SOIL SURVEY

King County Washington

Series 1938, No. 31

Issued September 1952

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Plant Industry, Soils, and Agricultural Engineering
In cooperation with the
WASHINGTON AGRICULTURAL EXPERIMENT STATION
and 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 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 land, locate the tract on the soil map, which is in the envelope inside the back cover. This is easily done by finding the township and 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 Kb are of the same kind. To find the name of the soil so marked, look at the legend printed near the margin of the map and find Kb. The color where the symbol appears in the legend will be the same as where it appears on the map. The Kb means Kitsap silt loam, undulating. A section of this report tells what this phase is like, for what it is mainly used, and some of the uses to which it is suited.

How productive is Kitsap silt loam, undulating? Find this soil name in the left-hand column of table 7 and note the yields of the different crops opposite it. This table also gives expectable yields for all the other soils mapped, so that the different soils can be compared. Read in the section on Soil Series and Units to learn what are good uses and management practices for this soil. Look also at the section headed Soil Management and Productivity, where general management requirements for the various crops are given.

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 principal farm products and how they are marketed; the sizes of farms; availability of schools, churches, highways, railroads, steamships, airlines, and telephone and electric services; industries; and cities, towns, 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 King County, Wash., is a cooperative contribution from the—

BUREAU OF PLANT INDUSTRY, SOILS, AND AGRICULTURAL ENGINEERING

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Series 1938, No. 31 Issued September 1952

SOIL SURVEY OF KING 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.

LUMBERING is the most important industry in King County. A large part of the timber has been removed from the most accessible lands, and consequently the fertile soils of the stream bottoms and upland depressions are largely cleared for farms. Agriculture consists chiefly of truck farming, dairying, and poultry raising. Seattle, engaged largely in commerce, shipping, fishing, lumbering, and manufacturing, requires a considerable part of the agricultural products. Other lumbering and coal mining centers provide additional local markets, and surplus produce is shipped to Pacific coast and eastern markets. To provide a basis for the best agricultural uses of the land a cooperative soil survey was begun in 1938 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

King County, located in the west-central part of Washington (fig. 1), borders Puget Sound on the west. Seattle, the county seat and largest city in the State, is 25 miles north of Tacoma, 45 miles northeast of Olympia, and 230 miles west of Spokane. The eastern part of the county lies within the Snoqualmie National Forest and is not included in this survey. The area surveyed covers 1,221 square miles, or 781,440 acres. It is joined on the north by a similar soil survey of Snohomish County (*1*)[2] and on the south by a later soil survey of Pierce County.[3] The Western part, comprising some two-thirds of the area, is included in the reconnaissance soil survey of the eastern part of the Puget Sound Basin (*7*).[4] Lake Washington, Sammamish Lake, and numerous minor lakes cover a considerable part of the area surveyed. The survey also includes Vashon and Maury Islands, which lie off the mainland in Puget Sound.

[2] Italic numbers in parentheses refer to Literature Cited, p. 106.

[3] ANDERSON, A. C., NESS, A., and ANDERSON, W. SOIL SURVEY OF PIERCE COUNTY, WASHINGTON. U. S. Dept. Agr., Bur. Plant Indus., Soils, and Agr. Engin., Soil Survey Rpt., ser. 1939. [In progress.]

[4] This early survey is of much less intensive character. Owing to the small scale of mapping and to subsequent refinement in mapping technique and in development of soil science and soil classification, some of the soils recognized in the earlier survey are represented by two or several soil series and types in this report. The more obvious and important of these apparent conflicts in classification are noted in the section describing the soils.

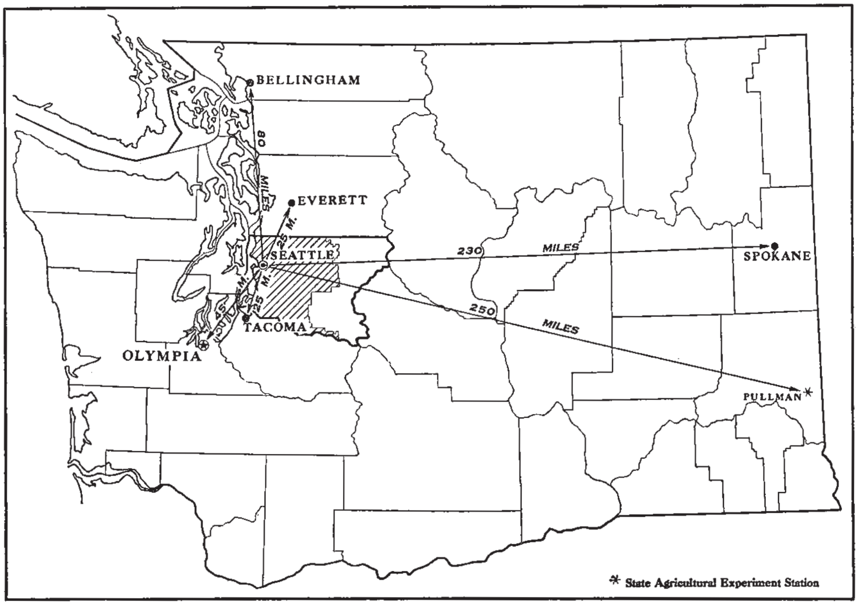

FIGURE 1.—Location of King County in Washington (eastern area in Snoqualmie National Forest not covered in the soil survey).

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

Most of the surveyed area is covered by a mantle of glacial drift, although prominent exposures of bedrock occur. The glacial drift extends into the valleys of the Cascade Mountains on the east, some of which have been modified by alpine glaciation. Geologists (*17*) have found evidence of at least two periods of continental glaciation, the Admiralty and Vashon. The Vashon probably was of Wisconsin age but there are certain relief features that may be attributed to an interglacial period of uplift.

Prominent foothills, mountain spurs, and peaks occur along the Snoqualmie National Forest boundary. A conspicuous spur cutting across the central part of the area divides it into north and south sections and forms a prominent feature of the landscape. Several low drainageways cut across this rounded ridge, which descends westward from an elevation of 3,500 feet at Rattlesnake Ledge to 1,980 feet at Squak Mountain. South of this divide, along the national forest boundary, elevations are less than 4,000 feet but reach 6,000 feet or more at the Cascade Mountains. North of the divide, near the national forest boundary, the mountains rise abruptly to higher elevations and include such prominent peaks as Mount Si with an elevation of 4,190 feet; Mount Lee, 4,550; Mount Teneriffe, 4,797; and Bessemer Mountain, 5,022.

West of the mountain and foothill region are deeply entrenched streams and lake basins, poorly defined glacial drift plains, fluvioglacial outwash plains, and valley trains. Streams have the erratic pattern associated with a glacially modified relief, many having been forced from their preglacial courses by glacial erosion and deposition. The larger agricultural valleys occupied by the White, Snoqualmie, and Sammamish Rivers and the Lake Washington and Sammamish Lake basins roughly parallel the north-south alinement of Puget Sound. To the east dendritic tributary streams descend rapidly from the Cascade Mountains. Many of these, especially the Cedar, Green, and White Rivers, traverse narrow stream valleys or canyons deeply entrenched in the drift deposits or underlying Tertiary rock formation.

The low flat-bottom valleys of the lower White, Duwamish, Snoqualmie, and Sammamish Rivers are less than 100 feet above sea level. The streams are sluggish and meandering, and swampy or marshy areas containing peat and muck are numerous. Most of the adjoining rolling glaciated upland area lies at elevations above 200 feet, and many of the ridges rise to 500 or 600 feet. These upland areas present a glacial relief in which stream courses are often poorly defined and local basins and depressions of retarded drainage are occupied by areas of marsh, swamp, or lake. Areas of sloping relief and of porous drift deposits are well to excessively drained, but in other places free moisture movement is often retarded by the underlying strata. In such areas either temporary winter and spring or permanent waterlogging may occur.

Elevations within the city limits of Seattle range from sea level to about 400 feet. Auburn, in the valley of the White River near the confluence with the Green River, has an elevation of 90 feet. Sammamish Lake is 35 feet, Issaquah at the south end of the lake is 96 feet, and Redmond at the north, 41 feet. In the valley of the Snoqualmie River, Duvall has an elevation of 88 feet, Tolt (Carnation P. O.) 77, and Fall City 92. Snoqualmie is 421 feet above sea level and North Bend 443 feet.

East of the Snoqualmie River, in the watershed of the North Fork of that river and of the Tolt River, the drift plain along the foothills reaches elevations of 1,000 to 1,500 feet or more in some places, though many of these higher points are occupied by bedrock formation above the drift area. Though similar in relief to other parts of the drift plain, drainage is better, owing to the greater porosity of the somewhat morainic drift. Similar high morainic deposits lie in the valleys of the Middle and South Forks of the Snoqualmie River. Where the forks divide near Tanner they descend in the valley of the Cedar River to a general elevation below Barneston of less than 1,000 feet and north and south of Landsburg reach the lower drift plain of the Puget Sound Basin.

South of the Green River is the Cascadian drift and outwash plain of the Osceola glacier (*17*), which differs in character, composition, relief, and drainage from that of the Vashon glaciation. It is a relatively smooth plain rising gently from the lower glacial basin west of Auburn and has an elevation of 742 feet at Enumclaw. It is broken by low, smooth, north-south morainic ridges. The outwash material occupies low flat positions between these ridges and is derived from distinctly basic rocks. These flat areas are waterlogged in the virgin condition or are slowly permeable to moisture. A high terrace occurs in the valley of the White River east of Enumclaw at an elevation of 1,400 to 1,500 feet.

CLIMATE

King County has a modified oceanic climate, the result of prevailing westerly air currents from the Pacific Ocean. Both the Rocky and Cascade Mountains are barriers against the temperature extremes of the continental interior. These conditions cause considerable moisture, cool summers, and comparatively mild winters. Variations in both temperature and precipitation result from the irregular relief. Differences in elevation are from the influence of the foothills and elevated Cascade Mountains of the eastern part of the county.

Approximately 70 percent of the annual precipitation occurs from October 1 to March 31. At lower elevations the winter moisture is largely rainfall, but in the mountainous areas snow accumulates to considerable depth. The occasional deep snowfalls along the coast remain on the ground only a short time, whereas in the foothills snow may remain for several weeks at a time.

Local differences in elevation make climatic data for any one location representative of only a limited area. The most complete climatic data in the county compiled from records of the United States Weather Bureau stations at Seattle and Cedar Lake are presented in table 1, and less complete data from other parts of the county are tabulated for comparison in table 2.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Seattle and Cedar Lake,*[1] *King County, Wash.*

SEATTLE, ELEVATION, 14 FEET

Month	Temperature			Precipitation			
	Average	Absolute maximum	Absolute minimum	Average	Total for the driest year	Total for the wettest year	Average snowfall
	° F.	° F.	° F.	*Inches*	*Inches*	*Inches*	*Inches*
December	42. 6	62	12	5. 60	5. 00	5. 70	2. 0
January	40. 8	63	3	4. 94	3. 53	5. 09	5. 2
February	42. 8	67	4	3. 89	2. 38	8. 44	4. 3
Winter	42. 0	67	3	14. 43	6. 91	19. 23	11. 5
March	46. 4	81	20	3. 05	1. 22	11. 92	1. 0
April	51. 1	85	30	2. 38	2. 01	3. 86	. 2
May	56. 6	92	36	1. 87	1. 14	4. 35	(2)
Spring	51. 4	92	20	7. 30	4. 37	20. 13	1. 2
June	61. 4	98	40	1. 33	1. 83	2. 87	0
July	65. 5	95	46	. 63	. 33	2. 22	0
August	65. 1	92	46	. 70	. 48	1. 58	0
Summer	64. 0	98	40	2. 66	1. 64	6. 67	0

See footnotes at end of table.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Seattle and Cedar Lake,*[1] *King County, Wash.*—Continued

SEATTLE, ELEVATION, 14 FEET—Continued

Month	Temperature: Average	Temperature: Absolute maximum	Temperature: Absolute minimum	Precipitation: Average	Precipitation: Total for the driest year	Precipitation: Total for the wettest year	Precipitation: Average snowfall
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
September	60. 3	87	36	1. 77	. 65	2. 13	0
October	53. 7	81	29	2. 84	1. 84	4. 45	(2)
November	46. 8	68	15	5. 03	4. 44	3. 83	1. 0
Fall	53. 6	87	15	9. 64	6. 93	10. 41	1. 0
Year	52. 8	98	3	34. 03	[3] 19. 85	[4] 56. 44	13. 7

CEDAR LAKE, ELEVATION 1,560 FEET

Month	Temperature: Average	Temperature: Absolute maximum	Temperature: Absolute minimum	Precipitation: Average	Precipitation: Total for the driest year	Precipitation: Total for the wettest year	Precipitation: Average snowfall
December	37. 7	66	6	15. 16	5. 63	46. 80	15. 5
January	35. 2	65	5	14. 03	5. 09	18. 10	25. 1
February	37. 4	65	6	10. 35	16. 09	9. 00	21. 6
Winter	36. 8	66	5	39. 54	26. 81	73. 90	62. 2
March	41. 1	77	14	11. 00	10. 13	14. 15	12. 7
April	46. 6	88	26	7. 44	4. 97	15. 60	6. 0
May	52. 2	90	31	6. 84	7. 80	2. 55	. 4
Spring	46. 6	90	14	25. 28	22. 90	32. 30	19. 1
June	57. 2	98	34	4. 78	4. 55	12. 80	(2)
July	62. 1	98	38	1. 90	(2)	. 50	0
August	62. 4	97	36	2. 55	. 06	. 35	0
Summer	60. 6	98	34	9. 23	4. 61	13. 65	0
September	67. 6	93	34	5. 29	1. 81	3. 75	0
October	50. 8	86	26	10. 13	10. 47	4. 30	. 2
November	42. 8	76	12	13. 83	5. 62	9. 90	2. 8
Fall	50. 4	93	12	29. 25	17. 90	17. 95	3. 0
Year	48. 6	98	5	103. 30	[5] 72. 22	[6] 137. 80	84. 3

[1] Outside the area surveyed.
[2] Trace.
[3] In 1944.
[4] In 1879.
[5] In 1930.
[6] In 1917.

TABLE 2.—*Climatic data for several stations in King County, Wash.*

Location	Elevation	Temperature			Precipitation		Frost-free period
		Average annual	Lowest	Highest	Average annual	Average snowfall	
	Feet	*° F.*	*° F.*	*° F.*	*Inches*	*Inches*	*Days*
Seattle	14	52. 8	3	98	34. 03	13. 7	259
Vashon Island	50	50. 5	5	94	41. 62	9. 2	230
Snoqualmie Falls	430	50. 6	3	104	55. 19	16. 1	170
Landsburg	535	49. 7	0	101	53. 01	14. 1	168
Palmer	895	49. 3	6	102	86. 04	24. 4	208
Cedar Lake [1]	1, 560	48. 6	5	98	103. 30	84. 3	203
Snoqualmie Pass [1]	3, 020	41. 6	−15	92	94. 74	398. 0	121

[1] Outside the area surveyed.

These data show how the average annual temperature decreases with the distance inland and with increase in elevation. Likewise, they show the increase in precipitation and depth of snowfall with rise in elevation. Stream valleys, as at Landsburg, though at relatively low elevations, have lower extremes of winter temperature and shorter growing seasons than similar points on the adjacent benches because cold air settles in these depressions. Numerous valleys and depressions are similarly affected. Fog often blankets the vegetation in these low areas, affording protection from late spring and early fall frosts. The average growing season for agricultural sections is relatively long, and even frosty areas have sufficient season to mature crops. Probably only in cases of specialized farming, where land is cropped several times during the season, would the longer growing season be essential.

VEGETATION

The native vegetation was dominated by a dense growth of conifers, which matured to huge size with a few small intervening open park-like and occasional prairie or marshy areas. Most of the merchantable timber has been removed in the area surveyed. A second growth of similar conifers is becoming established, though slowly in many places. No artificial reseeding or planting in reforestation is practiced. Farm areas have been cleared of stumps to permit tillage or grasses, and legumes have been seeded among the stumps for pasture.

The wide range in elevation within short distances influences the temperature and precipitation, and these factors, together with soil and drainage conditions, control the growth of vegetation. Though several of the more important types of plants grow over a wide range of conditions, others thrive only within well-defined limits.

Douglas-fir (*Pseudotsuga taxifolia*), most important in the timber industry, grows extensively throughout all parts of the area. Western hemlock (*Tsuga heterophylla*) is closely associated, grows as well, and withstands poorer drainage than the fir. Western redcedar

(*Thuja plicata*), second in importance to Douglas-fir, covers a wide region but favors low moist areas and is seldom found on droughty soils. Sitka spruce (*Picea sitchensis*), another important timber type, favors moist areas but is confined largely to the lower areas. A small area of lodgepole pine (*Pinus contorta*) is near North Bend.

Many other trees and shrubs, mostly deciduous and of little commercial importance, are associated with the conifers throughout various parts of the area. Bigleaf maple (*Acer macrophyllum*) is widely distributed with all conifers. Madrona (*Arbutus menziesii*), which is indigenous to this area, grows only in the lower farm area. Red alder (*Alnus rubra*), originally found largely in excessively wet depressions and along streams, has spread extensively to all cut-over areas of slow drainage. Black cottonwood (*Populus trichocarpa*) is found occasionally in low moist areas associated with alder. Willow (*Salix* spp.) and vine maple (*Acer circinatum*), though preferring low moist areas, spread rapidly to less favorable sites on cut-over land.

Cascara (*Rhamnus purshiana*), dogwood (*Cornus nuttallii*), and elderberry (*Sambucus coerulea*) are found largely in moist depressions and drainageways. Devilsclub (*Oplopanax horridum*) makes many of the moist areas of tangled undercover almost impenetrable. Scotch broom (*Cytisus scoparius*) covers moist slopes and depressions near the coast.

The following shrubby undergrowth, together with ferns, is present: Salal (*Gaultheria shallon*), kinnikinnik (*Arctostaphylos uva-ursi*), Oregon grape (*Mahonia aquifolium*), oceanspray (*Holodiscus discolor* var. *ariaefolius*), snowberry (*Symphoricarpos albus*), wild rose (*Rosa nutkana*), red huckleberry (*Vaccinium parvifolim*), blackberry (*Rubus macropetalus*), evergreen blackberry (*R. laciniatus*), salmonberry (*R. spectabilis*), and thimbleberry (*R. parviflorus*).

Some shrubby plants grow in depressions and in and around peat bogs, sometimes contributing considerably to peat formation themselves. Principal of these is spiraea (*Spiraea douglasii*), which invades and sometimes completely covers Mukilteo peat areas. Labrador-tea (*Ledum* spp.), swamp laurel (*Kalmia polifolia*), and cranberries (*Vaccinium oxycoccus*) are found in acid peat bogs largely of sphagnum and hypnum mosses.

Ferns and mosses are perhaps the most conspicuous feature of the forest floor. They cover a wide range of conditions—from open droughty areas to moist dense woods and marsh. Bracken fern (*Pteridium aquilinum* var. *pubescens*) grows extensively under a wide range of conditions. It spreads rapidly into open areas following logging or burns, forming dense cover to almost total exclusion of all other growth except the blackberry, which is almost equally prolific in moist areas. Horsetail fern (*Equisetum* spp.) is found in seepy areas and depressions, swordfern (*Polystichum munitum*) under dense shade on wet soil, triangular woodfern (*Dryopteris spinulosa*) in densely wooded areas, and lady fern (*Athyrium filix-femina*) in excessively wet marshy places. Maidenhair fern (*Adiantum pedatum*) prefers rocky seepage areas, and maidenhair spleenwort (*Asplenium trichomanes*), a similar dark-stemmed fern, is also found. Deerfern (*Struthiopteris spicant*), giant chainfern (*Woodwardia chamissoi*), and licorice fern (*Polypodium vulgare*) grow in various parts of the area.

Numerous water-tolerant grasses, sedges, rushes, and cattails thrive in open stream bottoms, low wet depressions, and basins. Many of these have contributed to the formation of Mukilteo peat and Carbondale muck, shallow.

ORGANIZATION AND POPULATION

Permanent settlement of the county began in 1851 when several families staked out claims and built homes at the mouth of the Duwamish River and at Alki Point. Similar activity immediately followed in the vicinity of what is now the main business section of Seattle. These early pioneers first engaged in cutting piling timber for wharves at San Francisco and spars for ships. Supplies were brought from that port in return. King County was organized in 1852, and in 1853 the county seat was established at Seattle by the Legislature of the Oregon Territory. The Washington Territory was created soon afterward.

In 1853 a steam sawmill was built at Seattle. Lumbering and salmon fishing became the principal industries, though enterprising pioneers invaded the fertile valleys of the Duwamish and White Rivers to establish subsistence farm homesteads. The valley of the Snoqualmie River above Snoqualmie Falls was first settled in 1858, and Tolt (Carnation P. O.), in the lower valley, in 1865. In the valley of the Sammamish River the first settlement was made at Redmond in 1870. Issaquah was settled about the same time. Later in the seventies, settlers became established at Enumclaw. These places have since become centers of important agricultural development.

The first settlers were largely from the Midwestern and Eastern States. The lumber, fishing, and shipping industries have attracted many Scandinavians, while the mines have drawn some inhabitants from southern Europe. Chinese were imported for labor at an early date, and many still remain. Japanese produce a large part of the truck crops.

According to preliminary census releases for 1950, the population of the county was 723,992. Seattle had a population of 462,440; Renton, 16,039; Auburn, 6,494; Enumclaw, 2,788; and Kent, 3,260.

INDUSTRIES

Lumbering and its allied industries are of first importance in the county (*9*). Disposition of the products involves over 60 percent of the rail traffic and about 80 percent of the offshore water tonnage in the county. The early lumber markets were largely those of the west coast, Hawaii, and the Orient, but because of the diminishing timber stands of the Great Lakes region and the South, increased demands now come from the Midwest and Eastern markets. Douglas-fir supplies the largest quantity of lumber products. Redcedar is important in the manufacture of shingles. Hemlock is pitchless and good for wood pulp. Spruce is light and tough and therefore used largely for airplane stock, kitchen interiors, and cabinets.

Seattle, the leading industrial city in the State, has shipping and manufacturing industries very important to the county. About 140 miles of water front in the fresh waters of Lake Union and Lake Washington are accessible to deep-water vessels. A large part of the cargo handled is from products of the Pacific Northwest. These consist mainly of logs and piling, lumber, paper, pulp, salmon, salt herring, metals, machinery, flour, grain, hides, apples, pears, canned milk, canned fruit, and groceries. Seattle shares lumber and shingle mills with other parts of the county. Yachts and pleasure craft are built and large ships overhauled. Logging and mining equipment, hoists, chains, ornamental iron fixtures, and tin cans are manufactured. It has one of the world's large airplane factories. Mills produce flour and breakfast foods, and plants process milk products.

Although coal had been discovered as early as 1853, the larger coal mines in the vicinity of Lake Washington were not developed until the seventies. Later, mostly after 1880 when railroads were built into the interior, mines were developed in the vicinities of Black Diamond, Ravensdale, Issaquah, Cedar Mountain, Cumberland, Bayne, Palmer, Durham, Franklin, and Enumclaw. Coal mining still remains one of the large industries, as newer developments are taking the place of those exhausted by continuous operation. The coal mines are confined largely to the southern half of the county. In 1938 the Black Diamond and Cumberland districts were producing the most coal. Valuable clays are found, and at Taylor the terra cotta clay deposits are used for vitrified products.

Hydroelectric power development is of great importance. The power sites are located principally on the Snoqualmie, Cedar, and White Rivers.

TRANSPORTATION AND MARKETS

Six transcontinental railroads serve Seattle, though only four—the Great Northern Railway, the Northern Pacific Railway, the Chicago, Milwaukee, St. Paul and Pacific Railroad, and the Union Pacific Railroad—have right-of-way within the county. The Southern Pacific Lines and the Canadian Pacific Railway operate jointly with them. The Canadian Pacific Railway has steamship connections at Seattle. Most agricultural sections profit by the network of railroads serving the lumber, mining, and other industries.

Ninety-five steamship companies have operating schedules from Seattle. These include both freight and passenger lines operating coastwise and abroad. The Northwest Airlines connect with eastern points and the United Airlines with those north and south of Seattle.

The county is supplied with several well-improved local public roads and State and Federal highways. United States Highway No. 99 runs north and south through the county near the coast, U. S. No. 10 extends east and west through the central part, and U. S. No. 410 parallels the White River along the southern boundary. In the western part of the county a number of State highways connect with these and serve the important towns. In the more remote sections, especially in the eastern part, old logging railroad grades are often improved and used as roads. A large part of the foothill and mountainous eastern half is accessible only by logging railroads or trails.

Seattle is the largest industrial city and seaport in the Pacific Northwest and is a market for the agricultural produce of the county. Its inhabitants are engaged largely in the lumbering, fishing, shipping, and manufacturing industries. Renton is on a railroad junction and has been important in the development of the lumbering and coal mining industries. Auburn is an agricultural center and railroad division point. Kent is a canning and shipping point for truck, fruit, and berry crops. Enumclaw lies in a lumbering and agricultural section. Important lumber mills are located at Snoqualmie and Selleck.

COMMUNITY IMPROVEMENTS

Electric power and telephone service are available in most rural sections. Elementary and high schools are in the towns and rural districts. School bus service is usually available for outlying districts without local schools. The towns and local community centers have churches or assembly halls.

AGRICULTURE

Though the pioneer development involved lumbering, salmon fishing, shipping, and farming, the natural setting and resources of King County have made agriculture supplementary to the other industries. The growth and expansion of the lumbering industry from the eighties to the present rapidly denuded the lower lying potentially agricultural land of its virgin timber until now logging operations are confined largely to the more remote mountainous sections. Agricultural development followed closely upon logging operations as the lands became more accessible and demands for agricultural products increased. Expansion progressed more rapidly on the valley lands, as these were more readily cleared, more fertile, and better supplied with moisture than upland soils.

CROPS

The acreages of the principal crops and number of fruit trees and grapevines are shown in table 3.

The acreage in hay has increased consistently with agricultural expansion. Of the cereal crops, only oats are important. The proportionate increase in vegetables exceeds that of all other crops. The most fertile lands of the stream bottoms are now used for truck crops. Fruits and berries also occupy a considerable acreage.

TABLE 3.—*Acreage of the principal crops and number*[1] *of fruit trees and grapevines in King County, Wash., in stated years*

Crop	1919	1929	1939	1944
	Acres	*Acres*	*Acres*	*Acres*
All hay	21, 167	20, 290	23, 461	26, 026
Timothy or timothy and clover	11, 823	9, 930	9, 805	9, 767
Clover alone	964	783	356	(2)
Alfalfa	192	345	534	431
Grains cut green	5, 604	4, 840	4, 744	2, 918
Legumes for hay	115	180	114	(2)
Other tame hay	1, 651	3, 472	6, 912	11, 638
Wild hay	818	740	996	1, 272
Corn:				
Silage	[3] 1, 893	729	1, 167	(2)
Forage	373	363	376	(2)
For grain	71	31	56	(2)
Oats:				
Threshed	2, 130	984	1, 587	585
Cut and fed unthreshed	(2)	788	855	1, 724
Wheat	1, 034	153	167	23
Barley	171	59	105	60
Root forage	488	110	64	(2)
Potatoes	3, 069	1, 049	299	186
Vegetables	1, 594	4, 782	7, 113	8, 632
Strawberries	645	497	427	149
Raspberries and loganberries	258	662	668	354
Blackberries and dewberries	138	180	193	216
	Number	*Number*	*Number*	*Number*
Cherries ... trees	26, 296	63, 385	105, 274	99, 166
Apples ... do	118, 115	60, 796	38, 636	47, 982
Pears ... do	18, 717	17, 434	11, 428	13, 559
Plums and prunes ... do	18, 755	13, 553	9, 860	14, 044
Grapevines	1, 530	41, 465	50, 242	49, 818

[1] Number of fruit trees and grapevines of bearing age given for all years except 1944; 1944 figures are for trees of all ages.
[2] Not reported.
[3] All silage crops.

LIVESTOCK

The number of livestock on farms in stated years is given in table 4.

TABLE 4.—*Number of livestock on farms in King County, Wash., in stated years*

Livestock	1920	1930	1940	1945
Cattle	32, 452	33, 547	[1] 32, 282	39, 791
Horses	4, 356	2, 596	[1] 3, 171	2, 950
Mules	32	79	[1] 66	90
Sheep	827	2, 004	[2] 1, 393	2, 252
Goats	199	1, 041	[3] 1, 431	1, 104
Swine	14, 883	6, 319	[3] 7, 013	11, 801
Chickens	349, 826	[2] 862, 695	[3] 591, 492	582, 198
Beehives	3, 436	2, 353	2, 525	(4)

[1] Over 3 months old, Apr. 1.
[2] Over 6 months old, Apr. 1.
[3] Over 4 months old, Apr. 1.
[4] Not reported.

The cattle are largely dairy breeds, as dairying is important on many farms. The number of horses, sheep, goats, and swine are relatively small. The decline in the number of horses since 1920 probably results from tractor and power farming in some sections.

