside the Olympic National Park, and there have been a number of large fires and blow-downs. The land, however, quickly gains a new second-growth cover of timber and brush more dense than the virgin forest. Much debris remains when a sec-

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Port Angeles, and precipitation at Forks and Sequim, Clallam County, Wash.

Month	Port Angeles (elevation, 98 feet)							Forks (elevation, 375 feet)				Sequim (elevation, 200 feet)			
	Temperature			Precipitation				Precipitation				Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year	Total for the wettest year	Average snowfall	Mean	Total for the driest year	Total for the wettest year	Average snowfall	Mean	Total for the driest year	Total for the wettest year	Average snowfall
	°F.	°F.	°F.	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
December.....	39 8	64	10	4 78	4 53	8 95	2 6	18 64	17 51	14 52	0 6	3 00	51	8 79	3 4
January.....	37 8	60	-1	4 54	1 38	5 27	2 7	17 81	6 19	29 70	7 0	2 16	1 47	3 36	1 7
February.....	39 2	59	3	3 29	91	4 16	3 4	13 25	3 40	16 96	2 1	1 37	68	1 06	1 8
Winter.....	38 9	64	-1	12 61	6 82	18 38	8 7	49 70	27 10	61 18	9 7	6 53	2 66	13 21	6 9
March.....	42 2	66	18	2 20	1 54	82	8	12 55	12 29	6 92	9	1 31	1 91	1 17	1
April.....	46 1	71	27	1 49	2 20	3 03	(¹) 0	7 96	10 43	10 31	3	1 03	1 23	1 03	1
May.....	50 7	81	30	1 18	62	92	0	5 39	4 42	4 53	0	.84	66	2 18	0
Spring.....	46 3	81	18	4 87	4 36	4 77	8	25 90	27 14	21 76	1 2	3 18	3 80	4 38	2
June.....	54 8	88	35	89	85	83	0	3 61	6 63	8 40	0	80	55	66	0
July.....	57 4	88	37	48	18	22	0	1 90	2 94	38	0	47	23	60	0
August.....	58 1	92	38	71	27	1 46	0	2 03	1 78	3 73	0	55	75	50	0
Summer.....	56 8	92	35	2 08	1 30	2 51	0	7 54	11 35	12 51	0	1 82	1 53	1 76	0
September.....	54 3	82	30	1 48	18	3 65	0	5 11	73	11 88	0	97	22	1 45	0
October.....	48 8	74	27	2 36	93	1 34	(¹) 6	12 01	7 55	25 87	(¹) 6	1 54	1 73	2 30	0
November.....	42 9	65	12	3 96	1 30	6 24	6	14 88	3 94	20 59	6	2 02	33	2 63	8
Fall.....	48 7	82	12	7 80	2 41	11 23	.6	32 00	12 22	58 34	.6	4 53	2 28	6 38	8
Year.....	47 7	92	-1	27 36	² 14 89	³ 36 89	10 1	115 14	⁴ 77 81	⁴ 153 79	11 5	16 06	⁵ 10 27	⁵ 25 73	7 9

¹ Trace² In 1929³ In 1891.⁴ In 1921.⁵ In 1943⁶ In 1933.

tion of timber is cut down (pl. 1, *B*). Even burning does not clear the ground, because many logs and all the stumps remain unconsumed.

ORGANIZATION AND POPULATION

The shores of the Olympic Peninsula were the first part of the Northwest sighted by white men in the sixteenth century. During the following 200 years the coast and Strait of Juan de Fuca were visited and explored by Spanish, English, and American navigators. Many geographic names, as Juan de Fuca and Port Angeles, are reminiscent of the Spanish. Cape Flattery was named by Cook; Mount Olympus, by John Meares; and Dungeness, Protection Island, and Port Discovery, by Vancouver. These occasional visits and later those during the height of the fur trade brought about little change, and the Canoe or Siwash Indians remained in full possession of their lands until the coming of the first American settlers in the middle of the nineteenth century.

Clallam County, created on April 26, 1854, is one of the 16 original counties established under the Washington Territorial Government. Few settlers were in the area at that time. On June 19, 1862, President Lincoln issued an order reserving a large area at Port Angeles for a lighthouse and military purposes. The customhouse was temporarily moved to the port, and a settlement grew up on the site that has continued as the principal town and county seat. Early settlers established themselves mainly in the eastern and more accessible part of the county near the shore and along the most easily cleared stream bottoms. The Sequim Prairie and the nearby Dungeness River bottom soon became an agricultural district. A few of the more intrepid newcomers, however, scattered widely, going as far as Forks and Quillayute Prairies and Ozette Lake in the west.

The pioneers were primarily homemakers of American or British stock who came by sea from the Eastern States or overland from the Midwest. The present white inhabitants are mainly of the same stock, but some are of Scandinavian or other western European ancestry.

In 1940 the 797 Indians in the county, chiefly of the Makah and related Quillayute tribes, were living on reservations at Neah Bay and La Push. The county then had a population of 21,848, of which 12,439, or 56.9 percent, was rural. Inhabitants of towns less than 2,500 are classed as rural. A considerable part of the rural population is not agricultural but depends on logging, merchandizing, and catering to the summer tourist and sportsman trade.

Port Angeles, the county seat and principal town of the Olympic Peninsula, in 1940 had a population of 9,409. With a good harbor at the entrance to Puget Sound, it has become a port of considerable importance. Smaller towns are Sequim, in the irrigated district of the Dungeness Valley; and Forks, an important trading center located on a prairie of the same name in the extreme western part. Sekiu, Clallam Bay, Pysht, and Sappho are logging camps and small trading centers. Carlsborg is a small sawmill settlement 3 miles west of Sequim. Neah Bay and La Push, though primarily Indian villages, are also United States Coast Guard stations and bases for the salmon fishing fleet that operates off the coast.

INDUSTRIES

Logging and the manufacture of timber products have provided the principal source of income for the county from the time of first settlement. The major logging operations are now largely confined to the western part; in the eastern part most of the merchantable timber has been removed. Logs are hauled by rail or floated as booms and rafts from Neah Bay and Pysht to Port Angeles, where they are used either by local mills or towed to Bellingham or to Puget Sound ports. Port Angeles has three large pulp and paper-product mills, which it is estimated are assured a perpetual supply of pulpwood by the natural growth of hemlock in the region. Moreover, the vast supply of wastewood in the forest probably could be more fully utilized in the future. Through distillation of wastewood many useful products, including charcoal briquets, naval stores, fuel alcohol, and various creosote substances, could be produced.

TRANSPORTATION AND PUBLIC FACILITIES

Transportation facilities in the county are well developed, considering the limited area of settlement. A branch line of the Chicago, Milwaukee, St. Paul, and Pacific Railroad connects Port Angeles with Port Townsend, from which cars are ferried to Seattle. The Port Angeles Western Railroad, used mainly for hauling logs, extends westward around Lake Crescent and down the Soleduck River to a point about 1 mile north of Forks. Logging railroads extend inland from Neah Bay, Clallam Bay, and Pysht.

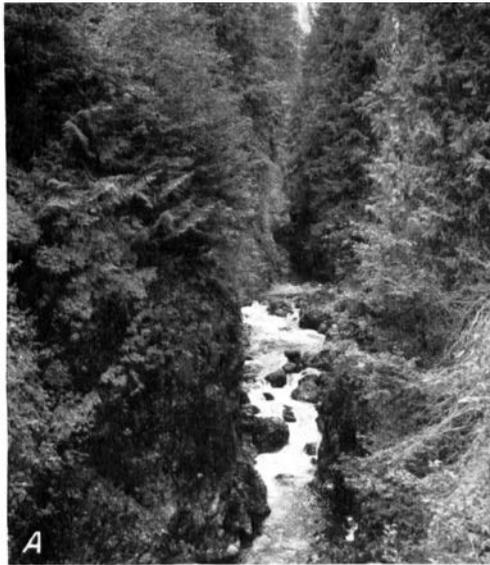
The Olympic Highway (U. S. No. 101), an important tourist route extending almost the length of the county, passes through the principal towns and connects Port Angeles with Port Townsend and the Puget Sound cities as well as with the coast and Grays Harbor. Another important road extends westward along the strait to Neah Bay, connecting with the Olympic Highway by cross roads to Lake Crescent and Sappho. There also is a road to Ozette Lake. Good gravel or black-top county roads adequately serve all settled districts and extend into the mountains to Olympic Hot Springs and other resort and recreational areas. Many miles of secondary roads and trails have recently been built in national and State forest lands. Passenger bus and motor freight lines serve all centers of population. School children for the most part are transported by bus to high-standard consolidated schools.

Regular boat service extends from Port Angeles to Port Townsend, Seattle, and Victoria, capital of British Columbia. The United States Coast Guard aviation base at Port Angeles maintains planes for emergency duty along the coast line.

In all the more accessible parts of the area telephones and electricity are in general use.

AGRICULTURE

Judged by ordinary production standards of common farm crops, the county is not, as a whole, an important agricultural area. Extensive farm development is forestalled by the scarcity of naturally fertile soil, the dense forest cover, and a climate characterized by cool summers and a winter rainfall that leaches the soil but does not furnish adequate moisture for crops during the growing season. Dairying,



A, Deep narrow gorge of small stream in western part of Clallam County; the 120-inch mean annual rainfall produces dense vegetation.

B, Cut-over land and standing timber on Solduc gravelly loam; the agricultural value of this land does not justify the cost of clearing



A, Typical workman's suburban home near Port Angeles

B, Typical stump ranch on Clallam loam in the eastern part of Clallam County.

seed growing, poultry raising, berry production, and the growing of pod peas for eastern markets and of a few other special crops for fancy canning constitute the major agricultural operations. Dairying, however, is the principal farm pursuit and the main means of support for practically all the larger and better farms.

For farming at a subsistence level or use for suburban home sites to whose owners farming is a side line, the region offers more possibilities. Actually the potentialities of the undeveloped lands should be considered from this angle. With the further development of local industries that will furnish employment, the building of more homes with a few acres sufficient for a cow, a small flock of chickens, and a garden will follow (pl. 2, A). The strong appeal of the equable climate, beaches, and mountain recreational areas is providing a further incentive to continued settlement.

CROPS

Hay is the principal field crop, and during recent years alfalfa has been gaining favor and is being sown on an increasing acreage. Although neither soil nor climate appears to be suited particularly to this crop, fair yields are obtained wherever a good stand can be established and maintained by irrigation and the use of barnyard manures. The tonnage of alfalfa hay is greater than that of the clovers and grasses which it is replacing. The average yield of 2.8 tons an acre in 1939 was but little less than the average in some irrigated districts of eastern Washington. Yields of 6 tons or more have been reported. Alfalfa produces best on deep well-drained alluvial soils in the eastern part and is ill suited to the high rainfall of the western part. Under favorable conditions two cuttings and some pasture are obtained each year. Irrigation is not usually resorted to until a field is established.

Oats, the principal grain crop, is one of the best crops for drained swamplands and soils of the damp depressions, as the Bellingham. During some summers it is difficult to cure hay or grain for threshing, for even though there is little measurable rainfall, light rains and fogs are common and the humidity is usually high at night.

The acreage of the various crops and the number of apple trees in stated years are shown in table 2.

Although a number of seed crops can be grown successfully, only peas now occupy an important acreage. These are chiefly the Austrian Winter field variety, a recently introduced purple-bloom pea. In a few years this pea has become the principal cash crop of the area, and as such it has several advantages. Being a legume, it improves the soil; because it matures before the drought late in summer, it can be grown successfully on the upland soils; and the straw makes fair winter feed for dry cows and young stock. The average acre yield of dry peas is about 25 bushels, but it may range up to 40 bushels under favorable conditions.

In recent years a sizeable acreage of green canning and fancy pod peas has been raised under contract. Both pole and dwarf varieties are grown.

Garden vegetables and root crops are grown mainly for home use and livestock feeding. Carrots produce well, but like other root crops they are damaged by root maggots.

TABLE 2.—*Acreage of the principal crops and number of bearing apple trees in Clallam County, Wash., in stated years*

Crop	1879	1889	1899	1909	1919	1929	1939	1944
	<i>Acres</i>							
Oats, threshed.....	282	179	872	1, 135	1, 219	497	818	525
Wheat.....	945	244	863	591	2, 009	383	278	418
Barley.....	171	40	68	117	239	92	156	231
Hay, total.....	803	1, 828	3, 877	6, 743	7, 858	9, 986	12, 686	12, 589
Alfalfa.....				125	403	2, 552	4, 561	4, 707
Timothy and clover, alone or mixed.....				4, 046	4, 654	3, 890	2, 735	3, 177
Clover alone.....			899	412	348	485	1, 673	
Annual legumes for hay.....					60	483	219	38
Small-grain hay.....			399	1, 963	1, 511	1, 852	1, 997	1, 718
Other tame hay.....			2, 579	14	809	578	1, 951	2, 315
Wild hay.....				183	73	146	550	634
Peas, field.....			170	214	973	212	1, 153	685
Potatoes.....	694	252	229	508	561	233	277	98
Market vegetables.....					31	54	462	432
	<i>Number</i>							
Apples.....trees..		2, 676	16, 208	19, 038	15, 605	7, 571	7, 352	8, 473

¹ Sweetclover only.

² Includes sweetclover and lespedeza.

³ Bearing and nonbearing trees.

In 1939 the 277 acres of farm land planted to potatoes averaged 133 bushels, or approximately 5 tons to the acre. Most of the crop is for home use, but part is shipped to local markets. Scab, which has long infested the older farm land, and the flea beetles, a recent pest, make it increasingly difficult to produce a commercial grade of potatoes.

Loganberries, youngberries, raspberries, blackberries, strawberries, and other berries grow well, even on the poor upland soils. If a local market were established, either by canneries or other processing plants, berry growing could be expanded to produce many tons of first-quality fruit and would employ many people at picking time.

LIVESTOCK AND LIVESTOCK PRODUCTS

The dairy industry benefits from a good market, cool summers and mild winters, and succulent pastures during the greater part of the year. The Sequim-Dungeness district, which has the lightest rainfall in western Washington, has a highly favorable climate for dairying. There are few insects or other annoyances, no intense summer heat, and no appreciable winter cold to decrease milk production. Even in the western part of the county, where rainfall is high, dairying is the only profitable enterprise on the few farms that have been developed. The necessity of purchasing high-priced feed during part of each year, moreover, has led to the elimination of scrub cattle and has raised the average milk and butterfat production to a high level. One of the highest producing Guernsey herds in the United States has been developed at Sequim.

Practically all the cattle are of dairy strain and mainly of Jersey and Guernsey breeds. In 1940, 8,171 of the 10,941 cattle in the county were cows and heifers 2 years old or over. Of this number 7,823 were kept for milk production, and in 1939, 7,022 cows produced 4,665,623 gallons of milk.

The number of various types of livestock in Clallam County is given in table 3.

TABLE 3.—*Number of livestock on farms in Clallam County, Wash., in stated years*

Livestock	1880	1890	1900	1910	1920	1930	1940	1945
Horses.....	220	295	739	1, 486	1, 299	801	¹ 1, 005	811
Mules.....	1	1	19	13	12	21	¹ 34	19
Cattle.....	2, 890	2, 447	4, 420	6, 890	7, 210	12, 184	¹ 10, 941	13, 567
Dairy cows..	996	845	1, 493	2, 876	4, 193	5, 676	¹ 7, 823	7, 418
Swine.....	1, 682	887	1, 246	2, 680	4, 005	2, 775	² 1, 494	1, 288
Sheep.....	565	1, 113	3, 685	2, 336	2, 194	2, 078	² 655	745
Goats.....	(⁴)	(⁴)	48	40	21	48	² 178	253
Chickens.....	⁵ 3, 464	⁵ 4, 629	⁵ 10, 902	} ⁵ 15, 904	{ 27, 139	⁵ 41, 816	² 39, 473	48, 826
Other poultry..	⁵ 554	⁵ 564	⁵ 551		{ 722	(⁴)	² 561	(⁴)
Bees...hives..	(⁴)	(⁴)	451	217	555	345	322	(⁴)

¹ Over 3 months old, Apr. 1.

² Over 4 months old, Apr. 1.

³ Over 6 months old, Apr. 1.

⁴ Data not available.

⁵ Excludes poultry under 3 months old.

Because of the isolated position of the county and the added cost of transportation to Puget Sound markets, poultry is not raised on a large scale. Most of the chickens represent farm flocks, and large percentages of the eggs and meat are sold in local markets. In 1939, 48,280 chickens were raised and 352,684 dozen eggs produced.