LAND USE

After 1890 land acquisition increased rapidly with the phenomenal rise of the lumber industry. By 1920 considerable readjustment had taken place, the acreage of the county held as farm units dropping to about 11 percent. By 1945 this had increased only 0.9 percent, but there were nearly twice as many farms, indicating that the average farm became smaller. Small farm units of only a few acres are found near Seattle, whereas in the more remote cut-over sections they often include several hundred acres. The trend is progressively towards smaller units with a larger cleared acreage operated under more intensive practices. Only the less desirable lands are now available for expansion and specialized farming is developing to meet Seattle's growing market requirements and demands from outside markets.

Farm and population trends for stated years are given in table 5.

TABLE 5.—*Farm and population trends in King County, Wash., in stated years*

Year	Farms	Land in farms			Population	
		Area in county	Area per farm	Improved land per farm	Rural	Urban
	Number	*Percent*	*Acres*	*Percent*		
1920	3, 801	11. 2	30. 9	45. 0	67, 497	321, 776
1930	4, 656	10. 2	29. 6	45. 6	89, 966	373, 551
1940	5, 760	11. 2	26. 5	50. 7	122, 766	382, 214
1945	6, 495	12. 1	25. 5	44. 8	(1)	(1)

1 Not reported.

FARM EXPENDITURES

In 1939, 20.1 percent of the farmers reported the use of commercial fertilizer for which they expended $168,474, or $145.86 per farm. In 1920 only about half that number bought fertilizer. Truck farmers fertilize heavily, and the reclamation of peat requires a considerable quantity of fertilizer. The kinds of fertilizer used are generally 3–10–7,[5] 5–10–10, 3–10–10, 4–8–8, and 6–10–4. Much superphosphate carrying 18- to 20-percent available phosphoric acid is also used. In 1944, 37.6 percent of the farms reported expenditures for labor amounting to $2,822,992, or an average of $1,154.59 per farm. At this time many of the farm laborers were Japanese, and farm laborers could usually be had when there was a demand.

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

SOIL SURVEY METHODS AND DEFINITIONS

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

The color, texture, structure, porosity, consistence, and content of organic matter, roots, gravel, and stone are noted. The darkness of the topmost layer is usually related to its content of organic matter. Streaks and spots of gray, yellow, and brown in lower layers generally indicate poor drainage and aeration. Texture, or the content of sand, silt, and clay in each layer, is determined by the feel and is checked by mechanical analyses in the laboratory. Texture has much to do with the quantity of moisture the soil will hold available to plants, the plant nutrients or fertilizers held in forms available to plants or leached out, and the difficulty of cultivation. Structure, or the way the soil granulates, and the quantity of pores or open space between particles indicate how easily plant roots and water penetrate the soil. Consistence, or the tendency of the soil to crumble or to stick together, indicates how difficult it is to keep the soil open and porous under cultivation. The kind of rocks from which the soil has been developed—the parent rock—affects the quantity and kind of plant nutrients the soil may have naturally. Simple chemical tests show how acid the soil may be.[6] The depth to bedrock or to compact layers is determined. The quantity of gravel or rocks that may interfere with cultivation, the steepness and kind of slope, the quantity of soil lost by erosion, and other external features are observed.

On the basis of all these characteristics, soil areas that are similar in the kind, thickness, and arrangement of their layers are mapped as one soil type. Some soil types are separated into two or more units. For example, if a soil type has slopes that range from 3 up to 12 percent, the type may be mapped in two units, an undulating one (3- to 8-percent slopes) and a gently rolling one (8- to 12-percent slopes). A soil that has been eroded in places may be mapped in two or more units, an uneroded, or normal, unit (denoted by the name of the soil type only); an eroded one; and perhaps a severely eroded one. A soil type will be subdivided into units primarily because of differences in the soil other than those of kind, thickness, and arrangement of layers. The slope of a soil, the frequency of outcropping bedrock, the extent of erosion, or artificial drainage are examples of characteristics that might cause a soil type to be divided.

[6] 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 soil type, or where the soil type is subdivided, the soil unit, is the unit of mapping in soil surveys. It is the soil that is most nearly uniform and has the narrowest range of characteristics. For this reason land use and soil management practices can be more definitely specified for it than for broader groups of soil that contain more variation.

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

The series are given geographic names taken from localities near which they were first identified. Puyallup, Norma, Snoqualmie, Alderwood, and Puget are names of important soil series in King County. Three types of the Puyallup series are found—Puyallup fine sandy loam, Puyallup silt loam, and Puyallup very fine sandy loam. These differ in the texture of the surface soil, as their names show. Puyallup fine sandy loam is divided into three units—a normal one, or Puyallup fine sandy loam; Puyallup fine sandy loam, high bottom; and Puyallup fine sandy loam, shallow (over Buckley soil material).

Areas that have little true soil are not designated with series and type names but are given descriptive names, as Coastal beach, Made land, and Rough broken and stony land.

SOILS

The great diversity among the soils of King County is due mainly to the heterogeneous character of the underlying glacial and stream deposits, which largely determine the content of the soil and the relief of the land. In a few areas consolidated rock formations have produced important soil differences. In most places the agencies of soil development have not been sufficiently strong nor have they acted long enough to modify the parent material greatly, and the material has retained its inherent textural and mineralogical characteristics. The extreme variation both in surface and in internal drainage has been an important factor in producing wide differences.

On the basis of their characteristics, the soils are grouped as (1) soils of uplands and terraces, (2) soils of lake basins and depressions, (3) soils of stream valleys, and (4) organic soils. The soils of uplands and terraces are subdivided into soils with cemented or consolidated substratum and soils with loose or permeable substratum. The soils of stream valleys are subgrouped into soils with permeable subsoil and substratum and soils with compact slowly permeable subsoil and substratum. These subgroups, based on the character of the subsoil and substratum, have distinguishing properties and drainage features that are important in the classification and use of the soils.

The soils of uplands and terraces include the forested rough mountainous and rough broken lands and cover a large area. They were densely forested in their native state, but now very little virgin timber remains. These good timber-producing soils are not so well suited to cultivated crops, therefore large areas having little or no potential agricultural value should be systematically reforested. The soils range from smooth outwash plains and terraces to rolling ridged morainic relief or relief produced by erosion. Though slopes have fairly definite limits, the degree of variability occurring within these limits requires careful inspection prior to purchase or selection of land so that only the most suitable lands are brought into cultivation.

The upland and terrace soils are light brown, brown, pale reddish brown, and grayish brown and are low in organic matter and available nitrogen because little organic residue from the coniferous forest has been incorporated. Since leaching has not progressed to an advanced stage, they are only moderately acid and retain much of their inherent mineral fertility. They are not appreciably benefited by lime or potash, but responses to phosphate applications are significant. Legume crops, especially, require some form of phosphate fertilizer, the most valuable of which is superphosphate for continuous successful growth on these soils. Some farmers claim that cut-over lands retain a resin toxicity for a number of years after the timber is removed. Such effect is not significant, however, because clearing and cultivation practices follow so slowly after logging or are purposely delayed for many years.

Aside from relief, the most significant differences in the soils of this group is texture, both of the surface soil and subsoil. Texture is largely inherent, as only a small to moderate quantity of weathering and translocation of concentration of material appears to have taken place in the profile during soil development. Soils of open, porous, sandy, gravelly, and stony character predominate, owing to the extensive parent glacial drift and fluvioglacial outwash deposits of coarse texture. Gravelly sandy loam, gravelly loam, and gravelly fine sandy loam are the predominant surface textures. Frequently cultivation is hindered by large pieces of gravel and a considerable quantity of stone. The light textures are readily cultivated under a wide range of moisture conditions but being low in organic matter they are not very retentive of moisture. Much moisture is often lost during the prolonged dry summer, and late crops suffer from lack of sufficient moisture.

Owing largely to the parent material, the loams, silt loams, and clay loams have increasingly heavier textured subsoils and therefore better moisture-holding properties. Because of the deficiency of rainfall in summer, only the soils that have subsoil and substratum with good moisture-holding capacity can be cropped continuously and successfully. Such soils are, however, inextensive and confined largely to bordering terraces and scattered localized areas. More extensive but less favorable for crops are those heavy soils overlying consolidated rock formations. On the other hand, the extensive light-textured soils overlying consolidated or cemented substratum become waterlogged in winter and spring but may not retain the moisture in the dry summer. Least favorable for agricultural development, though they

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usually have the smoothest relief, are those soils with an open porous subsoil and substratum. These soils are in many places gravelly and stony throughout the profile and usually do not retain sufficient moisture for other than early-maturing crops. As the supply of moisture is so necessary in the production of crops, the subsoil characteristics are important in the classification of the soils of uplands and terraces.

The soils of lake basins and depressions and of stream valleys are darker or grayer than those of the uplands and terraces. The highly organic soils are dark brown to black, while those of lower organic-matter content are brown to grayish brown. These dark-colored soils are inherently fertile and have a plentiful supply of moisture because of their position. During their development they have benefited from moderate to large quantities of organic matter derived from a dense growth of deciduous trees, shrubs, grasses, sedges, and water-loving vegetation. The nitrogen content is relatively high, and the mineral elements of fertility are plentiful owing to the absence of leaching and to the addition of plant nutrients carried in by drainage waters from higher lying areas.

The soils of lake basins and depressions are consistently a little heavier textured and more highly organic than those of stream valleys. The textures range from fine sandy loam to silty clay, and usually the organic matter is high enough to make the soils readily tractable. The surface soil of the stream valleys ranges in texture from silty clay to sand, and some of the lighter members may contain considerable gravel, usually in the subsoil. The lighter textured soils contain the least organic matter and are the least desirable.

Most of the soils of lake basins and depressions and of stream valleys have a smooth favorable relief and can be cultivated with a minimum of leveling and labor. They usually require some form of drainage or flood protection before they can be successfully farmed. Many lie in a favorable position if irrigation is necessary in the dry summer season, but very few lands are irrigated at present. Soils with heavy clay subsoil and substratum are the most difficult to drain. The more impermeable soils remain cold and wet in spring and can be used only for pasture and hay. Subsoil and substratum conditions are important factors in land selection and utilization for crops.

Organic soils are found widely scattered in old lake basins, in depressions on seeped slopes, and in low stream bottoms. They include deep and shallow peats and muck of varied origin and composition and are among the important agricultural soils when fertilized and properly drained. They are used largely for truck crops. Large areas cannot be drained successfully, and some are too acid for cultivated crops but have other commercial value.

The miscellaneous land types—Coastal beach, Gravel pits, Made land, Marsh, Mine dumps, Riverwash, Rough broken and stony land, and Rough mountainous land—are not agricultural soils, but most of them have considerable value for forest and pasture. Unclassified city land is unclassified land within the limits of the larger cities.

SOILS OF UPLANDS AND TERRACES

SOILS OF UPLANDS AND TERRACES WITH CEMENTED OR CONSOLIDATED SUBSTRATUM

The upland and terrace soils with cemented or consolidated substratum are of the Alderwood, Tokul, Cathcart, Stossel, and Oso series. Although there are occasional areas of smoother and flatter relief, they are mostly rolling to ridgy. The Alderwood and Tokul soils are developed on cemented glacial drift and occur largely on north and north-trending rolling ridges or benches that lie roughly parallel to Puget Sound and the foothills and mountains. These two series have similar relief and parent material, and their distinguishing features are mainly identified with differences in the physical character of the profile. The Cathcart, Oso, and Stossel soils are developed on glacially scoured consolidated Tertiary rock formations, usually thinly mantled by glacial debris. They are largely marginal to the foothills and mountains and occur on irregularly rolling and sometimes hilly relief.

This soil group is intimately associated with soils developed on loose drift and grades almost imperceptibly into them. Its continuous widespread distribution is interrupted by soils of the entrenched stream valleys and skirting terraces and by the numerous lakes, peaty bogs, marshes, and depressions of dark soils in the glacially pitted relief.

These are good forest soils but only fair for cultivated crops. Large areas are too steep for farming and are suitable only for reforestation. Probably less than 5 percent of them is cultivated, the cultivated areas being scattered in the western part of the county, mainly north and south of Seattle and in the vicinity of Enumclaw. These cultivated soils belong largely to the Alderwood series.

SOILS OF UPLANDS AND TERRACES WITH LOOSE OR PERMEABLE SUBSTRATUM

Soils with loose or permeable substratum belong to the Everett, Barneston, Klaus, Snoqualmie, Indianola, Lynden, Greenwater, Ragnar, and Kitsap series. These soils are widely distributed in close association with soils of uplands and terraces with cemented or consolidated substratum. Frequently they merge almost imperceptibly with those soils and identification is difficult. Owing to the differences in the underlying parent material, these soils fall naturally into three divisions that are important in their agricultural use. The Everett, Barneston, Klaus, and Snoqualmie soils are underlain by porous gravelly material; the Indianola, Lynden, Greenwater, and Ragnar soils by sandy drift; and the Kitsap by fine-textured stratified material largely of glacial-lake origin.

The soils underlain by gravelly and stony glacial drift are gravelly and stony and of low moisture-holding capacity. In summer they often do not hold sufficient moisture to mature crops. Many areas contain gravel and stone in sufficient quantity to interfere with or to prohibit cultivation. The Barneston and Klaus soils have the highest stone content and most irregular relief. The Everett and

Snoqualmie are smoother and less stony as they are largely of fluvio-glacial or glacial-outwash character.

Soils over sandy drift are less droughty than those over gravel but are not so retentive of moisture as those over the stratified silt and clay material. They are relatively free of gravel and stone. The Lynden and Greenwater soils occupy favorable smooth terrace positions, whereas the Indianola and especially the Ragnar have less favorable rolling upland relief.

Soils of the Kitsap series have the best moisture-holding capacity of any of the light-colored soils. They are developed on horizontally stratified silt and clay material in terrace positions that give them a smooth favorable relief.

Most of the soils in this group are poor agriculturally but are well suited to forestry. Probably less than 5 percent of the total acreage is cleared for farms or pasture. Most farms are on soils having clay or sandy subsoil and substratum, as these have better moisture-holding properties than soils underlain by loose gravel. Aside from relief, gravel, and stone content, this is the most important consideration in land use, as all the light-colored forested soils have a similar fertility deficiency.

SOILS OF LAKE BASINS AND DEPRESSIONS

The soils of lake basins and depressions are members of the Norma, Bellingham, Buckley, and Enumclaw series. They are all poorly or imperfectly drained and require some form of drainage before they can be used satisfactorily for crop production. They are high in organic matter, mildly acid, and have a relatively high inherent fertility. The Norma and Bellingham are dark-colored poorly drained soils that are widely distributed in small depressions in association with the Alderwood, Everett, Barneston, Indianola, Kitsap, and other light-colored soils of the uplands derived from Vashon drift.

Most of this group is cultivated, and the rest is rapidly being cleared and brought under cultivation. Occasionally seeped or enclosed basin areas occur that cannot be drained satisfactorily and are therefore used for permanent pasture. The soils are moderately to highly productive of hay crops, pasture grasses, and small grains. Truck crops do well on the Norma and Enumclaw soils and on the more favorable sites of the other soils. Fruits and berries are frequently grown successfully on the higher better drained areas.

SOILS OF STREAM VALLEYS

Soils of stream valleys are the most important and most extensively farmed soils in the area surveyed. Most of the truck farms and a large percentage of the dairy farms are located on these soils. They are fertile, highly productive, and well supplied with moisture. About 56 percent of this group consists of soils with permeable subsoil and substratum; the rest has compact slowly permeable subsoil and substratum.

SOILS OF STREAM VALLEYS WITH PERMEABLE SUBSOIL AND SUBSTRATUM

Soils of the Puyallup, Pilchuck, Edgewick, Nooksack, Salal, Snohomish, Issaquah, and Sammamish series and Alluvial soils, undifferentiated, comprise the groups of soils of the stream valleys with permeable subsoil and substratum. The soils occur mainly in the large wide alluvial valleys of the White, Duwamish, Sammamish, and Snoqualmie Rivers, but areas are widely distributed throughout the other stream valleys. Probably more than 90 percent of the area of these soils is cleared and used for cultivated crops and permanent pasture.

Many of the lighter textured more porous members, as the Puyallup, Edgewick, Nooksack, and Salal soils, occupy the more elevated positions in the stream valleys and have good to fair natural drainage, which frequently is supplemented by open ditches to carry off the spring floodwaters. The Issaquah and Sammamish, which are normally marshy and more slowly drained, require some form of artificial drainage before they can be successfully farmed. Alluvial soils, undifferentiated, occur along small streams or on small alluvial fans, where they often require flood protection and artificial drainage before they can be properly utilized. They are developed from a wide variety of alluvial material of open porous character and vary considerably in organic-matter content and color. The subsoil is slightly acid to neutral stratified sand and gravel with considerable stone.

SOILS OF STREAM VALLEYS WITH COMPACT SLOWLY PERMEABLE SUBSOIL AND SUBSTRATUM

Soils of the stream valleys with relatively impermeable subsoil and substratum are the Sultan, Puget, and Woodinville. They are dominated by heavy clay subsoil and substratum through which water moves very slowly. They are all saturated in winter and spring, and the Puget and Woodinville soils become more or less inundated. Where the soils of this group occur in the valleys of the White and Snoqualmie Rivers, they are frequently flooded by early spring floods that often leave a deposit of fine sediments, especially in the lower areas. As tile drainage systems are frequently impaired by accumulation of fine sediments, open drainage ditches that can be readily cleaned and repaired are commonly used.

Areas of these soils are mostly in the valleys of the White, Sammamish, and Snoqualmie Rivers, but others are widely scattered throughout other stream valleys. About 95 percent is cleared and used for cultivated crops and permanent pasture. The Sultan soils are important for truck crops and forage crops, but the others, which are low lying and difficult to drain effectively for cultivated crops, are used largely for forage crops and permanent pasture in association with dairying.

ORGANIC SOILS

The organic soils occur as widely distributed small bodies in lake basins, pot holes, depressions, low stream bottoms, and on slopes affected by seepage. They are derived from organic remains of plants in various stages of decomposition but frequently in a high state of preservation where natural conditions have inhibited decay. Plant succession during the accumulation and development of these organic remains has played an important part in determining the character of the profile of these organic soils. The character and composition of the remains, especially in the upper few feet, have been important factors in their identification and classification. Aside from their composition, the depth of these materials and the degree of decomposition and mineral soil contamination are important considerations in determining their use.

Rifle, Mukilteo, and Greenwood peats and Carbondale muck are mapped in this county. Peat consists of organic soils in which the remains may be identified as partly decomposed fibrous and matted material. Rifle peat is derived mainly from woody material, Mukilteo peat from sedges and reeds, and Greenwood peat from sphagnum and other mosses. Carbondale muck consists of well-decomposed finely divided organic remains with some included mineral soil material. The fibers and fragments of the parent materials are not recognizable, but the soils are identified by the vegetative cover or by their association with identified peats.

SOIL SERIES AND UNITS

In the following pages the soil series and units, identified by the same symbols as those on the soil map, are described in detail and their agricultural relations discussed. Six of the miscellaneous land types—Coastal beach, Made land, Marsh, Riverwash, Rough broken and stony land, and Rough mountainous land—are included, but Gravel pits, Mine dumps, and Unclassified city land are not described. The location and distribution of all the soils are shown on the map in the envelope on page 3 of cover, and their acreage and proportionate extent are given in table 6.

TABLE 6.—*Acreage and proportionate extent of the soils mapped in King County, Wash.*

Soil	Acres	Percent
Alderwood gravelly loam:		
Gently undulating	3, 179	0. 4
Rolling	60, 372	7. 7
Alderwood gravelly sandy loam:		
Gently undulating	260	[1]
Hilly	16, 942	2. 2
Rolling	164, 623	21. 3
Alluvial soils, undifferentiated	1, 998	. 3
Barneston gravelly fine sandy loam:		
Gently undulating	4, 016	. 5
Hilly	6, 318	. 8
Rolling	39, 566	5. 1
Barneston gravelly loamy sand:		
Hilly	122	[1]
Rolling	2, 130	. 3
Bellingham silty clay	2, 231	. 3
Buckley clay loam	332	[1]
Buckley silt loam	11, 793	1. 5
Carbondale muck	1, 725	0. 2
Shallow	753	. 1
Cathcart gravelly loam:		
Rolling	4, 630	. 6
Steep	79	[1]
Cathcart loam:		
Hilly	1, 486	. 2
Rolling	2, 987	. 4
Coastal beach	282	[1]
Edgewick fine sandy loam	2, 340	. 3
Edgewick sand	291	[1]
Edgewick silt loam	287	[1]
Edgewick very fine sandy loam	1, 466	. 2
Enumclaw loam	5, 325	. 7
Everett gravelly loamy sand, rolling	2, 563	. 3
Everett gravelly sandy loam:		
Gently undulating	5, 483	. 7
Hilly	6, 360	. 8
Rolling	15, 691	2. 0

See footnote at end of table.

TABLE 6.—*Acreage and proportionate extent of the soils mapped in King County, Wash.*—Continued

Soil	Acres	Percent	Soil	Acres	Percent
Gravel pits	294	(1)	Puyallup very fine sandy loam	5, 408	0. 7
Greenwater sand	1, 765	0. 2	Ragnar fine sandy loam:		
Greenwood peat	977	. 1	Hilly	496	. 1
Indianola fine sandy loam:			Rolling	1, 538	. 2
Hilly	1, 150	. 1	Terrace, gently sloping	116	(1)
Rolling	8, 113	1. 0	Rifle peat	7, 626	1. 0
Indianola loamy fine sand, rolling	2, 497	. 3	Shallow	528	. 1
Issaquah silt loam	379	(1)	Sloping	44	(1)
Kitsap silt loam:			Riverwash	2, 401	. 3
Hilly	4, 270	. 5	Rough broken and stony land	39, 331	5. 0
Undulating	11, 549	1. 5	Rough mountainous land	195, 164	25. 3
Klaus gravelly loam:			Salal fine sandy loam	351	(1)
Hilly	1, 449	. 2	Salal silt loam	212	(1)
Rolling	15, 576	2. 0	Sammamish silt loam	794	. 1
Lynden loamy sand	2, 665	. 3	Snohomish silt loam	2, 154	. 3
Made land	582	. 1	Snoqualmie gravelly loam	918	. 1
Marsh	223	(1)	Snoqualmie gravelly loamy sand	1, 593	. 2
Mine dumps	45	(1)	Snoqualmie gravelly sandy loam	4, 071	. 5
Mukilteo peat	1, 519	. 2	High terrace	666	. 1
Shallow	108	(1)	Stossel clay loam, rolling	232	(1)
Nooksack silt loam	3, 131	. 4	Stossel stony loam, hilly	1, 551	. 2
Norma fine sandy loam	4, 103	. 5	Sultan fine sandy loam	104	(1)
Norma silty clay	381	(1)	Sultan silt loam	3, 975	. 5
Oso loam:			High bottom	402	. 1
Hilly phase	1, 129	. 1	Shallow (over Buckley material)	830	. 1
Rolling phase	2, 854	. 4	Tokul gravelly sandy loam, rolling	4, 622	. 6
Pilchuck loamy fine sand	2, 377	. 3	Unclassified city land	40, 695	5. 2
Shallow	2, 594	. 3	Woodinville silt loam	932	. 1
Puget silty clay	251	(1)			
Puget silty clay loam	8, 426	1. 1			
Puget very fine sandy loam	509	. 1			
Puyallup fine sandy loam	10, 996	1. 4			
High bottom	2, 238	. 3			
Shallow (over Buckley soil material)	106	(1)			
Puyallup silt loam	6, 250	. 8			
Low bottom	550	. 1	Total	781, 440	100. 0

1 Less than 0.1 percent.

ALDERWOOD SERIES

The Alderwood soils [7] are covered with several inches of forest litter, which grades sharply to a pale reddish-brown or reddish-tinged brown friable surface soil. This in turn grades to a yellowish brown and finally to a grayish color at depths of 30 to 36 inches, where it is under-

7 In an early reconnaissance survey (7) the Alderwood soils were included with the Everett. Transitional areas occur in which the line of demarcation between these soils is difficult to determine and small areas of Alderwood soils join with Everett soils of the Snohomish County survey on the north.

lain by indurated drift that is often dense and platy at the immediate surface. This gray silica-cemented drift continues to undetermined depths but has been observed at 40 feet or more in deep exposures. Cemented shot pellets (*15*), usually less than one-fourth inch in diameter, are abundant in the surface soil. Pieces of gravel are scattered throughout, and occasionally stone and boulders occur. Most of the indurated substratum, composed largely of sand with embedded gravel, stone, and boulders and in many places stratified, is slowly permeable to water. Roots penetrated it to a shallow depth in places, though they more commonly form a horizontal mat above it. The parent material is largely of granitic character but includes substantial quantities of quartzite, shale, sandstone, and occasionally basaltic and andesitic materials.

Alderwood gravelly sandy loam, rolling (AE).[8]—This soil is developed on the rolling parts of the extensive benchlike upland drift plains. The glacial drift consists mostly of light-colored material predominantly from granitic rock, although a wide variety of other rock is also found. The drift apparently became cemented in early geologic time when the deposits were supposedly submerged in both marine and fresh waters (*2*).

Surface drainage is sufficient, but the internal water movement is greatly retarded by the cemented substratum. Waterlogging frequently occurs at the surface of the indurated material in winter and early in spring. The soil is therefore cold and late as compared with the more porous permeable soils of the uplands and terraces. Although it delays spring planting, this moisture is an asset since it is held in the dry summer when the moisture deficiency is critical on the droughty soils. Domestic water supply can usually be reached in shallow wells part of the year, but the deeper water strata are reached only by deep wells. This soil has not been subjected to accelerated erosion because of the forest litter and organic mat, which covers the soil even after logging. In burned areas native vegetation rapidly forms a dense tangled cover.

In a virgin condition the surface soil is covered by a partly decomposed dark-brown organic mat several inches thick. Under cultivation this highly acid layer becomes mixed with the mineral soil to form a moderately acid surface soil. Abruptly under this layer is a brown to pale reddish-brown friable gravelly sandy loam 12 to 14 inches thick. Round shotlike concretionary or cemented pellets of impure iron or manganese minerals are numerous. Beneath this is the upper subsoil of mildly acid yellowish-brown gravelly sandy loam with a decreasing quantity of pellets. A lighter yellowish-gray 6-inch layer, frequently matted with roots, usually is over the indurated silica-cemented substratum that occurs at 28 to 36 inches.

Saturation in winter and spring causes yellow and brown discoloration immediately above the indurated drift, and the roots are horizontally matted because of inability to penetrate the substratum freely. Characteristically the surface few inches of the cemented

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[8] In the early extensive and much less detailed reconnaissance soil survey (7) this soil was included with the associated and closely related Everett gravelly sandy loam and gravelly loamy sand.

strata has successive layers of thin fragmental plates. Roots penetrate to some extent between these and reach the more softly cemented material beneath. Water likewise moves downward but apparently with difficulty, as the soils become saturated during the wet season. The light-gray to gray material is usually sand and gravel with more or less embedded stone and boulders and extends to undetermined depths. The greater part of it is neutral, but there is a slight acidity developed at the upper surface.

In general the depth to the cemented substratum increases eastward, but there is considerable variation locally from place to place. Likewise there is also a color transition eastward, the darker soils being found near the coast line. In the vicinity of Lake Youngs and numerous places east of Seattle the soil is noticeably browner. An increased consistence suggests that this may be caused by an increase in the organic matter resulting from a deciduous undercover.

Although there is considerable variation in gravel and stone content from place to place, the content is rarely large enough to interfere with cultivation. Occasional scattered small included areas have a yellowish-brown surface soil of gravelly loamy sand and proportionately coarse subsoil. They are developed on coarse gravelly drift that is cemented to only shallow depth. They are better drained than the typical soil but are droughty in dry summer. Also included is a small area south of the Green River in the vicinity of Enumclaw in which the cemented substratum consists of finer and less firmly cemented materials. This inclusion is associated with the Buckley and Enumclaw soils. The better drained part is preferred and utilized for farmsteads, orchards, and home gardens. A proportionally larger area is cleared and used for pasture and other crops than in the dominant areas of the typical soil.

Use and management.—Alderwood gravelly sandy loam, rolling, is a good forest soil from which nearly all the merchantable timber has been removed, but it is slowly and thinly restocking to the original timber types, as only a small part has been cleared for farms or building sites. The land was so severely denuded by logging or by burns that not enough trees were left for satisfactory reseeding (pl. 1, *A*). Alder, vine maple, willow, and other vegetation have spread rapidly over logged land, and therefore systematic reforestation is necessary for satisfactory restocking to good timber trees. Originally the soil was heavily forested with Douglas-fir, hemlock, and redcedar. Lumbermen have estimated that the average yield of such timber from an acre of land in western Washington to have been 40,000 board feet (*4*). Under present conditions this logged land offers better inducement for reforestation than for agriculture, as the cost of clearing stumps and second growth is high and the soil cannot be farmed successfully in competition with better soils locally and elsewhere in the State.

Experienced farmers have found that for the most part only fair crops can be grown, and unless more productive soils of the stream bottoms or upland depressions are included in the farm unit, part time employment elsewhere is usually necessary. The cleared cultivated acreage is very small. Most of it is in the western part, largely near Seattle, where numerous small tracts of 2 to 5 acres are developed as home sites or farms. On Vashon Island a considerable part of this soil is used for fruits; the rest of the cultivated acreage is in small scattered areas often associated with the more fertile soils of the stream bottoms and upland depressions.