Other farm enterprises offering possibilities for a satisfactory livelihood are raising ducks, geese, and goats. For many years goats have been advocated as profitable animals for the stump ranches because they clear land by eating brush and the sprouts from stumps of deciduous trees. Farms for breeding muskrats or other fur-bearing animals may be established, and domestic rabbits could be raised for meat and fur.

LAND USE

The rapid expansion in farm acreage or in the number of country homes is deterred not only by the lack of extensive areas of soil suitable for farm land but also by the cost and difficulty of clearing the land of timber and stumps. Hemmed in by shore and mountain slopes and held back by the dense timber, rugged terrain, and high rainfall in the western part, about 90 percent of the farming is confined to the eastern less rainy section.

Most of the farm land centers about the Sequim-Dungeness district, which comprises less than 40 square miles of arable land. This section lies directly in the lee of the Olympic Mountains and has supported a moderately prosperous farm community since the time of early settlement. Because of the low rainfall, which averages only 16 inches annually, irrigation is necessary on most of the land during the sum-

mer months. Fortunately, however, water can be easily diverted from the Dungeness River. At the time of the survey about 8,000 acres were cropped or pastured under irrigation; at least 10,000 acres more could be put under irrigation if cleared and ditched.

One of the major farm-management problems is the maintenance of an optimum supply of soil moisture for satisfactory crop production. In the well-drained upland sections the cool, damp weather in spring greatly retards plant growth, and by the time the temperature is satisfactory for plant growth little available moisture is left in the soil. On the other hand, the inadequate drainage of the low-lying lands keeps crops from being planted until the season is far advanced.

The value of land is controlled by many factors. Water-front property usually has higher value than other land. Nearness to town and work, ease of clearing, and the quantity of remaining timber from which revenue can be derived also are important factors. When not overshadowed by other considerations, alluvial stream bottoms and wet depressional land are the most desirable as potential farm land.

The urge to produce more feed crops has created a demand for desirable land and raised its price out of proportion to its productive capacity, as compared with land values in other more truly farming sections of the United States. At the time of the survey logged-off land sold at prices ranging from \$5 to \$40 an acre, but clearing costs were high. The problem of profitably using the land, once it is cleared, is of prime importance. The establishment of further small farms or country homes cannot outdistance the expansion of local industry. As the remaining virgin timber is logged off, many loggers will inevitably be seeking other work. Some areas, moreover, have already been abandoned for farming purposes. Logged-off land reverting to the county for taxes, has been deeded to the State for fire protection and reforestation.

TYPES OF FARMS

Few farms are without some irrigation or situated other than on alluvial stream bottoms or drained swampland. The most desirable lands are already largely occupied, but a few moderately successful farms have been maintained on the prairies of the western part despite their low productivity.

Selected farm statistics as reported by the United States census are given in table 4.

The number of farms is increasing while their average size is generally decreasing, as shown in table 4. The average acreages per farm in 1940 and 1945 are not representative, having been raised out of true proportion by a few large holdings that are mainly timberland. For example, of the 1,226 farms in 1940, only 84 were between 50 and 70 acres in size; while 778, or 63.5 percent, were less than 50 acres; and 577, or 47.1 percent, were less than 30 acres.

During the thirties the trend toward a greater number of farms and decrease in the acreage of the average farm was accelerated by an influx of new settlers mainly from drought-stricken areas of the Great Plains. These uprooted farm people, struggling to reestablish themselves, took whatever small tracts of land were available.

It takes a number of years to clear enough land to support a family, and usually the period is lengthened by the necessity of working out to

TABLE 4.—Selected Statistics for farms in Clallam County, Wash., in stated years

Year	Farms	Land in farms				Farm values			Farm operation		
		Total	Area per farm	Improved land per farm		All prop- erty per farm	Land and buildings		Owners	Tenants	Man- agers
				Acres	Percent		Per farm	Per acre			
	<i>Number</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Percent</i>	<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
1880.....	102	18,056	177	50.5	28.5	2,035	1,548	8.75	86.3	13.7	-----
1890.....	97	18,827	194	80.0	41.2	8,952	7,770	40.04	95.9	4.1	-----
1900.....	395	52,667	133.3	25.6	19.2	2,745	2,222	16.66	84.9	12.6	2.5
1910.....	607	62,248	102.6	27.5	26.8	6,229	5,271	51.40	83.5	14.7	1.8
1920.....	607	58,043	95.6	33.2	34.7	10,648	8,754	91.55	82.9	15.3	1.8
1930.....	729	57,820	79.3	28.5	35.9	10,437	8,725	110.00	85.3	13.9	.8
1940.....	1,226	70,844	57.8	25.3	43.9	5,531	4,610	79.79	84.3	15.3	.4
1945.....	1,133	77,880	68.7	21.6	31.4	9,015	7,421	107.97	91.4	8.4	.2

make a living and finance farm improvements. Nearly all feed for livestock and poultry must be purchased at relatively high prices. Some income is derived from the sale of wood, shingle bolts, and other forest products, but it is usually insufficient.

A considerable number of the holdings listed by the census as farms are not really self-supporting farms but only stump ranches. Under this colloquial but very appropriate term may be classed the pioneer farmsteads of new settlers, the country homes of working people, and the mere subsistence-level homes of the less fortunate. Whether a given stump ranch can ever be developed into a farm depends largely upon the character of the soil, the size and frequency of the stumps, contemporary economic conditions, and the resources and energy of the stump rancher (pl. 2, *B*).

Raising poultry and growing berries are generally relegated to the stump ranches. Requiring but a small acreage of cleared land of mediocre quality, these enterprises are usually taken up from necessity by those located on small upland holdings of limited productivity. As yet, neither poultry raising nor berry growing, which are now so important along the shores of Puget Sound, has become extensive in the county. These enterprises offer a possible means of livelihood for those who settle in the logged-off lands.

Many of the stump ranchers find seasonal or full-time employment in logging camps, sawmills, and pulp mills. Others go part of each year to the towns and cities of Puget Sound to work. A few spend the summers in Alaska or with the fishing fleet.

SOIL SURVEY METHODS AND DEFINITIONS

In making a soil survey the soils are examined, classified, and mapped in the field and their characteristics recorded, particularly in regard to the production of crops, grasses, and forests.

The soils and the underlying formations are examined systematically in many locations. Test pits are dug, borings made, and highway or railroad cuts and other exposures studied. Each reveals a series of distinct layers, or horizons, termed collectively the soil profile. Each horizon, 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 stones are noted. The chemical reaction of the soil and its content of lime and salts are determined by simple tests.² Other features taken into account are drainage, both internal and external, the relief, or lay of the land, and the interrelations of soil and vegetation.

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 to the growing of crop plants, grasses, and trees. On the basis of these characteristics the soils are grouped in the following classification units: (1) Series, (2) types, (3) phases, (4) complexes, and (5) miscellaneous land types.

² The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values, alkalinity; and lower values, acidity. Indicator solutions are used to determine the chemical reaction. The presence of lime is detected by the use of a dilute solution of hydrochloric acid.

The series is a group of soils having the same genetic horizons, similar in their important characteristics and arrangement in the profile, and having similar parent material. Thus, the series comprises soils having essentially the same color, structure, natural drainage, 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. Bellingham, Sekiu, Chehalis, Clallam, and Everett are names of important soil series in Clallam 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—sand, loamy sand, sandy loam, silt loam, loam, clay loam, silty clay loam, or clay—is added to the series designation to give a complete name to the soil type. Bellingham clay and Bellingham loam are soil types within the Bellingham 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. In comparisons of the type and phases of that type, to avoid the repetition of their complete names, the type is sometimes referred to as the normal phase.

A soil phase specifically named is a variation within the type, differing from the normal phase of the type in some minor feature, generally external, that may be of special practical significance but not differing in the major characteristics of the soil profile. For example, within the normal range of relief of a soil type some areas may have slopes that allow 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 profile 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 instances the more sloping parts of the soil type may be segregated on the map as a sloping or a hilly phase. Some soils possess a narrow range of characteristics, and hence are not divided into phases. Such soil types could be thought of as consisting of only one phase. Most soils in Clallam County are present only in the normal phase.

In some places two or more of these principal units may be in such intimate or mixed pattern that they cannot be clearly mapped separately on a small scale but must be shown as a complex. Agnew-Elwha complex is an example of such a mapping unit.

Other areas that have no true soil—as Riverwash and Rough broken land—are called miscellaneous land types.

The soil surveyor makes a map of the county or area, showing the location and extent 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 cultural and natural features of the landscape.

In this survey the mountainous and forested parts of the county were mapped on a reconnaissance basis, much of it being accessible only by infrequent trails and abandoned logging roads and railroads, usually thickly grown up with brush. In the western part the more accessible

stream valleys of some potential agricultural importance were mapped in fair extent of detail, less time being given to the rougher mountainous and hilly areas having value for forestry and recreation rather than for agriculture. The more rugged and less accessible part of the eastern two-thirds of the country included within national forest and national park boundaries, while of high value for forestry and recreational purposes, is of insignificant agricultural importance and is included in this survey only for its geographical relation to other parts of the county. The older settled parts of the county—in the northeast, where most of the agricultural development is confined—are mapped in greater detail.

SOILS

Clallam County is part of the northern Pacific coastal region, where the rainfall is moderately to extremely high in winter and low in summer. Most of the soils have developed under a dense forest cover and have been subjected to continuous leaching during rainy seasons when the ground is rarely frozen, even to a slight depth. The older soils tend to be deficient in some of the more important mineral plant-food elements. As the soils occur under a wide range of rainfall and on different parent materials that have lain in place for varying periods, they have reached different stages of maturity, or development. The diversity of rainfall, topography, and porosity of the substrata has given rise to important differences in drainage. In general, under natural conditions the soils are either too wet or too dry for most farm crops.

In the county are soils developed on a wide variety of parent materials, chief of which are gravelly glacial-drift and glacial-outwash deposits of gravel, sand, and silt derived from many sources but containing a high proportion of basic igneous rock material. Some are developed by the weathering in place of shale and shaly sandstone; others are developed on mountain outwash and colluvial material derived principally from basalt. In the valleys stream-laid sediments derived from shale and sandstone, basic igneous rock, or glacial deposits have furnished the material for the stream-bottom soils. Still other soils are developed in upland depressions on local alluvium or have been built up by the accumulation of decomposing plant remains.

Further differences in parent soil materials, relief, and vegetation have given rise to differences in color, texture, depth, and profile, some of which are of minor or local character. The uprooting and overturning of large trees by winds, especially in old areas, has disturbed the natural development of soil profiles. It is not practicable to show all these local differences on the map, even if it were possible to locate them correctly in the heavily forested and more inaccessible areas.

On the basis of topographic position the arable soils of the area fall into four natural groups: (1) Soils of rolling upland and hilly areas; (2) soils of lower slopes and terraces; (3) soils of depressions and wet slopes; and (4) soils of stream valleys. The soils of these groups are classified further into a number of categories on the basis of differences in parent material, natural vegetation, and drainage. A fifth group is represented by a number of miscellaneous land types of no agricultural significance.

Since environmental conditions of climate, vegetation, and drainage that govern processes of soil development pass from one to another

through indefinite stages of transition, these categories are not everywhere perceptible but merge one with another by degrees without distinctive soil boundaries.

SOILS OF ROLLING UPLAND AND HILLY AREAS

The soils of rolling upland and hilly areas form four related groups. The Astoria, Hoko, and Sekiu soils have developed in place on consolidated bedrock and compact glacial drift. The Clallam, Elwha, Sadie, and the Townsend are developed on undulating and rolling compact glacial drift under which the underlying bedrock is more deeply buried and of little significance. They show a progression in profile development with increasing rainfall. The Clallam, Elwha, and Sadie are forested; the Townsend is in prairie areas. The Everett soils are developed on looser glacial drift of lower moisture-holding capacity; the Crescent on stony foot-slope material.

SOILS DEVELOPED ON BEDROCK AND COMPACT GLACIAL-DRIFT MATERIAL

Soils developed on bedrock and compact glacial-drift material are the Astoria, Hoko, and Sekiu. The Hoko soil reflects the extreme of soil development occurring under the mild and very humid climate near the coast. Beneath a thick cover of decomposing forest litter and a few inches of rich-brown surface soil the main part of the soil profile is a yellowish-brown clay containing variable quantities of partly decomposed pebbles and gravel. The substrata consist of compact gravelly drift or, in some areas, fine-textured glacial till or outwash sediments. This soil occurs mainly in the unsettled and less accessible areas of the western part of the county.

The Astoria soil occupies hill slopes, usually in close association with the Hoko, and is developed on beds of shale and shaly sandstone not covered by a glacial mantle. Because of relief and degree of erosion this soil is for the most part shallow, with common outcrops of parent material. The surface soil consists of reddish-brown clay and overlies a subsoil containing angular shale fragments that increase in size and number as the underlying partly disintegrated rock is reached. The soil is of little agricultural importance. Combined with the Hoko and Sekiu soils it forms part of a general group of soils known as Astoria, Hoko, and Sekiu soils, undifferentiated.

SOILS DEVELOPED ON COMPACT GLACIAL-DRIFT MATERIAL

Soils of the Clallam, Elwha, Sadie, and Townsend series were developed on compact glacial-drift material. The Clallam soils, which occur under the light rainfall of the eastern part, have a gray surface soil that grades to light grayish brown. They usually have a medium or fine texture and are acid. The subsoil is moderately compact gravelly sandy clay underlain by a compact admixture of gravel, sand, and fine material. Clallam loam and its foothill phase are mapped. Both include a number of local variations and grade into the paler brown inclusions of the Elwha soils.

The Elwha soils lie chiefly west of the Clallam and developed under a 25- to 45-inch rainfall. These soils are browner in the surface layer and are slightly yellowish in the subsoil and substratum, but in other characteristics they are similar to the Clallam. They are represented by the Elwha loam and its foothill phase.

The Sadie soil occurs in a relatively limited district west of the Lyre River, where the rainfall is intermediate between moderate and excessive. The dark rich-brown surface layer overlies a grayish-brown sub-surface soil and subsoil. The substratum, or parent material, consists of compact, massive, yellowish-brown stained drift or boulder till. Sadie clay loam is the only type mapped.

The Townsend soil has developed from glacial drift under prairie or park-land cover. It adjoins the shore-line bluff west of Dungeness. The surface soil is dark-brown gritty loam containing some gravel. Beneath the surface layer the soil closely resembles the Clallam soils. Townsend loam is the only type mapped.

SOILS DEVELOPED ON LOOSE GLACIAL-DRIFT MATERIAL

The shallow Everett soils are developed on loose glacial-drift material of old gravelly modified glacial drift and outwash spread by ancient streams before their courses became entrenched in the glacial-drift plain. These deposits are in part assorted into beds of fine and coarse gravel with some layers of coarse sand. The beds are commonly stained brown to a depth of 6 to 7 feet or more. The light-brown soils are mainly shallow. Everett gravelly loam and Everett gravelly sandy loam are mapped.

SOILS DEVELOPED ON ALLUVIAL-COLLUVIAL FOOT-SLOPE MATERIAL

The reddish-brown Crescent soil has developed on alluvial-colluvial foot-slope material derived chiefly from basalt. It has developed under coniferous forest, and there is little evidence of profile development. Variable quantities of angular basalt fragments are present, and bodies of landslide material contain basalt boulders. Many local variations occur in texture, depth, and stoniness. Crescent gravelly loam is the only soil of the series mapped.

SOILS OF LOWER SLOPES AND TERRACES

The soils of lower slopes and benchlands, or terraces, include members of the Agnew, Dick, Carlsborg, and Solduc series, which are timbered in the virgin state; and the Quillayute, Wellman, and Sequim series, which developed under prairie conditions. The Agnew and Quillayute soils have developed on compact glacial and river-terrace material, whereas the Dick, Carlsborg, Solduc, Wellman, and Sequim soils have developed on loose glacial-outwash and river-terrace material.

SOILS DEVELOPED ON COMPACT GLACIAL AND RIVER-TERRACE MATERIAL

The Agnew and Quillayute soils have developed on compact glacial and river-terrace material. The Agnew soils occupy nearly flat benchlands that border the shore-line bluffs. Beneath a thin forest litter the surface soil consists of light grayish-brown material underlain by very compact yellowish-brown clay mottled with rusty brown and gray. This, in turn, is underlain by compact and partly consolidated beds of clay, silt, sand, and fine gravel. Agnew silty clay loam and Agnew-Elwha complex are mapped.

The Quillayute soil occurs only on the Quillayute and Forks Prairies, which occupy benchlands and terraces in the southwestern corner of the county. The surface soil is black granular clay or silty clay loam.

At depths of 12 to 20 inches it rests on a layer of yellowish-brown clay developed on a massive bed of yellowish silty material. Compact gravel beds occur at 4 to 8 feet. Quillayute silty clay loam is the only type mapped.

SOILS DEVELOPED ON LOOSE GLACIAL-OUTWASH AND RIVER-TERRACE MATERIAL

The soils developed on loose glacial-outwash and river-terrace material include Dick loamy fine sand, Carlsborg gravelly and gravelly sandy loams, Solduc gravelly loam, Sequim clay and gravelly loams, and Wellman gravelly and silty clay loams.

Dick loamy fine sand is a gray or light grayish-brown soil overlying gray stratified sandy deposits. It occupies remnants of a high old terrace near Dungeness on undulating to gently rolling relief.

The Carlsborg soils are limited to an ancient gravelly fan deposit built up by the Dungeness River. The surface soil consists of brown gravelly loam, and the shallow gravelly subsoil overlies loose open deposits of unassorted gravel.

The Solduc soil occupies gravelly river terraces along the Quillayute River and its three large tributaries. This bright-brown soil is gravelly and shallow for the most part. The gravel of the substratum is coarse and open in character and is derived mainly from basalt.

The Sequim soils occur in association with the Carlsborg soils, which they resemble except for the surface soil, which is very dark brown or black to a depth of 10 to 18 inches.

The Wellman soils closely resemble the Quillayute in the surface layer, but the subsoil consists of more open brown gravelly loam and overlies a compact gravel substratum.

SOILS OF DEPRESSIONS AND WET SLOPES

Soils of depressions and wet slopes consist of mineral soils, represented by the Bellingham soils and Sekiu clay, and soils developed from organic material resting on muck and peat.

MINERAL SOILS

The Bellingham soils, which with Sekiu clay constitute the mineral soils of the depressions and wet slopes, developed on sediments laid down chiefly in shallow lakes that once occupied glacial depressions. The surface soil usually is of fine texture, very dark grayish brown or black, and relatively high in organic-matter content. The mottled drab-colored compact clay subsoil is underlain by beds of compact, relatively impervious silt and sand. Texture variations have given rise to the clay, loam, and fine sandy loam types.

The Sekiu clay developed in the western part of the county on flats and shallow depressions where drainage is impaired. The nearly black clay surface soil is beneath a thick cover of rotting logs and other forest mold. The dark-colored clay subsoil is conspicuously mottled with bright orange and has a very heavy and tenacious texture. The underlying material is chiefly compact and impervious gravelly glacial drift, but in some places shales occur in the substrata. Sekiu clay is differentiated on the map, as along the road at the north end of Ozette Lake, but the greater part is mapped in association with the Astoria and Hoko soils, with which it has been grouped.

ORGANIC SOILS

The organic soils include Rifle peat, Spalding peat and its burned phase, Greenwood peat, and Muck. Bodies of peat in this county are classified as far as possible on the basis of their parent plant materials, but in many cases classification is difficult because of the mixed or indefinite origin of the parent material.

SOILS OF STREAM VALLEYS

The soils of stream valleys are of the Dungeness, Pilchuck, Puget, Shuwah, Chehalis, and Reed series. The soil materials are of relatively recent deposition and consist entirely of unconsolidated sediments. Insufficient time has elapsed for development of soil-formed horizons, and the layers occurring in the soil profile are due to stratification of the parent material as it was laid down by water. As these soils have been subjected to leaching processes for a much shorter time than the upland soils, they are naturally more fertile and more valuable for agricultural purposes. The Dungeness soil is well drained, whereas the Pilchuck, Puget, Chehalis, and Reed soils have fair to poor drainage.

SOILS DEVELOPED ON LOW-TERRACE MATERIAL

The Dungeness soil, which has developed on low-terrace material, occupies the higher, or second-bottom, lands in the eastern part, occurring principally on the Dungeness River delta and in the valley of the lower Elwha River. The alluvium is composed of a wide range of materials, including rock glacial flour that has been brought down by mountain streams. The surface is medium-textured light-brown or light grayish-brown soil, which usually changes little to depths of 2 or 4 feet. Layers of sand or fine gravel occur in the lower soil. Dungeness loam is naturally fertile and well drained and provides the most valuable farm land of the county.

SOILS DEVELOPED ON FLOOD-PLAIN MATERIAL

The Pilchuck, Puget, Chehalis, Shuwah, and Reed soils are developed on flood-plain material. The Pilchuck soil, represented by Pilchuck fine sandy loam, is of recent origin and occurs only in the lower bottoms along the streams of the eastern parts. The soil consists of gray to light-gray fine sandy material that is subject to occasional overflow. Small gravelly patches on beds of gravel are common in the lower-lying areas near the stream banks.

The Puget soil occupies areas of impaired drainage in association with the Dungeness and Pilchuck. Its smooth silty surface soil is grayish brown or dark grayish brown when moist and gray when dry. The subsoil is mottled drab and gray fine silt or silty clay. Puget silty clay loam is mapped.

Chehalis loam, the only soil of the series in the county, occurs on bottom lands and lower terraces along the streams of the western part on alluvial material derived largely from shale and sandstone. All the soil is medium brown, but there are a number of variations in texture. It is naturally fertile and the most desirable farm land in the western part of the county.

The Shuwah soil occurs in the valley of the Soleduck River. It was developed under prairie conditions on moderately recent alluvial material like that of the Chehalis soil. The soil is dark grayish

brown or nearly black. Shuwah silty clay loam is the only type mapped.

Reed clay occurs in association with Chehalis loam in areas subject to deposition of finer sediments or where swampy conditions are induced by impaired drainage. The surface soil ranges from medium brown, as in the Chehalis soil, to very dark gray. The drab-colored subsoil is intensely mottled.

SOIL TYPES* AND PHASES

In the following pages the soil types and phases are described in detail and their agricultural relations discussed. Five miscellaneous land types—Coastal beach, Riverwash, Rough broken land, Rough mountainous land, and Tidal marsh—are included. The location and distribution of all are shown on the accompanying soil map, and their acreage and proportionate extent in table 5.

Agnew silty clay loam.—This soil occupies nearly flat terrace plains, which for the most part border the eastern shore-line bluffs. It has been formed under forest cover on old glacial-outwash sediments that have predominantly medium or fine texture.

A typical area of virgin soil $\frac{1}{4}$ mile inland and 1 mile west of McDonald Creek is forested with second-growth Douglas-fir and a few associated scattered hemlock, cedar, and alder trees and is covered by a thin layer of dark organic litter of decomposing conifer needles and woody fragments. The 2-inch surface soil consists of light ashy-gray smooth loam, slightly mottled with brown stains from the organic litter. The upper part of the layer is loose; the lower, lumpy. Between 4 to 8 inches the soil is smooth silty clay loam, which when dry is light gray, slightly vesicular, and mottled with brown. This layer is compact but breaks easily into irregular chunks. To a depth of 28 inches the light olive-brown very fine sandy clay layer, mottled with gray and darker shades of brown, is compact and vesicular and breaks into irregular moderately friable chunks. The lower subsoil, to a depth of 60 inches or more, is dull-yellow slightly mottled massive sandy clay or clayey sand, moderately compact above and looser below. The underlying substratum consists of stratified silt, sand, and beds of fine gravel.

Although related to Clallam loam and occurring mainly in the same climatic zone, the Agnew soil has a more strongly developed profile because of its flatter relief. In the virgin state it always exhibits the gray podzolized horizon immediately below the surface cover of leaf-mold. Except where gravel in the parent material has given rise to gravelly sandy clay, the subsoil consists of mottled compact clay, silty clay, or sandy clay. Small patches with gravelly or sandy surface soil occur between the siding at Agnew and Siebert Creek.

The larger areas of Agnew silty clay loam, which occur in the Agnew and Sequim-Dungeness districts, are irrigated. The older farm lands that have been well managed and fertilized give fair to good yields of peas, grain, or hay. Some alfalfa is grown, which yields up to 4 tons an acre. Because of the acid reaction and low fertility in the virgin condition, newly cleared land requires several years to become productive.

* When a soil type is subdivided into phases the type classification that bears no phase name is referred to as the normal phase of the type.

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

Soil	Acres	Percent
Agnew-Elwha complex.....	898	0.1
Agnew silty clay loam.....	5,533	.5
Astoria, Hoko, and Sekiu soils, undifferentiated.....	375,800	32.9
Bellingham clay.....	260	(¹)
Bellingham fine sandy loam.....	311	(¹)
Bellingham loam.....	3,949	.3
Carlsborg gravelly loam.....	1,763	.2
Carlsborg gravelly sandy loam.....	943	.1
Chehalis loam.....	18,963	1.6
Clallam loam.....	37,666	3.3
Foothill phase.....	4,602	.4
Coastal beach.....	2,916	.3
Crescent gravelly loam.....	15,718	1.4
Dick loamy fine sand.....	2,922	.3
Dungeness loam.....	6,111	.5
Elwha loam.....	27,466	2.4
Foothill phase.....	10,356	.9
Everett gravelly loam.....	2,422	.2
Everett gravelly sandy loam.....	3,644	.3
Greenwood peat.....	114	(¹)
Muck.....	751	.1
Pilchuck fine sandy loam.....	2,198	.2
Puget silty clay loam.....	1,775	.2
Quillayute silty clay loam.....	2,446	.2
Reed clay.....	3,419	.3
Rifle peat.....	1,251	.1
Riverwash.....	1,392	.1
Rough broken land.....	11,440	1.0
Rough mountainous land.....	557,825	48.8
Sadie clay loam.....	7,814	.7
Sekiu clay.....	341	(¹)
Sequim clay loam.....	150	(¹)
Sequim gravelly loam.....	1,985	.2
Shuwah silty clay loam.....	332	(¹)
Solduc gravelly loam.....	24,948	2.2
Spalding peat.....	533	(¹)
Burned phase.....	39	(¹)
Tidal marsh.....	889	.1
Townsend loam.....	66	(¹)
Wellman gravelly loam.....	293	(¹)
Wellman silty clay loam.....	796	.1
Total.....	1,143,040	100.0

¹ Less than 0.1 percent.

Agnew-Elwha complex.—The gently sloping and undulating areas of this complex consist predominantly of Agnew silty clay loam and the many low mounds and ridges of glacial-drift material of Elwha loam. The complex occurs in the vicinity of Dry Creek School, about 5 miles west of Port Angeles. The greater part has been cleared for crops, but some areas remain in stump-land pasture. The land is used much the same as Agnew silty clay loam—hay, oats, and field peas being the principal crops. Irrigation is unnecessary, but yields are often uneven because of the complex nature of the soil.

Astoria, Hoko, and Sekiu soils, undifferentiated.—The closely associated soils of this group occupy the hilly uplands of the western third of the county. Most of the land is characterized by hills and ridges with moderate or steep slopes, and large areas are included that would be classed as Rough broken land or Rough mountainous land if mapped in detail. Elevations range from sea level to about 2,000 feet. The prominent physiographic features are structural in origin. Only the stream valleys and shore line near the few roads that serve the district are settled. About 500 square miles is a nearly impenetrable wilderness of dense virgin forest or young timber and brush in which there are no roads and few passable trails. As this land is largely nonagricultural and will probably remain so for many years, only a reconnaissance survey was made.

The timber cover consists chiefly of hemlock, with Sitka spruce and cedar common at lower elevations and along streams. A much more dense growth of alder, salmonberry, thimbleberry, vine maple, and other shrubbery than that of the virgin forest underbrush quickly springs up when the timber is destroyed by logging or blow-downs and the sunlight can reach the ground. After the big blow-down of 1921 the spruce left standing became prey of boring beetles that gained entrance through bark injuries and inflicted considerable damage. Many trees were killed and others were left with dead tops. Fallen timber and a thick cover of decomposing forest litter are common. The land rarely dries out sufficiently to allow fires to do any extensive damage to standing timber or to clear the ground of the great quantity of forest debris.

The rainfall ranges from 55 to 60 inches annually at Twin Rivers to more than 115 inches in the hills east of Forks. Rains, mists, and heavy fogs frequently occur in summer, and in winter the soils remain wet for long periods and are subjected to almost continuous leaching. The extreme humidity discourages agricultural expansion.

Astoria clay is the most extensive of the three soils of this undifferentiated group. It occupies the upper elevations of the higher hills or steeper slopes in lower regions. It is developed on residual material derived from the weathering in place of shale and shaly sandstone, which dominate the underlying rock formations of the Olympic Peninsula. The slopes over large areas are so steep that the soil is very shallow or entirely removed by erosion, leaving fragments of shale exposed over disintegrating bedrock. If mapped in detail, much of this soil would be classed as a shallow phase.

The virgin surface soil, which is topped by a 3- to 4-inch mat of decomposing forest litter, consists of about 6 inches of brown or rich-brown granular clay containing many small shale fragments. This layer grades into a loose mass of small platy or angular fragments of disintegrated shale mixed with a little fine soil material. The shale fragments are rusty brown on the surface and olive gray in the unweathered interior. At a depth of 18 to 36 inches or more is partly weathered or more massive bedrock.

An isolated body of Astoria clay covers about 700 acres in the vicinity of Crescent Bay under the moderate rainfall of the central part of the county. This soil lies on smooth upland, and since it is somewhat deeper than the normal soil, it is suitable for cultivation. A few acres of Astoria clay on the slopes immediately west of Twin Rivers are cultivated. Elsewhere the soil is in isolated or unpopulated districts,

and because of its shallow character and steep relief it usually is unfit for agricultural use.

Hoko clay occurs on the lower and gentler slopes of the hills and undulating or rolling benchlands. It is a well-drained soil developed on compact gravelly glacial drift and local areas of silty glacial outwash deposits with local admixture of material from shale bedrock. In the virgin state it has a surface cover of dark-brown decomposing forest litter, which ranges in thickness from 3 or 4 inches to several feet where large logs have rotted or mounds have been built up by swordferns.

The 12-inch surface layer of the mineral soil is rich brown, loose, and granular and contains hard shotlike aggregates.⁴ The fine gravel is in varying stages of decomposition. A few of these aggregates can be crushed with the fingers. Although it has the physical characteristics of a loam it works into a soft gritty clay when moistened and rubbed for a few minutes. The 30- to 36-inch subsoil consists of granular yellowish-brown clay that appears loamy but can be worked until it becomes soft and jellylike. It contains hard irregular shotlike aggregates and decomposing gravel. The underlying glacial drift material is mottled yellowish-brown gravelly clayey sand, very compact and partly cemented.

In many places the Hoko soil occurs in close association with the Astoria. Variations in texture, depth, and quantity of rock fragments follow the changing character of the relief and parent material. A very few acres of Hoko clay have been cleared for cultivation. The extremely humid climate and the cost of clearing, however, make it better adapted to forestry than to agriculture.

Because of its intimate association with the Astoria and Hoko soils, some Sekiu clay is included in the group. As it is developed in relatively flat or depressed areas with poorly developed or retarded drainage, it is also classified and described with the soils of depressions and wet slopes.

Bellingham clay.—This inextensive dark-colored plastic tenacious clay occurs in four small bodies near the Louella Guard Station at the head of Jimmycomelately Creek and in about 20 other very small patches widely scattered through the hills south and southwest of Sequim. It is developed in depressions and on wet slopes subject to seepage, in association with upland glacial soils.

A profile three-fourths of a mile southeast of the Louella Guard Station has a forest cover of alder, cedar, and deciduous brush, beneath which there is about 2 inches of nearly black decomposing forest litter. The 2-inch nearly black granular heavy clay surface soil overlies 5 inches of very dark heavy tenacious clay streaked with rich rusty brown along root holes. When dry this soil forms large prisms separated by vertical cracks. At a depth of 9 to 15 inches the soil is nearly black heavy tenacious tarlike clay, intensely mottled with red, orange, and yellowish brown. This layer is underlain at a depth of 30 inches by light-gray slightly sandy clay that is compact and hard when dry but less tenacious when wet. Inclusions of dark-gray heavy clay appear. Below 30 inches the material is light grayish-brown compact

⁴ WHEETING, L. C. SHOT SOILS OF WESTERN WASHINGTON. *Soil Sci.* 41: 35-44, illus. 1936.



A, An older upland farm in the eastern part of Clallam County. Low-lying area of Bellingham loam in foreground, grain and forage crop on Clallam loam in background.

B, An 8-year-old dairy farm on woody muck and Clallam loam in the Agnew district. The stump land in the foreground is kept moist by slope seepage and furnishes abundant pasture of white clover and mixed grasses.

C, Young spruce encroaching on old farm land on the Quillayute Prairie.



A, Exposed road cut of Clallam loam developed on compact glacial drift that does not allow rapid loss of soil moisture by downward percolation.

B, Exposed section of Solduc gravelly loam, loose gravelly parent material in foreground.

slightly clayey sand, which grades into less compact sand mottled with orange stains.