The principal crops are hay, pasture, small grains, and fruit. The hay crop is largely red clover with ryegrass and timothy mixtures. The small grains, principally oats, are used as nurse crops when the mixtures are seeded and are nearly always cut for hay and yield from 3/4 to 1 ton an acre. The mixed hay crops yield 1 1/4 to 1 4/5 tons. Most farmers find that the clover and ryegrass mixture gives the highest yield. Recently alta fescue has been successfully used in place of ryegrass. Clover alone yields somewhat less than the mixture. Hayfields are usually pastured after the hay is cut, but the pasture is light, owing to lack of summer rains.

Some pasture is available when the fall rains begin. Older fields are often used for pasture after other grasses and white clover appear through natural revegetation. In some cases such mixtures are also cut for hay. The more successful farmers, however, prefer to reseed such lands to better hay or pasture mixtures with higher carrying capacity. Pastures provide grazing for only about 3 months, owing to the dry summer. A pasture mixture for soils of the uplands recommended by the State Agricultural Extension Service is alta fescue, English, and Italian ryegrasses, tall meadow oatgrass, orchard grass, Kentucky bluegrass, and common white, red subterranean, and alsike clovers. The logged lands can be seeded successfully only after burning, as otherwise competition with the natural vegetation, especially bracken fern, is too severe. Stands once established on the uncleared land provide good pasture if the competing vegetation is kept under control. The ryegrass, orchard grass, and white clover mixture is probably the best under these circumstances.

Alfalfa has been successfully grown on areas that have good surface drainage and sufficient internal drainage. Four tons or more an acre have been grown, which far exceeds that of any other hay crop. Most farmers find it difficult, however, to get a good stand and to maintain it afterward. Grasses and weeds are difficult to keep out by cultivation in the second and third year. The alfalfa acreage is increasing, however, and probably will continue to do so as its culture becomes better understood. Sweetclover, which tolerates wet soils better than alfalfa, probably could be grown with success on the wetter areas having slow internal drainage.

Small grains are seldom harvested because yields are much lower than those obtained on the more fertile soils of the stream bottoms and upland depressions. Harvesting and threshing are difficult because of fall rains. Oats yield about 30 to 40 bushels an acre; barley, 20 to 30; and wheat, 10 to 20.

Cherries, raspberries, blackberries, and strawberries are grown in commercial quantities adjacent to the lower valley of the White River, in the vicinity of Seattle, and on Vashon Island. Mostly sour cherries are grown because in wet weather sweet cherries crack. Cherries yield well for 10 or 12 years and then decline rapidly. Sour cherries yield 1 to 3 tons an acre. Raspberries yield 2,000 to 2,700 quarts; blackberries, 3,000 to 3,500 quarts; and strawberries, 2,000 to 2,300 quarts per acre. Other fruits, as apples, pears, plums, and prunes, are grown mostly for home use. Yields of these fruits are small and of poor quality because of diseases and insects. Farm gardens supply many kinds of vegetables for home use.

This soil is deficient in organic matter and nitrogen, and under cultivation it is necessary to use barnyard manure, crop residues, or proper rotation with legumes. Crops respond materially to applications of superphosphate but are not appreciably benefited by other commercial fertilizers or amendments as lime. An initial application of 300 pounds of superphosphate followed by 250 pounds each year is the usual procedure.

Alderwood gravelly sandy loam, hilly (AD).—Areas of this soil are widely distributed as small elongated bodies among the other Alderwood soils. They occupy strongly rolling to ridgy upland areas and short steep slopes along drainageways. Slopes range from 15 to 25 percent. Surface drainage is more rapid than on Alderwood gravelly sandy loam, rolling, and the subsoil does not become so highly saturated in winter and spring. This soil consequently is droughtier in dry summer, especially on the steeper slopes, where the surface soil and subsoil over the indurated substratum are thinner. More stone and gravel are on the slopes than on the smoother areas. Erosion is not a serious problem but would probably become accelerated under cultivation.

Use and management.—Alderwood gravelly sandy loam, hilly, is limited in its agricultural use and is best used for forestry. None of it is cultivated, except in the vicinity of Seattle where home sites and small cleared tracts occur occasionally, because of the difficulty in crossing the land with farm machinery. Logging operations and burns have severely denuded extensive areas that are reseeding very slowly and in competition with deciduous trees and brush of no economic importance. Restocking could be successfully done under favorable circumstances of controlled reseeding or replanting.

Alderwood gravelly sandy loam, gently undulating (AC).—This soil consists of areas of Alderwood gravelly sandy loam having smooth relief—slopes do not exceed 6 percent. Areas are usually too small to be differentiated on the map, but occasionally larger ones occur as scattered bodies. These areas have favorable relief for cultivated crops, but flatter situations may become saturated in winter and early in spring. Crop yields usually exceed those on the rolling soil.

Alderwood gravelly loam, rolling (AB).—Although this soil occupies upland benchlike drift plains similar to those of Alderwood gravelly sandy loam, rolling, it has a somewhat smoother rolling relief. The surface drainage is rapid, but accelerated erosion is at a minimum because of the protecting vegetation and forest litter. A domestic water supply can usually be reached by shallow wells for at least part of the year, but permanent supplies can be had only by drilling deep wells.

A large part lies northeast and east of Seattle. Small tracts are developed as home sites and farms near Seattle, and the remaining cleared acreage is widely distributed on the more favorable sites. The soil was heavily timbered but now is largely logged off. The second growth of good timber trees is sparse, and systematic restocking is necessary for a satisfactory return of the land to forest.

This soil has essentially the same profile as Alderwood gravelly sandy loam, rolling, but the surface soil texture is gravelly loam and the subsoil is heavier. In general the cemented substratum contains less sand. The lower subsoil directly above the indurated substratum usually is slightly grayer and more definitely mottled with yellow and brown, thus indicating somewhat slower drainage above the cemented substratum. Though this soil usually drains more slowly and remains saturated and colder for a longer time in spring, it is somewhat more productive of most crops than Alderwood gravelly sandy loam, rolling, because it retains moisture better for plant growth in dry summer.

In a few small areas north of Georgetown and north of Franklin the deeper underlying material consists of shale and sandstone bedrock. The subsoil material above the cemented material is somewhat heavier in texture than in most areas. The hardpanlike material above the bedrock consists of successive thin laminated wavy and dense glazed plates, between which are irregular layers of softly cemented glacial drift material.

Use and management.—Crops grown on Alderwood gravelly loam, rolling, are similar to those on Alderwood gravelly sandy loam, rolling. The same cultural practices are used. Strawberries are not so successful because of the high moisture saturation in winter and spring. Alfalfa also would be affected by this condition, except in places of more favorable subsoil drainage. Sweetclover is well adapted to these conditions. Grain hays yield 1 to 1¼ tons an acre, and mixed hay crops 1½ to 2 tons. Pastures have a slightly greater carrying capacity and can be pastured longer than those on Alderwood gravelly sandy loam, rolling. Yields of grain crops are also slightly higher. Fruits and vegetables yield about the same as on Alderwood gravelly sandy loam, rolling, in years of normal rainfall.

Alderwood gravelly loam, gently undulating (AA).—This soil occurs in association with Alderwood gravelly loam, rolling, northeast of Seattle. The smooth relief generally does not exceed 6 percent, making this soil more favorable for cultivated crops than the associated soil. A larger part therefore is farmed. Some of the flatter areas become waterlogged in winter and early in spring, and low basins may require artificial drainage. Although the soil is wet and cold for early crops, it is well suited to hay, small grains, and permanent pasture. Owing to the higher moisture-holding capacity, yields of these crops exceed those on the rolling soil.

ALLUVIAL SOILS, UNDIFFERENTIATED

Alluvial soils, undifferentiated (AF), are a group of inextensive soils widely distributed as small bodies along streams and on alluvial fans issuing into the larger stream valleys. Areas occur in situations where they are subjected to flooding and are wet in winter and early in spring. Some areas remain permanently wet and swampy, but with drainage most of them can be used for either permanent pasture or cultivated crops. In many places building adequate drains is prohibitive, owing to the small areas involved. Effective drainage

A, Logged-off timberland on Alderwood gravelly sandy loam, rolling, slowly being reseeded.
B, Labrador-tea dominating vegetation on Greenwood peat; encroaching marginal coniferous forest in background.

A, Logged-off area on Klaus gravelly loam, rolling; second-growth coniferous forest, mainly Douglas-fir, in background.

B, Logged-off and burned-over area of Rough mountainous land in eastern part of the area surveyed.

systems frequently involve deepening the stream channels and digging tributary and intercepting drains. Small higher lying areas are occupied by a loam soil similar to that of the Snoqualmie series. A few high areas contain large quantities of stone and boulders and are unsuitable for cultivation.

Use and management.—The small cleared acreage of Alluvial soils, undifferentiated, is used for hay, pasture, vegetables, and fruit. Vegetables and fruit occupy the better drained areas that lie adjacent to home sites. These soils are productive and yields are similar to those on Norma fine sandy loam. Uncleared areas support a second growth of Douglas-fir, hemlock, and redcedar, with which alder, maple, and a dense undergrowth of vines and shrubs are usually associated.

BARNESTON SERIES

The Barneston soils occur east of the Everett soils in a higher rainfall belt and at somewhat higher elevation, usually between 500 and 1,000 feet above sea level. They are therefore somewhat more leached and have a slightly more developed profile. They are slightly more acid and have a deeper surface soil and subsoil, the subsoil showing some infiltrated clay concentration and iron staining. The parent glacial drift material is similar to that of the Everett but is usually less modified and assorted by water. At higher elevations is the least modified material, which frequently retains a morainic relief. In these areas scattered boulders lie over the surface and are densely massed in the subsoil and substratum.

A smaller proportion of the Barneston soils is farmed because they occur largely in more remote sections than the Everett. They are better forest soils than the Everett and support a greater variety of timber trees. They also receive more moisture and hold it more effectively; consequently, crops suffer less frequently from drought.

Barneston gravelly fine sandy loam, rolling (Bc).—This soil forms a large part of the soils in the eastern part of the area above an elevation of 600 feet. Though there are occasional areas of gently rolling relief, the greater part is rolling to strongly rolling. Surface drainage is rapid and internal drainage open and free to excessive. Satisfactory all-year domestic water can usually be obtained only in deeply drilled wells.

In uncleared virgin areas a moderately acid dark-brown partly decomposed organic layer from 1 to several inches thick forms a distinct mat. The surface soil below this is moderately acid, rich medium-brown or reddish-brown gravelly friable fine sandy loam, containing a sprinkling of shot pellets. At a depth of 16 inches is yellowish-brown moderately acid gravelly sandy loam. Between 28 and 60 inches the slightly acid yellowish-brown or yellowish-gray iron-stained clayey sand and clay-coated gravel lower subsoil are underlain by substratum material of slightly acid to neutral light yellowish-brown or yellowish-gray poorly assorted glacial drift. The drift consists of open porous sand, gravel, and stone, somewhat coated with clay, rusty-brown iron stains, and occasionally silica. At greater depths the material appears to be washed free of fine material. The drift material is frequently embedded with boulders. Granite or similar rocks and quartzite are the predominant till material. Smaller quantities of argillite, sandstone, shale, and occasionally basalt and andesite materials are present.

The acidity of the soil increases slightly from west to east with increased rainfall and cooler temperature. The soil in the higher areas receives more rainfall and has somewhat greater capacity for holding it, owing to the deeper surface soil and the increased clay content in the subsoil. There is considerable range in degree of leaching and soil profile development from west to east since this soil lies in a belt intermediate between the low and high rainfall areas in the county. Where areas of this soil join the Everett soils, which it closely resembles, boundaries are indistinct. In the lower lying positions the drift deposits are considerably smoother, better assorted, and more modified than in the higher eastern part and in the elevated localities. The glacial drift material is frequently definitely morainic, unassorted, and strewn with boulders. Such stony areas are not suited to agriculture.

Use and management.—Though Barneston gravelly fine sandy loam, rolling, has been logged off, stumps and second-growth trees indicate response in the type and size of the tree growth. On areas adjoining the Everett soils Douglas-fir is associated with a few hemlock, both of which grow only to fair size. Progressively eastward hemlock increases in this association and occasionally redcedars are found. Stumps indicate the trees in the eastern part grew to larger size. The second timber crop to which these lands are restocking probably will respond similarly to the soil conditions and local environment. Since both relief and soil are more favorable for timber than for cultivated crops, the greater part will probably remain in forest.

Probably less than 5 percent is cleared for home sites, farms, and pasture. These areas are widely scattered and largely confined to the lower western part and adjacent valleys where farmers often have part time employment cutting cordwood or working in lumber mills and coal mines.

Though the Barneston soil has somewhat better moisture properties than the Everett it is equally deficient in organic matter and nitrogen and is markedly benefited by applications of superphosphate. Similar crops are grown, but yields are slightly higher on the Barneston and crops suffer less frequently from drought. Fruits and vegetables are grown largely for home use.

Legumes are essential in crop rotation to bring the limited organic matter and nitrogen to satisfactory levels for crop production. Farmers find clover with ryegrass and alta fescue satisfactory in such rotation, and yields of 1 to 1⅘ tons of hay an acre are larger than in crops of clover alone. Alfalfa probably would give higher yields if stands could be properly maintained. Small grains used largely as nurse crops for hay yield slightly less than 1 ton an acre. When harvested for grain, oats yield 20 to 30 bushels; barley, 5 to 25; and wheat, 7 to 15.

As compared with the Everett soils, pastures supply slightly more abundant feeding value and the grazing season is longer, owing to the heavier rainfall and better moisture-holding capacity. Stump lands produce fair pasture if after burning they are seeded to such mixtures as white clover, ryegrass, and orchard grass and if the competing vegetation is kept under control.

Barneston gravelly fine sandy loam, hilly (Bb).—Areas of this soil occur on short steep slopes along drainageways or terrace fronts and on slopes in the strongly rolling or ridge upland. A large part occupies steep slopes or ridges adjacent to the foothills and mountains where the glacial drift deposits are frequently morainic and stony. Slopes range from 15 to 25 percent. Erosion is not accelerated, but the surface soil is frequently thin and gravelly. In some localized areas, especially in the eastern part, stone and boulders would prohibit cultivation. Though largely nonagricultural, it is a good timber-producing soil and its use for forest should be encouraged. At present it is logged off and in second-growth timber.

Barneston gravelly fine sandy loam, gently undulating (Ba).—This soil occupies areas of smooth gently undulating relief in which the slope is less than 6 percent. It occurs where glacial outwash deposits are more common. Surface waters move off rapidly, and internal drainage is free and often excessive. This land is more favorable for farm sites, and crop yields are probably slightly higher than on the rolling phase because of somewhat more consistently uniform growth. Areas are not uncommon, however, in which coarse stratified materials add to the droughtiness, reducing pasture yields or lowering the carrying capacity. A slightly larger proportion of this soil is farmed than of the rolling phase.

Barneston gravelly loamy sand, rolling (Be).—Although this soil closely resembles Barneston gravelly fine sandy loam, rolling, it is more droughty because of its coarser surface texture and its more open porous subsoil and substratum. The relief is gently rolling to rolling. Surface drainage is rapid and internal drainage excessive. Deep wells are necessary for a satisfactory domestic water supply. Less of this soil is farmed than of Barneston gravelly fine sandy loam, rolling. Similar crops are grown, but yields are lower because of lack of moisture in summer. Cleared and farmed areas are widely scattered on the more favorable sites, mostly adjacent to coal mines, lumber mills, and other industries that offer part time employment.

Barneston gravelly loamy sand, hilly (Bd).—Areas of this soil are on short steep slopes along drainageways or terrace fronts and on slopes in the strongly rolling upland. Slopes are approximately 15 to 25 percent. Drainage is rapid but accelerated erosion is held to a minimum, owing to rapid absorption of water by the soil and to the excellent protection afforded by the native vegetation, forest litter, and organic mat. On many areas the surface soil is thinner than that of the rolling phase and gravel and stone may be more frequent. It differs little from the rolling soil in its capacity for timber production. All of it has been logged off, and a second growth of similar lumber-producing trees, largely Douglas-fir, is becoming established. The relief would be unfavorable for use of farm machinery, and little of the soil is farmed.

BELLINGHAM SERIES

The Bellingham soil occupies the same positions as the Norma soils, but finer silt and clay sediments probably laid down in temporarily arrested waters have contributed to its development. The Bellingham soil is more frequently associated with the Alderwood and Kitsap than with other upland soils. The surface soil resembles that of Norma soils, but the subsoil is dominated by stratified clay and silty material in which gravel may occur. The underlying substratum consists of gray stratified clay and silt and occasionally clayey drift.

While the Bellingham soil is typically representative of and is classified with the soils of lake basins and depressions, small areas of Bellingham silty clay, as occurring in this survey, are closely identified with and related to the recent alluvial soils of the stream valleys. In some places small areas of soils recognized as Bellingham were included with the Puget soils of the earlier reconnaissance survey (7).

Bellingham silty clay (BF).—This soil is widely distributed throughout the upland depressions. It is most frequently associated with the Alderwood and Kitsap soils but is more desirable than those soils for hay, pasture, and truck crops. In the virgin condition the soil is wet and waterlogged, and some form of drainage is necessary before it can be successfully cultivated and used for crops. The areas are small and similar to those of Norma fine sandy loam but more difficult to drain because of the heavy clay layers in the subsoil and substratum. Closer spacing of drainage ditches and effective intercepting drains are usually necessary for complete and successful drainage. Small low-lying areas frequently remain permanently wet.

In typical occurrence the 6- to 10-inch surface soil is moderately acid dark dull-brown to nearly black granular highly organic silty clay. The upper subsoil is mildly acid drab or dark grayish-brown somewhat mealy fairly friable silty clay loam or silty clay. Below 18 inches are laminated strata of bluish- or greenish-gray clay, silty clay, and silt, stained or mottled rusty brown and yellow with green and blue in the deeper part. These stratified deposits are very slightly acid to neutral.

Small included areas are closely associated in occurrence, relief, and use with the recent alluvial Issaquah and Sammamish soils. They occur mainly near Issaquah and differ to some extent from typical Bellingham silty clay. The surface soil is a slightly acid dark grayish-brown or nearly black granular but plastic silty clay that is underlain abruptly by slightly acid light brownish-gray stratified silty clay and clay of puttylike consistence mottled with bluish-gray and brown stains. These areas occupy low flat drainage depressions, most of which have been cleared and drained. They are used mainly for pasture.

Use and management.—About 75 percent of Bellingham silty clay is cleared and used for pasture or cultivated crops. All of it has been logged off, and at present more acreage is being brought into cultivation as soon as it can be cleared and drained. Its fertility is similar to that of Norma fine sandy loam, but the heavy subsoil and slow drainage make crop selection a little more difficult. Uncleared areas support a scattered second growth of redcedar, spruce, hemlock, and some fir, with a dense undergrowth of alder, vine maple, and willow, often with spiraea, briers, sedges, and water-tolerant grasses.

The soil is used largely for hay, oats, pasture, and leafy vegetables. For hay both red and alsike clovers are used in mixtures of ryegrass and timothy. The hay yield is 2 to 3½ tons an acre. The second growth is usually pastured. Oats yield about 1½ tons of hay when used as a nurse crop for hay and pasture mixtures. Permanent pasture is seeded to the same mixture as on Norma fine sandy loam, and the carrying capacity and seasonal period of grazing are about the same. Low wet areas can be successfully used for hay and pasture when seeded to reed canarygrass or a mixture of meadow foxtail and big trefoil. Hay crops of 3 to 5 tons an acre are obtained. The pasture is good and lasts throughout the year. Stump lands are often used successfully for permanent pasture when grass and clover mixtures are seeded following burning, and the competing native vegetation is kept under control. The truck crops grown are largely peas, cabbage, cauliflower, lettuce, and spinach. Yields are about the same as on Norma fine sandy loam. The cold wet condition of the soil is unsatisfactory for berries or fruits.

The soil is managed in the same way as Norma fine sandy loam. It drains more slowly, however, and consequently is not in condition for plowing and seeding until later in spring.

BUCKLEY SERIES

The dark poorly drained Buckley soils are largely developed on unmodified glacial drift and outwash deposits laid down during the retreat of the Cascadian Osceola glacier (*17*). These soils have developed under a waterlogged and completely saturated condition with a mixed deciduous and coniferous forest and a luxuriant water-tolerant understory cover. They have a highly organic, moderately acid, dark grayish-brown to nearly black surface soil and a slightly acid to neutral light yellowish- to medium-gray iron-stained, sticky, plastic, gritty, and gravelly subsoil. The substratum is slightly alkaline light- or medium-gray tough plastic clay glacial drift material highly mottled with iron stains and containing embedded angular disintegrated rock fragments. This material is largely from dark basic rock and is slowly pervious to water. Deeper exposures indicate the presence of highly impervious clay bedding and some cementation in the lower deeper material.

Buckley silt loam (Bh).—This soil occurs on elongated level and depressed areas of the relatively smooth glacial till plain between the Green and White Rivers near Enumclaw. Drainage is restricted to poor. In a virgin condition the soil is saturated and waterlogged and requires artificial drainage before it can be successfully farmed. The glacial till material, derived fom Cascadian glaciation, is very slowly permeable to water and contains more dark basic rock material than the drift found elsewhere in the area. East of Enumclaw is a wet waterlogged high valley terrace having a surface broken by numerous low sags, swells, and basins. In this area the surface soil varies somewhat in color and texture within short distances.

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This soil has been logged over, and probably about 80 percent is cleared for farms. The second growth on the uncleared part includes timber-producing trees of redcedar, hemlock, spruce, and Douglas-fir and deciduous trees of alder, vine maple, big leaf maple, and cottonwood. There is an understory of snowberry, oceanspray, and bracken fern.

The upper surface soil to a depth of about 8 inches is moderately acid, highly organic, very dark-brown to black granular silt loam with a small quantity of angular coarse sand and gravel. The black organic matter is of sooty character and almost completely masks the mineral soil. When wet it is smooth and slick but not plastic. From about 8 to 14 inches is moderately acid dark-brown less organic silt loam or with considerable angular coarse sand and gravel. This in many places becomes more grayish at the lower limits. The upper subsoil to about 30 inches is a yellowish medium-gray to light yellowish-gray slightly acid to neutral gritty clay loam filled with angular gravel and mottled with rusty brown. Below 30 inches is slightly alkaline medium-gray sandy or gritty clay with yellow and brown spots and stains, containing much angular weathered gravel and stone. This clay till is tough and dense and breaks into angular fragments.

Use and management.—When properly drained Buckley silt loam is used successfully for hay crops, permanent pasture, and oat hay. It is more productive of these crops than the associated Enumclaw loam but is less favorable for other crops because of its wet cold condition. The hay crops are largely red or alsike clover with ryegrass and timothy mixtures. These yield 2 to 3½ tons an acre. Two cuttings can usually be obtained, but the second crop is often pastured. Oats are usually planted as a nurse crop with hay and pasture mixtures and cut for hay. This crop yields about 1½ tons an acre. Permanent pastures have a high carrying capacity and can be pastured for a long season owing to adequate moisture throughout the year. The most successful pastures are those seeded to the mixture recommended by the State Agricultural Extension Service. This includes alta fescue, Italian and English ryegrasses, orchard grass, Kentucky bluegrass, and common white, red, and alsike clovers. Permanently wet low areas can be successfully seeded to reed canarygrass or a mixture of meadow foxtail and big trefoil. As pasture it provides all-year grazing, and as hay it yields 3 to 5 tons an acre.

Owing to the large continuous areas that this soil occupies near Enumclaw, farmers have organized districts for constructing a network of adequate drainage ditches to provide outlets for drainage water from the individual farms. This soil can be successfully drained only by tile, owing to the close spacing necessary in the slowly permeable clay subsoil and substratum. Tile trenches, however, are difficult to dig in the dense stony and gravelly clay.

The soil is wet and cold in spring, making tillage operations usually late. Because of the high content of organic matter the soil can usually be worked under a fairly wide range of moisture conditions without unfavorable effects or the use of excessive power. Dairy farmers use all available manure and supplement it by use of superphosphate for the legume hay crops. The superphosphate is applied at the rate of 300 pounds an acre the first year and 200 pounds each succeeding year.

Buckley clay loam (BG).—This soil is closely associated with Buckley silt loam in low basins and along drainage channels. It is very similar to that soil except that the heavier clay loam surface soil frequently includes a thin light-gray or yellowish-brown layer, probably of diatomaceous earth or a leached layer developed under surface organic accumulation. Most of this soil is cleared and used for the same crops as Buckley silt loam. It is a little more difficult to till because of the heavy texture and low-lying position, but yields are about the same or slightly lower.

CARBONDALE MUCK

Carbondale muck (CA) is widely distributed in wet basins of upland depressions and stream bottoms, frequently in association with Rifle peat or highly organic mineral soils. Areas are saturated and often flooded in winter and early in spring. The water table remains high, and drainage is necessary before the soil can be successfully farmed. Effective drainage can usually be accomplished by use of intercepting and central drains if a satisfactory outlet is available. As in Rifle peat areas the surface settles when drained and cultivated, and drains should therefore be installed so that the water table can be held at a definite depth below the surface for effective moisture control. Virgin areas support a vegetation similar to that found on Rifle peat.

In most areas the surface soil to a depth of about 16 inches is a moderately acid, granular, reddish dark-brown, finely divided, greasy, woody muck with a small quantity of silty mineral soil. This is underlain by a moderately acid dark reddish-brown woody and sedge muck with embedded woody fragments and fibers but containing more mineral soil than the layer above. Below 30 inches this rests on slightly acid mucky material, containing considerable gray mineral material with embedded woody material and remains of sedges and reeds. At about 60 inches is dark muck or dark sedimentary peat that continues to the underlying mineral substratum at variable depths. The average depth of the muck is probably 5 or 6 feet, but frequently areas are as deep as those of Rifle peat.

Considerable variation exists in Carbondale muck of this area. As mapped it includes grayish-black to dark-brown surface material of well-decomposed peaty muck to muck intermediate in mineral content between the highly organic mineral soil and Rifle peat. The consistence and plasticity of mineral soils, however, is lacking. The succeeding layers may have similar variations in color or in mineral content, but they are usually well decomposed. Layers with woody fibers and fragments succeeded by those containing fibers of sedges over sedimentary and mineral muck are the usual succession. Thin layers of white or yellowish diatomaceous earth are common near the surface.

Use and management.—Most of Carbondale muck in the stream valleys is cleared and farmed, but in the more remote upland depressions probably only 75 percent is cleared. The muck is used largely for leafy truck crops, but a considerable acreage is used for hay and oats. Crop yields usually exceed those on Rifle peat because of the more compact, finely divided, or colloidal character of the surface soil and the higher mineral content. This soil is more comparable to peat that has become decomposed and compacted under cultivation. Lettuce yields 300 to 500 crates an acre; cabbage, 300 to 500; cauliflower, 600 to 750; spinach, 475 to 575; and celery, 300 to 450. Peas yield 725 to 800 hampers of green pod peas and 2 to 3 tons of shelled green peas for frozen pack. Hay crops of alsike and timothy mixtures yield 2 to 2½ tons an acre and of oats about 2 tons. Oats yield 75 to 90 bushels of threshed grain. Muck is more frequently used for pasture than the peat soils, as the farmers state that mineral deficiency in peat causes reduction in milk production.

The soil works readily into an excellent seedbed when properly drained. Owing to its more highly decomposed character it has more available nitrogen for plant growth than Rifle peat. The higher quantity of organic and mineral colloids also provides a better storage reservoir for mineral plant nutrients. Truck farmers use manure supplemented with balanced fertilizer high in potash and phosphate in which this soil is deficient; 3–10–10 or 5–10–10 mixtures are most frequently used.

CARBONDALE MUCK, SHALLOW

Aside from its shallow depth of about 8 to 24 inches Carbondale muck, shallow (CB), is very similar to the typical muck. The mineral soil material is bluish-gray clay loam to gravelly loam. This soil has similar wide distribution, drainage, and native vegetation and is frequently associated with the typical muck along the outer margins of Rifle peat areas. It often occurs associated with Bellingham and Norma soils. A similar acreage is cleared, drained, and farmed. It is productive of the same crops and yields are similar. Because of the mineral substratum, which supplies mineral that may not be available for plants in the areas of deeper muck, it is considered better for pasture.

CATHCART SERIES

The Cathcart soils have developed on irregularly interstratified shale and sandstone scoured by glacial erosion and often thinly mantled by glacial debris. They include some parent glacial drift material. Areas are most frequently on the higher lying positions and shoulders of uplands along entrenched streams. The relief varies from gently rolling to steep. Small scattered areas are farmed, and they are considered better than the associated Alderwood soils because they have less gravel and rock. They also have better internal drainage and better moisture-retaining properties.

The surface soil color varies considerably with the parent material but is commonly medium brown to rich brown. It is low in organic matter and usually moderately acid. It is susceptible to erosion. The subsoil likewise varies in color and is often variegated. The parent material is usually medium to dark gray or yellow to buff.