Small patches that occur mainly in association with Clallam loam have been cleared. On the whole this soil has little agricultural significance, but it will produce oats if seeded early in spring. Alsike clover also will give fair yields.

Bellingham fine sandy loam.—All this land is cleared, and it is probably the best of the wet-land soils. It has developed in seepage areas from stratified sands similar to those of Dick loamy fine sand, with which it is associated. The original vegetation was probably alder, cedar, and hemlock. Two small areas are mapped; one is 2 miles west of Dungeness and the other 2 miles east of the siding at Agnew. Where the soil has been drained and the water table lowered to about 2 feet it gives good yields of grain and hay or makes good summer pasture.

The 12-inch surface soil in the area west of Dungeness consists of dark-brown friable fine sandy loam. A few boulders are scattered on the surface, and in places some gravel occurs in the top layer. The 12- to 23-inch subsoil is light-brown sand mottled with rust-brown iron stains. It is compact, massive, and wet from seepage. At a depth of 48 inches, which is below the water table, the soil is underlain by a compact stratum of mottled rusty-brown and bluish-gray compact clayey sand and sandy clay containing a few cobbles.

Bellingham loam.—This soil is developed upon fine sediments laid down in glacier-formed depressions once occupied by ponds or lakes. It occurs in small isolated bodies on the glacial plain from Port Angeles eastward and is subject to seasonal excessive moisture.

A representative virgin profile one-fourth mile west of the siding at Agnew has a cover of small alder, hawthorn, and other wet-land brush under which there is a 2-inch layer of dark grayish-brown leafmold, roots, and woody fragments. The 12-inch surface soil consists of very dark grayish-brown crumb-structured smooth silty loam. It is permeable and mellow but includes a few small compact lumps and scattered fragments of the light-gray subsoil. Between 12 and 20 inches the light-gray silty clay layer, mottled faintly to fairly distinctly with yellow and rich rusty brown, is compact and massive with a vesicular structure. To a depth of 48 inches the next layer is light-gray compact and vesicular silty clay mottled with brown and rich rusty brown and breaking out into sharp irregular fragments when disturbed. The lower soil to a depth of 55 inches or more is a silty clay, strongly mottled with rich brown, gray, and a few splotches of deep bluish gray that becomes the dominant color in the zone of the water table.

Areas with variations in color and a range in texture from silt loam to silty clay loam are included in mapping the numerous small depressional areas. The depth of the dark-colored highly organic surface layer ranges from 4 to 18 inches within short distances. In some places plowing turns up the light-gray subsoil. Small areas with gravel in the surface soil and others with small patches of woody muck are included.

The virgin cover of cedar, hemlock, deciduous trees, and brush is usually less costly to remove than the Douglas-fir stumps of the adjacent uplands. A considerable part has been cleared and drained for

cropland or pasture. Like other moist depressional soils, small areas on upland farms are valued because their ability to retain moisture through summer permits the growth of late vegetables and short-season crops, as oats or other grain, peas, vetch, or grass hay. Usually no irrigation is needed. The type is particularly good for pasture late in summer when forage has failed in the upland (pl. 3, A).

Carlsborg gravelly loam.—This inextensive soil occurs in the vicinity of Sequim and the nearby village of Carlsborg on remnants of a coarse gravelly alluvial fan built by the Dungeness River, apparently in late-glacial or early postglacial time. It is developed under a light or moderate stand of Douglas-fir in association with the prairie soils of the Sequim series on the same parent material. The relief is gently sloping and undulating.

The virgin surface soil consists of a 2-inch layer of dark rich-brown forest litter and about 14 inches of moderately compact medium-brown gravelly loam that breaks into irregular soft clods when disturbed. It is slightly mottled in the upper part with varying shades of gray. Surface cobbles are of common occurrence. Beneath this layer the soil grades into sandy coarse gravelly material derived largely from basalt rocks and stained brown by iron minerals to a depth of 6 to 8 feet.

Although this soil is dominantly shallow and droughty, the greater part is cleared and irrigated, and in recent years a closely settled well-developed dairy district has been established. Small acreages seeded to alfalfa and grain give fair yields, but like the adjacent Sequim gravelly loam, the type is best used for permanent irrigated pasture.

Carlsborg gravelly sandy loam.—This soil type is limited to one area on the east side of the Dungeness River southwest of Sequim. It differs from Carlsborg gravelly loam in having a more sandy texture and in being more open and droughty. Surface cobbles are very common. Small acreages have been cleared for farm land, but apparently this soil will produce moderate crop yields or permanent pasture only when built up by much fertilization and very frequently irrigated. The greater part still remains in second-growth Douglas-fir.

Chehalis loam.—This soil is dominant on the narrow bottoms along the streams of the western part of the county where it comprises the only land of real agricultural promise or significance. It is formed of moderately recent alluvial sediments derived chiefly from shale and sandstone exposed in the mountains and foothills, but also from some weathered basalt rock.

A representative area along the Hoko River has a very friable and slightly granular 6-inch surface soil of olive-brown smooth silty loam. About 1 inch of leafmold covers the surface. From a depth of 6 to 60 inches or to an undetermined depth the soil material is made up of olive-brown irregularly stratified sediments, ranging from very fine sandy loam to silt loam or silty clay but predominantly of smooth silty loam. This layer is slightly compact and massive, but it breaks into a single-grain structure when disturbed.

Owing to the difficulty of carrying out detailed studies of soils in areas of heavy timber and brush, no attempt is made to map minor variations in texture, color, and depth. Near the banks of the larger

streams there are small strips of lighter brown or slightly grayish-brown very fine and fine sandy loams of very recent accumulation. Small bodies of darker colored soil having impaired drainage, medium to fine texture, and mottlings of rich brown and gray in the subsoil also are included. The larger more typical bodies, which are free from surface gravel, exceed 4 feet in depth. In places along the smaller streams gravel or angular fragments of shale occur in the surface soil and a substratum of gravel at depths of less than 4 feet is more common.

This soil is inherently more fertile than the associated terrace and upland soils, which have been leached by the high rainfall for much longer periods. It is the only land in the district that warrants clearing for present agricultural use. The forest cover of alder, maple, and deciduous brush, with but a few large cedar, hemlock, and spruce trees, is less difficult to clear than the heavy stand of conifers common to the upland.

Although most of the self-supporting farms in the district are on this land, less than 10 percent of it has been cleared for cultivation. The excessively high rainfall, distance to market, and the cost of clearing are the chief factors retarding further settlement. The farming is confined to dairying, and the greater part of the cleared land is used for producing feed crops. Oats for hay, clover, and grass give good yields but usually are difficult to cure.

Clallam loam.—This soil is dominant on the undulating upland plain and foothill slopes of the eastern part of the county, extending from Port Angeles eastward beyond the county line. The surface relief ranges from undulating to moderately sloping, with the characteristic small knolls, low ridges, and shallow depressions of typical glacial drift plain topography. Elevations range from near sea level to about 1,700 feet. A large part of the soil was logged off many years ago, and the uncleared land is covered mainly by second-growth coniferous forest, chiefly Douglas-fir, hemlock, cedar, white fir, and, in some moist places, alder. In the Agnew district several men with a small donkey engine cleared 28 acres in 2 years at a cost of \$120 an acre (pl. 3, B).

The surface soil of a typical profile in virgin coniferous forest consists of three layers. Beneath about 4 inches of dark decomposing forest litter and 2 inches of dark-gray highly organic loam the soil to a depth of about 18 inches consists of a light-gray or light brownish-gray gritty loam containing small iron-cemented pellets and fine gravel. Although very mellow in the virgin state it is deficient in content of organic matter. It becomes more compact when cleared, especially if left in pasture. Coarse gravel, cobbles, and large erratic boulders are of common occurrence in the surface soil. The 32-inch light-gray gravelly sandy clay or clayey sand subsoil, slightly mottled with reddish brown and yellow, is compact, massive, and vesicular but can be readily broken into more friable aggregates.

The underlying grayish glacial drift consists chiefly of moderately compact gravel, sand, and fine material, with occasional embedded boulders that resemble soft concrete. There is, however, considerable local variation in the character of the glacial deposits. Small patches of permeable gravelly sandy material are of frequent occurrence, particularly on knolls and low ridges. In other places underlying shale

closely approaches the surface and has contributed to the parent material. These variations are reflected in the surface texture. Small areas having coarser or finer surface soil are included because of their size and the difficulty of mapping them separately in the densely forested districts.

Although this soil is slightly acid and relatively deficient in organic matter and mineral plant-food elements, it can be made moderately productive by liberal use of fertilizer. The relatively compact and slowly permeable subsoil and substrata are advantageous in retarding the percolation of the natural rainfall and retaining moisture into the growing season (pl. 4, A). The bodies of this soil that overlie the coarser and more porous materials are droughty, however, and of low value for agriculture.

Cultivated areas are used largely for hay and other feed crops and for pasture for dairy stock. A small acreage near Sequim is irrigated and produces moderate crops where adequately fertilized. Under the natural rainfall, however, late crops suffer for lack of moisture. In the more favorable localities garden crops are grown for local markets and home use.

Clallam loam, foothill phase.—Stony areas are more frequent on this phase than on the normal phase. This soil occupies moderate or steep slopes at higher elevations and smoother areas on the tops of several foothills. Some areas are browner than the normal phase and have a greater range in surface texture. The cooler nights and shorter growing season limit crop production, although the rainfall is somewhat higher than at lower elevations. The greater part of the soil is more valuable for forest than for cultivation.

Coastal beach.—Sloping beaches of gravel and sand built by wave action occur in narrow isolated strips along the shore line of the ocean and strait and include several important sandspits. The 3-mile stretch of Ediz Hook protects Port Angeles Harbor and is used as a site for the lighthouse and Coast Guard base. Dungeness Spit, about 4½ miles long, encloses a large shallow bay important as a fishing ground.

The seaward margins of the coastal beach areas are lined with piles of driftwood that provide a perpetual source of firewood (pl. 5, A). Commonly the inner margin is wooded with small conifers and brush, and, in some places, grasses and herbage furnish pasture. The chief value of coastal beach, however, is as protection for harbors and as sites for beach resorts, summer homes, and squatters' cabins—uses that make it worth far more than an equal acreage of farm land.

Crescent gravelly loam.—This soil occupies the lower foothill slopes and terraces in the small mountain valleys of the central part of the county and along the valley margins of the upper Soleduck River. It occurs in the forested and logged-off country, mainly within the national forest, where the annual rainfall ranges from about 40 to 80 inches in the most westerly areas. Consisting of loamy and stony colluvial slope and outwash material derived from basalt, as well as varying quantities of broken rock, the Crescent soil is without the developed profile of the Olympic series of western Oregon and Washington, which typically is formed on residual material derived from the weathering of basalt rock in place. In the earlier recon-



A, Driftwood on beach of Strait of Juan de Fuca; Pillar Point in distance.
B, Tract of old stump pasture on Dick loamy fine sand cleared with a bulldozer and being leveled for irrigation



A, Winter oats on Dungeness loam in the Dungeness district; English ryegrass and clover hay in foreground.
B, Irrigated Sequim soils in the valley of the Dungeness River
C, Jersey and Guernsey dairy cows on irrigated white clover and mixed grass pasture on Sequim gravelly loam.

naissance survey, this soil was included with the Olympic soils, to which it is related.

A fairly representative area along Indian Creek, about 2 miles east of Lake Sutherland, has a 2-inch layer of decomposing forest litter under which the soil to a depth of 48 inches consists of loose structureless rich-brown loam containing many small subangular fragments of weathering basalt. The underlying material to unknown depth is a mixture of lighter brown loam and broken rock.

Areas having minor variations in texture, depth, and quantities of broken rock have been included. In some places, as in the divide between Lake Crescent and the Soleduck River, are included much landslide material and many large boulders. The area of Crescent gravelly loam lying north of the highway in the valley of Indian Creek is much mixed and includes many patches of nontypical soil containing fragmental shale derived from outcropping beds of sedimentary rock.

Because of its unfavorable location this soil is of minor agricultural importance, but a few small areas outside the national and State forests may be considered potential farm land. Where the soil contains only moderate quantities of small rock fragments it retains moisture and is fertile. The few acres cleared for cultivation produce fair to good yields of crops commonly grown in the locality.

Dick loamy fine sand.—This soil is the gray counterpart of the Lynden soils of Kitsap County and other Puget Sound areas. It is developed on stratified sand, which appears to have been an extensive glacial-outwash plain. Several scattered remnants occur between Sequim Bay and lower Morse Creek, and the largest area lies southwest of Dungeness. In an area of virgin soil half a mile northwest of the Dungeness Cemetery the forest cover consists of small Douglas-fir and a few stunted cedar, with an underbrush dominantly of salal. The relief is undulating to gently rolling.

Beneath a 2- or 3-inch mat of organic litter and roots the upper 2 inches of surface soil consist of ashy-gray fine sandy loam that is slightly laminated, very light in weight, and friable. Between 4 and 12 inches the soil is light-gray loamy fine sand, streaked and blotched with pale reddish brown. It has a compact massive slightly vesicular structure but is easily broken into a single-grain mass when disturbed. The 12- to 30-inch subsoil consists of light-gray compact and massive loamy fine sand. The lower subsoil to a depth of 72 inches or more is slightly compact light-gray loamy fine sand in which there are a few irregular stringers and masses of compact and cohesive yellowish-brown clayey sand that represents incipient development of a hardpan. The substratum to a depth of 30 feet or more consists of stratified sand and occasionally some beds of fine gravel.

The color is typical of the gray soil belt that lies in areas of light rainfall within the climatic shadow of the Olympic Mountains. To the west the color approaches brown, and a small area that lies in a very narrow strip along the bluff extending through the business section of Port Angeles is distinctly brown. The surface texture varies but slightly. In some places small quantities of fine gravel occur in the surface soil.

This is an infertile droughty soil, but small acreages have been cleared and placed under irrigation (pl. 5, *B*). Early garden vege-

tables and fruits, particularly early strawberries, are best adapted to this sandy land.

Dungeness loam.—Because of its unleached condition, medium texture, good depth, and adequate drainage, this is the most adaptive and productive soil of the county. It consists of well-drained alluvium deposited in moderately recent times by the larger streams of the eastern part of the county. These stream-laid sediments are composed of comparatively fresh materials derived from a wide variety of rocks and contain a considerable proportion of rock flour from mountain glaciers.

A representative virgin profile $2\frac{1}{2}$ miles north of Sequim, under mixed second-growth of Douglas-fir, cedar, alder, and maple timber and a 2-inch surface layer of very dark-brown organic forest litter, has about a 1-inch surface of dark dull grayish-brown very friable highly organic loam. To 18 inches the underlying soil is slightly yellowish olive-brown smooth loam that closely approaches silt loam. This moderately compact, slightly vesicular, and massive layer is underlain to a depth of 60 inches by slightly olive-brown alluvial silty clay loam, compact and massive but permeable. On the whole the soil is rather uniform and even textured to depths of 4 feet or more, but, like many alluvial soils, it is stratified in places with fine sand and gravel. Surface gravel and cobbles occur in the area west of the Dungeness River and extend southward from 1 mile south of Carlsborg for a distance of about 4 miles.

Most of this soil is irrigated and is in the vicinity of Sequim and Dungeness, where it embraces a considerable part of the most important section of improved farm land in the county. Other smaller areas are in the lower valleys of the Elwha River and Morse Creek, which at present are without means of irrigation.

In the Sequim-Dungeness district, it is mainly used for cropland, while the less desirable areas are relegated to pasture. Hay, grains cut for hay (pl. 6, 4), and peas are the principal crops. Alfalfa is well adapted, and the acreage is being increased. Alfalfa yields up to 6 tons an acre. Fertilizer field tests conducted by the Washington Agricultural Experiment Station at Pullman indicate that potatoes make the best response when fertilized with moderate quantities of nitrogen and potash and that canning peas give best results by an application of straight ammonium phosphate or mixed fertilizer in 1-3-2 ratio.⁵

Elwha loam.—This is one of the more extensive and important upland soils in the east-central part of the county. It is a light-brown or brown soil formed from compact glacial-drift material similar to that of the Clallam soils but has developed under higher rainfall. Some areas are nearly flat, but the greater part of the soil lies on gentle to moderate slopes that extend back from near the shore line to elevations of 1,500 feet or more. Low mounds and morainic ridges with intervening depressions are characteristic. Steep slopes or abrupt escarpments border the streams.

The prevailing cover at the present time is second-growth coniferous timber, the age of which depends upon the time elapsed since the land was logged. Douglas-fir is the dominant species, and nearly pure stands grow on the drier locations and more droughty soil variations.