Cathcart loam, rolling (CF).—Throughout the lower basin part of the area and along entrenched streams, this soil occurs on gently to strongly rolling relief. Surface drainage is rapid, and accelerated erosion takes place on steeper areas if the soil is denuded of vegetation, especially where underlain by fractured shale. On the whole, the soil is sufficiently drained for cultivated crops and holds moisture well in dry summer. Areas of the heavier textured subsoil over shale substratum have slow drainage, and occasional seepage areas of darker soil occur.

This soil is developed from weathered shale and sandstone, often thinly mantled with glacial debris or embedded with surface stone and gravel. Profile characteristics and surface texture vary considerably from place to place with the frequently changing character of the underlying substratum and with the depth of the gravelly glacial mantle. Where developed on sandstone, the soil is browner, loamy, more friable, and more readily penetrated by roots and water than where underlain by shale. Where derived from shale, the soil is predominantly gray, clayey, sometimes waterlogged or eroded, and roots penetrate the lower subsoil and substratum with difficulty.

The following is a description of a representative profile developed from clayey sandstone. A 1½-inch moderately acid mat of dark-brown partly decomposed organic material overlies mildly acid medium-brown to rich-brown loam filled with rusty-brown shotlike pellets and some gravel. Between 10 and 24 inches the subsoil consists of mildly acid yellowish-brown clay loam of somewhat reddish cast. There are a few embedded gravel and occasional shot pellets and fragments of clayey sandstone. The 24- to 40-inch slightly acid buff or pale yellowish-brown clay loam with partly decomposed argillaceous sandstone fragments is underlain by dull yellowish-brown or grayish-buff jointed fine-textured argillaceous sandstone with rusty-brown stains along fractures. This material is neutral to slightly alkaline.

Use and management.—Cathcart loam, rolling, has been logged off and is now mostly in second growth of scattered timber-producing conifers with a dense growth of deciduous trees and brush—largely alder, willow, and vine maple. Small areas have been cleared for cultivated crops and pasture. Farmers consider the smoother areas more favorable for farm crops than the Alderwood soils, owing to the relative freedom from gravel and stone, to the more effective internal drainage, and to the better moisture-holding capacity. Crops are similar to those on the Alderwood soils, but yields are slightly higher.

Cathcart loam, hilly (CE).—Associated with the rolling Cathcart soil, this soil occupies the more irregular relief in the upland areas and slopes along drainageways. Slopes range from 15 to 25 percent, and consequently the use of farm machinery would often be impractical. The surface soil is usually thinner than on the smoother areas and is occasionally cut by erosion. Under cultivation erosion would become accelerated. The land has been logged off but not cleared for farms. It is slowly restocking to scattered timber trees and thicker growths of deciduous trees and brush.

Cathcart gravelly loam, rolling (CC).—This soil is developed on shallow glacial drift deposits over interstratified sandstone and sandy shale that have contributed considerably to the lower subsoil. The glacial mantle is somewhat thicker and makes up a greater proportion of the parent soil material than in Cathcart loam, rolling. The underlying bedrock stratum is massive and thick and rather horizontally bedded. It ranges from coarse-grained sandstone to finer textured argillaceous sandstone or sandy shale of yellow or buff to light gray or greenish gray.

In the southeastern part of the county this soil occupies the higher lying farm area adjacent to the foothills and mountains, where thin glacial deposits cover scoured smoothed sedimentary bedrock. Though the relief ranges considerably from rolling to strongly rolling, the glacial mantle is of remarkably uniform depth throughout. The consolidated stratum is seldom exposed, but weathered shale and sandstone materials are usually within a 6-foot depth. Surface drainage is rapid, but evidence of accelerated erosion is rare. Internal drainage is favorable, and the soil is seldom excessively wet in winter and spring, yet moisture is retained well for plant growth. A domestic water supply can usually be obtained from shallow wells most of the year.

Large areas occur in higher lying remote sections away from the population centers. Though the rainfall here is somewhat higher, the growing season is shorter and the topography is less favorable for farming. Stone and boulders are also more frequent. Such areas are in general better suited to forestry than to agriculture.

Virgin areas are covered with a moderately acid dark-brown organic layer several inches thick that gives way sharply to a moderately acid rich-brown or reddish-brown friable gravelly loam sprinkled with shotlike pellets. At a depth of about 14 inches and continuing to about 46 inches is a moderately acid yellowish-brown gravelly gritty friable clay loam of slightly reddish tint. Though this layer is definitely of glacial drift character, admixture of material derived from the underlying sandstone is apparent. Below this is a very slightly acid decomposing clayey sandstone that is yellowish brown but variegated with gray and reddish brown. At 70 inches is a yellowish-brown to buff sandstone with rusty-brown bands. This material is very slightly acid to neutral and is more massive and yellowish gray at greater depth.

Use and management.—All of Cathcart gravelly loam, rolling, has been logged over. It supported valuable growths of Douglas-fir, hemlock, and redcedar and is slowly restocking to similar trees. Deciduous trees and brush offer strong competition, however, and systematic reforestation is necessary to improve the stand of the valuable timber types.

In common with the other light-colored soils of the upland, this soil is deficient in organic matter and nitrogen, and crops respond materially to applications of superphosphate. Only a few scattered areas have been cleared for farm crops and pasture. Most of the farmed acreage is near Black Diamond. On these areas the soil responds well to the same treatment as given the Alderwood soils and similar crops are grown. Slightly higher yields are usually obtained.

Cathcart gravelly loam, steep (Cd).—This soil has a steep relief in which the slopes exceed 25 percent. It occupies short steep slopes along entrenched stream courses and strongly rolling areas throughout the extent of Cathcart gravelly loam, rolling. The relief is unfavorable for agriculture, and the soil is often thin and frequently stony.

There is, however, no appreciable difference from Cathcart gravelly loam, rolling, in capacity for timber production.

COASTAL BEACH

Coastal beach (CG) consists of long narrow areas of sand and gravel forming the beach line of Puget Sound. Small areas of tidal marsh are included. These beach areas occur above mean tide but are swept by storm waves and have no agricultural value.

EDGEWICK SERIES

The Edgewick soils are developed from somewhat greenish or yellowish-gray micaceous alluvium derived largely from granite or related rocks. The surface soil is low in organic matter, very slightly acid, yellowish brown to light yellowish olive brown, mellow, and friable. When dry it frequently has a duller or more greenish-gray cast. The very slightly acid to neutral subsoil is light yellowish- or light greenish-brown stratified sands often faintly mottled with yellow and rusty brown.

Edgewick fine sandy loam (EA).—This soil is in the stream valley of the Snoqualmie River and its forks in the vicinity of Snoqualmie Falls. It occupies the more elevated positions in the stream bottoms and natural levees along the streams. These level or gently sloping areas usually have gentle undulations or low sags and swells and frequently are flooded by stream overflow late in winter or early in spring. Surface and internal drainage are otherwise usually good.

The 6-inch surface soil is a very slightly acid yellowish medium-brown or light yellowish olive-brown mellow fine sandy loam underlain to about 26 inches by a very slightly acid to neutral light yellowish-brown or olive-drab micaceous mellow and smooth fine sandy loam. To a depth of 70 inches are very slightly acid to neutral light yellowish-gray to light grayish-brown somewhat greenish stratified sands that are thickly bedded and micaceous. Slight rusty brown staining or mottling is found in the stratified seams. The deeper substratum is gravelly. A few small areas with a gravelly shallow surface soil and a gravelly subsoil are included.

Use and management.—About 75 percent of Edgewick fine sandy loam is cleared and farmed. This mellow soil can be tilled under a wide range of moisture conditions. It is easily drained and is retentive of moisture. The uncleared part supports a scattered second growth of Douglas-fir, hemlock, and redcedar with a dense growth of alder and some vine maple. There is usually a thick brush undergrowth.

The soil is used largely for hay, small grains, and permanent pasture. The hay crops usually include red or alsike clovers with ryegrass and timothy mixtures. Yields are 2 to 3¼ tons an acre. A second cutting can usually be obtained, but many farmers prefer to pasture the second growth. Small grains, largely oats, are used as a nurse crop for hay and pasture seedings. These are usually cut for hay and yield about 1½ tons. Oats yield about 70 bushels when harvested for grain. Permanent pastures are seeded to clover and grass mixtures. Mixtures with the highest carrying capacity and highest feeding value consist of red, alsike, and white clovers, alta fescue, Italian and English ryegrasses, orchard grass, and Kentucky bluegrass. The soil retains sufficient moisture for a long grazing season.

Small home orchards and gardens are on most farms and home site tracts. Fruit trees grow well on the higher areas that have good subdrainage. Berries yield well. This soil is suitable for vegetables such as those grown on Puyallup fine sandy loam, but yields are slightly lower. It is less favorable than that soil for commercial truck farming because of its greater distance from the Seattle market and because the shorter growing season does not allow so wide a crop selection.

This soil is inherently fertile but is now low in organic matter and nitrogen. These can be brought up to a fairly satisfactory level largely by proper rotation with hay or pasture crops that include clover. Dairy farmers are able to add considerable quantities of barnyard manure, thus materially increasing productivity. Most farmers make applications of superphosphate to clover hay crops for increased hay yields. The acre rate of application is about 300 pounds the first year and 250 pounds in succeeding years.

Edgewick sand (Eb).—This soil is closely associated with other Edgewick soils and usually occupies positions adjacent to streams. It is frequently overflowed, and the texture of surface soil is often changed by deposition or erosion. The surface soil is light yellowish-brown sand that rarely exceeds 15 to 20 inches in depth. Gravel frequently occurs and is coarsely bedded with yellowish-gray sand in the subsoil; included gravel bars are common. This soil is generally unsuited to agriculture and is largely in native deciduous trees and brush.

Edgewick silt loam (Ec).—This soil is closely associated with Edgewick very fine sandy loam and occupies similar positions. The relief is level to gently sloping, but undulations or low sags and swells are frequent. Surface runoff is fairly good except after late winter or early spring floods, when water may stand in low basins for a considerable time. Internal drainage is usually good, and the soil has excellent water-holding capacity. This soil is farmed in conjunction with both Edgewick fine sandy loam and very fine sandy loam, and similar crops are grown. Yields are about the same. The 10-inch surface soil is very slightly acid yellowish medium-brown or light yellowish olive-brown smooth mellow silt loam. Between 10 and 30 inches is very slightly acid light yellowish-brown or olive-drab micaceous smooth silt loam with wavy bands of faint rusty-brown iron staining. This layer is underlain by very slightly acid to neutral light yellowish-gray to light grayish-brown micaceous granitic sand and silt in thick-banded stratifications and laminations.

Edgewick very fine sandy loam (Ed).—This soil is closely associated with and similar to Edgewick fine sandy loam. It differs in its surface soil texture and in usually lying farther from the streams at slightly lower elevations. The relief is level to gently sloping with frequent low sags and swells. The soil is subject to early spring floods, but surface runoff is fairly rapid. Internal drainage is usually good, and the soil retains sufficient moisture for all crops grown. The crops grown, management practices, and crop yields are the same as for Edgewick fine sandy loam.

ENUMCLAW SERIES

The Enumclaw soil occupies swells or higher undulations than the associated Buckley soils and is therefore better drained and lighter colored. It has developed in positions of imperfect restricted drainage under a forest cover, largely coniferous with a deciduous ground cover. This soil has a moderately acid and organic medium dark grayish-brown surface soil over a slightly acid to neutral light yellowish-brown to light brownish- or yellowish-gray iron-stained gritty, gravelly, yet plastic subsoil.

Enumclaw loam (Ee).[9]—Although developed from the same type of parent material, this soil occupies higher undulations or swells than the associated Buckley soils. Drainage is more effective owing to the higher position, and in places the two soils are drained by the same system. All the soil has been logged off, and uncleared areas are supporting a second growth, largely of timber-producing trees—Douglas-fir, hemlock, and redcedar. A scattering of alder and maple and an undercover of bracken fern, snowberry, oceanspray, salal, and Oregon grape are usually associated with these conifers.

In virgin areas the surface soil is covered by a moderately acid dark-brown root-matted partly decomposed organic layer about 1½ inches thick. The 9-inch surface soil is moderately acid medium dark grayish-brown gravelly heavy loam or gritty clay loam. At 9 to 20 inches the upper subsoil is slightly acid or nearly neutral yellowish-brown gravelly heavy loam or gritty clay loam. The lower subsoil to a depth of about 50 inches is slightly alkaline brownish- or yellowish-gray iron-stained or mottled gritty clay loam or sandy loam containing soft weathered gravel and stone. Below this is a substratum of medium gray iron-mottled tough and plastic clay till that is gravelly and stony with embedded angular weathered rock material.

Since drainage conditions are somewhat more variable for this soil than for the Buckley, both surface soil and subsoil may show considerable color variation within short distances. In the higher lying situations the soil is more yellowish brown throughout than typical, and where it merges with the Buckley soils it is dark brown in the surface soil and gray in the subsoil. Most of it associated with Buckley silt loam on the high valley terrace east of Enumclaw is more yellowish, open, and porous than elsewhere. A few small areas in sec. 6, T. 19 N., R. 7 E., have a coarse sandy subsoil.

Use and management.—The principal crops on Enumclaw loam are the same as those grown on Buckley silt loam. The soils are so closely associated that they are similarly managed. Hay mixtures and oats cut as hay yield slightly less than on that soil. Grazing, especially on the higher areas of permanent pastures, may be limited owing to lack of available moisture, but this better drained soil is selected for other crops that grow less favorably on the Buckley soils. These

[9] This soil was included with the Buckley soils in the early reconnaissance survey (7).

are largely garden vegetables, berries, and occasionally tree fruits. Home sites and small garden and fruit tracts are near Enumclaw.

EVERETT SERIES

The Everett soils occur in the lower rainfall belt adjacent to Puget Sound. They form the greater part of the soils associated with the Alderwood series at elevations below 500 feet and usually occupy slightly lower positions. The drift upon which they developed is assorted by fluvioglacial agencies and by waters associated with or subsequent to the retreat of the glacier. The material in the smoother terrace or terracelike positions is more definitely assorted than that in the rolling upland; it is largely coarse sand and gravel, but stones and boulders are occasionally found on the surface and are common throughout the underlying drift.

These soils are moderately acid, open, porous, and droughty. They have a brown to pale reddish-brown gravelly surface soil over which a thin partly decomposed organic layer has accumulated from the forest litter. The surface soil merges with the yellowish-brown gravelly subsoil, which in turn becomes grayish brown. There is little textural or structural development, but shot pellets are scattered throughout the upper layers. Like the associated Alderwood soils, the parent drift material, which occurs at depths of 20 to 26 inches, is derived largely from granite or similar rocks but includes considerable quartzite, shale, sandstone, and some basaltic and andesitic materials.

Though frequently farmed in conjunction with the Alderwood soils, the Everett are much less productive owing to their droughty character. The timber stands are dominated by Douglas-fir. The Everett soils are the least valuable of the more extensive upland timber soils.

Everett gravelly sandy loam, rolling (Ek).—This is the most extensive of the droughty gravelly soils associated with the Alderwood series. It is widely distributed throughout the rolling upland and terraces at elevations below 500 feet. The surface drainage is rapid and internal drainage excessive. It is a droughty soil and usually holds only sufficient moisture for early-maturing crops. Domestic water supply can be obtained only in deeply drilled wells.

In the virgin state this soil is covered to a depth of several inches by a partly decomposed dark-brown moderately acid organic layer. The surface soil of brown to pale reddish-brown gravelly sandy loam is sprinkled with shot pellets. At a depth of about 10 inches this changes to a moderately acid yellowish-brown gravelly loamy sand of coarse gritty character, containing a few scattered shot pellets. Below 24 to 26 inches are poorly assorted grayish sands and gravel derived from a wide variety of rocks, mostly granite and quartzite. The neutral sands present a salt-and-pepper effect from dark- and light-colored grains. Boulders and stone are occasionally found on the surface and are common throughout the underlying drift, which contains stratified sandy pockets, lenses, and cross-bedded layers. Stratified material is most frequent in the smoother terracelike areas. Gravel and stones or boulders seldom occur in sufficient quantity to prohibit cultivation, but locally small stoney areas are included from which farmers must remove stones before cultivating.

An area on the terraces between the Middle and South Forks of the Snoqualmie River east of Tanner has a somewhat thicker surface mat of organic material to which clings a thin, fragile, leached grayish-white mineral layer. This land has been logged off, and only a few small areas have been cleared for home sites or farms. The second growth consists of Douglas-fir and lodgepole pine with an undergrowth of salal.

Use and management.—All the merchantable timber has been removed from Everett gravelly sandy loam, rolling. The timber yield was not so heavy as on the associated Alderwood soils and consisted largely of Douglas-fir with a scattering of hemlock. The second growth is mainly Douglas-fir with which deciduous trees and brush and bracken fern are competing strongly. Systematic reforestation would improve the timber value.

Less of this land is cleared for farms than of the Alderwood soils. Because of its droughty character farmers generally find it unfavorable for all but early-maturing crops. Most of the cleared areas are along the coast in the more popular residential localities where they serve as home sites and garden and fruit tracts in association with the Alderwood and other soils. On the farms in the outlying districts this soil is frequently farmed in association with the Alderwood soils because of their interwoven pattern of occurrence. Usually similar crops are grown, but yields are lower than on the Alderwood soils and crops may not mature in dry years.

Of the hay crops red clover and ryegrass or timothy mixtures yield ¾ to 1¼ tons an acre and grains cut green about ¾ ton. Pasture crops are managed the same as on the Alderwood soils, but they have lower carrying capacity and the grazing season is shorter because of moisture deficiency. The cereal grains are seldom harvested for grain but are cured for hay. They often mature poorly and acre yields are low: Oats yield 15 to 30 bushels; barley, 10 to 20; and wheat, 5 to 10.

Strawberries are usually grown more successfully on this soil than on the Alderwood. Early crops are desirable for the best market prices and this soil is well drained and warms early in spring. Strawberries yield 2,000 to 2,500 quarts an acre. Raspberries and blackberries are also grown in commercial quantities. They do not yield so well as strawberries but do better than the tree fruits. From 1,500 to 2,500 quarts of raspberries and 2,500 to 3,000 quarts of blackberries are usually obtained per acre. Sour cherries yield better (1 to 2 tons) than the other tree fruits and are grown to a small extent for market. Other tree fruits are grown largely for home use. Fruit trees are often difficult to bring to bearing age owing to the droughtiness of the soil.

The soil is deficient in organic matter and nitrogen, and crops benefit by applications of superphosphate. To overcome these deficiencies legumes are grown in crop rotation in the same manner as on the Alderwood and other light-colored soils of the uplands and terraces. Superphosphate is applied at the same rate as on the Alderwood soils. Other management and cultivation practices are similar.

Everett gravelly sandy loam, hilly (Eg).—This soil occupies small areas of irregular relief scattered throughout the extent of Everett gravelly sandy loam, rolling. It occurs mostly on slopes along drainageways, on short slopes between terrace levels, and in the more strongly rolling and hilly uplands. The gradient ranges from 15 to 25 percent. The relief is unfavorable for efficient use of farm machinery, and the slopes are susceptible to accelerated erosion under cultivation. The surface soil is usually thinner and frequently coarser than on the more gentle slopes and is often stony and more gravelly. Little of the soil is farmed. It has all been logged off and is now in young scattered second growth of timber with a heavy brushy undergrowth in many places.

Everett gravelly sandy loam, gently undulating (EH).—This soil consists of inextensive areas of gently undulating relief in which the slope generally does not exceed 6 percent. It usually occurs on terraces or smooth areas in the rolling upland. Such areas have a more favorable relief for cultivated crops and farm sites than the rolling areas. They are, however, no more productive, and where a coarse gravel stratum is near the surface they may be more droughty. They have very similar profiles, though the subsoil is usually more stratified.

Everett gravelly loamy sand, rolling (EF).—This soil is widely associated with Everett gravelly sandy loam, rolling, but most frequently occurs on terraces and terracelike positions. It frequently includes small scattered smooth flat areas, but the relief is generally undulating to rolling. Surface drainage is rapid and internal drainage excessive. It is more droughty than Everett gravelly sandy loam, rolling, and gravel is usually more abundant and stratification of the material more pronounced. The profile is otherwise very similar except for the coarser texture of the surface soil.

Use and management.—All merchantable timber has been removed from Everett gravelly loamy sand, rolling, but very few areas have been cleared for farming or pasture. The land is generally considered too droughty for farm crops or satisfactory pasture. Stumps indicate the timber trees were scattered and relatively small; the yield was probably the lightest on any of the Everett soils. The second growth is largely of Douglas-fir with a thick understory cover of salal, Oregon grape, kinnikinnick, bracken fern, snowberry, rose, and blackberry. Systematic thinning in some areas and seeding and replanting in others would promote a better growth of timber.

GREENWATER SERIES

The Greenwater soil has developed on stream terraces of stratified subanglar coarse sand sprinkled with small angular gravel. The strata are usually more alkaline or basic in reaction than those of the Lynden soil. The soil occurs above an elevation of 1,000 feet and has some of the characteristics of soils developed under cooler temperature and higher rainfall. A discontinuous, or feebly developed, thin ash-gray layer is under the strongly acid surface organic mat. The reddish-brown or brown moderately acid surface soil is over a very slightly acid grayish-brown salt-and-pepper stratified subsoil.

The soil supports a dense growth of mixed conifers. Most areas are in virgin timber.

Greenwater sand (GA).—Areas of this soil occur on narrow well-drained terraces in the valley of the White River near Greenwater and support a dense growth of virgin timber. Where undisturbed, the surface soil is covered by a strongly acid organic mat under which is a thin somewhat discontinuous feebly developed ash-gray layer varying in thickness from a film to about one-half inch. The 9-inch surface soil is moderately acid reddish-brown sand. The upper subsoil, extending to about 24 inches, is slightly acid grayish-brown loamy sand with localized reddish inclusions in which the soil material adheres slightly in clusterlike masses. This is underlain by a very slightly acid salt-and-pepper brownish-gray stratified subangular coarse sand with a cattering of fine subangular gravel. The material is derived predominantly from andesitic and basaltic rocks. Some of the areas on the North Fork of the Snoqualmie River contain less of the basic soil material than is typical. In the wetter areas where the moisture is sufficient to support deciduous shrubs and water-loving vegetation are small areas of darker soil.

GREENWOOD PEAT

Greenwood peat (Gb) bogs are widely scattered throughout the county. They occur typically in deep basins, or kettle holes, and pot holes with poorly defined sluggish outlets. Water covers the surface in winter and remains at or near the surface for the rest of the year. Green or pale-green sphagnum and other mosses grow in mats up to 10 inches thick almost continuously over the surface of the peat. Thick growths of Labrador-tea (pl. 1, *B*) and a scattering of cranberries are most common over the central part of the bogs, but borders of invading spiraea and other vegetation usually occur.

The depth of the peat varies from 5 to more than 15 feet. The upper 36 inches is a very strongly acid, spongy, fibrous, yellowish-brown peat derived mainly from sphagnum but to some extent from other mosses. Between 36 and 60 inches is a strongly acid reddish-brown slightly decomposed but fibrous spongy moss peat in which are some woody particles and fibers from other forms of vegetation. This is underlain below 60 inches by a strongly acid darker brown more thoroughly decayed yet fibrous layer, predominantly of moss peat but containing remains of wood and sedge materials. This merges into dark greenish-brown sedimentary peat over the mineral substratum, which in turn occurs at variable depths.

Use and management.—Greenwood peat is nonagricultural owing to its strong acidity and fibrous raw character. Even if it had agricultural possibilities, drainage would be difficult or impracticable. Some commercial revenue is obtained by selling moss peat for packing, chicken bedding, and organic dressing to increase the humus content of lawns and gardens. Commercial cranberry bogs are developed on this type of peat.

INDIANOLA SERIES

The Indianola soils are more deeply developed than the Lynden soil. They occur in the rolling upland on eskers and kamelike sandy drift deposits and are derived from the same rocks as the drift giving rise to the Everett soils with which they and the Lynden are closely associated. A scattering of gravel frequently occurs and boulders are found occasionally. The surface soil is moderately acid brown to reddish brown, covered by a thin organic mat slightly more acid. Shot pellets are usually abundant. The subsoil is yellowish brown and mildly acid and grades into unoxidized and unmodified yellowish- or greenish-gray sands. Dark- and light-colored grains give a salt-and-pepper effect. About the same proportionate acreage as of the soils of the Everett series is cleared and farmed. The uncleared area is in second-growth timber and brush.

Indianola fine sandy loam, rolling (IB).—This soil is closely associated with the Alderwood and Everett soils. It occupies rolling areas of esker and kamelike relief in the upland. Surface runoff is rapid and internal drainage is free to somewhat excessive. The moisture-holding properties and drought resistance are better than in the Everett soils. The agricultural value therefore is slightly higher.

In virgin areas the surface soil is covered to a depth of several inches by a dark-brown partly decomposed moderately acid organic layer. The 12-inch surface soil is a moderately acid reddish-brown fine sandy loam containing some coarse sand grains, a considerable number of shot pellets, and occasional small pieces of gravel. The upper subsoil to a depth of about 30 inches is a moderately acid yellowish-brown sandy loam or loamy sand containing an occasional gravel. This is underlain by yellowish-gray or greenish-gray unoxidized unassorted salt-and-pepper sands with a scattering of gravel. These slightly acid to neutral sands are loose, porous, and without structural development. The deeper substratum frequently is stratified and becomes more gravelly. Occasional boulders are on the surface and embedded in the underlying material. The parent soil material has the same mineralogical origin as that of the Everett soils.

Use and management.—All the merchantable timber, which consisted largely of Douglas-fir with a scattering of hemlock, has been removed from Indianola fine sandy loam, rolling. Where the land has not been cleared for farming it is restocking to similar timber-producing trees. The cleared acreage, probably less than 10 percent, is scattered and small.

Most of the cleared and farmed acreage is near the coast. The crops grown are very similar to those on the closely associated Alderwood and Everett soils. The largest acreage is used for hay. Red clover with ryegrass and timothy is the most common and highest yielding hay crop with yields of 1 to 1½ tons an acre. Small grains cut for hay yield a little less than 1 ton. When these are harvested for grain, oats yield 20 to 30 bushels; barley, 15 to 25; and wheat, 7 to 15.

Because this soil retains moisture better, pastures have a slightly higher carrying capacity than those on the Everett soils and the land can be pastured later in summer. The most common pastures are old hayfields that have been invaded by white clover and grasses. The better pastures, however, include mixtures of alta fescue, ryegrass, tall meadow oatgrass, orchard grass, Kentucky bluegrass, and red, white, subterranean, and alsike clovers. Burned-over stump land can be successfully planted to ryegrass, orchard grass, and white clover and provide good pasture if competing vegetation, especially bracken fern, is controlled.

This is a better soil for strawberries than soils of the Alderwood or Everett series. Yields are 2,000 to 2,700 quarts an acre. Raspberries and blackberries yield better than on the Everett soils. Of the tree fruits sour cherries for market are most successful and yield 1 to 2½ tons an acre. Apples, pears, prunes, and plums are grown largely for home use, as methods for control of insects and diseases are not carried out successfully. Grapes do well. Farm gardens supply vegetables for home use.

Legumes in crop rotation are used largely to overcome the organic matter and nitrogen deficiencies. Alfalfa is excellent for this purpose and should be well adapted because of its deep-rooting habits. The alfalfa acreage is small, however, even though yields are better than for other crops. Most crops respond well to applications of superphosphate. The usual acre application is 300 pounds the first year followed by 200 pounds each succeeding year.

Indianola fine sandy loam, hilly (IA).—Areas of this soil occupy steep slopes along entrenched streams and steep areas in the upland. The slope ranges from 15 to 25 percent. Surface runoff is rapid, but erosion is at a minimum owing to the protective native vegetation, forest litter, and organic mat. Internal drainage is free to excessive.

Use and management.—The merchantable timber has been removed from Indianola fine sandy loam, hilly, and the land is restocking to similar timber types, largely Douglas-fir with a scattering of hemlock. Alder, willow, maple, and deciduous shrubs are strongly competing with this growth. Little of the soil has been cleared for farms. It is a good forest soil but not well suited to agriculture. The slopes are not favorable for use of farm machinery, and accelerated erosion would probably develop under cultivation.

Indianola loamy fine sand, rolling (IC).—The profile characteristics of this soil are very similar to those of Indianola fine sandy loam, rolling, except that the surface is loamy fine sand. This makes the soil a little less retentive of moisture. Surface drainage is well developed and rapid, and internal drainage is free to excessive. The soil occupies rolling to strongly rolling esker or drumlinlike areas in the upland.

Use and management.—Indianola loamy fine sand, rolling, has been logged over, and uncleared areas are restocking to similar timber trees, largely Douglas-fir with a scattering of hemlock. As with the associated soils, these stands are often thin and have considerable competition from alder, willow, maple, and deciduous shrubs. The timber-producing value could be materially increased by restocking to increase the valuable timber trees. About the same small proportion is cleared and cultivated as of Indianola fine sandy loam, rolling. Crops and cultivation practices are the same, but yields are usually slightly lower. Some areas were included with Everett loamy sand in the early reconnaissance survey (7).