⁵ Amounts, respectively, of nitrogen, phosphoric acid, and potash.

On the more typical soil, the forest includes a larger percentage of hemlock, cedar, and white fir. Alder and cedar occupy the very moist places in small depressions and the slopes subject to seepage. Underbrush is common. Alder is one of the first invaders of cut-over lands and is especially prevalent. In a few years, however, it is crowded out by the conifers; it continues to survive only where there is an abundant moisture supply throughout summer. Near the western limits of Elwha loam where the original forest contained many large cedars, hemlock, cedar, and alder are prevalent.

The virgin surface soil beneath about 3 inches of rich-brown decomposing forest litter consists of brown gritty loam containing pea-size iron-cemented pellets and much fine gravel in variable stages of decomposition. It is loose and mellow in the upper part but between 7 and 14 inches it is slightly compact, lighter brown, and slightly mottled with gray and rusty red. The subsoil to about 28 inches is pale-yellow gravelly clayey sand or sandy clay also containing cemented pellets locally known as shot. It is compact, massive, and vesicular, breaking out in irregular chunks when disturbed.

The underlying glacial drift to a depth of 5 or 6 feet is a compact, and slowly permeable mixture of gravel and light-olive mottled with gray and rust-brown clayey sand. The character of the glacial deposits varies from place to place, and the difference is reflected in the soil formed thereon. Some small areas are composed of porous beds of gravelly sand that make the soil droughty. In other places the mantle of glacial material over the older underlying shale formation is very thin or entirely absent, and the soil, developed in part from the shale, is a clay loam or clay. On slopes where there is seepage and in small depressions the greater moisture supply has induced the development of a darker surface soil.

Patches of grayish-brown soil transitional between the Elwha and Clallam soils are included with this soil. Small bodies of browner soil, on the other hand, are included with the Clallam. The most westerly areas of the Elwha soil, which are developed under an annual rainfall of about 45 inches, are a richer brown. These variations are so local and patchy in distribution that it was impracticable to map them separately.

Although Elwha loam is slightly acid and relatively low in plant food elements, it has considerable capacity for improvement and offers more promise for agricultural use than the other upland soils available for settlement. When well managed it will produce moderate to good yields of the crops adapted to this region where the higher rainfall makes irrigation unnecessary. The compact character of the substratum affords a moisture-holding reservoir.

Less than 10 percent of this soil has been cleared for cultivation, but a larger part now in stump land and woods affords pasture for dairy cattle. The cropland is largely given over to production of hay, forage, and garden crops for home use or local sale. Austrian Winter field peas, which constitute one of the few cash crops, yield about 1 ton to the acre.

Elwha loam, foothill phase.—The areas included in this phase occupy moderate to steep slopes and the rounded tops of some of the foothills. The soil for the most part is more stony and variable than the normal phase. The growing season is cooler, and frosts are more

frequent. The greater part of this land is better suited for timber production than for farming.

Everett gravelly loam.—This soil occupies terraces and glacial plains that usually border the escarpments along the narrow entrenched valleys of the present streams. It is developed over old glacial-outwash deposits consisting of beds of assorted gravel and sand and occurs mainly in small isolated widely scattered areas extending from the eastern end of the county westward to the Lyre River. The forest cover usually consists of an almost pure stand of Douglas-fir with considerable underbrush.

Beneath about 1½ inches of dark-brown forest litter the 3½-inch surface soil layer is made up of brown gritty loam. This layer contains coarse sand and varying quantities of gravel, but it has a high organic-matter content that makes it very loose and light in weight. Between 5 and 24 inches the soil is a grayish-brown gravelly loam, slightly compact, and has very little structure. The subsoil to a depth of 34 inches is yellowish-brown gravelly sandy loam of low moisture-holding capacity. Underlying the subsoil is gravelly sandy glacial-outwash material, which is freely permeable and commonly stained brown by iron compounds to depths of 6 to 10 feet. In some places cobbles and small boulders are on the surface, in the surface soil, and in the substratum.

This soil is too gravelly and shallow to warrant its clearing for general farm use. It is subject to drought, and because of its location very little of it can be irrigated. In the vicinity of Port Angeles, however, small acreages have been cleared for home sites and small subsistence farms. The soil is best suited to growing early fruits and vegetables and to poultry raising, but if it is properly fertilized and sufficiently watered during the dry part of summer, it is satisfactory for the cultivation of decorative shrubs, flowers, and lawngrass.

Everett gravelly sandy loam.—Areas of this soil occur on nearly flat glacial-outwash terraces and on undulating, hummocky, and rolling terrain where the parent material is gravelly and sandy glacial drift. Small isolated bodies are widely distributed in the eastern part of the county.

An area of typical virgin soil about one-fourth mile west of Siebert Creek and approximately one-half mile inland has a 6-inch surface layer of grayish-brown loose gravelly sandy loam with large splotches of light gray and deeper brown. The thin layer of dark-colored decomposing forest litter on top of this becomes light gray at the base. Below a depth of 6 inches the soil is yellowish brown and very gravelly and sandy. At 18 inches it grades into the loose substratum of coarse gravel, cobbles, and sandy interstitial material. Surface cobbles and boulders are common.

Shallow, gravelly, and droughty this soil is of little value as farm land. Most of it has been logged off and has since grown up to second-growth Douglas-fir and brush, very few acres of which have been cleared for cultivation.

Greenwood peat.—This organic soil occurs in four very small areas, one of which comprises about 40 acres near the mouth of the Sooes River on the ocean. The other three small areas are in the eastern end of the county. Other unidentified bodies probably occur

in the inaccessible hinterland and are consequently included with Astoria, Hoko, and Sekiu soils, undifferentiated.

This peat is derived chiefly from the sphagnum and hypnum mosses covering the open surface between clumps of bog shrubs and stunted conifers. It is raw, fibrous, and too acid for any common agricultural use except perhaps cranberry culture. It also might be used in various commercial ways, one of which could be as litter in poultry houses to replace the dry baled peat moss now shipped to western Washington.

Muck.—This organic soil has accumulated in numerous widely distributed bogs in the eastern part of the county. The greater number of these areas are of small acreage, but several in the district between Sequim and Dungeness comprise up to 100 acres.

Muck is mainly derived from woody material built up by the accumulation of leafy litter and rotting logs of mixed, but mainly deciduous trees and brush. This black granular material has reached a more advanced stage of decomposition than the peats and usually contains a higher proportion of mineral matter. In depth it ranges from a few inches to 2 or 3 feet. The underlying material commonly consists of bluish-gray and rusty-brown mottled compact and relatively impervious gravelly glacial-drift material or ponded sediments similar to those underlying the Bellingham soils. In a few places muck has developed from the further decomposition of the surface layers of deeper peat deposits. The water table fluctuates seasonally and in winter is usually near the surface:

When cleared and drained woody muck makes moderately productive cropland suited to oats, clover, timothy, and redtop or other grass-hay crops. When well fertilized it can be used for late garden vegetables. About half of the muck land is cleared of trees, but the greater part is used for unimproved pasture. Areas in upland farms can be used profitably as garden patches and as pastures late in summer.

Pilchuck fine sandy loam.—This inherently fertile soil of the low bottoms occurs mainly in association with Riverwash along the streams of the eastern part of the county. It is composed of very recent sediments containing considerable quantities of rock flour from glaciers. The surface is commonly billowy and broken by abandoned stream channels.

Under an original cover of willow, alder, cottonwood, and brush, an area of this soil near the mouth of the Dungeness River has a 4-inch surface soil of dark grayish and slightly olive-brown fine sandy loam that becomes distinctly gray when dry. This layer is slightly compact and massive but is easily broken down to single grains when disturbed. Between depths of 4 and 18 inches the soil is light-gray fine sandy loam, moderately compact, massive, and structureless. From 18 to 60 inches or more the lower soil material consists of stratified dark olive-brown silt and sand.

Less than half the soil has been cleared, and, although it makes good cropland or pasture, the areas are for the most part small and subject to occasional overflow.

Puget silty clay loam.—This soil is the inadequately drained associate of the Pilchuck and Dungeness soils, from which it is distinguished by its more compact and more highly mottled subsoil. It is composed of finer textured sediments laid down in moderately recent

times by slow-moving floodwaters from glacier-fed streams, and in this county it is limited to the Sequim-Dungeness district and one tiny strip near the mouth of the Elwha River. The largest area is at Dungeness.

A virgin profile taken a mile south of Jamestown has a dense stand of medium-sized alder and deciduous underbrush cover, beneath which there is a 3-inch layer of forest litter composed principally of decomposing alder leaves. The upper 3 inches of soil consists of dark dull-brown granular silty clay loam, which is irregularly mottled and splotched with nearly black organic stains from the leafmold above. When dry this layer is of much lighter gray color. Between 6 and 22 inches in depth the soil is light yellowish olive-brown alluvial silt loam, gray when dry, and faintly mottled with rusty brown. It is moderately compact, rather massive, and faintly vesicular. From 22 to 60 inches or more the lower subsoil material consists of olive-brown to gray stratified silt and very fine sand mottled with rust brown and bluish gray. It is more compact and bluish in color below the water table.

When adequately drained, this soil makes good farm land. It generally needs no irrigation. The greater part has been cleared for cropland or remains in brush and stump-land pasture. It is well-adapted to the production of oats, grass hay, or pasture, but is ill-suited to alfalfa.

Quillayute silty clay loam.—This peculiar prairie soil is typical of the Quillayute and Forks Prairies in the western part of the county. These prairies occupy nearly flat to undulating terraces, and the soil is developed on fine-textured old alluvial or glacial-outwash plain sediments, which are underlain at depths of 4 to 8 or 10 feet by compact brown-stained gravel. Their treeless condition was obviously not induced by moisture relations, character of the soil, or underlying material, but probably originated as a result of periodic burning by the Indians. In the case of each of the several prairies of this district the treeless areas extend over parent soil materials that are elsewhere heavily timbered. In several places the prairies have tongue-like extensions running up the bordering hill slopes after the manner of forest burns. On the treeless areas the surface soil has been darkened to varying depths, depending largely upon the length of time that has elapsed since the forest cover was removed. The soil development processes may have taken many thousands of years.

A representative profile 1 mile east of the Quillayute School, beneath a cover of tall bracken, weeds, and grass, has an 18-inch surface soil of strongly acid dark grayish-brown silty clay loam, which is nearly black when moist. This layer is friable and granular and slightly laminated in the immediate surface. The depth of the surface soil varies from 10 to 20 inches. Between 18 and 26 inches is dark grayish-brown silty clay loam, which is compact but easily broken into irregular fragments. This layer is mottled with small yellowish-brownish spots. The subsoil is light yellowish-brown massive vesicular clay to a depth of 50 inches or more. It is compact but breaks out easily when disturbed and is permeable to the downward movement of water. It is underlain at a depth of 4 to 10 feet by stratified brown-stained gravel beds or in some cases by compact gravelly glacial drift. The profile is rather uniformly developed on

both the Quillayute and Forks Prairies, but in some places the surface texture ranges from silty clay loam to clay.

Although dark, mellow, and very fertile in outward appearance, the Quillayute silty clay loam is deceptive. In the early days people tramped over many miles of difficult pack trail or voyaged around Cape Flattery in small sailboats and paddled up the rivers in canoes to settle on this prairie land that needed no clearing. Good crops of oats were grown at first, but during recent years all attempts to farm this soil have led to disappointment (pl. 3, C).

The finely divided and colloidal organic matter, ranging up to 30 percent in the surface soil, is derived largely from the decay of bracken roots, which have been reduced to the inert end products of organic decomposition. With its high absorptive capacity, this soil will tie up large quantities of fertilizer in unavailable form before releasing any to growing plants. During the heaviest winter rains water stands on the surface in the flatter areas for a few hours but soon drains away through the permeable clay subsoil, and a short time after the last effective rains the soil becomes too dry for good plant growth. Owing to the high colloid content of the soil, plants reach the wilting point while the soil still holds a relatively high percentage of moisture.⁶

Reed clay.—The widely distributed areas of this inextensive soil occur on low-lying stream bottoms in the zone of high rainfall. The swampland associate of Chehalis loam, the soil is developed on fine sediments laid down at flood stage from slow-moving or still backwaters. The dense forest cover consists mainly of cedar, hemlock, some alder, and much deciduous brush, including extensive growths of salmonberry. Beneath the brush is usually a thrifty undercover of skunkcabbage.

A representative profile along the Pysht River, where the ground is perennially wet, has a 3-inch surface soil of dark grayish-brown clay with a high content of organic matter. Although compact in its wet condition, this layer is friable when dry. Between 3 and 36 inches the soil is gray or drab compact plastic heavy clay mottled with yellow and orange. The heavy underlying blue clay extends to a depth of more than 60 inches.

Some of this land has been logged off, but practically no acreage has been cleared for cultivation. It is probably too costly to clear and too difficult to drain to warrant its development as farm land.

Rife peat.—This material, built up of partly decomposed plant remains under conditions of excessive moisture, has accumulated on flat swampland and has also filled in ponds by concentric encroachment. It occurs in widely distributed depressions of small to moderate size. It is derived mainly from woody material and is commonly densely forested with alder, cedar, hemlock, and, in the western part of the county, with spruce. Some areas, however, have only small deciduous trees and brush. In most cases there has been a succession of vegetation types, and the resulting peat shows layers of different plant remains.

The dark-brown or very dark-brown spongy fibrous material, matted with roots of sedges, swamp herbs, weeds, or brushy plants, usually contains many undecomposed sticks, roots, and even logs,

⁶ WHEETTING, L. C. PRAIRIE SOILS OF THE OLYMPIC PENINSULA, WASHINGTON. Amer. Soil Survey Assoc., Bul. 17, pp. 166-170. 1936.

mainly of cedar, that resist decay when submerged in ground water. In most areas this material ranges from 1 to 4 feet in thickness over compact and impervious gravelly glacial drift, glacial outwash, or local alluvial sediments. Where the forest has encroached as climax vegetation upon old lake or pond beds, a surface layer of woody peat of variable thickness overlies organic accumulations from other types of plants.

From an agricultural standpoint this is the most important type of peat, although the agricultural or other economic value varies considerably in accordance with the type of plant tissue that has entered into its composition. Particularly where derived from deciduous trees and shrubs, Rifle peat can be made into cropland if well drained and fertilized. It improves with cultivation, approaching the character of muck as the woody material is further decomposed.

At the present time the cost and difficulty of clearing and draining are too great to justify the improvement of much of this land. A few small cut-over and partly cleared areas furnish some pasture. One body covering about 35 acres just north of Fairview School has been cleared; a part is used for oats and hay and the rest is in pasture.

Riverwash.—This poorly assorted mixture of sand, gravel, and cobbles occupies stream beds and channels along the Dungeness River. It is covered by overflow during flood but is exposed during normal dry or low-water periods. It contains little organic matter, supports little vegetation, except occasional annual weeds, willows, or shrubs, and in physical character is unsuited to agricultural use, although in some places where there is shade and water for livestock it can be utilized for pasture or grazing.

Rough broken land.—This land type includes beach bluffs, escarpments, steep slopes along entrenched stream channels, and other areas that have no agricultural value because of steep or broken relief. The covering of soil material is variable in character and depth, but for the most part it is shallow and stony, in many places consisting of exposed basaltic or other rocks, sedimentary beds, or glacial gravel. Except in places where there are nearly vertical banks or cliffs, this land was once densely forested. Many areas still remain heavily forested, and where the timber has been cut over there is usually a new growth of small trees and brush.

Rough mountainous land.—More than half of the area of the county is included in this land type, which covers rolling, rough, and dissected foothills, as well as the higher and more rugged slopes of the northern end of the Olympic Mountain Range. The greater part of the mountainous area is within the Olympic National Park. Smoother bodies of arable land that would not warrant clearing for cultivation under present conditions because of inaccessibility and elevation also are included. With the exception of small rock outcrops and some higher peaks that extend above timber line, this land is covered with dense coniferous forest. The covering of soil and soil material varies in depth and character, but rock fragments of variable size are usually at or near the surface.

The land is chiefly uninhabited and seldom visited, except at places where there are hot-spring resorts and forest-protection trails. When considered in connection with its scenic and recreational value, its timber and mineral resources, and its watershed protection, this land

type is of great importance. Mineral deposits include large bodies of manganese ore that sometime may be mined.

Sadie clay loam.—This soil is limited to the rolling hills between the Lyre and the West Twin Rivers in the north-central part of the county. It is developed on compact glacial drift or boulder till under an annual rainfall of about 50 inches. The original stand of large cedar, hemlock, and Douglas-fir has been logged off, but the land is being rapidly reforested by young trees of the same species and considerable alder.