ISSAQUAH SERIES

The Issaquah soil has developed under restricted drainage of the subsoil and substratum. It has a very dark-brown to nearly black mildly or slightly acid highly organic surface soil over a yellowish-brown upper subsoil that overlies a lower subsoil of yellowish-brown or light grayish-brown highly iron-stained or mottled interstratified sand, clayey sand, and occasional sandy clay. The subsoil is very slightly acid to neutral or slightly alkaline. Gravel usually occurs in the substratum.

Issaquah silt loam (Id).—This soil occurs mainly near Issaquah at the southern end of Sammamish Lake. A few scattered areas are near North Bend. In general the relief is gently sloping with slight undulations or sags and swells. Small basins and shallow abandoned drainage depressions are frequent. Both surface and internal drainage are slow, and tile drainage is necessary before the soil can be fully utilized. The typical surface 12 inches is a slightly acid very dark-brown to nearly black granular silt loam. Numerous small basins are included, and flat areas are frequently of silty clay loam texture. The surface soil changes abruptly to a dull yellowish-brown or reddish-brown slightly to very slightly acid silty clay loam layer about 6 inches thick. The 18- to 25-inch subsoil is composed of brown very slightly acid to neutral stratified sandy clay, clay loam, and clayey sand that is micaceous, gritty, and highly mottled with rust brown or streaked with light grayish brown or brownish medium gray. Rusty reddish-brown layers slightly cemented by iron are not uncommon, and occasionally thin beddings of dark mucky layers occur. These deeper substrata materials are neutral to slightly alkaline and usually contain interstratified gravel layers. A scattering of gravel sometimes occurs in the lower subsoil.

Use and management.—Most of Issaquah silt loam is farmed. It is used chiefly for permanent pasture and hay crops in conjunction with dairying. The hay mixture is usually red and alsike clovers with ryegrass and sometimes timothy. This yields 2 to 3 tons an acre when two cuttings are made. The second crop is frequently pastured. Permanent pastures are usually mixtures of alsike and white clovers with ryegrass. The carrying capacity can usually be increased by including alta fescue, orchard grass, and Kentucky bluegrass. The pasture is excellent for long periods because of the plentiful moisture supply, but the wet condition of the soil in the rainy winter months prohibits its use for grazing at that time.

Owing to the gentle natural slope and the permeable character of the subsoil, this land can be effectively drained when tile drains are properly installed. It is a wet late soil and is most successfully used for hay and pasture. Plowing and preparation of seedbeds are late because of the winter saturation, especially in the depressions that remain wet for extended periods. Superphosphate increases the hay yields and carrying capacity of the pastures. Rates of application are the same as for the other soils of the stream bottoms.

KITSAP SERIES

The Kitsap soils are in the lower basin area with the Alderwood and associated soils at elevations below 500 feet. They are developed on eroded remnants of fine-textured lacustrine sediments, largely silt and clay, probably of glacial lake origin. The soils occur mostly marginal to the rolling upland along the larger entrenched stream valleys and lakes. Their relief is generally undulating to gently sloping, but both flat and steep areas are frequent. Surface runoff is rapid but internal drainage somewhat restricted. The Kitsap are considered among the most drought-resistant soils of the area and are widely used for small-grain crops and hay.

The dull brown to grayish-brown surface soil is moderately acid and filled with rust-brown shot pellets. In uncleared areas it is covered with a dark-brown organic mat more acid than the surface soil. The heavy-textured upper subsoil is moderately to mildly acid, drab, mottled grayish brown, and sprinkled with shot pellets. The lower subsoil is slightly acid and highly mottled with iron stains and rests on slightly acid to neutral unmodified bluish-gray stratified and laminated sediments of clay and silt.

Kitsap silt loam, undulating (KB).—This soil occurs in association with the Alderwood, Everett, and Barneston soils, mainly on terraces in the deeply entrenched valleys of the larger streams and glacial lakes. It has developed on eroded glacial lake or other fine-textured sediments having their origin in a variety of rocks. The relief is mostly gently undulating to gently sloping, but occasional small flat or level areas occur. Surface drainage is usually complete, but internal drainage is somewhat retarded. Domestic water supplies can be obtained from shallow wells.

In virgin areas there is a moderately to strongly acid dark-brown partly decomposed organic layer 1½ to 2 inches thick. This layer is frequently bound together by fine surface roots in the more moist areas. Where typically developed the surface soil below this to a depth of about 12 inches is moderately acid dull-brown or grayish-brown and faintly reddish heavy silt loam that is plastic when wet but crumbly when dry or moist. It contains an abundance of rust-brown shot pellets of buckshot to pea size. The upper subsoil is drab-yellow and brown mottled grayish-brown silty clay loam, containing fewer shot pellets than the surface soil. It is mildly acid. The lower subsoil between 24 and 40 inches is a slightly acid brownish-gray silty clay streaked and spotted with yellow and rusty brown and faintly laminated. This is underlain by bluish or slate-gray horizontal compact laminated clay with seams or thin layers of silt and very fine sand. This clay is slightly acid to neutral and continues to undetermined depth.

The surface soil in many places varies in thickness and in color, ranging from yellowish or lighter grayish brown to dark brown within short distances, depending on slope and surface and internal drainage conditions. The clay stratum is darker and more compact and laminated in the lower western part of the area than in the eastern. In the valley of the Snoqualmie River it is light or yellowish gray and more thickly stratified. The drainage here is more effective, and the surface soil is often more yellowish brown. Gravel and stone are infrequent, but in areas that are closely associated or merge with glacial drift materials, small quantities may occur. A few small included areas south of Tolt (Carnation P. O.) have a clay loam surface soil over a tight clay subsoil.

Use and management.—Probably about half of Kitsap silt loam, undulating, is cleared for farms. It is one of the most productive of the light-colored soils of the uplands and terraces for hay, pasture, and small grains. It is somewhat colder and later than many of the associated soils but has greater moisture-retaining capacity and holds moisture well in the dry summer. The hay crops are largely red clover with ryegrass and timothy mixtures that yield 2 to 3 tons an acre. Occasionally a small second cutting is obtained but this growth is usually pastured. Small grains that are used mainly as nurse crops for the permanent hay crops yield about 1½ tons an acre. Sweetclover and subterranean clover could probably be successfully grown for hay and pasture, but alfalfa would have to be confined to higher areas of more rapid drainage.

Hayfields can be pastured more successfully and for a longer period following the removal of the hay crops than on any of the associated Alderwood, Everett, Barneston, or Indianola soils. Permanent pastures also have a greater carrying capacity and can be grazed for a longer period. Many pastures are old hayfields that are revegetating to native grasses and white clover. The more productive pastures, however, are those that are seeded to a mixture recommended by the State Agricultural Extension Service. This includes alta fescue, English and Italian ryegrasses, tall meadow oatgrass, orchard grass, Kentucky bluegrass, and common white, red subterranean, and alsike clovers. Lands that have been cleared but are still covered by stumps are successfully pastured, provided the competing native vegetation and weeds are kept under control. These areas are usually seeded following burning, as it is otherwise difficult or impossible to get a satisfactory stand. Ryegrass, orchard grass, and white clover seem to be the best for these pasture mixtures.

Though larger yields of small grains are obtained on this soil than on the more droughty soils of the uplands, they are not commonly harvested for grain. Harvesting and threshing is difficult because of the fall rains, and the tracts are not large enough to justify purchase of the necessary harvesting and threshing equipment. Oats yield 40 to 50 bushels an acre; barley, 30 to 40; and wheat, 15 to 25.

Near Seattle and Hobart and in other localities small tracts are used for fruits and berries, which grow and produce best on the higher or more sloping areas that have the best drainage. This soil is late and cold for early strawberries. Raspberries and blackberries yield about the same as on the phases of Alderwood gravelly loam; tree fruits are grown mostly for home use and also yield about the same. Vegetables are grown in home gardens and usually do well, but the soil is somewhat wet and cold for potatoes.

This soil has the same deficiencies as the associated light-colored soils. Proper rotation with legumes and application of available barnyard manure increases the organic matter and nitrogen content and consequently improves crop production. Supplementary application of superphosphate at the acre rate of about 300 pounds the first year and an additional yearly application of 200 pounds is practiced by the more successful farmers.

Farmers find this soil a little more difficult to plow and cultivate than the associated light-textured gravelly soils. It dries out slowly in spring and often not uniformly because of minor depressions that remain wet. During clearing and leveling operations much clay is brought to the surface and mixed with it, making it heavier than in the virgin condition. This soil is often put into seeding condition late, but sufficient moisture is retained during the dry summer to mature crops.

The uncleared areas support a second growth of Douglas-fir, hemlock, and cedar, with considerable alder, willow, maple, and deciduous brush. The stand of the valuable timber trees could be materially improved by artificial restocking.

Kitsap silt loam, hilly (KA).—This soil occupies moderately steep slopes and more irregular relief than the undulating soil of this series. Is is unsatisfactory for cultivated crops because it is difficult to traverse with farm machinery. The soft sediments are also readily susceptible to erosion, which would become accelerated under cultivation. Small areas in which a wet condition is maintained by seepage are frequent. The surface soil is usually thinner than in the undulating soil, and the subsoil is sometimes exposed on the steeper slopes. On most of the area, however, the native vegetation and organic mat effectively hold erosion in check. The soil is in second-growth Douglas-fir, hemlock, and redcedar. There is frequently a thick association of alder, maple, willow, and deciduous shrubs, especially in the more moist or seepy areas. It has the same capacity for timber production as the undulating soil.

KLAUS SERIES

The Klaus soils occur on rolling to strongly rolling and hilly relief adjacent to the foothills and mountains at elevations above 1,000 feet. Scattered boulders frequently cover the surface. Under a heavy rainfall and cool temperature these soils have become strongly acid and have definite Podzol profile characteristics that distinguish them from the Everett and Barneston soils. The organic layer is humified and strongly acid and has promoted the development of an irregular thin leached gray layer immediately beneath. Under this leached layer the surface soil is rusty brown, irregular in thickness, and in places more reddish, compact, and harsh. It averages about 7 inches thick and irregularly grades to a yellowish-brown layer that is over poorly assorted glacial drift similar to that of the Barneston soils. The subsoil and underlying drift deposits are slightly modified by infiltrated clay and iron.

Owing to the remote location and generally unfavorable relief, these soils have not been cleared for farming or pasture. Only a few small areas adjacent to the Snoqualmie National Forest east of the Snoqualmie River remain in virgin forest. The rest has been so recently cutover and burned that the second growth is not yet well established.

Klaus gravelly loam, rolling (KD).—Characteristically this soil is of more definite morainic relief and contains more stone and boulders than most of the Barneston soils, although the parent drift materials are similar in origin and composition. External drainage is well developed and rapid and internal drainage excessive. Areas are in remote sections adjacent to the foothills and mountains.

In virgin forested areas a very acid humified 2- or 3-inch organic layer covered with forest litter covers the surface mineral soil. The mineral soil is leached light brownish-gray sand or loamy sand that is less than an inch to 2 inches or more thick and grades to rusty-brown or rich reddish-brown gravelly gritty loam. This surface layer is strongly acid. At an average depth of 11 or 12 inches this is irregularly underlain by moderately acid yellowish-brown gravelly gritty heavy loam showing some reddish iron staining. This grades at about 28 to 36 inches to yellowish-gray iron-stained poorly assorted sand with gravel, stone, and occasional boulders. The gravels and stone are coated with clay. The material is moderately acid and becomes coarser with depth, and the clay coating and iron staining disappear.

The gray layer that underlies the organic mat varies considerably in thickness from place to place and is most strongly developed in protected places of deep forest litter and near the tree trunks in the protection of large radiating roots. It is most conspicuous in the dry summer. After logging operations and burning it often disappears in all but the more protected places. The surface soil is usually more reddish and compact and the subsoil more highly stained where the light-colored layer is most deeply developed. In places the subsoil material is slightly cemented in small irregular ortsteinlike fragments.

Use and management.—None of Klaus gravelly loam, rolling, is cleared or farmed, and it is best adapted to forest. In the virgin state it supports dense stands of large lumber-producing trees. Douglas-fir predominates, but there is considerable hemlock and some redcedar. Only a small area adjoining the national forest remains uncut. The rest of the area has been so recently logged off and burned over that a favorable second growth has not yet been established (pl. 2, *A*). Systematic reforestation would materially aid in restocking to valuable forest growth. Since the soil is in the higher more remote sections, it will probably remain in forest indefinitely.

Klaus gravelly loam, hilly (Kc).—Areas of this soil occupy 15- to 25-percent slopes along drainageways, foothills, and the more ridgy morainic areas. Surface drainage is rapid, but accelerated erosion is rarely developed because of the protective native vegetation, forest litter, and organic mat. Stone and boulders frequently occur on the surface, and in many places the surface soil is thinner and more gravelly than that of the rolling soil.

Use and management.—Klaus gravelly loam, hilly, is a good forest soil but is unsuited to farming. Many of the slopes are unfavorable for farm machinery. Most of the land has been logged off, but little has been cleared for farms. It is slowly restocking to valuable timber trees. Systematic reforestation would add materially to the value of the new growth.

LYNDEN SERIES

The Lynden soil resembles the Indianola soils but is found on smoother terracelike positions or on glacial deltas. It is occasionally darker or more reddish brown. The sandy material is stratified and gravel is not common, although it may occur in the deeper subsoil or substratum.

Lynden loamy sand (La).—Most of this soil occurs northeast of Redmond. It occupies smooth level terraces of stratified sand in which stone is absent and gravel less common than in the Indianola soils from which it is distinguished by its topographic position and redder surface soil. This soil is similar to the Indianola soils in that it absorbs water readily but does not retain it well. It is less droughty, however, than the Everett soils and holds moisture better in the dry summer.

In virgin areas the surface soil is covered by forest litter under which is a 2-inch moderately acid dark-brown organic layer of matted roots mixed with some sand. The surface soil is moderately acid rich reddish-brown loamy sand with considerable coarse sand and a scattering of shot pellets. The upper 10-inch subsoil is a moderately acid yellowish-brown loamy sand. At about 26 inches are unmodified and unoxidized yellowish- or greenish-gray sands with dark and light grains. The bedding is thick, but with depth it becomes thinner and the stratification more conspicuous. These materials are slightly acid to neutral. East of Redmond and in other scattered localized areas the surface soil is of somewhat lighter texture. Some of the lower lying areas near Sammamish Lake are also grayer than the typical soil. In the upper part of the valley of Bear Creek the soil materials contain more gravel in the subsoil and substratum than farther south.

Use and management.—The same crops are grown on Lynden loamy sand as on the Indianola fine sandy loam soils, but yields are usually slightly higher owing to the smoother relief that promotes more uniform growth. A slightly larger proportion of this soil is cleared. The uncleared area is in second-growth timber trees, largely Douglas-fir with a scattering of hemlock. Deciduous trees and brush are frequently thick, especially in those places adjacent to the moister areas.

MADE LAND

Made land (Ma) consists of areas that have been built up or extensively modified by man by dredging, grading, or industrial operations. Some graded areas have the soil removed to a depth of several feet. An extensive area occurs in southwestern Seattle where water-laid clays and glacial drift have been artificially deposited in reclaiming shallow swampy areas for building sites and streets. At other locations, noticeably north of Seattle, extensive grading and leveling processes have exposed the underlying drift.

MARSH

Areas of fresh water marsh (Mb) and swampy areas, bordering lakes and in flat undrained basins where the water table remains at or above the land surface during the year, support a cover of reeds, sedges, and cattails. The soil frequently consists of thin peaty layers over light- or bluish-gray mineral soil material. The borders of these areas may support a growth of spiraea, willows, and other shrubs or deciduous trees. Most of these areas cannot be drained artificially. Some small areas lie adjacent to Lake Washington.

MUKILTEO PEAT

The largest areas of Mukilteo peat (Md) occur on stream delta deposits or other flat areas adjacent to lakes, but other areas are extensively scattered throughout flat upland depressions. They are usually more swampy and open than Rifle peat and are often inundated for a considerable part of the year. There is usually a gradual transition from an open sedge, reed, cattail, and marsh grass vegetation to tree- and brush-covered areas resembling Rifle peat areas.

In a representative area the surface 8 inches is a moderately acid brown to dark-brown spongy finely fibrous peat that is bound together by roots of sedges and coarse marsh grasses. Greasy finely decomposed material of colloidal nature makes up a large part of this layer. The moderately acid brown 8- to 24-inch layer is fibrous and matted partly decomposed sedge peat of a smooth greasy consistence from the high content of colloidal peat. The slightly acid 24- to 60-inch material is a very fibrous and matted raw sedge peat embedded in a minor quantity of brown greasy organic colloidal material. Between this and the mineral substratum are colloidal sedimentary peat materials more or less mixed with mineral materials at the lower limits. The mineral substratum occurs at extremely variable depths.

Though predominantly of sedge and reed origin, Mukilteo peat often contains the remains of many other materials. Woody materials derived from trees and brush, however, are confined mainly to the surface owing to the natural succession of plant growth in peat development. Layers of peat derived from mosses are not uncommon in areas in the upland depressions. In numerous small kettle holes and pot holes of sluggish outlet in the uplands, the peat is often difficult to identify owing to the fine colloidal material that obscures the parent fibrous material, especially in the deeper parts. These holes are usually swampy and often covered with water much of the year. They support sedges and cattails in the central parts but are surrounded by invading growths of spiraea. Both sedge and other fibrous material appear in the surface layer, and probably moss peat occurs in the deeper colloidal materials. The more acid nature, small size, and difficulty in draining make these inclusions less valuable for agriculture than the typical peat, and few areas are cultivated. Several small areas of dark-brown sedimentary peat are also included.

Use and management.—Drainage is necessary before Mukilteo peat can be properly utilized for cultivated crops. Many areas, especially those bordering lakes or in deep kettle-hole depressions, are difficult or impossible to drain. Probably only about one-third of the total area is drained and used for farm crops. It is commonly a little more acid and raw than Rifle peat and less productive of most crops. Although similar crops are grown, yields are usually lower. Small areas near Seattle are used for nursery stock, but the plants suffer from mineral deficiency if not moved while very young. Perennial flowers, bulbs, and rock garden plants are also grown. Drainage and management practices are similar to those used on Rifle peat.

MUKILTEO PEAT, SHALLOW

Shallow Mukilteo peat (Me) occupies areas in which the peaty material over the mineral substratum is less than 3 feet thick. It occurs largely along borders of deeper Mukilteo peat areas, but scattered areas are widely distributed in shallow basins. In virgin areas the drainage conditions and the native cover are the same as on the deeper peat. About the same proportion is farmed, and similar crops are grown. Yields are about the same. The deeper rooting crops probably profit from contact with the underlying mineral soil.

NOOKSACK SERIES

The Nooksack soil is derived from the same granites and related rocks as the Edgewick series and has a similar surface soil. It has a thickly bedded smooth uniform silt and very fine sand subsoil, becoming slightly heavier and plastic in the lower subsoil. When dry, the subsoil has a pale greenish-gray cast.

Nooksack silt loam (NA).—This soil occurs in the vicinity of Snoqualmie Falls and other places in the valley of the Snoqualmie River. It occupies smooth alluvial flats of wavy slightly undulating relief and is occasionally flooded late in winter or early in spring. Runoff is generally fairly rapid because of the slightly elevated position. Most of the soil below Snoqualmie Falls is well drained, but areas above it are frequently low and flat with slow drainage. In such areas the deeper subsoil is heavier textured and mottled. Most of these areas are artificially drained. North of Snoqualmie several small unfarmed areas are saturated and marshy because of the slow drainage caused by impounded water in sawmill ponds.

The 10-inch surface soil is very slightly acid dull yellowish- or grayish-brown smooth mellow silt loam with a faint greenish cast when moist. This is underlain to about 36 inches by a very slightly acid to neutral grayish olive-drab uniform smooth mellow heavy silt loam, which is free from discoloration but has a greenish-gray cast when moist. Under this to a depth of about 70 inches is very similar material, which is frequently slightly heavier and shows some rust-brown mottling. In lower flat areas this mottling is more pronounced. The underlying substratum material is thickly stratified, fine-textured, micaceous, and yellowish gray.

Use and management.—Most of Nooksack silt loam is farmed. It is used for a wide variety of crops but principally for hay, permanent pasture, and small-grain crops in association with dairying. Near Fall City Station some is used for truck crops. Both root and leafy vegetables are grown successfully, but yields are somewhat lower than on Puyallup silt loam, largely because the Nooksack soil is lower in organic matter and the soils in this section are not fertilized so heavily or farmed so intensively. Under similar management, yields would probably be almost the same. At and near Snoqualmie a considerable area is used for home sites, usually with small garden and fruit tracts. Berries yield well, and fruit trees are grown successfully where underdrainage is sufficient.

Red clover and occasionally alsike clover with ryegrass and timothy mixtures are the most popular and highest yielding hay crops. Yields of 2 to 3¼ tons an acre are obtained. The second growth is frequently pastured. Sufficient subsoil moisture is available for a heavy growth and for late grazing on the hayfields and permanent pastures. Permanent pastures commonly include red and alsike clovers with ryegrass mixtures. White clover comes in from natural revegetation. The State Agricultural Extension Service recommends inclusion of alta fescue, orchard grass, and Kentucky bluegrass in the mixtures.

Small grains, usually oats, are used as nurse crops for seedings of hay and pasture mixtures. These are commonly cut for hay and yield about 1½ tons an acre. Corn is grown for silage, and yields average about 11 tons an acre.

This mellow friable soil is readily tilled under a wide range of moisture conditions. The moisture-holding capacity is excellent, and moisture is held well for late crops. It has a high inherent mineral fertility and almost neutral reaction but is low in organic-matter content and nitrogen. Legume crops respond well to applications of superphosphate. Hay and pasture mixtures with clover are used in the rotation to increase and maintain organic matter and nitrogen. Superphosphate applications are usually given these mixtures at the acre rate of 300 pounds the first year and 250 pounds each succeeding year. This materially increases yields of hay and other crops.

NORMA SERIES

The Norma soils [10] occupy glacial basins and depressions that have been modified by erosion and deposition. The surface soil is very dark brown, highly organic, and moderately acid. The slightly acid to neutral gray, yellow, and brown mottled subsoil of stratified sand and gravel rests on gray stratified sand and gravel or sandy drift that is coarser than the substrata material of the Bellingham soil. These soils are usually more effectively drained than the Bellingham soil and therefore are suitable for a wider range of crops and can be more extensively and completely utilized under cultivation.

Norma fine sandy loam (Nb).—This soil is widely distributed in upland depressions, most frequently associated with the Alderwood and Everett soils. It is much more desirable than those soils for the important crops of the area because of its higher fertility and adequate moisture supply. It is wet and marshy in the virgin condition and must be drained before it can be successfully farmed. Owing to the permeable character of the subsoil and to the relatively small size of the individual areas, it is usually improved with a minimum of drains if there is proper outlet. Low-lying areas without feasible outlets that cannot be successfully drained are uncommon.

The 10-inch surface soil is a moderately acid highly organic slightly gritty very dark-brown fine sandy loam. The surface few inches in many places contain a large quantity of finely divided mucky organic matter. The upper subsoil is slightly acid to neutral lighter brown or dull brownish-gray slightly gritty silt loam or fine sandy loam mottled with yellow and brown. It is underlain below about 24 inches by stratified sand with some gravel and occasional heavier textured layers. These layers are light gray mottled with yellow, brown, and other iron strains and are slightly acid to neutral.

Use and management.—Probably more than 80 percent of Norma fine sandy loam is used for cultivated crops or permanent pasture. Many areas are being cleared and drained at present. The moisture

[10] The Norma soils had not been recognized at the time of the early reconnaissance survey (7), and small areas of Norma soils of the present survey were included with the Bellingham series in the reconnaissance classification and mapping.

supply is adequate, and the soil is highly productive when effectively drained and properly managed. The principal crops are hay, pasture, small grains, and truck crops. Red or alsike clover with ryegrasses and timothy are the most popular hay crops. These yield 2 to 3½ tons an acre. A small second cutting can usually be obtained, but the common practice is to pasture this second growth. Permanently wet low areas are often seeded to reed canarygrass, which gives yields of 3 to 5 tons of hay an acre or provides good all-year pasture. Permanent pastures are seeded to clover and grass mixtures. Pasture mixtures of alsike and common white clovers with alta fescue, Italian and English ryegrasses, orchard grass, and Kentucky bluegrass, recommended by the State Agricultural Extension Service, provide excellent pasture. Pastures are superior to those on the lighter colored associated soils and can be grazed for a longer period each season. Land on which stumps remain can usually be successfully seeded to similar mixtures following burning; otherwise, it is difficult to get a satisfactory stand because of the competing native vegetation.

Small grains are usually used as nurse crops for hay and pasture mixtures. They yield about 1½ tons an acre as hay and are seldom harvested for grain. When grown for grain, oats are the most satisfactory for this soil, and acre yields of 60 to 70 bushels are obtained.

Though a wide variety of garden and truck crops can be grown, this soil is not so satisfactory for commercial use as soils of the stream bottoms because of its widely scattered distribution in small bodies. Peas, cabbage, cauliflower, lettuce, spinach, and carrots are the most common truck crops, but turnips, radishes, and tomatoes are also grown. Many of the peas are grown for frozen pack. Acre yields are 1¾ to 2¼ tons of green shelled peas and 550 to 700 hampers of green market peas. Cabbage yields 225 to 325 crates per acre; cauliflower, 450 to 625; lettuce, 225 to 325; spinach, 350 to 500; and carrots, 200 to 325. Mangels are grown as root forage and yield 20 to 30 tons an acre. This soil is a little cold and wet for potatoes, and insects and diseases are difficult to control. Berries are sometimes grown on the higher better drained areas.

This highly organic soil is granular and friable and can be worked under a fairly wide range of moisture conditions when properly drained. Owing to the small size of the areas, they are often successfully drained with small open ditches. Clover is usually fertilized with a 300-pound acre application of superphosphate the first year and a 200-pound application each succeeding year. Barnyard manure is applied heavily to all truck-garden soils and frequently supplemented by a complete fertilizer. A 3–10–7 mixture is usually used for leafy vegetables and a 4–10–10 for root vegetables. These are applied at the rate of about 800 pounds an acre.

As mapped the soil includes small areas of somewhat lighter texture than typical. These occupy slightly more elevated and better drained positions and are considered slightly more productive of small grains, potatoes, and root crops but less desirable for leafy vegetables.

Norma silty clay (Nc).—This soil lies in scattered bodies in the uplands in low swampy depressions that are difficult or impossible to drain and therefore are uncleared or used for permanent pasture. Reed canarygrass can be used successfully for such land. The native vegetation is largely alder, vine maple, and willow, and some scattered redcedar. Sedges and water-tolerant grasses are found in the more open areas.

The surface soil to a depth of about 4 inches is slightly acid highly organic or mucky granular silty clay. From 5 to 20 inches is dark drab grayish-brown silty clay highly mottled with rust-brown iron stains. It has a rubbery consistence but is greasy and slick with organic matter and is very slightly acid. Below 20 inches the very slightly acid to neutral stratified clayey sand and sand are bluish gray but discolored with rusty brown, yellow, and green.

OSO SERIES

The Oso soils have a rolling or strongly rolling to hilly and steep relief. They are developed from weathered andesite and basalt thinly mantled by glacial debris. The surface soil is dull grayish brown, the subsoil somewhat greenish olive brown, and the substratum purplish brown, usually variegated or spotted with yellow, red, and rusty brown in the more weathered material. Gravel and stone are deeply embedded in the disintegrating substratum. Both the surface soil and subsoil are slightly acid to neutral and are retentive of moisture. Small areas of favorable relief have been farmed successfully, but the relief in the larger areas is more favorable for forest.

Oso loam, rolling (Ob).—Most of this soil lies at an elevation of about 500 feet on rolling to strongly rolling relief, although minor smoother undulating areas occur. Surface drainage is usually well developed though there are occasional depressions of trapped drainage. Internal drainage is normally slow but adequate. The soil occurs east of Duvall and in the valley of the White River east of Enumclaw. In virgin wooded areas this soil is covered with a forest litter under which is a root-matted very slightly acid granular organic and mineral layer several inches thick overlying the mineral soil. The surface soil is very slightly acid to neutral dull grayish-brown friable loam. Shotlike pellets are abundant and there is a sprinkling of gravel. The 12- to 40-inch subsoil is yellowish or greenish olive-brown friable but plastic clay loam that is very slightly acid to neutral. It contains a scattering of shot pellets and gravel. Between 40 and 60 inches is a very slightly acid to neutral dark purplish-brown clay loam with decomposing yellowish fragments of andesite and a few embedded gravel of glacial origin. Below this is a dark-purple or purplish-brown layer of crumbly decomposing andesite spotted with yellow and white phenocrysts.

The soil varies somewhat from place to place depending on the thickness of the glacial mantle and the character of the underlying bedrock. In areas where a glacial mantle almost completely covers the bedrock, the soils are more yellowish brown and gravelly. Where they are more closely associated with the bedrock they are darker brown and relatively free from gravel. Such areas are also frequently wetter and darker. Where derived from basalt the soil is usually more reddish brown than where developed from andesite. The areas in the valley of the White River are developed on deeply weathered andesite and are more yellowish or reddish throughout the profile than typical.