The virgin soil is covered with about 6 inches of rich-brown rotting wood and forest litter. Below this is about 4 inches of dark-brown loose granular highly organic clay loam containing a variable quantity of fine gravel. This layer is underlain by grayish-brown open permeable material ranging from friable and softly granular coarse sand or sandy loam to pea-sized gravel or cobbles. To about 4 feet the deeper subsoil is a yellow compact gravelly sandy clay, mottled in the lower part with gray and orange. The substratum is more uniformly compact than that of the Elwha soil. The underlying glacial material is dull yellowish-brown fine sandy till containing some gravel, cobbles, and occasional boulders. It is massive and partly indurated.

In the earlier reconnaissance survey⁷ the Sadie soil was mainly included with the Clallam and the Olympic soils.

Adapted to much the same crops as the Elwha soil and with an even greater moisture-holding capacity during the dry season, this soil would be suitable for farming. As yet none of it has been cleared for cultivation, probably largely because the removal of the large stumps and great quantity of fallen timber would be both difficult and expensive.

Sekiu clay.—This inextensive soil, developed under swampy or Half Bog conditions, occupies very gentle slopes or flat areas and slight depressions in the western part of the county, as at the north end of Ozette Lake. The greater part occurs in isolated districts, where it is not differentiated on the map but included with the Hoko and Astoria soils. The forest growth consists principally of hemlock, with some large cedars and a few scattered spruces; the cedar trees are usually hollow and dead at the top, and the spruce are of poor quality. The agricultural importance of this soil is only minor, since very little has ever been cleared for cultivation.

Below the 12-inch dark-brown layer of organic forest litter and mold under hemlock and cedar forest in a typical virgin profile the surface soil consists of a 5-inch layer of dark-gray highly organic clay, which becomes black when wet. If disturbed when moderately dry, it breaks out into irregular friable clods. Between 17 and 48 inches the subsoil consists of dark-gray or black compact clay that is tenacious when wet and breaks out in irregular hard prisms when dry. The underlying material to depths of 6 or 7 feet is compact gray sandy clay, closely mottled with yellow, orange, and rusty red.

Sequim clay loam.—Only two small bodies of this soil are mapped; one is just west of Carlsborg, and the other is 1¼ miles east of Sequim. This soil has developed under prairie conditions in slight

⁷ MANGUM, A. W., and party. RECONNAISSANCE SOIL SURVEY OF THE WESTERN PART OF THE PUGET SOUND BASIN, WASHINGTON. U. S. Dept. Agr., Bur. Soils Field Oper. (1910) Rpt. 12: 1491-1600, illus. 1912.

depressions where fine alluvium has accumulated over the gravelly fan deposits. In most places it is well drained and relatively fertile, making good pasture or cropland. As yet it has not been saturated by excessive irrigation.

The 16-inch surface soil consists of dark-brown friable and granular clay loam containing little gravel. It is underlain by brown gravelly heavy loam, which grades at 28 to 36 inches into a coarse gravelly sandy substratum similar to that of Sequim gravelly loam.

Sequim gravelly loam.—This soil is confined to the immediate vicinity of the town of Sequim. It has developed under prairie conditions on a gravelly fan built in the late or postglacial period by the Dungeness River when it flowed northeastward into Sequim Bay. An area one-third of a mile east of Sequim has a 4-inch surface soil of dark-brown gritty loam with considerable coarse gravel. It is high in organic matter, slightly acid to neutral, and loose and faintly granular. The 4- to 24-inch subsurface soil is dark slightly grayish-brown gritty gravelly loam that is very friable and faintly and irregularly granular in the upper part. Below 24 inches, and extending to 60, the subsoil is brown gravelly open and porous sandy material containing some large cobbles.

This soil varies from place to place in depth and in the quantity of surface gravel and cobbles, but the greater part is too gravelly to plow. It is under irrigation and largely used for pasture (pl. 6, *B* and *C*). In summer fields of white clover and mixed grasses provide pasture for as many as four cows an acre. So much irrigation water has been used on this porous soil that the substratum has become saturated. In a number of strips of lower ground that represent old stream channels the surface soil is perennially wet. The pasture value of these areas is impaired by a growth of reeds and other marsh plants of no forage value.

Shuwah silty clay loam.—This soil occurs in four bodies in the valley of the Soleduck River. It was developed under prairie conditions on moderately recent alluvial material like that of the Chehalis soil. An area under a cover of grass, weeds, and bracken just east of Shuwah School has a 2-inch surface soil of dark-brown granular friable silty clay loam of coarser texture that in places contains moderate quantities of fine gravel. Between 2 and 8 inches the soil becomes slightly darker grayish brown or nearly black. The next layer, to a depth of 20 inches, is dark grayish-brown moderately compact silt loam. When disturbed it breaks into vesicular prismatic blocks that are easily reduced to a granular mass. Beneath this layer and extending to 28 inches is dull grayish-brown compact faintly vesicular and granular silt loam that is pervious and easily broken up. The lower subsoil, which extends to from 28 to 60 inches in depth, is compact and massive but permeable olive-brown silt loam. It overlies river sediments of silt, sand, and gravel.

Good crops of oats and hay were once grown on this soil, but continued cropping has reduced it to a state of low productivity. It, however, appears to be the best of the prairie soils in the western part of the county. Considerable quantities of fertilizer would probably be required to restore good crop production.

Solduc gravelly loam.—Areas of this soil occupy the higher undulating terraces in the valleys of the Soleduck and other large rivers in

the southwestern corner of the county. The virgin surface soil consists of 1 or 2 inches of decomposing forest litter over 3 to 6 inches of brown gritty loam containing much pea-sized gravel. The 18-inch underlying soil is a bright-brown friable gravelly loam that overlies unconsolidated beds of partly assorted gravel, cobbles, and boulders, largely of basalt or other basic igneous rocks transported from the Olympic Mountains. To a depth of 6 or 7 feet the gravel is stained yellowish or reddish brown by iron compounds. At lower depths there are dark-purple manganese stains.

The surface soil varies in depth and in quantity of gravel and stones but is predominantly shallow, droughty, and of low agricultural value (pl. 4, *B*). The Douglas-fir timber, which because of the extreme humidity is elsewhere replaced by other species, extends westward on the Solduc soil almost to the ocean. Although nearly all this soil has been logged off, only a few acres have been cleared for cultivation.

Spalding peat.—This peat ranks next to Rifle peat both in extent and potential value as cropland. In its virgin condition the land is mostly open, with brush and stunted timber in clumps or encroaching around the margin. The upper layer of 8 inches or more is medium to dark brown and is derived mainly from sedges, reeds, and other marsh plants. It contains much fine organic material that imparts a very smooth feel when moist but is spongy and matted when dry. Below the upper layer the material becomes more raw, fibrous, and spongy with increase in depth and is lighter brown. The water table is commonly very near the surface most of the year. One small pot-hole area on the old highway between Fairview School and Siebert Creek is under water throughout the winter and has a dense cover of hardhack (*Spiraea* sp.).

Most of these areas remain in the virgin state or have been partly drained to allow the replacement of the marsh vegetation by pasture grass. A few areas have been developed into cropland and are used to produce oats and hay. This peat improves in productivity after drainage when properly cultivated and fertilized. Addition of potash fertilizer is generally needed.

Spalding peat, burned phase.—Most of the original organic material in this phase has been destroyed by burning. Surface materials now consist of exposed gravelly glacial substratum material and patches of a mixture of ash and unburned peat of indefinite origin. The only area mapped lies just back of the shore-line bluff, about 2 miles east of the mouth of Morse Creek, in the bottom of what was once Bagley Lake. It has been periodically used as cropland but produces only mediocre pasture.

Tidal marsh.—Composed chiefly of fine-textured mottled bluish-gray material, this land type consists of fine estuarine sediments that are inundated by the higher tides and support a cover of salt-tolerant herbs, sedges, and grasses. The largest area, about 400 acres along the Waatch River, southwest of Neah Bay, furnishes pasture for horses. Smaller bodies are at Mora, in Crescent and Sequim Bays, Blyn, and at the old quarantine station on Dungeness Spit. Where the tidal marsh adjoins the coastal beach, small gravelly and sandy patches are included. On Puget Sound some tracts of land of similar character have been diked and reclaimed as farm land. At present reclamation

is hardly justified, although small areas might be protected from tidal inundation by dikes and in time improved.

Townsend loam.—This is a dark-colored prairie soil of small extent and limited importance. The only body in the county borders the shore-line bluff half a mile west of Dungeness. Although it has developed on glacial drift similar to that of the Clallam soil, it occurs in a prairie, or park-land area. Fragments of clamshells in the soil indicate that it may once have been an Indian camping site.

Where the soil occurs at the edge of the bluff overlooking the beach it has a cover of mixed grasses, herbs, and wild roses, with a few stunted Douglas-firs along the slope of the bluff. To a depth of 6 inches the surface soil is dark-brown light-textured loam containing some fine gravel and shell fragments. It is slightly acid, finely granular, and mellow. At the surface it is light and fluffy, owing to the high content of organic matter. Between 6 and 12 inches the subsurface soil consists of dark-brown very friable light-textured loam approaching a sandy loam and containing coarse sand and fine gravel. The lower subsoil to 68 inches consists of grayish compact gravelly glacial drift material that breaks out easily in small sharp fragments when disturbed. The underlying substratum consists of dull-gray gravelly sandy compact glacial-drift material resembling soft concrete.

All the soil is under irrigation in cropland and pasture, and it produces good yields of the common crops.

Wellman silty clay loam.—This soil occurs in the Little Quillayute Prairie, in a narrow strip along the northern margin of the Forks Prairie, and as two small bodies, one just north of the junction of Bear Creek with the Soleduck River and the other at Beaver. The surface soil closely resembles Quillayute silty clay loam, but the subsoil is gravelly and more open. The substratum resembles the glacial-outwash gravel deposits underlying the soils of the Solduc series.

On the Little Quillayute Prairie a typical area has a 9-inch surface soil of dark dull-brown to black mellow and granular silty clay loam containing some fine gravel. The dark color is intensified, becoming nearly black when moist. To a depth of 24 inches the subsoil is a dark-brown mellow and granular gravelly gritty loam or clay loam containing many decomposing fern roots. Between 24 and 36 inches the lower subsoil consists of brown sandy gravelly loam. It overlies beds of moderately compact brown-stained gravel.

The Wellman soil is as infertile as the Quillayute and because it is developed on looser material is somewhat more subject to drought.

Wellman gravelly loam.—Areas of this soil occur on the prairies around Tyee, Beaver, and Shuwah School. Consisting of the most recent of the burned parts, it is made up of gravelly loam with 2 to 6 inches of dark-brown to very dark-brown surface soil. The areas are of value chiefly for the small extent of pasture they afford. The vegetative cover is largely of bracken.

ESTIMATED YIELDS AND PRODUCTIVITY RATINGS

The average acre yields of the principal crops on important soils in Clallam County under prevailing practices over a period of years are given in table 6.

TABLE 6.—*Estimated average acre yields of the principal crops on important soils in Clallam County, Wash., under prevailing management practices*

[Blank spaces indicate that the soil is not adapted to the particular crop]

Soil	Oats	Wheat	Oat hay	Mixed hay	Alfalfa	Pasture	Potatoes	Canning peas
	<i>Bu.</i>	<i>Bu.</i>	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>	<i>Tons</i> ¹	<i>Bu.</i>	<i>Tons</i>
Agnew silty clay loam.....	80	35	3.2	3.0	3.5	4.0	200	2.8
Bellingham clay.....	70	30	2.8	2.5	-----	5.0	-----	1.7
Bellingham fine sandy loam.....	75	35	2.7	2.5	-----	5.0	200	2.0
Bellingham loam.....	75	35	2.8	2.5	-----	5.0	200	2.0
Carlsborg gravelly loam.....	50	20	2.2	2.0	3.0	3.0	125	-----
Carlsborg gravelly sandy loam.....	45	18	2.0	2.0	2.5	3.0	125	-----
Chehalis loam.....	90	35	3.0	3.0	3.5	4.0	200	2.8
Clallam loam.....	35	20	2.5	2.5	3.2	4.0	150	2.0
Crescent gravelly loam.....	60	20	3.0	2.5	3.5	4.0	200	1.9
Dick loamy fine sand.....	30	10	1.5	1.4	2.0	2.5	100	-----
Dungeness loam.....	100	40	5.5	4.5	5.0	5.5	250	3.0
Elwha loam.....	35	20	2.2	2.0	3.6	3.8	150	-----
Everett gravelly loam.....	30	12	2.0	1.7	2.5	2.8	125	-----
Everett gravelly sandy loam.....	30	10	1.8	1.5	2.5	2.5	100	-----
Muck.....	75	-----	3.0	2.5	-----	4.0	225	2.3
Pilchuck fine sandy loam.....	70	25	3.0	2.8	-----	4.0	200	1.7
Puget silty clay loam.....	90	40	4.0	3.5	-----	5.0	200	2.3
Quillayute silty clay loam.....	30	15	2.0	1.8	2.5	4.0	150	1.7
Reed clay.....	60	25	3.0	2.5	-----	4.0	-----	-----
Rifle peat.....	70	20	2.5	2.5	-----	4.0	-----	-----
Sadie clay loam.....	75	25	3.0	3.0	3.5	4.5	225	2.3
Sequim clay loam.....	70	20	3.3	3.0	4.0	4.5	200	2.3
Sequim gravelly loam.....	-----	-----	-----	3.0	-----	4.0	-----	-----
Shuwah silty clay loam.....	90	35	3.0	3.0	3.5	4.0	-----	2.5
Solduc gravelly loam.....	30	12	2.2	2.0	3.2	3.0	125	-----
Spalding peat.....	50	10	2.5	2.0	-----	3.5	-----	-----
Townsend loam.....	80	25	3.0	2.5	3.5	4.0	200	2.0
Wellman silty clay loam.....	40	15	2.2	2.0	2.5	4.0	150	1.7

¹ Air-dry weight, equivalent to that of hay.

In order to compare the yields obtained on the most important agricultural soils in Clallam County with those obtained from the same crops in other parts of the country, yield figures have been converted in table 7 to indexes based on standard yields of reference. The soils are listed in the order of their general productivity under prevailing farming practices, the most productive soils being put at the head of the table.

TABLE 7.—*Productivity ratings of important soils in Clallam County, Wash.*

[Blank spaces indicate that the soil is not adapted to the particular crop]

Soil ¹	Crop productivity index ² for—				Potatoes (100= 200 bu.)
	Oats (100= 50 bu.)	Wheat (100= 25 bu.)	Hay		
			Mixed (100= 2 tons)	Alfalfa (100= 4 tons)	
Dungeness loam.....	200	160	225	125	125
Chehalis loam.....	180	140	150	87	100
Shuwah silty clay loam.....	180	140	150	87	100
Puget silty clay loam.....	180	160	175	-----	100
Agnew silty clay loam.....	160	140	150	87	100
Sadie clay loam.....	150	100	150	87	113
Bellingham clay.....	140	120	125	-----	-----
Bellingham fine sandy loam.....	150	140	125	-----	100
Bellingham loam.....	150	140	125	-----	100
Crescent gravelly loam.....	120	80	125	87	100
Elwha loam.....	70	80	100	90	75
Muck.....	150	-----	125	-----	113
Pilchuck fine sandy loam.....	140	100	140	-----	100
Reed clay.....	120	100	125	-----	-----
Rife peat.....	140	80	125	-----	-----
Sequim clay loam.....	140	80	150	100	100
Sequim gravelly loam.....	-----	-----	150	-----	-----
Townsend loam.....	160	100	125	87	100
Carlsborg gravelly loam.....	100	80	100	75	63
Carlsborg gravelly sandy loam.....	-----	-----	100	-----	63
Clallam loam.....	70	80	125	80	75
Quillayute silty clay loam.....	60	60	90	62	75
Wellman silty clay loam.....	80	60	100	62	75
Dick loamy fine sand.....	60	40	70	-----	50
Solduc gravelly loam.....	60	48	100	80	63
Everett gravelly loam.....	60	48	85	-----	63
Everett gravelly sandy loam.....	60	40	75	-----	50
Spalding peat.....	100	40	100	-----	-----
Greenwood peat.....	-----	-----	-----	-----	-----
Astoria, Hoko, and Sekiu soils, undifferentiated.....	-----	-----	-----	-----	-----
Sekiu clay.....	-----	-----	-----	-----	-----

¹ Arranged in descending order of general productivity.

² The soils are given indexes that indicate the estimated average production of the crop indicated on each soil as expressed in terms of a percentage of the standard; the standard, represented by the index of 100, denotes the approximate average acre yield without the use of amendments on the more extensive and better soil types in regions of the United States where the crop is most widely grown.