Use and management.—All of Oso loam, rolling, has been logged off. A few areas are cleared for farms and home sites. The uncleared areas are slowly restocking to valuable timber growth. More favorable stands could be obtained if artificial seeding and replanting were undertaken. Large areas having a strongly rolling relief are more favorable for growing timber than cultivated crops.

The small cultivated acreage is planted to home gardens, fruits, hay, and small grains. This soil, like the other light-colored forest soils, is deficient in organic matter, nitrogen, and available phosphorus, but these can be built up to a satisfactory level by rotation with legume crops and application of superphosphate. This soil has the capacity for holding moisture well in dry summer, yet it does not become waterlogged in the winter and spring except in local depressions or in areas shallow to bedrock. Crops yield a little higher than on the Alderwood soils.

Oso loam, hilly (OA).—This soil occupies slopes of 15 to 25 percent in areas of irregular and hilly relief. It is better suited to timber trees than to cultivated crops and would be difficult to traverse with farm machinery. Accelerated erosion would be difficult to control. The soil is shallower and less fertile than the associated rolling soil.

PILCHUCK SERIES

The Pilchuck soils occur on alluvial bottom lands. They are developed on relatively open and porous stratified sandy material derived from a variety of rocks. The surface soil is grayish brown, and the subsoil is lighter grayish brown with rust-brown mottling. Surface drainage is adequate, and internal drainage is free, but the soils are subject to overflow.

Pilchuck loamy fine sand (PA).—This soil is widely distributed as small bodies and occupies the natural levees along streams or the higher swells and undulations in the principal stream valleys. It drains freely and the moisture-retaining capacity is lower than in the Puyallup soils. To a depth of about 12 inches the surface soil is a very slightly acid grayish-brown to medium grayish-brown mellow uniform loamy fine sand. The upper subsoil to about 34 inches is a very slightly acid to neutral somewhat lighter grayish-brown stratified loamy fine sand with rust-brown mottling. Below this are very slightly acid to neutral stratified light bluish-gray fine sand and sand. Gravel occurs occasionally throughout the soil, and stratified gravel is not uncommon in the lower subsoil or substratum.

The soil includes a few higher lying areas that are somewhat lighter brown in the surface soil and lighter gray in the subsoil. Surrounding Lake Washington are areas that were submerged until the lake was permanently lowered by the construction of a canal to Lake Union. Some areas remain in a swampy condition. Coal-contaminated sediments from tributary streams give some areas a darker color than typical. Reclaimed areas have become largely building sites and permanent pasture. In the upper courses of many of the larger streams the surface soil is frequently lighter grayish brown than typical.

Use and management.—Probably 70 percent of Pilchuck loamy fine sand is used for permanent pasture and cultivated crops. The uncleared areas are largely in deciduous trees or brush, which may afford some pasture or browse. More than half the cleared area is in permanent pasture; the other part is used largely for hay and general farm crops and occasionally for truck crops where it is closely associated with the more productive Puyallup soils. The hay mixtures, largely red clover with ryegrass and timothy, yield 2 to 3 tons an acre. Oats used as a nurse crop for hay and pasture mixtures yield about 1¼ tons per acre. Pasture mixtures are similar to those used on the other lowland areas. The carrying capacity is lower and the grazing season shorter in dry years than on Puyallup fine sandy loam, and when truck crops—usually root or tuber vegetables—are grown, yields are lower.

Pilchuck loamy fine sand, shallow (PB).—Consisting of areas of shallow gravelly loamy fine sand over coarse stratified gravel, the surface material of this soil rarely exceeds 15 inches in depth. These areas are largely along stream courses, and the frequent floods often produce changes in surface texture and depth to gravel. The soil is largely uncleared and supports a scattered growth of conifers and a dense growth of deciduous trees and brush. It has little agricultural value other than for permanent pasture. Permanent pastures have a low carrying capacity and because of droughtiness afford grazing for only a short period.

PUGET SERIES

The Puget soils occupy low basins or flat stream bottoms associated with the Sultan soils. They have a slightly to very slightly acid light grayish-brown or light brownish-gray surface soil slightly mottled with rusty iron stains. The heavy-textured stratified subsoil is very slightly acid to neutral, light gray, and highly mottled and stained.

Puget silty clay (PC).—This soil occupies low permanently wet or marshy areas that are often inundated a large part of the year. It cannot be sufficiently drained for cultivated crops and is used for improved permanent pastures or remains as swampy areas supporting cattails, sedges, spiraea, and water-tolerant grasses. Seaside bent, bluegrass, and white clover provide the main grazing on areas from which surface waters can be removed by surface drains. Reed canarygrass is excellent for these situations. A mixture of meadow foxtail and big trefoil (*Lotus uliginosus*) also has proved satisfactory for wet land. Spike sedge (*Carex* spp.) competes very strongly with pasture grasses.

The 10-inch surface soil is a very slightly acid light brownish-gray silty clay mottled with rust brown. The upper subsoil to a depth of about 20 inches is a very slightly acid light bluish-gray laminated silty clay or clay mottled with rust iron stains. The lower subsoil is light-gray stratified and laminated rubbery clay of neutral reaction, usually discolored with blue, green, and brown stains.

Puget silty clay loam (PD).—This soil is the most extensive and important of the Puget series. It is widely distributed throughout the larger stream valleys, the largest bodies occurring in the valleys of the Sammamish, Snoqualmie, and Green Rivers. Areas occupy low flat bottom positions and scattered low basins and depressions throughout the stream bottoms. They lie slightly higher than Puget silty clay and frequently surround organic soils. In winter and spring the land is inundated, and it remains permanently wet and waterlogged unless artificially drained. In the valley of the Snoqualmie River floods carry sediments into the low areas, and tile drainage is usually impractical. Open drains, however, remove surface water sufficiently so that the soil can be pastured for a long summer season and hay may be grown on the higher better drained areas. These better drained areas are on the most prominent swells and undulations between sags and drainage channels of an otherwise smooth flat relief.

The surface 3 inches in typical areas is a slightly acid light grayish-brown or light brownish-gray slightly mottled with rust-brown silty clay loam that has a feebly developed crumb structure. Between 3 and 14 inches the soil becomes slightly acid light brownish-gray silty clay loam somewhat laminated and lightly mottled with rust brown. The subsoil is very slightly acid to neutral light-gray stratified and laminated silty clay and clay mottled with iron stains.

Use and management.—Most of Puget silty clay loam has been cleared for hayfields and permanent pasture. Small uncleared areas support scattered second growths of hemlock, redcedar, and some Douglas-fir. Alder, vine maple, willow, blackberry, spiraea, and wildrose form a dense undergrowth.

Hay mixtures usually include red and alsike clovers with ryegrass and timothy. Alsike clover is preferred for the more poorly drained areas. White clover usually appears in the hayfields through natural vegetation. One cutting of hay is usually harvested, with acre yields of 1½ to 2½ tons, and then the fields are pastured for the rest of the season. Most permanently wet areas can be seeded to reed canarygrass, which supplies pasture through the year or yields 3 to 5 tons of hay an acre. Permanent pasture mixtures usually include red, alsike, and white clovers with ryegrass. The State Agricultural Extension Service has demonstrated that the carrying capacity of the pastures can be increased by seeding alta fescue, orchard grass, and Kentucky bluegrass in addition to the mixtures given above. Pastures provide grazing for a long period but cannot be grazed during the wet winter season.

Puget very fine sandy loam (Pe).—Near Renton this soil occurs in low basins and is swampy throughout the year, but near Duvall it occupies situations similar to that of the associated Puget silty clay loam and is used for hay and pasture. The 12-inch surface soil is a very slightly acid light brownish-gray or light grayish-brown very fine sandy loam mottled with rust brown. The upper subsoil is a very slightly acid light brownish-gray mottled stratified and laminated silty clay loam to a depth of about 24 inches. The lower subsoil is light-gray iron mottled stratified and laminated silty clay. The underlying material is similar but of more bluish light-gray color. Both the lower subsoil and substratum are neutral in reaction.

PUYALLUP SERIES

The Puyallup soils are derived from gray to light-gray recent alluvium of mixed origin. They have a mildly acid brown or grayish-brown mellow friable surface soil that is moderately high in organic matter over a slightly acid to neutral grayish-brown to gray iron-mottled stratified sandy subsoil.

Puyallup fine sandy loam (PF).—This soil occupies the more elevated situations in the stream bottoms or on natural levees along streams. The relief is level to gently sloping. Both surface and internal drainage are usually good, but occasional lower areas have only fair drainage. Many areas, especially in the valleys of the White and Snoqualmie Rivers, are flooded by overflow waters late in winter or early in spring. Surface drains carry the water off but are often difficult to maintain owing to deposition of sediments or to erosion. Houses and barns in the valleys of the Snoqualmie River are built above the high-water line.

The 12-inch mellow surface soil is a slightly acid grayish-brown smooth fine sandy loam. It is underlain to about 36 inches by a very slightly acid medium grayish-brown to light grayish-brown loamy fine sand or fine sandy loam faintly mottled with gray and brown. This rests on neutral light-gray to gray interstratified fine sand and loamy fine sand somewhat mottled with rust brown.

Along the upper courses of most of the streams the surface soil is usually lighter brown and the subsoil grayer than typical. In the lower part of the valley of the Snoqualmie River the surface soil is yellowish brown and the subsoil more yellowish or light gray than elsewhere. Near Enumclaw the surface soil is more yellowish and also gritty from inclusion of coarser sands, and the subsoil is frequently more yellowish and more open and porous. Here gravel is not uncommon throughout the soil profile, which is better suited to fruits than elsewhere. In the vicinities of Auburn and Kent the deeper materials are dark gray or a mixture of light- and dark-gray sand.

Use and management.—Probably 95 percent of Puyallup fine sandy loam is farmed. Of this, at least 65 percent is in cultivated crops and the rest in permanent pasture. Areas near the White River are used largely for truck crops, but elsewhere hay crops, small grains, and permanent pasture occupy the larger acreage. The soil is inherently fertile, fairly high in active organic matter, and well supplied with moisture. These factors and the mellow friable surface soil make it well suited to truck crops. It is probably one of the best soils for root crops but is also productive of leafy vegetables, the crops for which the largest acreage is used. Lettuce, cabbage, cauliflower, peas, and spinach are shipped to outside markets. Asparagus, brussels sprouts, celery, tomatoes, beans, potatoes, carrots, beets, turnips, radishes, onions, sweet corn, and cucumbers are grown largely for local markets.

Lettuce yields 250 to 325 crates an acre; cabbage, 250 to 325; cauliflower, 500 to 650; spinach, 450 to 550; celery, 250 to 300; asparagus, 1,300 to 1,450; and carrots, beets, and turnips, 250 to 400. Green peas yield 600 to 700 hampers and tomatoes 600 to 700 lugs an acre. Potatoes are grown to some extent but are attacked by the flea beetle and diseases that reduce the yield and marketing value. Yields are 150 to 350 bushels an acre. Strawberries and raspberries are frequently grown, and yields are good. Fruit trees are grown successfully on the more elevated areas where underdrainage is sufficient.

The hay crops are largely red clover and ryegrass or timothy mixtures and yield 2 to 4 tons an acre. Alsike clover is also frequently used in these mixtures. Two cuttings can usually be obtained, but the second growth is more often pastured. Alfalfa can be grown on the more elevated situations, and yields usually exceed 4 tons an acre; corn is grown for silage on some dairy farms and averages 11 or more tons. Permanent pastures have a high carrying capacity and provide grazing for a relatively long season owing to the plentiful subsoil moisture. The best pasture mixtures are red, alsike, and white clovers with alta fescue, Italian and English ryegrasses, orchard grass, and Kentucky bluegrass. Small grains, largely oats, are used as nurse crops for both hay and pasture mixtures. These crops are usually cut for hay, which yields about 1½ tons an acre, but when harvested for grain the yield averages 90 bushels.

This soil can be plowed and made into an excellent seedbed under a wide range of moisture conditions. It is one of the best drained of the important stream bottom soils and warms up early in spring, thus providing a long growing season. This is invaluable for the truck farmers who usually crop the land several times a year. Truck farmers use barnyard manure heavily and often supplement it with dressings of balanced commercial fertilizer. Acre applications of about 800 pounds of 3–10–7 fertilizer are used for leafy vegetables and the same quantity of 4–10–10 for root vegetables. For hay crops and pasture containing clover, an initial acre application of 300 pounds of superphosphate is usually made. This is followed by a 250-pound application in following years. The same rate is used for alfalfa. Yields of cultivated intertilled crops can be maintained by proper crop rotations that include a legume.

Puyallup fine sandy loam, high bottom (PG).—This soil occurs mostly in the valley of the Green River on the higher gently rolling or undulating areas in association with the fine sandy loam. The surface soil is lighter brown and the subsoil more grayish. Some areas of very fine sandy loam and silt loam texture are included. Subsoil moisture is found only at considerable depth late in summer, and shallow-rooted crops may suffer from lack of sufficient moisture. This soil is used for hay, permanent pasture, and fruits. It is not used as successfully for truck crops as Puyallup fine sandy loam, and hay and pasture yields are lower.

Puyallup fine sandy loam, shallow (over Buckley soil material) (PH).—Areas of this soil are developed where streams have invaded areas of Buckley soils and deposited alluvium that has given rise to Puyallup fine sandy loam over older Buckley soil materials, which usually occur at a depth of 2 to 3 feet. The soil is on Boise Creek near Enumclaw. Some small areas of silt loam texture are included. Underdrainage is considerably slower than in the normal fine sandy loam. This soil is suitable for a wider range of crops than the Buckley soils but is not so valuable for all crops as the typical soil. It is considered more desirable than the Buckley soils for garden vegetables, root and tuber crops, berries, and other specialized crops.

Puyallup silt loam (Pk).—This soil occurs principally in the valley of the Green River closely associated with Puyallup very fine sandy loam and fine sandy loam. It usually occupies a slightly lower position than Puyallup fine sandy loam, but drainage is about equally as effective. Where it lies adjacent to the Sultan soils, the subsoil is frequently a little heavier and the internal drainage a little slower. After floods or heavy rains, flat or shallow basinlike areas frequently remain wet longer than the better drained areas. In these wetter places the soil is frequently more mottled with iron stains and the surface soil darker.

The 14-inch surface soil is a slightly acid grayish-brown mellow friable silt loam. The upper subsoil to a depth of about 30 inches is very slightly acid to neutral light or medium grayish-brown silt loam or very fine sandy loam stratified with faint bands of fine sandy loam at the lower limits. There is rust-brown mottling throughout. Under this are stratified layers of silt, very fine sand, fine sand, and sand that are very slightly acid to neutral and are light grayish brown or light brownish gray mottled with rust brown and bluish gray.

Use and management.—Most of Puyallup silt loam is farmed. Probably 60 or 70 percent is used for truck and hay crops, and the rest is in permanent pasture. It is used as extensively for as wide a variety of truck crops as Puyallup fine sandy loam and very fine sandy loam but is slightly more desirable for leafy vegetables, yields of which are usually slightly higher. Yields of the other crops are about the same. Hay crops yield slightly higher, and in dry years the carrying capacity of pastures is greater and the grazing season longer owing to the higher moisture retaining capacity.

Puyallup silt loam, low bottom (Pl).—This soil occurs largely in the valleys of the Green and Sammamish Rivers. It occupies low basins and back bottom positions that are subject to overflow and are swampy before they are reclaimed for cultivation. Owing to the sandy character of the subsoil, tile and open-ditch drains are effective if there is proper outlet for drainage waters.

The 10-inch surface soil is a moderately acid rich-brown or dark-brown highly organic smooth silt loam. It probably contains 25 to 50 percent organic matter, and angular fragments of partly decomposed peaty material are present. This changes sharply to a moderately acid light grayish-brown upper subsoil of interstratified silt, fine sand, and clayey layers, having considerable blue, gray, and brown mottling and some dark organic staining. Embedded roots and sedge and woody fragments are not uncommon. The lower subsoil, 24 to 70 inches thick, consists of very slightly acid light bluish-gray stratified sands mottled with rust-brown iron stains.

Use and management.—Probably half of Puyallup silt loam, low bottom, is in cultivated crops, and the rest is in pasture or uncleared, supporting dense growths of alder, willow, and brush. Leafy vegetables are the main cultivated crops, and yields are high. Cabbage yields 275 to 475 crates an acre; lettuce, 275 to 475; cauliflower, 500 to 700; and spinach, 450 to 575. For these crops the land is heavily fertilized with barnyard manure and commercial fertilizer.

Pasture mixtures are usually alsike and white clovers and grass on areas that can be drained and reed canarygrass on the permanently wet areas. This combination assures the most effective use of the land. Uncleared or partly cleared areas of native grass and brush vegetation furnish some pasture or browse.

Puyallup very fine sandy loam (PM).—This soil occurs mainly in the valley of the Green River closely associated with Puyallup fine sandy loam. It has a profile very similar to that soil except for the surface soil. Drainage conditions are about the same. Most of it is farmed in conjunction with Puyallup fine sandy loam, and similar crops are grown, the same management used, and similar yields obtained.

RAGNAR SERIES

The Ragnar soils occupy a high strongly rolling sandy drift plain south of North Bend. This is at an elevation near or somewhat above 1,000 feet, where the rainfall is heavy and the temperature relatively cool. The profile characteristics of these higher areas therefore distinguish them from the Indianola soils. The decomposed organic layer is strongly acid and lies over a thin irregular or feebly developed leached light-gray layer of mineral soil. The surface soil below this is moderately acid rich reddish brown or rust brown and 6 to 8 inches thick. Where this layer is thin and compact, shot pellets are absent. The less acid subsoil is yellowish brown, in places streaked with infiltrated red and brown stains. The parent sandy drift or glacial outwash is usually at a depth of about 2 feet. This is yellowish or greenish-gray and of mixed salt-and-pepper appearance from dark- and light-colored mineral grains. There is usually a scattering of gravel and some stone, lenses of clay, and at lower depths cross bedding of gravel. The glacial outwash material is similar to that giving rise to the Indianola and Lynden soils.

These well-drained soils occur under heavier rainfall and retain moisture better than the Indianola and Lynden soils. All the forest has been logged, but only a few scattered areas are cleared for home sites and farms. A fair growth of merchantable timber is becoming established.

Ragnar fine sandy loam, rolling (RB).—This soil is found on rolling to strongly rolling relief on a high glacial outwash plain south of North Bend. The glacial material is derived from rock sources similar to those of the Indianola and Lynden soils. Surface drainage is well developed and rapid, but accelerated erosion is held to a minimum by the native vegetation, forest litter, and organic mat. Internal drainage is good, but the deeper moisture is frequently retarded and deflected horizontally by clay layers in the substratum. This soil receives more than twice as much rainfall as the Indianola and Lynden soils and is more retentive of moisture. As it occurs at an elevation of about 1,000 feet, the growing season is shorter than on those soils.

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In virgin areas the surface soil is covered by forest litter in which the lower 2 or 3 inches is a dark-brown strongly acid humified organic layer. Under this is a thin ($1\frac{1}{2}$ inches) irregular and sometimes discontinuous or feebly developed strongly to moderately acid brownish light-gray fine sand material. This rests on the 6- to 8-inch surface soil of moderately acid rich reddish- to rust-brown fine sandy loam of somewhat irregular development. The thinner layers are usually compact; the thicker ones are more friable and may contain shot pellets. At about 8 and continuing to 20 inches is a mildly acid yellowish-brown fine sandy loam sometimes penetrated by rust-brown tongues. The underlying substratum consists of greenish- or yellowish-gray sands usually sprinkled with gravel and including some stone. It is frequently bedded with clay and coarse gravel layers with embedded boulders.

Use and management.—Only a few small areas of Ragnar fine sandy loam, rolling, are cleared for home sites and farms. The agricultural possibilities have not yet been definitely demonstrated, but the productivity probably would exceed that of the Indianola and Lynden soils. This is a good timber-producing soil. The merchantable timber has been removed and a second growth of Douglas-fir, hemlock, and some redcedar is becoming established.

Ragnar fine sandy loam, hilly (RA).—Areas of this soil occupy moderately steep slopes of 15 to 25 percent in association with the rolling soil. Surface runoff is rapid, but accelerated erosion has not developed because of the protecting forest cover and organic litter. These slopes are not suitable for effective use of farm machinery, and erosion control probably would become a problem if the soil were cultivated. A second growth of trees is becoming established on this valuable timber-producing soil.

Ragnar fine sandy loam, terrace, gently sloping (RC).—This soil occurs on a gently sloping terrace adjacent to the national forest in the valley of the Middle Fork of the Snoqualmie River. Surface drainage is good and internal drainage good to fair. The native vegetation is a dense growth of Douglas-fir, hemlock, and redcedar with little ground cover other than ferns and mosses.

In virgin areas this soil is covered by forest litter and peaty material, the lower 2 inches of which is acid dark-brown humified organic matter. This lies over a strongly acid and leached grayish-white sand about 2 inches thick. Under this is a 12-inch layer of strongly acid rusty reddish-brown or light coffee-brown gritty fine sandy loam or loam that has considerable compaction in places. This is also irregular in depth and varies somewhat in color and degree of compaction from place to place. At a depth of about 17 inches is a moderately acid yellowish-brown iron-stained somewhat compact plastic loam or sandy clay loam. This continues to a depth of about 36 inches where it is underlain by yellowish-gray compact fine-textured stratified clayey sand and sandy clay that continue to undetermined depths. These materials are derived largely from granite and related rocks.

RIFLE PEAT

Rifle peat (RD) is widely distributed in depressions throughout both the uplands and stream valleys, but the larger areas occur in flat back bottom positions or swampy areas of stream bottoms and marginal to the larger lakes. Virgin areas are saturated with water and are swampy. They support redcedar, hemlock, spruce, alder, vine maple, cottonwood, and dense undergrowth of willow, elderberry, dogwood, spiraea, bracken fern, and other brush and shrubs. This organic soil requires drainage before it can be effectively utilized. The water table must be lowered yet retained at a depth of a few feet so that the peat will contain sufficient moisture for plant growth. Peat areas frequently sink several feet when drained. Most of the areas in the valleys of the White and Snoqualmie Rivers are drained by open ditches. Intercepting drains are usually necessary along the outer margins of the areas to effect satisfactory uniform drainage.

In a representative area the 16-inch surface soil is a moderately acid granular decomposing dark reddish-brown woody peat. Roots and woody debris are in the surface few inches, and under this fibrous mat rotting wood fragments are abundant. Between 16 and 48 inches is a moderately acid dark-brown peat more thoroughly decomposed and colloidal than the material above but containing fibrous woody fragments throughout and some sedge fibers at the lower limits. At 48 and extending to 70 inches is a fibrous-matted mildly or slightly acid peat composed of compressed sedge, reed, and root remains embedded in colloidal organic material. Below this is more highly colloidal material consisting largely of greenish-brown to very dark-brown or black sedimentary peat. A substratum of mineral soil material occurs at extremely variable depths.

The above profile represents the usual succession of layers found in this peat, but considerable variation in the total depth and in the thickness of the various layers often occurs in the individual areas. Those areas having at least 10 inches of woody surface peat are recognized as the typical peat. Where the total thickness of the profile is less than 3 feet, it is classified as Rifle peat, shallow.

Use and management.—Rifle peat is one of the important agricultural soils and is considered one of the most productive of leafy vegetables (pl. 3). Probably more than 90 percent is cleared and farmed in the larger valleys, and the rest is being cleared and put under cultivation. In the uplands the more accessible areas are cleared, but the more remote areas still remain in the virgin state. Probably 75 percent of the woody peat in the upland depressions is farmed.

The truck crops grown are chiefly lettuce, cabbage, cauliflower, and spinach. Lettuce yields 300 to 450 crates an acre; cabbage, 300 to 450; cauliflower, 600 to 700; and spinach, 450 to 550. Peas are also grown and yield about 700 to 750 hampers of green market peas and 2 to 2½ tons of shelled green peas for frozen pack.

Hay crops and oats also occupy a considerable acreage. The hay crops are usually alsike clover and timothy mixtures and yield 2 to 3 tons. When cut for hay, oats yield about 3 tons; as grain they produce 70 to 90 bushels an acre.

This peat improves with tillage, as the surface becomes more thoroughly decomposed, finely divided, and compacted. The improved consistency promotes a better seedbed and ease of cultivation. The soil is most deficient in phosphorus and potash, which usually have to be applied in some form for satisfactory yields. Truck farmers apply manure supplemented with fertilizer, as 4-10-10 or 3-10-10. Lime is not always necessary but is beneficial on the more acid areas.

RIFLE PEAT, SHALLOW

Rifle peat, shallow (RE), consists of areas in which the depth of peat is less than 3 feet. The succession of layers is the same as in Rifle peat, but in many places the sedimentary and sedgy peat layers are thin. In the shallower areas the entire profile may be almost entirely of woody origin. These shallower areas are usually found in seeped areas or in small stream bottoms relatively free from overflow but continuously saturated. This soil has similar wide distribution and is frequently associated with the normal peat on the outer margins of the peat beds. About the same proportion is cleared and drained for cultivation. Natural vegetation and crop yields are similar. The deeper roots of crops probably reach the underlying mineral soil in these areas.

RIFLE PEAT, SLOPING

A few scattered areas of Rifle peat, sloping (RF), are on sidehill slopes subjected to seepage. The slopes are highly saturated throughout the year but usually can be effectively drained. Good intercepting as well as central drains are necessary. The whole profile is mainly woody peat and is frequently shallow. The same crops are grown as on Rifle peat, and similar yields are obtained.

RIVERWASH

Riverwash (RG) consists of narrow elongated areas of sand, gravel, and stone along channels of the larger streams. These nonagricultural areas are either barren of vegetation or support a scattering of cottonwood, willows, and other trees and brush. They are frequently overflowed and altered by erosion and deposition.

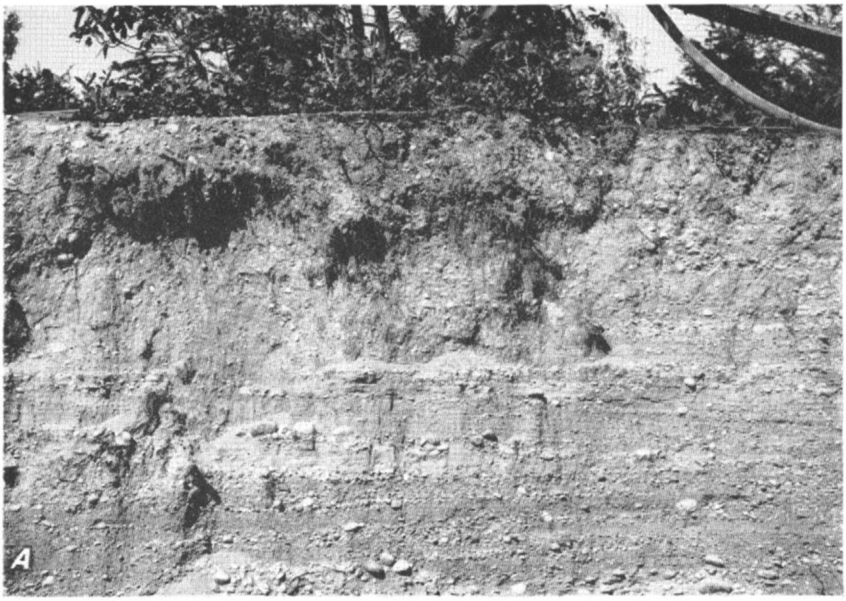
ROUGH BROKEN AND STONY LAND

Rough broken and stony land (RH) is a diversity of undifferentiated soils on steep positions of more than 25 percent slope. Though the profiles are usually thin and feebly developed, the soils show a close relation to the soils they adjoin and usually are derived from similar material. Probably every soil series of the uplands and terraces is represented. This land type consists of relatively narrow bodies of land throughout the area on which agriculture is impracticable, owing to the steep broken relief and unfavorable thin gravelly and stony soil.

It occupies sharp breaks along gullies and stream channels or entrenched valleys. Numerous areas also include short steep slopes and escarpments between terrace levels and steep areas or irregularities in the rolling uplands.

The thin soil material and steep irregular relief are unfavorable for agriculture, and none of the land is cleared for farming. The land is valuable for forestry, however, but little systematic reforestation has been undertaken since the timber was removed and the second growth of better timber-producing trees is often thin and scattered. The second growth is largely Douglas-fir and hemlock but varies with depth and character of the soil.

Lettuce on Rifle peat; terrace in background occupied by Everett soils.



A, Exposed profile in the Everett series, showing stratified parent glacial drift.
B, Exposed profile in the Barneston series, showing poorly assorted parent glacial drift.

ROUGH MOUNTAINOUS LAND

Rough mountainous land (Rk) occupies a large area of foothills bordering mountain spurs in the eastern and central parts of the area surveyed. The soils are thin and have a considerable range in origin, texture, and color within short distances. Gravel, stone, and boulders are prominent. The profiles are usually feebly developed. The soils most frequently represent materials of or are closely related to the Cathcart, Stossel, Oso, Klaus, and Ragnar series. In many places they represent a complex association of these soils. Small narrow areas of darker soils along stream courses are included.

The relief varies from somewhat smooth hills and low spurs at elevations of 1,500 to 3,000 feet to rugged mountain areas attaining an elevation of 5,000 feet or more. A few adjoining areas of steep canyon walls or steep areas along entrenched streams are included. Extensive areas, especially at the higher elevations, are rough, broken, or stony with bold outcrops of bedrock. Small scattered smooth areas occasionally occur that, except for their inaccessibility, might be used for agriculture; otherwise this land is suited only to forestry. Below 3,000 feet the soil mantle is derived largely from thin glacial deposits over a wide variety of bedrock, including sandstone, shale, quartzite, argillite, andesite, basalt, and granodiorite. Above 3,000 feet residual materials are the more important soil constituents. Minor narrow areas along canyonlike stream courses are largely of mixed alluvial origin.

The steep relief causes rapid runoff and drainage, but the dense forest cover protects most slopes from accelerated erosion. The rainfall varies from 60 to 100 inches, and valuable coniferous timber stands of Douglas-fir, hemlock, and redcedar are on virgin areas. Probably only about one-third of this virgin timber remains. Burned-over and logged-off areas are slowly restocking to similar timber-producing trees. On these valuable timberlands there is need for systematic reforestation and carefully planned cutting to maintain a sustained and profitable production of timber (pl. 2, *B*).

SALAL SERIES

The Salal soils resemble those of the Edgewick and Nooksack series in parent material. Their very dark-brown to black sooty highly organic rather strongly acid friable surface soil rests on reddish dark-brown silt loam or fine sandy loam. This in turn is underlain by a thickly stratified yellowish olive-brown to light greenish gray-brown sandy subsoil somewhat mottled with yellow and rust brown.

Salal silt loam (Sb).—This soil occupies the higher swells and undulations in the undulating alluvial plain in the vicinity of North Bend. The surface drains effectively, and the internal drainage is more rapid than in the associated Edgewick soils. The 12-inch soil is a very dark-brown to almost black highly organic silt loam of moderate to slightly strong acidity. It is light in weight and floury or sootlike. Between 12 and 20 inches is a moderately acid reddish dark-brown silt loam or fine sandy loam of light weight. This is underlain at 40 inches by a slightly acid to neutral light yellowish-brown silty clay loam with greenish tint and some faint rust-brown mottling. Below this are granitic micaceous stratified sands and silty materials that are light yellowish brown or light yellowish gray with some brown mottling in seams and in localized areas. These strata are neutral in reaction.

Use and management.—Most of Salal silt loam is farmed. It is used largely for hay and permanent pasture, but some corn and general farm crops are grown. Near North Bend are small vegetable and fruit tracts in association with home sites. It is farmed in conjunction with the Edgewick soils and is managed in the same way. Yields are the same or slightly higher than on Edgewick silt loam.

Salal fine sandy loam (Sa).—Occurring in close association with Salal silt loam, this soil has similar relief and drainage conditions. The crops grown, soil management, and yields are also similar. To a depth of about 14 inches the surface soil is a very dark-brown to nearly black mellow fine sandy loam moderately to somewhat strongly acid. The upper subsoil to a depth of about 28 inches is a moderately acid dark-brown or dark reddish-brown mellow fine sandy loam. Below 28 inches and continuing to 70 inches or more are stratified layers of fine sandy loam, fine sand, and silt. These are light yellowish- to light greenish-brown or grayish olive-drab friable and porous material of slightly acid to neutral reaction.

SAMMAMISH SERIES

The Sammamish soil has developed under restricted drainage on elevated positions, as low swells, undulations, or natural levees along streams. Consequently it is lighter colored than the Issaquah soil. The subsoil consists of interstratified sand, clayey sand, and sandy clay. Gravel frequently occurs in the substratum.

Sammamish silt loam (Sc).—This soil occurs mainly near Issaquah in close association with Issaquah silt loam. It occupies higher undulations or swells and natural levees along streams. Owing to its slightly elevated position, surface drainage is a little more rapid and the upper soil drains a little more freely than in the Issaquah soil. Most of it is drained by tile; drainage is effective because of the permeable subsoil and gentle slope.

The surface soil to a depth of 10 inches is a mildly acid light-brown or medium grayish-brown crumbly or granular silt loam. The upper 17-inch subsoil is a mildly to slightly acid light yellowish-brown silty clay loam, frequently with a reddish cast or rust-brown mottling. The lower subsoil, to 60 inches or more, consists of neutral or slightly alkaline interstratified light- to medium-gray sand, clayey sand, and sandy clay mottled with rust-iron stains. It frequently includes considerable iron segregation or platy cementation. Gravel occasionally occurs in the subsoil and is usually present in the underlying substrata.

Use and management.—Sammamish silt loam is farmed in conjunction with Issaquah silt loam and is managed in the same way. The main crops are hay and pasture. Both hay yields and the carrying capacity of the pastures are slightly lower.

SNOHOMISH SERIES

The Snohomish soil consists of recent alluvial stream deposits that are relatively thin and have been superimposed over organic peat and muck materials. Areas occur in low depressions in the stream valleys. Most of the soil has been drained and is being used agriculturally.

Snohomish silt loam (Sd).—This soil occurs in low depressions in the stream valleys of the Sammamish and Snoqualmie Rivers. The largest areas are in back bottom positions along the outer fringe of the stream valleys. These are subject to overflow and, especially in the valley of the Snoqualmie River, are still receiving annual sediments from floodwaters. The soil is composed of alluvial mineral soils that have been superimposed over materials more definitely segregated than in the peat and muck materials.

In a representative location the surface 16 inches is composed of moderately acid grayish-brown or dark-brown smooth silt loam relatively high in organic matter and becoming a more pronounced gray when dry. This is underlain abruptly by an acid dark reddish-brown well-decomposed woody peat. Below 40 inches is medium acid fibrous peaty material in which compressed sedge fibers are recognizable. At 60 or 70 inches this merges through dark colloidal sedimentary peat or colloidal mineral matter to the deeper mineral substratum, which is at extremely variable depths.

The surface soil has a considerable range in color and organic-matter content. In the valley of the Sammamish River it probably contains 20 to 50 percent organic matter and when moist it is brown to very dark brown or grayish black. In the valley of the Snoqualmie River the surface soil is lighter brown or lighter grayish brown and has a lower organic content. The underlying peaty material is frequently stratified with thin layers of light-gray mineral soil. A small area of about one-fourth square mile has surface soil of lighter fine sandy loam texture.

Use and management.—Only a small part of Snohomish silt loam remains in an uncleared natural swampy condition, as drainage systems have been installed that provide drainage for cultivated crops and pasture. In the valley of the Sammamish River this soil is used largely for truck crops, but in the valley of the Snoqualmie River it is used almost exclusively for hay and permanent pasture.

The truck crops are largely leafy vegetables. Yields are similar to those on Puyallup silt loam, low bottom. The hay crops that are grown, chiefly near the Snoqualmie River, are mostly red clover and ryegrass mixtures. Yields average about 3 tons an acre. This soil is better for permanent pasture than the peat soils, as the forage does not have the mineral deficiency of the peaty soils.

SNOQUALMIE SERIES

The young moderately acid Snoqualmie soils are widely distributed on low stream terraces in close association with soils of the stream bottoms. They are frequently farmed with those soils but are droughty and closely resemble the higher terrace soils in the upland. They have a yellowish-brown or reddish-brown gravelly surface soil, the top few inches of which is frequently darker brown. The subsoil is washed stratified coarse sand and gravel.

Snoqualmie gravelly loam (Se).—A number of the larger acreages of this soil occur on the Snoqualmie River near Fall City. They occupy low stream terraces slightly above the stream bottom soils and often merge with them in gentle slopes. The relief is level to gently sloping and undulating. Surface runoff is rapid. The soil absorbs water freely but retains it poorly because of the open droughty character of the subsoil. In low-lying positions adjacent to the stream-bottom soils the water table may be fairly high part of the year.

To a depth of about 3 inches incorporated organic matter makes this soil somewhat granular dark-brown or dark medium-brown gravelly loam. The 3- to 20-inch gravelly loam is reddish brown or dull yellowish brown, structureless, loose, and open. Both layers are moderately acid. Below these are open, porous, coarse sand and gravel of yellowish-gray salt-and-pepper color that become more gray and washed and unweathered with depth. This loosely stratified layer is similar to the glacial drift deposits of the associated upland soils, the Alderwood and Everett series.

The surface soil varies considerably in depth and is frequently very gravelly and interrupted by gravel bars that may contain much larger gravel or small stone. In these areas the soils are of lighter and more yellowish or grayish color. Near Tolt is a small area where the surface soil is very dark brown or nearly black and resembles the Spanaway soils (*7*).

Use and management.—None of Snoqualmie gravelly loam remains in virgin timber. Probably about half has been cleared for farms and pasture. The soil is most frequently and most successfully used for pasture, since the associated fertile and moist stream-bottom soils are more favorable for intertilled and other cultivated crops. Home gardens and fruits are grown on residence tracts near Fall City. Hay is grown with fair success on the more favorable areas, especially where there is a high water table part of the year. Pastures have low carrying capacity, and the grazing season is short because of lack of moisture in dry summer. Mixed hay crops yield 1 to 1½ tons an acre, and alfalfa yields are slightly higher. Other crops yield about the same or slightly better than on Everett gravelly sandy loam, gently undulating, which has similar management practices and the same deficiencies in productivity.

Snoqualmie gravelly loamy sand (SF).—Found largely in the valleys of the Middle and South Forks of the Snoqualmie River, this soil occurs on slightly elevated positions in alluvial flats and along the streams. It is a shallow soil over loose, porous, stratified coarse sand and gravel. The soil has been logged over, but most of it is not cleared. Where associated with the more productive soils it is used for pasture. It is too droughty and unproductive for any other agricultural use.

Profile characteristics are variable and feeble. In the more typical areas the 15-inch surface soil is yellowish-brown or grayish-brown gravelly loamy sand without any appreciable compaction or structure. The subsoil has a grayish washed salt-and-pepper appearance. The soil is derived largely from granite and quartzite, but appreciable quantities of materal from dark argillite are also present. Where gravel bars and shallower areas occur, the surface soil is often light yellowish-gray loose gravelly sand.

Snoqualmie gravelly sandy loam (SG).—This soil is closely associated with Snoqualmie gravelly loam, but it often occupies slightly higher positions on the low stream terraces. It has a similar profile except for the surface soil, which is a gravelly sandy loam often of higher gravel content. This surface soil varies in depth and color within short distances and is probably more frequently broken by gravel bars than the gravelly loam.

Use and management.—All of Snoqualmie gravelly sandy loam has been logged off, but less than half has been cleared for farms and pasture. A large part is used for pasture, but the carrying capacity is lower and the grazing season is shorter than on Snoqualmie gravelly loam owing to the more droughty profile. Crops grown are similar on both soils, but yields are lower on the lighter textured soil.

Snoqualmie gravelly sandy loam, high terrace (SH).—Areas of this soil occur on high narrow terrace remnants and short alluvial or colluvial fan slopes marginal to the entrenched stream valleys. They are small, many being from ½ to 5 acres. The relief is benchlike with small level or sloping areas and steep escarpment fronts. Surface drainage is moderate to rapid and internal drainage excessive. The soil is droughty and poorly adapted to agriculture and it is used largely for home sites because of favorable location.

On most areas the soil is probably older than the other Snoqualmie soils but younger than soils of the Everett series. Profile characteristics are feebly developed and vary considerably from place to place and within individual areas. These textural and color variations are similar to those of Snoqualmie gravelly sandy loam. The surface soil includes variations in color from reddish or yellowish brown to light grayish brown. The upper subsoil is yellowish brown or grayish brown. The deeper subsoil and substrata are gray and often poorly assorted, especially on the steeper slopes.

STOSSEL SERIES

The Stossel soils are developed largely from boulder clay that apparently originated from highly colored clay shale as the glacier plowed over it. The parent material is mixed and complex from place to place. Huge slabs of shale forced out of place are found embedded in glacial debris, and barren weathered shale is exposed. As the weathered fragmental underlying shale yields readily to erosion, bedrock is exposed in many places.

These soils occupy rolling to strongly rolling short slopes bordering the mountains and foothills. Seeped areas are frequent, and in many localities massed areas of huge boulders would prohibit cultivation. Though better adapted to forests than to cultivated crops a few houses with gardens are on these soils because they are retentive of moisture and domestic water is readily available.

Stossel clay loam, rolling (SK).—A number of small areas of this soil are near Harris Creek east of Duvall. The relief consists of rolling to strongly rolling short slopes in the valley and similar areas adjacent to the foothills. Surface drainage is rapid, and accelerated erosion has exposed bedrock in many places. The heavy soil materials absorb water slowly, and the exposed fragmental clay and weathered shale yield readily to erosion. Internal drainage is likewise slow through the heavy subsoil and dense substratum. Many seepage areas occur, and the soil is cold and wet in spring.

Developed from a variety of complex highly colored gravelly and stony clay materials, this soil has the appearance of a relatively thin very heterogeneous bouldery clay till derived from local highly colored soft shale with transported till deposits largely of granitic origin. Embedded huge flat slabs of shale have apparently moved only a short distance from their source. Underlying interbedded shales of variable color, ranging from yellow, orange, brown, and red to blue and purple with occasional strata of dark carbonaceous character, are frequently exposed.

A representative profile has a slightly acid dark-brown organic mat about 1½ inches thick over a 7-inch surface mineral soil of dull reddish-brown slightly acid clay loam. Many rust-brown shotlike pellets and some gravel are present. The very slightly acid upper subsoil to a depth of about 18 inches is dull somewhat greenish olive-brown clay loam containing some gravel and stone. From 18 to 50 inches is a very slightly acid stiff plastic boulder clay of highly variegated yellow, red, brown, orange, and bluish gray. Below this is interstratified highly colored shale of similar but more pronounced color. Some boulders and gravel appear to be ground or forced into the upper strata. The shale is neutral in reaction and continues to undetermined depths.

The soil profile varies considerably from place to place with differences in character of the parent material. The surface soil is dark brown to medium brown, and the subsoil varies from grayish, yellowish, or reddish brown to dark purplish brown.

Use and management.—All of Stossel clay loam, rolling, has been logged off. Only a few scattered selected areas adjacent to Harris Creek are cleared and used for home sites and small gardens. It is a cold soil, difficult to cultivate. Owing to these conditions and to the unfavorable relief and cost of clearing, this soil is more desirable for forestry than for farming.

Stossel stony loam, hilly (SL).—This hilly soil occurs adjacent to the mountain and foothill region near Harris Creek. It is developed from thicker glacial till deposits over highly colored shale than is Stossel clay loam, rolling. The till is also more open and porous and is densely embedded with stone and boulders, which are concentrated over the surface and through the soil. Surface drainage is rapid but internal drainage somewhat retarded. The stones prohibit cultivation, and since they cannot be economically removed they limit the use of the soil to forest. All of it has been logged, and a second growth of similar timber trees is becoming established.

A dark-brown organic layer about 1½ inches thick is over the mildly acid medium-brown surface mineral soil. Numerous stones are embedded, large angular boulders protrude from the surface, and a scattering of shotlike pellets is present. The 10- to 24-inch upper subsoil is mildly acid yellowish-brown stony gravelly loam containing some shot pellets. Between 24 and 36 inches similar materials become more grayish and sometimes have a greenish tinge. From 36 to 70 inches is a stony gravelly clay loam, predominantly dull yellowish brown or olive brown but with orange and rust-brown inclusions. This is underlain by highly colored and variegated boulder clay, over warped interbedded yellow, orange, rust-brown, and bluish-gray shale. The lower subsoil and substrata materials are neutral in reaction.

SULTAN SERIES

The productive Sultan [11] soils resemble the closely associated Puyallup soils in surface soil characteristics but differ in that they have slowly permeable clayey subsoils. They have a grayish- or medium-brown mildly to slightly acid friable surface soil that is moderately high in organic matter over a very slightly acid to neutral brownish-gray highly iron mottled or stained stratified clayey subsoil.

Sultan silt loam (Sn).—Distributed as small bodies throughout the larger stream valleys, this soil occupies positions having intermediate drainage between the Puyallup soils and the lower Puget soils. In these situations the surface drainage is fair to good but the internal drainage is slow. Most areas are sufficiently elevated and have adequate slope for effective artificial drainage when drains are properly installed and spaced. Most of the drains are open ditches because in the valleys of the White and Snoqualmie Rivers the drains often become clogged by fine sediments. Farm buildings in the valley of the Snoqualmie River are often built on piles to keep them above seasonal floodwaters.

The 10-inch smooth surface soil is slightly acid granular silt loam of grayish or medium brown. The upper subsoil to about 24 inches is very slightly acid brownish-gray silty clay loam mottled with rust brown. Below 24 inches the very slightly acid subsoil is light brownish-gray stratified and laminated silty clay loam and silty clay highly mottled with yellow and rust brown.

In the valley of the Snoqualmie River and near Enumclaw the soil is more yellow in the surface soil than elsewhere in the area. Where it adjoins the Puyallup soils, the subsoil may be slightly stratified with thin sandy or silty layers. Where it merges with the Puget soils, the subsoil is frequently heavier and denser than normal.

Use and management.—When properly drained Sultan silt loam is a moderately to highly productive soil. Most of it is cleared and farmed, and probably about 80 percent is used for cultivated crops and the rest for permanent pasture. About one-half the area in cultivated crops is used for truck crops, and the rest is used for forage and grain crops in association with dairying. Both root and leafy vegetables are grown, but the largest acreage is planted to leafy vegetables. Peas yield 600 to 725 hampers an acre as green market peas and 1½ to 2½ tons of green shelled peas for frozen pack. Lettuce yields 250 to 350 crates an acre; cabbage, 250 to 350; cauliflower, 500 to 650; spinach, 450 to 550; and carrots, beets, and turnips, 200 to 350 crates. Potatoes yield 125 to 300 bushels an acre, but only a few

[11] At the time of the earlier reconnaissance soil survey (7), the Sultan soils had not been recognized, and they were included with soils of the Puget series from which they are distinguished by browner color and somewhat better drainage.

are grown because insect and disease injury reduce their value or make them unsalable.

Hay mixtures, largely red clover with ryegrass or timothy, yield 2 to 3¾ tons an acre when two cuttings are harvested. Many farmers prefer to pasture the second growth. Small grains, principally oats, are grown as nurse crops for seedings of both hay and pasture mixtures. This crop is usually cut for hay, and acre yields average about 1¾ tons. As grain, oats yield about 75 to 90 bushels. Corn is grown for silage on some of the dairy farms and yields 10 to 12 tons.

Permanent pastures are most commonly mixtures of red, alsike, and white clovers with ryegrass, orchard grass, and Kentucky bluegrass. Pastures have a high carrying capacity and can be grazed for a long period owing to the plentiful moisture supply.

This soil has a high inherent mineral fertility and a fair organic-matter content. When intertilled crops are properly rotated with hay or pasture crops containing clover, the organic matter and nitrogen can be kept to a satisfactory level for successful crop production. Superphosphate is usually applied to clovers at the rate of 300 pounds an acre the first year and 250 pounds the following years. Truck farmers frequently do not rotate with hay crops but instead apply barnyard manure heavily and often supplement it with commercial fertilizer. For root vegetables 800 pounds of 4–10–10 fertilizer is applied per acre, and for leafy vegetables dressings of 800 pounds of 3–10–7 are most common.

Sultan silt loam, high bottom (So).—This soil is undulating to gently rolling and occurs above the general level of Sultan silt loam. Its drainage is therefore more complete and artificial drainage not necessary. The surface soil is deeper and lighter brown and the subsoil contains less mottling. As mapped the soil includes some minor areas of Sultan fine and very fine sandy loam.

Use and management.—Sultan silt loam, high bottom, is less valuable for truck crops than Sultan silt loam and is used largely for hay, pasture, and fruit. Hay yields are slightly lower, and subsoil moisture for late pasture is not so plentiful. Good yields of berries are obtained

Sultan silt loam, shallow (over Buckley soil material) (Sp).—In this soil the silt loam extends to a depth of about 2 or 3 feet over Buckley soil material. Internal drainage is slower than in Sultan silt loam but not so retarded as in the Buckley soils. Areas are near Enumclaw, and a few small areas of very fine sandy loam and fine sandy loam are included. This shallow soil is more desirable than the Buckley soils for garden vegetables, root and tuber crops, and specialized crops including berries.

Sultan fine sandy loam (Sm).—Scattered areas of this soil are in the larger stream valleys. The surface is gently undulating or somewhat irregular with low sags and swells. The soil is closely associated with both the Puyallup and Puget soils and occupies positions of intermediate drainage. It is better drained than the Puget soils but not so effectively drained as the Puyallup. Most areas require some form of artificial drainage before they can be properly utilized for all crops. In most cases tile drains are impractical as they become clogged with sediment.

The 12-inch surface soil is slightly acid grayish medium-brown mellow fine sandy loam. The 12- to 36-inch upper subsoil is a very slightly acid brownish-gray rust-mottled silty clay loam. This is underlain to about 65 inches by very slightly acid to neutral light bluish-gray stratified and laminated silty clay loam and silty clay. These materials are very plastic and have rust-brown and yellow mottling.

This soil includes a few scattered areas of very fine sandy loam texture. Along the Snoqualmie River the surface soil is more yellowish brown than elsewhere. Where the soil merges with the Puyallup soils, thin sandy layers in the subsoil are frequent. Adjoining the Puget soils the subsoil is usually heavier and more impermeable than typical and the surface soil grayer and less deeply developed.

Use and management.—Most of Sultan fine sandy loam has been cleared for farms. At least 80 percent is in cultivated crops and the rest in permanent pasture. More than half the cultivated acreage is in truck crops; hay, forage, and grain crops occupy most of the rest. Both root and leafy vegetables are grown, but the soil is better for root crops. Peas and leafy vegetables yield slightly lower than on Sultan silt loam, but yields of carrots, turnips, beets, and other root crops are slightly higher. Hay and pasture mixtures are the same as those used for the silt loam. Hay yields are about the same, and pastures have similar carrying capacities. Other crops commonly grown on Sultan silt loam are also grown on this soil.

This soil warms up a little earlier in spring and can usually be prepared sooner for seeding than Sultan silt loam. The mellow surface soil yields readily to cultivation. Fertilizing and other management practices are similar to those used on the other Sultan soils.

TOKUL SERIES

The Tokul soil has an eroded morainic relief and lies at higher elevations under heavier rainfall than the less acid Alderwood soils. In virgin undisturbed positions a thin gray layer is under the organic mat. The surface soil is irregularly penetrated by rust-brown as well as grayish tongues. The soil profile is similar to that of the Alderwood, but the drift though of similar origin, is of morainic-till character. The indurated substratum lies at slightly deeper and at irregular depths and is not generally glazed over or platy at the surface. The silica cementation does not continue as definitely nor to so great a depth as in the Alderwood soils.

Tokul gravelly sandy loam, rolling (Ta).—This soil is on rolling to strongly rolling relief in the high foothill region east of Snoqualmie Falls. It occurs on erosion-modified glacial deposits that lie at elevations of about 1,000 feet or higher. Surface drainage is rapid but internal drainage is slow. Accelerated erosion has not developed. The soil has formed from glacial drift materials similar to those of the Alderwood soils, but because it occurs at higher elevations of cooler temperatures and heavier rainfall, it is more acid and has certain characteristics that distinguish it from those soils. These characteristics are well developed in areas of virgin timber but are not always conspicuous or may be destroyed in logged-over areas.

The virgin growth of Douglas-fir, hemlock, and redcedar was heavy and valuable, but most of this has been removed. Logging practices and burning have left the land badly denuded, and it is now slowly restocking to valuable timber trees. Alder, maple, and other deciduous growths are competing strongly with the timber types, and systematic reforestation will be necessary for satisfactory restocking.

Under virgin forest this soil is covered with a litter of needles, twigs, and rotting wood and logs covered by a green mat of mosses and ferns. The lower few inches are partly decomposed and humified into a dark-brown strongly acid layer. This is underlain by a thin irregular layer of bleached light-gray surface mineral soil over a rust-brown firm gravelly sandy loam. Both these layers are irregular in thickness but together average about 8 inches, the top layer being ½ to 1½ inches thick. At an average depth of about 10 inches is pale reddish-brown gravelly sandy loam that continues to a depth of about 24 inches. Between this and the indurated substratum, which usually occurs at 30 to 40 inches, is a gravelly sandy loam that becomes more yellowish brown or grayish brown with depth.

Roots are not so definitely matted on top of the indurated layer as in some of the Alderwood soils, but the deeper subsoil is stained yellow and brown owing to slow drainage. The surface soil is strongly acid, the subsoil moderately acid. The gray silica-cemented substratum is a poorly assorted glacial till, not so firmly or so continuously cemented as in the Alderwood soils, but more highly stained with yellow and rust brown. The gray color and discoloration continue to indefinite depths, but the stronger cementation usually ends at 15 or 20 feet. The substratum is moderately acid but becomes neutral at the lower limits.

Use and management.—None of Tokul gravelly sandy loam, rolling, is cleared for farming. The areas are not readily accessible, and the growing season is much shorter than in the lower stream valleys. Many areas are not favorable for cultivation owing to the irregular relief or stone content. For the most part this soil is probably better for forest than cultivated crops.

WOODINVILLE SERIES

The Woodinville soil occupies flat basins in low bottom positions frequently associated with the Puget soils. It differs from the more permeable Puyallup silt loam, low bottom, principally in the clayey character of the subsoil and substratum materials. The surface soil is moderately acid, highly organic, dull dark brown or dull brown, smooth, and silty. The organic matter is usually finely divided, but fragments of woody and sedge peat are discernible. This layer changes abruptly to slightly acid to neutral light grayish-brown to light brownish-gray interstratified and laminated silty clay loam, silty clay, and clay subsoil materials mottled with iron and organic stains. The upper subsoil is frequently bedded with dark peaty layers that may contain remains of sedges, rushes, and other plants.

Woodinville silt loam (WA).—Occupying shallow flat basins in low bottom positions frequently associated with the Puget soils, this soil is subject to frequent flooding and in places remains inundated or swampy for a large part of the year. It is often difficult to drain, and only a small part has been successfully drained by shallow open ditches for cultivated crops. Areas are chiefly in the stream bottoms of the valleys of the Green and Sammamish Rivers.

The 12-inch surface soil is a moderately acid highly organic dark dull-brown or dull rich-brown smooth greasy silt loam. When dry it crumbles to fine powdery particles. Finely divided organic matter probably makes up 25 to 50 percent of the soil. The surface soil is underlain abruptly by an upper subsoil of laminated and interstratified very slightly acid light brownish-gray silty clay loam, silty clay, and clay mottled with iron stains. Brown fragments and imprints of roots, sedge fibers, and other organic remains are found in the layer. The subsoil below 24 inches is light brownish-gray thick-bedded, laminated, and rubbery very slightly acid to neutral silty clay and clay. Subsoil and substratum materials are frequently interstratified with thin dark peaty or mucky layers.

Use and management.—Probably about half of Woodinville silt loam has been cleared for cultivated crops and permanent pasture. The uncleared areas support dense growths of alder, vine maple, willow, and brush with occasional coarse sedges and water-tolerant grasses. Cleared uncultivated areas naturally vegetate to coarse sedges, water-tolerant grasses, grasses such as seaside bent and bluegrass, and white clover. This provides fair grazing but can be materially improved by drainage and by seeding reed canarygrass or pasture mixtures recommended by the State Agricultural Extension Service. Some hay is cut from small areas of alsike clocer and grass mixtures, and good yields are obtained. The better drained areas are used for leafy vegetables, which yield about the same as on Puyallup silt loam, low bottom.

SOIL MANAGEMENT AND PRODUCTIVITY

RELATION OF SOILS AND CROPS

Since the first settlers recognized the value and importance of soil fertility and moisture supply, agricultural development and expansion was most rapid on the soils of bottom lands and upland depressions. Land of the stream bottoms were readily accessible by water, whereas those of the upland depressions were widely scattered among the dense timber and largely unavailable until the lands were logged. Subsistence homesteads were therefore established on many of the stream bottoms and were prepared to supply hay, grain, and other farm products to the lumber camps, mill towns, and mining towns that moved inland with the rapid expansion of the lumber industry and development of the coal mines.

Though most of the stream bottom lands were cleared and farmed to supply the growing demand for agricultural products, the acreage was not enough to keep pace with the rapid expansion. Soils of the upland depressions and organic soils came into demand as soon as they were made available by logging operations. Many of the less desirable soils of the uplands and terraces also were cleared and proved to be satisfactory fruit soils because of freedom from frost and because of good drainage. Around the industrial centers and centers of logging operations many people sought home sites, and as operations ceased or moved to the rough mountainous timbered areas, they often returned to these homes or sought part time outside employment.

Experience in the relation between soils and crops acquired during this early period, with helpful experiments carried on by the State Agricultural Experiment Station, has resulted in a more rational agricultural expansion and a more successful agriculture. The principal crops—hay, grain (largely for hay), and truck and fruit crops—have become important because of local and outside market demands and because they fit soil and climatic environment.