The ratings compare the productivity of each of the important soils to a standard of 100. This standard index represents the approximate average acre yield obtained without amendments on the more extensive and better soil types in the regions of the United States where the crop is most widely grown. An index of 50 indicates that the soil is about half as productive for the specified crop as the average soil. Soils that have been given amendments, as lime and fertilizer, or are irrigated, together with unusually productive soils of small extent, have indexes of more than 100 for some crops.

The natural factors influencing the productivity of land are mainly climate, soil, relief, or lay of the land, and management, including the use of amendments. In Clallam County the climatic factor looms particularly high in determining the use and productivity of the soils.

Crop yields over a long period of years have been used largely as the basis for the productivity indexes in table 7. A low index for a particular crop may be due to some local condition of unfavorable relief, drainage, or climate rather than to lack of soil fertility. The productivity ratings are not to be interpreted directly into specific land values. In basing them on the essentially permanent factors of the productivity of the soils and their responsiveness to management, little attention is given to the more transitory economic conditions influencing land values.

MORPHOLOGY AND GENESIS OF SOILS

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

The soils of Clallam County, in common with others of the Pacific Border province, fall into the great class of Pedalfers—soils that accumulate iron and alumina in the solum and are leached of free alkalis and alkaline earth bases. The zonal soils of this region have been classified as belonging to the Gray-Brown Podzolic group, although in most cases certain differences have been recognized. The climatic and resulting biologic environments under which soils have formed in this region of cool equable temperatures and heavy winter rainfall differ considerably from those of the Gray-Brown Podzolic zones of the eastern United States and northern Europe and consequently may be expected to produce corresponding variations in the soil.

These facts were recognized by Marbut⁸ who has pointed out that

⁸ MARBUT, C. F. SOILS OF THE UNITED STATES. U. S. Dept. Agr. Atlas of American Agriculture, pt. 3, 98 pp., illus. 1935.

in all parts of the West and Northwest the soils, although apparently belonging to the Gray-Brown Podzolic and the Red and Yellow soil groups, are not identical with these groups as found in the East. Large areas of soil in the Pacific Northwest seem to belong to the Gray-Brown Podzolic group, but in general their degree of podzolization, measured by the development of a light-colored A horizon, is not so complete. They apparently belong in a stage of podzolic development nearer to that of the soils described by Ramann^o as Brown Forest soils than they do to the true Gray-Brown Podzolic soil group. The Brown Forest soils are now recognized as still in a stage of practically complete saturation by bases. They have developed under forest cover but have not yet been podzolized, or their podzolization is as yet scarcely perceptible. The soils of the Northwest seem to have passed this stage but have not yet reached that of the Gray-Brown Podzolic soils.

The almost universal occurrence of angular, spheroidal, persistent aggregates in the soil profiles of the region is one of the most striking differences between the Gray-Brown Podzolic soils of the Pacific coast and those of the Central and Eastern States. It is believed by some that these aggregates, locally designated as shot, are in reality diffused B horizons that develop around innumerable local nuclei coincident with the severe drying-out process occurring late in summer. Under certain conditions of impeded internal drainage the accumulation of shot may constitute as much as 65 percent of the total soil mass. These aggregates range from the size of fine sand to that of marbles and appear to be mainly ordinary soil particles cemented together with iron and aluminum compounds, although some contain a gravel nucleus. They are considerably richer in phosphorus than the soil around them. The occurrence of shot in the forested soils of the Northwest is as common as the presence of the hardpan layer in the Podzol regions of the East.

In northwestern Washington the local diversity of relief is obscured to the casual observer by an apparent sameness of aspect caused largely by dense forests dominated by Douglas-fir. This tree grows to large size in the virgin forests there and springs up in dense thickets of second growth in denuded areas over a wide range of soil, temperature, and moisture conditions. Over the greater part of western Washington it dominates a number of plant associations that make up the natural vegetation of well-drained upland from the shore line to elevations of 3,000 feet or more on the mountain slopes.

Where the fir dominates the forest, differences in soil character and biologic equilibrium are made manifest to the critical observer by the more selective plants. There is an intermingling of other coniferous species, as the western hemlock, western redcedar, and, in the more humid sections, the Sitka spruce. Deciduous trees, including alder, maple, dogwood, and madrone, enter these associations, and in all the forests there is considerable undergrowth of many deciduous species of

^o These soils constitute a group established by the late E. Ramann, of Munich, Germany. They were not fully defined by him, but at a later date Stremme and Aarnio defined them as neutral Brown Forest soils, or soils in which podzolization had not taken place. Such soils occur in small areas among the Gray-Brown Podzolic soils of the United States but not in large continuous areas. According to the American point of view they are potential Gray-Brown soils not yet podzolized.

shrubs and brush. Several kinds of mosses, lichens, and ferns also are prevalent. It is largely these plants that determine the character of the organic matter and affect the soil-forming processes.

Soils that reflect the local diversity of parent soil material and variations in climatic conditions and natural vegetation by a comparatively wide range in degree of podzolization are found in western Washington. Some soils very closely approach the true Podzols, some resemble the Gray-Brown Podzolic soils of the East, some may be similar to the Brown Forest soils of Ramann, and others resemble in color and chemical reaction the Red and Yellow Podzolic soils of the southeastern United States and approach a lateritic character. Through all these, however, there are distinctive Pacific coast characteristics that reflect the effect of climatic and biologic forces unique to North America and possibly the whole world.

Throughout most of the dominant upland soils of the Northwest, as mentioned by Marbut, there is but slight podzolization, yet moderately podzolized profiles do occur. The lack of podzolic development cannot be caused by lack of age in all cases, as there are many places where the terrain has remained unaffected by erosion or deposition since the retreat of the last glacial ice sheet.

A peculiar combination of factors that strongly contribute to a tendency to replenish the soil with bases and inhibit the formation of marked podzolic profiles has been observed. Much of the soil is developed on gravelly and sandy glacial-drift and outwash material derived from a variety of rocks that are predominantly basic and granitic. The primary minerals of these rock fragments weather at different rates and continue to give up their bases for long periods. As some fragments disintegrate, others that are relatively unweathered take their place throughout the soil column through the action of soil-disturbing agencies.

Neither the soil nor the upper substratum materials remain permanently in place under the great forests. Large trees uproot and overturn and invert masses of soil to a depth of several feet, and the growth of roots pushes the soil about. The soil-disturbing action of burrowing animals also is considerable, for mountain beavers burrow extensively and deeply, bringing up large quantities of sand and gravel from the substratum. Fires occasionally sweep through most of the forested areas, leaving ash from which bases are leached back into the surface soil. The fires are followed by a cycle of deciduous vegetation in association with young conifers. Deciduous undergrowth persists beneath stands of old-growth coniferous timber and commonly includes a number of species that feed strongly upon the calcium supply and tend to keep it in the biologic cycle. Where the forest litter consists largely of deciduous leaves, the organic matter is closer to the neutral black-mull type of the Brown Forest soils than to the raw acid humus of the true Podzols.

The forest floor is commonly very uneven in microrelief. Pits and mounds have been made by uprooted trees, and the mounds built up by animal burrows. There are also depressions where large stumps and roots of dead trees that did not uproot have rotted away and allowed the soil to cave in. Usually a crisscross of fallen tree trunks is in all stages of decay. The surficial organic litter is very uneven in thickness, varying from an inch or two to several feet where rotten logs or tussocks of decaying vegetation have been built up by swordferns

(*Polystichum munifolium*). The soil profile becomes a patchwork rather than an arrangement of definite horizontal layers. Under these conditions it is difficult to find or even agree upon what is a representative soil profile. The apparent immaturity of the heavily forested soils is due neither to lack of age nor to surficial erosion but simply to the dynamic forces of the forest itself. Another probable reason for the lack of strongly podzolized profile development is the warm winter temperature. The average January temperature for much of the county is about 39° F., which is about the same as that of Oklahoma City, Okla.

In the districts of excessive rainfall—60 to 120 inches—the forces of the forest are accelerated. The greater humidity is accompanied by milder winter temperature. The dry summer period is shorter, and optimum or excessive soil moisture conditions are maintained through a greater part of the year. In abundance and rapidity of growth the vegetation approaches that of a tropical rain forest (pl. 1, A). Here the podzolic process is largely held in check, and the soils, like the Red and Yellow Podzolic soils of the South Atlantic States, are intermediate between the Podzols and the Laterites.

There is much downward movement of water through the soil, but it takes place largely in winter. At that time microbiologic activity and the attendant chemical changes that release free bases are at a low ebb. During the growing season the bases are quickly taken up by the luxuriant vegetative growth and largely held in the biologic cycle. Thus the soil remains nearly neutral in reaction, and though some iron is carried away in the ground water, it is replenished by the weathering of basic gravel and remains the dominant element in imparting the soil color.

Wherever lower rainfall, more droughty soil, or lower temperatures limit the forest to a nearly pure stand of Douglas-fir of smaller size and slower growth, the soil apparently is less disturbed by microorganisms and remains in place for longer periods. The undergrowth is predominantly of the more acid-tolerant type, and effects of the process of podzolization are more evident. As noted by Kellogg¹⁰ it seems necessary to the podzolic process that there be a dry season during which there is an upward capillary movement of water. Such an environment is found in parts of northeastern Clallam County that lie in the district of low rainfall described as in the climatic shadow of the Olympic Mountains.

The wide variation in average annual rainfall, which ranges from 16 inches or less near Sequim and Dungeness to 115 inches or more in western Clallam County near the ocean, is reflected by marked differences in soil-forming processes. A group of four soils, the Clallam, Elwha, Sadie, and Hoko, represents the profiles characteristic of zones that follow the progressive increase in rainfall from east to west. These soils are developed on undulating upland terrain from gravelly glacial-drift material derived from a variety of rocks, dominantly basaltic and granitic. In color, and to a lesser extent in other characteristics, these soils range from a close approach to the true Gray-Brown Podzolic soils in the Clallam series to a marked similarity to the Red and Yellow Podzolic soils in the Hoko series. Here in the

¹⁰ KELLOGG, C. E. DEVELOPMENT AND SIGNIFICANCE OF THE GREAT SOIL GROUPS OF THE UNITED STATES. U. S. Dept. Agr. Misc. Pub. 229, 40 pp., illus. 1936.

Northwest is found, within a distance of 50 miles, a change in zonal soil character as great as that occurring in the Eastern or Central States between Maine and the Carolinas, or that evident between Minnesota and Texas.

The zone of lower rainfall northeast of the Olympic Mountains is characterized by soils that are distinctly gray and others at least grayer than those of the surrounding area. It has been noted by Wheating that soils of Gray Podzolic character in the Puget Sound region appear mainly to the east of the Olympic Range, where the zone of lower rainfall extends northeastward across the peninsulas and islands to the eastern shores of Puget Sound.

Many great soil groups can be identified in the county, but they have not been studied in sufficient detail to say definitely to which great soil group they belong. The names of the soil groups in this county are tentative, and it is possible that some of the soil series now listed under one group may be changed to another, or that the group name may be changed. Following is a classification of the soil series of the county according to the great soil groups.

ZONAL SOILS

Gray Podzolic:	Brown Lateritic:
Agnew	Hoko
Clallam	Astoria
Dick	Sadie
Brown Podzolic:	Prairie:
Carlsborg	Quillayute
Crescent	Sequim
Elwha	Townsend
Everett	Wellman
Solduc	

INTRAZONAL SOILS

Wiesenboden:	Half Bog:
Bellingham	Muck
Sekiu	Rendzina:
Bog:	Soil not mapped,
Greenwood peat	probably Neptune.
Rifle peat	
Spalding peat	

AZONAL SOILS

Alluvial (well to moderately well drained):	Alluvial (poorly drained):
Chehalis	Puget
Shuwah	Reed
Dungeness	
Pilchuck	

Clallam loam is believed to represent the normal zonal soil of north-eastern Clallam County, where the annual rainfall ranges from less than 15 to about 20 inches. Although this rainfall is but slightly more than that east of the Cascade Mountains where scattered pine and sagebrush prevail, the natural vegetation here differs but little from that of adjacent humid districts. There is a preponderance of Douglas-fir, often in nearly pure stands and commonly of small size and slower growth. The madrone (*Arbutus menziesii*), which requires much sunlight, is prevalent in the more open woods. A number of acid-tolerant plants, of which the rhododendron is probably the most significant, also are present in the undergrowth. In western Washington

the rhododendron is limited to the more acid and usually to the more droughty soils.

Clallam loam is dominantly light gray but may be light grayish brown in places throughout the solum and substratum. Its pH value ranges from 6.0 in the surface soil to 7.0 in the substratum. In virgin or nearly virgin forest situations it has a covering of 3 or 4 inches of partly decomposed litter, beneath which the uppermost layer of soil consists of about 2 inches of dark grayish-brown highly organic loam containing some gravel. In some places, evidently where the ground has not been disturbed or burned over for a long time, the top layer includes a thin horizon of nearly white fine sandy or ashy material, which varies from a mere film to a thickness of half an inch or more. This layer evidently represents the beginning of a strongly podzolized A_2 horizon, which has formed since the upper soil was last disturbed. It is underlain by about 6 inches of light-gray or slightly brown gritty loam containing much fine gravel and small shot aggregates. This is very loose and mellow and grades into about 7 inches of similar material, but slightly more compact and light grayish brown.

The 18- to 32-inch subsoil is an intimate mixture of gravel, sand, and finer material that has a compact slightly vesicular structure and is slightly mottled with rusty brown and yellow. The subsoil grades into parent material of compact gravelly glacial drift derived from a wide variety of rocks (pl. 4, A). It is dull gray irregularly mottled or blotched with rusty brown, yellow, and varying shades of gray. Apparently there has been but slight eluviation and translocation, if any, of sesquioxides or organic matter into the B horizon. This character probably constitutes its most marked difference from the well-developed Gray-Brown Podzolic soils of the northeastern part of the United States.

The Dick and Agnew soils occupy remnants of glacial outwash terraces in association with the upland Clallam loam. In some situations they show a greater degree of podzolization, evidently because of flatter relief. This is particularly true of Agnew silty clay loam, in which there is an A_2 horizon of nearly white highly podzolized material up to 2 inches or more thick. There also is more accumulation of iron and other translocated substances in the subsoil claypan. Dick loamy fine sand also exhibits about 2 inches of very light-gray material immediately beneath the organic litter. Probably because of the very sandy texture, there has been little development of a B horizon.

The Carlsborg soils, developed on coarse gravelly alluvial-fan or outwash material of intermediate age, are distinctly brown. The occurrence of this darker color in a zone of gray soils may be caused by the high content of iron in the basaltic parent material and its oxidation by excessive aeration. The Everett soils, which are derived from less firm material, are grayer in the surface horizons where they extend eastward into the lowest rainfall zone.

To the west, where the annual rainfall is 20 to 25 inches, the gray Clallam loam grades in an irregular and patchy manner into the brown Elwha loam, tentatively called a Brown Podzolic soil. This soil, developed under the same conditions of relief and on what is apparently a continuation of the same glacial-drift material as the Clallam, varies from pale slightly grayish brown to rich brown at its western limits, where the rainfall is about 45 inches.

With a loose surface soil of similar gritty loam texture containing gravel and iron concretions, the Elwha soil lacks the light-gray horizon of the Clallam but appears to have a greater accumulation of iron and alumina in its compact yellowish mottled subsoil. The pH value of this soil ranges from 5.0 in the surface soil to 6.0 in the substratum.

The virgin forest cover is of larger and more rapid growth and contains a mixture of alder, maple, hemlock, and cedar, as well as considerable deciduous undergrowth in association with the dominant Douglas-fir. The organic matter of the forest floor approaches the neutral or nearly neutral character of the black-mull type. The climatic regime of this zonal type of forest is essentially the same as that which prevails over a large part of the Puget Sound Basin and extends southward into Oregon.

West of the zone of the Elwha soil, Sadie clay loam occupies a limited area of smooth undulating and rolling hills that border the shore line of the strait. Its rainfall of 45 to 60 inches may be classed as intermediate between moderate and excessive. Although the entire area of Sadie clay loam has been logged off and much of it burned over, the area having the following profile was probably left undisturbed for a long time.

Beneath about 6 inches of rich-brown rotting wood and forest litter the upper 4-inch surface soil consists of dark-brown highly organic mellow granular clay loam containing fine gravel in varying stages of decomposition. This layer is underlain by 14 inches of light-yellow clay loam, which contains much coarse material ranging from sand and pea-sized gravel to cobbles. It is friable and softly granular. The 14-inch subsoil is yellow compact massive gravelly sandy clay, mottled with gray and orange in the lower part. The underlying glacial material is dull yellowish-brown fine sandy till containing some gravel, cobbles, and occasional boulders. It is massive and partly indurated.

The extreme development of the surface horizon in this particular profile is rarely found in the upland soils of the region; it probably represents what would be uniform development if the soil were not disturbed by the agencies described in preceding pages. The limited eluviation of clay from the surface soil under rainfall and temperature conditions such as these is remarkable and indicates the presence of an abundance of some kinds of materials in the profile that maintain the clay in a stable state of aggregation. This soil ranges from a pH value of about 4.3 in the surface soil to about 5.5 in the substratum.

Hoko clay is developed under the highest rainfall and most humid forest conditions in the Northwest. It has been tentatively classified as a Brown Lateritic soil and occupies the lower more moderate slopes of the hills and undulating or rolling benchlands in the western part of the county near the ocean. Here the virgin forest is very dense, the dominant species being hemlock in association with spruce and cedar. Under the dense stand of mature forest, underbrush is largely replaced, owing to lack of sufficient light, by the swordfern. This plant grows in dense clumps, with fronds often 4 feet long, and in places builds up mounds of dead plant residue.

Whenever the old growth timber is devastated by blow-downs, fire, or logging, the land is quickly claimed by a dense and vigorous growth of many deciduous species of brush. The brush dominates the new vegetative cover for a number of years, but the young coniferous trees

finally gain complete ascendancy. It is reasonable to assume that similar cycles occurred in the past.

A typical profile of Hoko clay reflects in striking degree the intensity of the biologic pressure exerted upon it. The pH value of this soil ranges from about 4.5 to 5.0 throughout. In the virgin state a surface cover of decomposing forest litter ranges from 3 or 4 inches to several feet thick where large tree trunks have rotted down or mounds have been built up by swordferns. The surface layer of the mineral soil, about 12 inches thick, is dark brown, loose, and granular. It contains hard aggregates and fine gravel in varying stages of decomposition, including a few that can be crushed with the fingers. The surface soil has the physical character of a loam but works into a soft gritty clay when moistened and rubbed for a few moments.

The 36-inch subsoil, a mellow faintly granular yellowish-brown clay, also resembles a loam but rubs down into a peculiar soft jellylike clay. This layer contains hard irregular soil aggregates, chiefly iron concretions and decomposing gravel. The underlying glacial-drift material is very compact and partly cemented yellowish-mottled gravelly clayey sand. In areas having flatter relief, the weathering of the gravelly parent material extends deeper and there is less undecomposed gravel remaining in the solum.

Hoko clay and similar soils developed in the high rainfall belt along the Pacific coast seem to resemble most closely the Yellowish-Brown Lateritic soils. The similarity is chiefly in granules, texture, permeability, and reaction. The surficial organic matter and surface texture of Hoko clay is markedly different from that of the Red and Yellow Podzolic soils. The soils of the Southeast are under the influence of rains of high intensity and show a strong tendency to become sandy in the surface horizon and to develop tenacious clay in the subsoil. On the Pacific coast rains are rarely torrential. The surface soils are protected by a much more luxuriant vegetation and a thick cover of organic litter. The clays formed by the chemical weathering remain flocculated in the surface soil and are but slightly affected by erosion or downward translocation. These Pacific coast clay soils seem to resemble the Laterites in having developed a porous tubular structure that allows the free downward movement of large quantities of percolating water. All well-drained and developed soils of the high rainfall zone have become yellowish or rich reddish brown, indicating that much iron remains in the solum.

The Astoria soil occupies mainly the steeper and higher slopes of the hills and is for the most part shallow and poorly developed. Much of it would be classed as Rough broken or Rough mountainous land if such nonagricultural land types had been differentiated in this part of the county. In typical locations beneath 3 or 4 inches of forest litter there is a surface soil of about 6 inches of rich-brown loose granular clay and small shale fragments. This layer grades into a mass of rusty-brown stained shale fragments that in turn overlie disintegrating rock at shallow depths. The parent bedrock of shale, sandy shale, or sandstone is usually olive gray where unweathered but commonly contains many joints and cracks deeply stained with rusty brown. In only a few places on flatter relief does this soil approach the depth and profile development of the Astoria soils of southwestern Washington and western Oregon.

Solduc gravelly loam, a soil of the older river terrace, has excessive underdrainage and aeration because of porous gravelly character. Its rich-brown or reddish-brown color is typical of soils developed under such conditions. The substratum gravel is stained brown with iron to considerable depths. Purplish manganese stains also are common on the gravel of the deeper substratum.

Crescent gravelly loam occurs on fragmental colluvial and outwash foot-slope and terrace materials in the narrow valleys of the central part of the county, where the rock formations of the mountain slopes are predominantly basalt. The soils are related to and in some measure resemble the Olympic soils of southwestern Washington and northwestern Oregon, but for the most part are immature and lack the profile development of the Olympic soils. The Crescent soil usually consists of a rich-brown nearly structureless mass of loamy material containing widely variable quantities of angular basalt fragments ranging in size from small gravel to boulders. Iron or shot concretions are rare or absent. The surface soil has the loose mellow character so common in the upland forest soils of the region. The subsoil is soft and only slightly compacted.

Dark-colored soils developed under treeless or park-land conditions occur in both the eastern and western parts of the county, but there are none in the central part. The origin of these treeless areas is unknown, but the weight of evidence indicates that it was accidental or artificial rather than natural, and that the absence of trees is transitory rather than permanent. In every case the parent material and moisture relations are the same as in adjacent forested areas.

In the eastern part the Sequim and Townsend soils occur on old gravelly-fan and glacial-drift materials, respectively, and may be considered Prairie soils in a correlated position with those of the forested Carlsborg and Clallam series. The surface soils to depths of 12 to 24 inches are dark-brown or nearly black mellow gravelly loam and loam. They are slightly acid to nearly neutral, of high organic-matter content,¹¹ and relatively fertile.

The underlying materials closely resemble those of the forest soils. The occurrence of a few clumps of Oregon white oak (*Quercus garryana*) on the prairie around Sequim may indicate a considerable lapse of time in an unforested state. This oak is common on the prairies of southwestern Washington and western Oregon and is accepted as an indicator of well-established prairie or open park-land conditions. It is found nowhere else in Clallam County. Under an annual rainfall of only 15 inches it is probable that a prairie area once established in grass, herb, and shrub cover might resist the encroachment of coniferous forest for a long time. It is significant, however, that these prairies are generally situated at Indian village sites near large bays and rivers where shellfish and salmon abound.

In the western part of the county are a number of areas of open land, or prairies, that have distinctive dark-colored soils. Such soils are developed on several types of parent material and vary in age and stage of development. Several areas, apparently burned over com-

¹¹ Determinations made at the Washington Agricultural Experiment Station, Pullman, indicated pH values by glass-electrode method of 6.25 and 6.49, and total organic-matter content of 13.80 and 9.77 percent, for Townsend loam and Sequim gravelly loam, respectively.

paratively recently, have large fire-scarred trees still standing. There has been slight change in the surface soil. Wellman gravelly loam occurs on land of this class and has a dark-brown or very dark-brown surface layer 2 to 6 inches thick.

Quillayute silty clay loam, on the other hand, reflects the development of the soil under herbaceous and bracken cover for a relatively long period. In a representative well-developed profile with a cover of tall bracken and some grass and weeds, the upper 18 inches is dark grayish-brown silty clay loam, nearly black when moist. It is friable and granular and slightly laminated for the first inch or two. Between 18 and 26 inches is dark grayish-brown clay, which is compact but easily broken into irregular nutlike fragments. This horizon is mottled with small yellowish-brown spots. The subsoil is light yellowish-brown massive vesicular clay to a depth of 4 feet or more. It is compact but breaks out easily when disturbed and is permeable to roots and to the downward movement of water. It is underlain by brown-stained compact stratified gravel or in some places by unassorted glacial drift. The lower subsoil clay horizon and substratum are similar to those observed in smoother high terrace situations in Hoko clay.

Although the dark-colored surface soil superficially resembles the rich Wiesenbodens and Prairie soils of the Eastern States, it is infertile for crop plants, and at present is largely in bracken, which grows head high. The organic-matter content of the surface horizon, which may exceed 20 percent,¹² is evidently derived largely from the rhizomes of the bracken rather than from grass roots. Under mild temperatures and excessive leaching it has been reduced to the more stable end-products of organic decomposition and is especially high in lignin. Because of the high absorptive capacity of the unsaturated colloidal complex, relatively large quantities of lime and fertilizer are required to make the soil productive.

Paradoxical as it may seem, in view of the dominantly heavy rainfall, crops on this soil also often suffer drought conditions during short rainless periods in midsummer. During heavy rains, water stands a few hours on the flatter areas and soon penetrates through the subsoil clay, which has a permeable structure. A short time after the last effective rains the soil becomes too dry for good plant growth. Owing to the high content of colloidal material the wilting point is reached when the soil still holds a relatively large percentage of moisture.

Wellman silty clay loam, another Prairie soil, is similar to the Quillayute soil in its surface horizons but is developed over porous stratified gravel similar to that of the Solduc series.

The greater part of the prairie land has once been farmed. When cultivation was given up, the land was quickly taken over by a vigorous growth of bracken, with which few other plants can successfully compete. Many abandoned fields, nevertheless, are now covered with young conifers, which now are able to cope with the partly eradicated bracken more successfully than they were originally. The ferns

¹²Determinations made at the Washington Agricultural Experiment Station of representative samples of Quillayute silty clay loam from the Quillayute and Forks Prairies gave pH values by glass-electrode method of 4.98 and 4.87, and organic-matter content of 26.70 and 19.10 percent, respectively.

doubtless dominated the natural vegetation before the coming of white settlers and induced the formation of a type of organic matter much different from that of the usual grassland prairie soils.

The fact that all the prairies extend over two or more types of parent material and in several places up slopes in tongues after the manner of forest burns, as well as often being situated near the ocean coast and along large rivers, lends credence to the belief that they originated as forest burns and were maintained thereafter by the Indians for hunting and camping grounds by periodic burning. Old settlers of the district state that there are often rainless periods in February, when the dead ferns can be burned without danger to the surrounding forests. There is difficulty, however, in finding in the soil any highly resistant charcoal, which has been known to persist for many years following clearing and burning of forest lands.

At present, since the prevention of fire and the reduction in vigor of fern growth, the forest margins are rapidly encroaching upon the prairies. In one locality a dark-colored soil identical with Quillayute silty clay loam was observed in the deep forest under hemlocks and spruces 4 and 5 feet in diameter.

The Rendzina soil in Clallam County is of significance only as an interesting phenomenon. In areas too small to map, it occurs along the coastal beaches where quantities of sea shells have been thrown up by waves or scattered about Indian camp sites. Lime and phosphorus from the decomposing shells have stimulated a vigorous grass growth and the formation of a dark-colored fertile soil.

The hydrogenic soils of the county are, in general, not greatly different from those of other northern humid forest regions. These dark-colored highly organic soils, which were formed under conditions of excess moisture in situations with impaired drainage, occupy practically all depressions and in the zone of high rainfall even cover much of the gently sloping uplands. The local differences in parent material, conditions of drainage, and vegetation are reflected in the occurrence of an unusually wide variety of Meadow, Half Bog, and Bog soils, many of which are of such small size and minor importance that they are not shown on the map.

Bellingham loam is tentatively classified as a Wiesenboden soil and is developed on pond and local alluvial sediments in shallow glacial depressions. It closely resembles grassland meadow soils of other areas and has a dark grayish-brown surface soil formed under deciduous timber and brush cover. Its compact grayish glei horizon is well developed. Rusty-brown and yellowish-brown mottling to depths of more than 4½ feet indicate a wide fluctuation of the water table.

Seki clay, classified as a Wiesenboden soil, occupies flat and gently sloping areas in the zone of high rainfall in association with the Hoko and Astoria soils. The effects of intense weathering of parent material and the high biologic pressure on soil-forming processes are made strikingly evident in its extreme development. Over a typical virgin soil the dark-brown organic forest mold from the hemlock and cedar forest is about 12 inches thick. Beneath the mold is 5 or 6 inches of dark-gray or black highly organic clay, which when moderately dry breaks out in irregular friable granular clods. The underlying soil to 48 inches in depth is dark-gray or black compact clay, which is tenacious when wet but when dry breaks out in hard irregular prisms. To depths of 6 or 7 feet the glei horizon consists of compact

gray sandy clay, which is mottled with yellow, orange, and rusty red and indicates considerable seasonal fluctuation of the water table. In some places compact and partly cemented gravelly drift or outwash material is encountered in the substratum.

In contrast with the very permeable character of the well-aerated Hoko soil, the Sekiu subsoil and substratum are relatively impervious. With slightly flatter relief, surface runoff is held to a minimum by the great quantity of fallen timber and organic litter. The soil becomes waterlogged during the long rainy season. Anaerobic conditions initiate the processes of gleization that develop in the impervious subsoil and substratum.

In the eastern and central parts of the county, Muck has developed under Half Bog conditions in small depressions. It is formed mainly by decay of woody plants. The greater part of the Muck is shallow and rests upon a glei horizon formed on gravelly glacial material or local alluvial or pond sediments.

The peat deposits of the Bog areas vary in depth and composition according to the age and character of the vegetation from which they are derived. Most of the peat areas are derived from woody plants, at least in the surface layers, and have formed under mixed forest and dense underbrush cover. A number of bogs have deposits of complex or mixed origin and character. The central part of a bog is often occupied by an open area of sedge peat, and encroaching upon the margins and enclosing the sedge peat is woody peat formed by forest growth. Woody and sedge peats are but moderately acid and can be used for cropland where reclaimed by drainage. These are identified in this survey by the Rifle and the Spalding peats. Moss peat, represented by Greenwood peat, which is of more rare occurrence, is highly acid and of limited use for agriculture.

The recent alluvial soils of the stream valleys have not yet developed true soil profiles and are classified as Alluvial. They owe their distinguishing characteristics to differences in parent material, drainage, and texture. As they are relatively unleached and consist largely of fresh mineral fragments, these soils are inherently more fertile and, where not too poorly drained, more valuable for agriculture than the older soils of the uplands.

The Dungeness soil occupies second bottoms along the larger streams in the eastern part of the county, mostly in the present valley of the Dungeness River. The material is chiefly brown smooth silty loam, although stratified layers of both coarser and finer sediments are common, as is also considerable rock flour from glaciers. It forms one of the most fertile and valuable soils of the county.

Pilchuck fine sandy loam, on the lower bottoms still subject to overflow, consists of recently deposited grayish sandy sediments composed of fresh rock particles, many of which are formed by the grinding action of glaciers.

The Chehalis soil occupies the stream bottoms in the western part of the county. The alluvium consists of smooth loamy or silty materials derived largely from the erosion of sedimentary rocks and basaltic lava. Under high rainfall Chehalis loam has undergone some leaching, but it still retains much of the original mineral plant nutrients of the parent rocks and constitutes the most fertile soil of the district in which it occurs. A brown or rich-brown color indicates some oxidation of the iron-bearing minerals. The darker colored

Shuwah soil was developed on similar material but evidently under a grass-fern vegetative cover.

Puget silty clay loam and Reed clay are timbered poorly drained alluvial soils of the stream-bottom lands in which the first stages of gleization have been developed. The Puget soil occupies low-lying areas with impaired drainage in association with the Dungeness and Pilchuck soils. The surface soil has been darkened slightly by organic matter, and the lower soil is mottled with brown iron stains. It becomes drab gray beneath a perennial water table.

Reed clay occupies the wet-land areas on the stream bottoms in the western part of the county in association with the Chehalis soil. It remains wet the greater part of the year. The surface soil to 3 or 4 inches in depth is dark grayish-brown clay with a high content of organic matter. It is compact but friable when dry. The underlying soil to about 36 inches is dark-gray clay grading to light gray mottled with yellow. It is compact and tenacious and is underlain to unknown depths by heavy bluish-gray clay.

On the whole, the dominant forest soils of Clallam County and of the region of which it is a part, are probably better adapted to the growth of trees and shrubs than to the staple farm crops. In suitability for agriculture the greater part of the land compares unfavorably with the treeless Prairie, Chernozem, and Brown soil zones of the Middle Western States. Like the Podzolic and Gray-Brown Podzolic zones of the North Central and Atlantic States this region seems better suited to industry, urban development, homes, and small farms producing a variety of special crops than it is to large-scale farming operations. There is an abundance of water and water power, fuel, and building material, and the shore line furnishes good harbors. Opportunities of gaining a livelihood are many and varied, but a large proportion of the people must depend in part on industrial, maritime, and commercial pursuits rather than solely on agriculture.

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