Hay is of first importance, largely because of the extensive wet and cold bottom lands. It is essential in feeding livestock, chiefly dairy cattle as there is a good market demand for dairy products. The practice of growing timothy or timothy and clover on the wet lowlands still persists in many sections. Most farmers prefer a clover and ryegrass mixture. Both red and alsike clovers are used in these mixtures, but alsike is more suitable for the wetter areas. Red clover is used also on the soils of the uplands and terraces but sometimes suffers from lack of moisture on the more droughty areas. The better permanent pastures are usually mixtures of alsike clover, white or red clover, alta fescue, ryegrass, Kentucky bluegrass, and orchard grass.

Most farmers recognize the value of legumes in crop rotations to increase the organic-matter and nitrogen contents that are especially low in the upland and terrace soils. Even though most of the agricultural soils are better for clover than alfalfa, farmers prize alfalfa highly because of the high yields and excellent feeding value. Sweetclover, which is an excellent soil-building legume, could no doubt be used satisfactorily, especially as a pasture crop on soils that are not quite well enough drained for alfalfa.

Alfalfa is grown most successfully on the naturally well-drained but not droughty soils of the uplands and terraces; most soils of the bottoms and upland depressions are too wet and cold. This deep-rooted crop withstands summer drought better than clover or grasses because it reaches the moisture of the deeper subsoil and substratum. Soils with cemented and consolidated subsoils and substrata often are waterlogged in spring and not well suited to alfalfa. Soils with fine-textured material in the subsoil in which the moisture is more uniformly distributed are most successfully used.

Of the grains planted, a large percent is cut for hay, forage, and silage. Oats are planted most extensively for hay, and corn for silage and forage. Oats and other small grains are used largely as nurse crops for hay and pasture seedings but are also used on newly cleared land where other hay crops are not established and on soils too wet for cultivation early in spring. Winter wheat and rye produce early hay crops and sometimes are used for winter pasture. Corn for silage and forage is grown on the fertile stream bottoms, where it is fed to dairy herds. Silage, however, is not so important because of the mild winters, which permit grazing a large part of the year. Where green peas are used for frozen pack, the bulk and stems are used as silage. If trench or other silos are not available, they are often stacked and covered with soil. Forage crops have also been successfully handled in this manner. Farmers state that they obtain one-third more feed value in this way, which obviates loss that might otherwise result from rain in harvest periods.

Although wheat and barley can be successfully grown for cereal grains, the oat crop is the only one that occupies a significant acreage. Oats are better adapted to the wet cold highly organic soils of the stream bottoms and upland depressions, where the cereals are largely grown. They give higher yields than other grains and also mature more rapidly. This is important because some soils drain slowly in spring, thus materially shortening the growing season.

Truck farming shares similar importance with poultry raising and dairying in supplying Seattle and nearby markets. The soils of both the stream bottoms and of the upland depressions are good for truck crops, but the stream bottoms are exceptionally well suited to a variety of such crops, owing to the wide range in texture, organic-matter content, and drainage conditions. Many of the soils are peats and mucks, those derived from woody material being preferred. Crop rotation is not practiced for maintenance of fertility, but the land is fertilized heavily with both barnyard manure and balanced commercial fertilizer. Potatoes occupy a relatively large area, but the largest acreage is used for other truck crops. Most important are peas, beans, beets, carrots, lettuce, spinach, cabbage, celery, cauliflower, asparagus, and rhubarb, with brussels sprouts, tomatoes, sweet corn, and cucumbers also being grown. In addition to truck and fruit crops produced commercially, garden vegetables and fruits are grown on most farms for home use. These are usually grown on the best soils available for the individual crops but must necessarily cover a wide range of soils.

Fruits and berries are grown commercially in fairly large quantities. Of the tree fruits, cherries are most important, followed by apples, plums and prunes, and pears. Grapes are of considerable importance. Most orchards and vineyards are on the well-drained soils of the uplands and terraces or on better drained alluvial fans or slopes skirting the stream bottoms. The higher lying areas are warmer and have greater freedom from frosts late in spring or early in fall.

The best orchards are on soils having sufficient moisture within the root zone during the growing season and not oversaturated or waterlogged in winter and spring. On the uplands and terraces few soils meet these requirements as they are largely either open permeable droughty soils or soils with cemented subsoil or substratum that restrict root and water movement. The soils having cemented layers are often waterlogged in winter and spring, but they lose this moisture in the dry summer before the fruit matures.

Strawberries, raspberries, and blackberries are the most important berry crops. The better drained lighter textured soils of the stream bottoms and upland depressions and many of the soils of the uplands and terraces are used successfully for small fruits. Blackberries withstand considerable moisture. Strawberries are often grown successfully on the more droughty soils, as the berries mature before the summer dry period.

The relatively long grazing season and the possibility of producing good pasture on partly cleared upland cut-over lands and on wet bottom lands make livestock raising essential and profitable. Such

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lands could probably not be made profitable in any other way, and the sale of animal products is the most remunerative way of obtaining revenue. Enough hay for winter feeding can always be produced on the bottom lands, but lack of hay for winter feeding often is a problem on the cut-over lands of the uplands and terraces in contrast to the extensive summer pasture available. Careful crop rotation with such leguminous hay crops as alfalfa and clover in place of the more carelessly grown hay or native mixtures will help overcome this deficiency.

SOIL MANAGEMENT

The light-colored soils of uplands and terraces developed under coniferous forest cover are characteristically low in organic-matter and nitrogen content. Since the organic residues are largely raw and fibrous and yield little active organic matter and available nitrogen for farm crops (*16*), they have to be supplied in an available form before the lands can be successfully farmed. The cheapest and most satisfactory way of supplying and maintaining them is through use of legumes in crop rotation and use of green-manure crops and of all available barnyard manure (*5*, *6*, *11*). Cost of commercial fertilizer carriers of nitrogen may be prohibitive except in cases of special crops. Phosphate applications indicate that phosphorus is not sufficient or available for the best growth, especially of legumes (*13*, *14*). Potash and lime applications seem beneficial in some cases, but further study is necessary before definite conclusions can be drawn. The more acid soils, as the Klaus and Ragnar, under heavy rainfall in the eastern part of the area will probably benefit by applications of lime to neutralize the acidity. If sulfur is deficient for legume growth, it could be supplied by the gypsum in superphosphate applications.

Scattered but comprehensive experiments on similar or related soils developed from glacial material on uplands and terraces occurring in adjacent counties showed the benefits that result from application of various fertilizers singly and in combination (*12*). The greatest response of forage crops to a single fertilizer was to nitrogen, but additional increases were obtained when phosphate and potash were combined with it. This combination on all experiments produced a total average acre yield of 3.9 tons of forage crops, whereas that of the check plots was only 2.3 tons. Legumes benefited from applications of lime on certain soils, but results were not altogether conclusive. The more droughty soils, similar to the Everett of this county, showed no material benefit from the various applications probably because of both the moisture deficiency and the lack of mineral and organic colloids to act as a reservoir for plant nutrients.

Experiments on soils of the stream valleys and upland depressions similar to those in King County demonstrated their natural inherent medium to high productivity but indicated that these soils are becoming deficient in nitrogen and phosphorus under continuous cropping. On the stream bottoms the average acre production of forage crops on the unfertilized checks was 2.6 tons. Nitrogen fertilizers increased this to 3.8 tons and nitrogen, phosphorus, and potash to 4.32. Pasture production was increased an average of 32 percent when pastures were treated with 125 pounds of ammonium sulfate, 300 pounds of superphosphate, 100 pounds sulfate of potash, and 500 pounds of lime per acre. Similar treatment for hay gave an average increase of 29 percent. Favorable increases in yield were also obtained with treatments of superphosphate alone; superphosphate and sulfate of potash; and superphosphate, sulfate of potash, and lime.

Analyses of the pasture clippings and hay indicated that the feeding value was improved by increases in the protein and the mineral content, noticeably calcium and phosphorus. Nitrogen fertilizer alone caused increased yields, but the mineral content was low. There was also indication that the pasture crops removed 35 to 40 percent more plant nutrients from the soil than did hay. This explains why pasture is better feed than hay and shows that pastures make heavy demands on soil fertility. Pastures therefore should be fertilized heavily.

Of soils of the upland depressions Bellingham silt loam (not in King County) produced 3.08 tons of oat hay an acre normally and 5.18 tons when fertilized with nitrogen. Nitrogen with phosphate and potash in combination did not produce any increase. Buckley loam, also not in this county, produced 1.40 tons of oat hay when untreated and 3.63 tons with an application of nitrogen and phosphate. On another field of that soil, oat hay yielded 3.56 tons per acre on the untreated plot; 5.05 tons with nitrogen; and 4.98 with nitrogen and phosphate combined.

In adjacent Snohomish County an application of phosphate, potash, and lime increased the oat production on peat from a yield of 44 to 94 bushels an acre. In another peat field, the oat yield increased from 22 to 92 bushels with nitrogen and phosphate and to 89 bushels with nitrogen, phosphate, and potash. A check plot on peat yielded 0.94 ton of grass hay, whereas a plot treated with phosphate and potash yielded 3.13 tons per acre. A cabbage check plot yielded 1.08 tons and 3.13 tons with a phosphate and potash application. In adjoining Pierce County a 1-ton increase in pasture cutting and in hay on two respective peat areas was obtained with a complete fertilizer including lime.

No specific information on the fertilizer requirements or the rate of application on the individual soil types has been determined in this county. General information gained from such experiments as those above and the demands that certain plants or group of plants make upon soils, however, has led to general recommendations by the State Agricultural Extension Service (*13*, *14*).

Aside from using commercial fertilizer and lime on peat and muck soils, fertilizers other than superphosphate for legumes are not commonly used for general field crops when rotated with legumes with supplementary green-manure crops and barnyard manure. Superphosphate, carrying 16- or 18-percent available phosphoric acid, is applied to legumes in rotation at the rate of 300 pounds an acre the first year and 250 pounds each succeeding year.

In crop rotation with such legumes as clover and alfalfa, satisfactory results are obtained when these are grown with the equivalent of 2 years of intertilled or small-grain crops. If a legume crop remains 2 years, a 4-year period for the other crops should be satisfactory, especially if crop residues are conserved and all available manure is applied or an occasional green-manure crop plowed under. Superphosphate applied to legumes usually assures sufficient phosphorus for the other crop in the rotation. Red and alsike clovers are the most common legumes grown in rotation, but a small quantity of Grimm alfalfa is also used. Alsike clover is used largely on the more moist but drained situations on the stream bottoms and upland depressions. Alfalfa does not withstand poor drainage and is grown only on well-drained situations in the stream valleys and uplands.

Vetches in mixtures with cereals are the most common green-manure crops. Fall-seeded crops made from September 15 to October 15 are the most satisfactory. A Rosen rye and hairy vetch mixture is recommended. Hairy vetch is preferable to common vetch because of its winter hardiness and because of its ability to grow in cool weather. Wheat is more subject to winter injury than rye, and winter oats suffer even more than wheat. Cereals alone are not effective in supplying the much-needed nitrogen. In seeding for green manure, 30 pounds an acre of hairy vetch and 90 pounds of either Rosen rye or winter wheat are commonly used; 50 pounds of common vetch is needed if substituted for hairy vetch. The more desirable spring-seeded green-manure crops are wheat or oats with field peas; 60 pounds of each is satisfactory. Seeding late in February or early in March is best for spring planting on well-drained soils but may have to be delayed on wet soils. The most satisfactory time to plow under the green-manure crop is at the time the cereal begins to show heads. After the first of May it may not decompose properly, owing to the dry summer.

Temporary or permanent pastures seeded to legumes and grasses are excellent for checking erosion and building up and maintaining a high fertility in the soil. Pasture mixtures recommended by the State Agricultural Extension Service are low sod-forming grasses and upright-growing grasses with clovers to thicken the stand and add feeding value to the mixtures. Species recommended for soils of the stream bottoms and upland depressions include alta fescue, Italian and English ryegrasses, orchard grass, Kentucky bluegrass, and white, red, and alsike clovers. For soils of uplands and terraces recommended species are alta fescue, English and Italian ryegrasses, tall meadow oatgrass, orchard grass, Kentucky bluegrass, and alsike, subterranean, red, and common white clovers. On low wet areas that cannot be satisfactorily drained a mixture of meadow foxtail and big trefoil or a straight seeding of reed canarygrass is suitable.

Pastures are materially improved by a fall or winter dressing of 6 to 8 loads of manure an acre supplemented by 400 pounds of superphosphate. Under heavy grazing it may be necessary to add a nitrogen fertilizer or even a complete fertilizer. One hundred pounds of sulfate of ammonia applied early in spring and again in April and in May is usually satisfactory under heavy grazing.

When the small-grain crops follow legumes on mineral soils, no fertilization should be necessary, especially if the legume has been fertilized with superphosphate. At other times it may be necessary to add nitrogen or phosphorus or both to cereal hay crops. From 100 to 200 pounds of sulfate of ammonia and 200 pounds of superphosphate are usually satisfactory quantities to apply. Oats may require 60 pounds of sulfate of ammonia, 150 to 200 pounds of superphosphate, and 40 to 60 pounds of muriate of potash, or the equivalent in other fertilizers.

Victory oats have proved the highest yielding and most satisfactory for this region. Federation and Pacific Bluestem are the best adapted and highest yielding wheat varieties. When the cereal crops are used as nurse crops for hay and pasture mixtures, the rate of seeding of grains is usually reduced one-half on the soils of uplands and terraces and one-third on soils of stream bottoms and upland depressions.

For truck crops intensive farming methods are employed and the soils are heavily fertilized. Since several crops are usually grown on the same soil each season, there is a heavy drain on plant nutrients. Rotations with legumes are infrequent, and therefore heavy applications of both barnyard manure and commercial fertilizer are necessary. Root crops and tubers, as beets, mangels, and potatoes, respond best to complete fertilizers, but under the less intensive methods of general farming 6 to 8 tons of barnyard manure an acre supplemented by 200 to 300 pounds of superphosphate probably would give satisfactory yields following regular crop rotations. Under the more intensive truck-crop farming, in addition to manure it may be necessary to apply the following or its equivalent per acre: 100 to 125 pounds of sulfate of ammonia, 300 to 400 pounds of superphosphate, and 80 to 120 pounds of muriate of potash.

The following truck crop varieties are best adapted to the soils of King County:

Potatoes—Netted Gem, Irish Cobbler, Early Rose.
Table beets—Early Wonder, Eclipse, Crosby Egyptian, Detroit Red.
Carrots—Early Scarlet Short Horn, Coreless Chantenay, Danvers Half Long.
Turnips—Purple Top White Globe, Purple Top White Milan.
Radish—Scarlet varieties, White Icicle.
Sweetcorn—Golden Bantam, Golden Sunshine.
Peas—Gradus, Alaska, Little Marvel, Thomas Laxton, Alderman, Improved Telephone, Stratagem.
Beans—New Stringless Green Pod, Black Wax, Kentucky Wonder.
Cabbage—Copenhagen Market, Early Jersey Wakefield, Danish Ballhead.
Cauliflower—Snowball, Dry Weather.
Brussels sprouts—Improved Half Dwarf.
Asparagus—Martha Washington, Mary Washington.
Celery—Golden Self Blanching.
Rhubarb—Victoria, Linnaeus.
Lettuce—New York (head), Black-Seeded Simpson (leaf).
Spinach—Improved Thick Leaved, Savoy Leaved.
Tomatoes—Earliana, Bonny Best, John Baer.

Leafy vegetables, as cabbage, asparagus, celery, and rhubarb, produce good yields with about 12 to 15 tons of barnyard manure supplemented by 600 to 800 pounds of superphosphate. On muck or peat soils about one-half the manure, the same quantity of superphosphate, and 70 to 100 pounds of muriate of potash give satisfactory yields. Where manure is not used on either mineral or peat and muck soils, 1,000 to 1,200 pounds an acre of 6–10–4 fertilizer is recommended. This is equivalent to about 300 to 350 pounds of sulfate of ammonia, 600 to 750 of superphosphate, and 75 to 100 of muriate of potash an acre. For lettuce 1,000 to 1,200 pounds an acre of 4–8–8 fertilizer is frequently used. For mineral soils 375 pounds of sulfate of ammonia, 550 pounds of superphosphate, and 250 pounds of muriate of potash are satisfactory. On peat and muck soils, 225 pounds of sulfate of ammonia, 900 of superphosphate, and 300 of muriate of potash are necessary for the best lettuce yields.

Table beets, carrots, and sweet corn respond well when 12 to 15 tons of barnyard manure is supplemented by 600 to 750 pounds of superphosphate. Without manure the following acre application is satisfactory on both mineral and peat or muck soils: 200 to 250 pounds of sulfate of ammonia, 625 to 800 pounds of superphosphate, and 120 to 150 pounds of muriate of potash, or the equivalent of these in other commercial fertilizer.

Garden peas and beans are usually fertilized with 150 pounds of sulfate of ammonia, 625 of superphosphate, and 200 of muriate of potash per acre, or their equivalent in other fertilizers.

Strawberries are given a dressing of 6 to 8 tons of well-rotted barnyard manure supplemented by 400 to 600 pounds of superphosphate. Without manure 150 to 300 pounds of sulfate of ammonia, 250 to 500 pounds of superphosphate, and 60 to 120 pounds of muriate of potash per acre are given. Any equivalent amount in a 6–8–6 fertilizer gives good results. The manure and fertilizer applications are made following the harvest or in fall. The Marshall variety of strawberries is the most popular and most extensively grown.

Raspberries and blackberries respond well to 8 to 12 tons of well-rotted barnyard manure supplemented by 400 to 600 pounds of superphosphate. When manure is not available, 100 to 175 pounds of sulfate of ammonia, 450 to 750 of superphosphate, and 100 to 150 of potash should be applied per acre. The Cuthbert and Washington are the best adapted raspberries. The blackberries are largely Texas, Brainerd, and Evergreen, although wild native blackberries supply considerable fruit. The Evergreen variety is rapidly spreading to uncultivated sections.

Orchards are frequently planted to such cover crops as vetch and rye that may be plowed under as green manure. Nitrogen and occasionally other fertilizers are applied with benefit in some cases. For nitrogen deficiency 2½ to 5 pounds of sulfate of ammonia per tree usually gives good response. Sour cherries, which are the most extensively grown of the tree fruits, are mostly of the Montmorency variety. Sweet cherries are largely Royal Ann, Bing, and Lambert. Esopus Spitzenberg and Golden Delicious are the most common varieties of apples. Pears are of the Bartlett and Anjou varieties.

The Campbell Early (Island Bell) and Niagara varieties of grapes are grown.

ESTIMATED YIELDS

The estimated acre crop yields on the soils of King County are given in table 7. These yields are obtainable under average management practices. Under good management, which includes skilled farm operators, use of fertilizer, improved varieties, and possibly supplemental irrigation, yields may be as much as 100 percent greater than those indicated. The greatest relative increases in yield owing to good management will tend to be on the soils giving low yields under ordinary management.

TABLE 7.—*Estimated crop yields per acre on King County, Wash., soils under average management practices*

[Blank spaces indicate that the soil is not well suited to the crop]

Soil	Corn silage	Oats	Wheat	Hay			Pasture [1]	Potatoes	Canning peas	Strawberries	Raspberries	Blackberries	Forest
				Oat	Mixed	Alfalfa							
	Tons	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Tons*	*Qt.*	*Qt.*	*Qt.*	
Alderwood gravelly loam:													
Rolling		35	20	2.2	2.0	3.6	3.5	125		2,500	3,000	3,700	Good.
Gently undulating phase		35	20	2.2	2.0	3.6	3.5	125		2,500	3,000	3,700	Do.
Alderwood gravelly sandy loam:													
Rolling		30	16	2.0	1.8	3.0	3.0	110		2,000	2,700	3,500	Do.
Hilly		25	12	1.5	1.5	2.5	2.5						Do.
Gently undulating		30	16	2.0	1.8	3.0	3.0	110		2,000	2,700	3,500	Do.
Alluvial soils, undifferentiated		70	25	3.0	3.0		4.0	175		3,000	3,500	4,000	Fair.
Barneston gravelly fine sandy loam:													
Rolling		30	15	1.9	1.8	3.0	2.5	125		2,000	2,000	3,000	Good.
Gently undulating		30	15	1.9	1.8	3.0	2.5	125		2,000	3,000	3,000	Do.
Hilly	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	Do.
Barneston gravelly loamy sand:													
Rolling		20	10	1.7	1.7	2.5	2.2	100		1,500	1,500	2,500	Fair.
Hilly	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	Do.
Bellingham silty clay	7.0	75	35	2.8	2.5		5.0		2.0			4,000	Do.
Buckley clay loam	6.6	80	40	3.5	2.7	4.0	5.0	180	2.0	3,000	4,000	4,500	Do.
Buckley silt loam	6.8	80	40	3.5	3.0	4.0	5.0	200	2.0	3,000	4,000	4,500	Do.
Carbondale muck	10.0	90		3.2	3.0		6.0	250	2.0			5,000	Poor.
Shallow	10.0	90		3.2	3.0		5.5	250	2.0			5,000	Do.
Cathcart gravelly loam:													
Rolling	6.0	60	20	2.9	2.5	3.5	4.0	140		3,000	3,300	3,800	Good.
Steep	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	Do.
Cathcart loam:													
Rolling	6.0	60	20	3.0	2.5	3.6	4.2	150		3,000	3,400	4,000	Do.
Hilly	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	Do.

See footnotes at end of table.

TABLE 7.—*Estimated crop yields per acre on King County, Wash., soils under average management practices*—Con.

[Blank spaces indicate that the soil is not well suited to the crop]

Soil	Corn silage	Oats	Wheat	Hay			Pasture [1]	Potatoes	Canning peas	Strawberries	Raspberries	Blackberries	Forest
				Oat	Mixed	Alfalfa							
	Tons	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Tons*	*Qt.*	*Qt.*	*Qt.*	
Coastal beach	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Poor.
Edgewick fine sandy loam	7. 0	70	25	3. 0	2. 8		4. 5	200	1. 7	3, 000	3, 200	3, 500	Fair.
Edgewick sand							3. 5					3, 000	Do.
Edgewick silt loam	7. 5	80	28	3. 3	3. 0		4. 5	220	1. 8	3, 200	3, 400	3, 800	Do.
Edgewick very fine sandy loam	7. 0	70	25	3. 0	2. 8		4. 5	200	1. 7	3, 000	3, 200	3, 500	Do.
Enumclaw loam	6. 5	75	40	3. 4	3. 0	4. 0	4. 6	200	2. 0	3, 500	4, 000	4, 500	Do.
Everett gravelly loamy sand, rolling		25	8	1. 6	1. 2	2. 0	2. 0	75		2, 000	1, 500	2, 500	Do.
Everett gravelly sandy loam:													
Rolling		30	10	1. 8	1. 5	2. 5	2. 5	100		2, 500	2, 000	3, 000	Good.
Gently undulating		30	10	1. 8	1. 5	2. 5	2. 5	100		2, 500	2, 000	3, 000	Do.
Hilly		[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	Do.
Gravel pits	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	
Greenwater sand	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Do.
Greenwood peat [4]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	Poor.
Indianola fine sandy loam:													
Rolling		50	15	2. 2	1. 8	2. 5	3. 0	150		2, 700	3, 000	3, 500	Good.
Hilly	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	Do.
Indianola loamy fine sand, rolling		40	10	1. 9	1. 5	2. 0	2. 5	125		2, 300	2, 700	3, 000	Do.
Issaquah silt loam	8. 0	90	35	3. 4	3. 0		4. 5	160	2. 0	3, 000	3, 400	4, 000	Do.
Kitsap silt loam:													
Undulating	7. 5	50	25	3. 3	3. 0	4. 0	4. 5	160	2. 0	3, 000	3, 500	4, 000	Do.
Hilly	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	Do.
Klaus gravelly loam:													
Rolling	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Do.
Hilly	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Do.

Lynden loamy sand		30	10	1. 5	1. 2	2. 0	2. 0	100		2, 500	2, 700	3, 000	Fair.
Made land	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Poor.
Marsh	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Do.
Mine dump	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	
Mukilteo peat		60	15	2. 5	2. 2		4. 0					3, 500	Do.
Shallow		60	15	2. 5	2. 3		4. 0					3, 500	Do.
Nooksack silt loam	11. 2	90	35	4. 2	4. 0		5. 0	180	1. 7	3, 500	4, 000	5, 500	Good.
Norma fine sandy loam	8. 0	70	25	3. 5	3. 5		4. 5		1. 0			3, 000	Fair.
Norma silty clay					3. 0		4. 0					2, 500	Do.
Oso loam:													
Rolling		45	22	2. 8	2. 3	3. 7	3. 7	130		2, 600	3, 200	3, 500	Good.
Hilly	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Do.
Pilchuck loamy fine sand	8. 0	75	30	3. 5	3. 0		4. 0	200	2. 0	3, 000	4, 000	5, 500	Do.
Shallow							2. 5						Fair.
Puget silty clay					3. 5		4. 5					4, 000	Do.
Puget silty clay loam	10. 0	90	40	4. 0	3. 5		4. 5	200	2. 1			4, 000	Do.
Puget very fine sandy loam	10. 0	85	35	4. 0	3. 5		4. 2	200	2. 0			4, 000	Do.
Puyallup fine sandy loam	11. 0	90	40	5. 0	4. 0		5. 0	250	2. 0	3, 500	4, 500	6, 000	Good.
High bottom	10. 5	85	35	3. 5	3. 3		4. 0	225	1. 8	3, 500	4, 500	6, 000	Excellent.
Shallow (over Buckley soil material)	10. 5	80	35	3. 5	3. 5		4. 5	250	2. 0	3, 500	4, 500	6, 000	Good.
Puyallup silt loam	12. 0	100	45	5. 5	4. 5		5. 5	225	2. 0	3, 800	4, 500	6, 000	Do.
Low bottom	11. 0	90	40	5. 0	4. 0		5. 0	240	2. 0	3, 800	4, 500	6, 000	Do.
Puyallup very fine sandy loam	11. 0	90	40	5. 0	4. 0		5. 0	250	2. 0	3, 500	4, 500	6, 000	Excellent.
Ragnar fine sandy loam:													
Rolling	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Good.
Hilly	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Do.
Terrace, gently sloping	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Do.
Rifle peat		80	25	3. 0	3. 0		4. 5	175	1. 2			4, 000	Poor.
Shallow		80	25	3. 0	3. 0		4. 5	175	1. 2			4, 500	Do.
Sloping		80	25	3. 0	3. 0		4. 5	175	1. 2			4, 500	Fair.
Riverwash	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Poor.
Rough broken and stony land	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Good.
Rough mountainous land	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	Do.
Salal fine sandy loam	6. 6	75	25	3. 0	2. 8	3. 5	4. 0	200	1. 7	3, 000	3, 200	3, 500	Fair.
Salal silt loam	7. 0	80	28	3. 3	3. 0	3. 8	4. 5	220	1. 8	3, 200	3, 400	3, 800	Do.
Sammamish silt loam	7. 5	80	30	3. 4	3. 0	3. 5	4. 2	200	1. 8	3, 000	3, 500	5, 000	Good.
Snohomish silt loam	10. 0	90	30	3. 5	3. 0		5. 0	220	2. 0			6, 000	Fair.

See footnotes at end of table.

TABLE 7.—*Estimated crop yields per acre on King County, Wash., soils under average management practices*—Con.

[Blank spaces indicate that the soil is not well suited to the crop]

Soil	Corn silage	Oats	Wheat	Hay			Pasture [1]	Potatoes	Canning peas	Strawberries	Raspberries	Blackberries	Forest
				Oat	Mixed	Alfalfa							
	Tons	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Tons*	*Qt.*	*Qt.*	*Qt.*	
Snoqualmie gravelly loam	------	30	10	1. 8	1. 5	2. 5	2. 7	100	------	2, 500	2, 000	3, 000	Good.
Snoqualmie gravelly loamy sand	------	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	Do.
Snoqualmie gravelly sandy loam	------	25	8	1. 5	1. 2	2. 0	2. 5	85	------	2, 000	1, 800	2, 600	Do.
High terrace	------	20	8	1. 5	1. 2	2. 0	2. 2	------	------	2, 000	2, 000	------	Do.
Stossel clay loam, rolling	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	Do.
Stossel stony loam, hilly	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	Do.
Sultan fine sandy loam	11. 0	80	40	4. 5	4. 0	------	5. 0	250	2. 0	3, 000	3, 600	5, 500	Do.
Sultan silt loam	12. 0	90	40	4. 5	4. 2	------	5. 5	250	2. 0	3, 500	4, 000	6, 000	Do.
High bottom	11. 0	85	35	4. 0	3. 8	------	5. 0	250	1. 8	3, 500	4, 000	6, 000	Excellent.
Shallow (over Buckley soil material)	11. 0	80	35	4. 0	3. 8	------	5. 0	250	1. 8	3, 500	4, 000	6, 000	Good.
Tokul gravelly sandy loam, rolling	------	35	20	2. 5	2. 2	3. 5	3. 5	125	------	2, 500	3, 000	3, 700	Do.
Unclassified city land	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	
Woodinville silt loam	12. 0	100	40	5. 5	4. 5	------	5. 5	250	2. 0	------	------	5, 000	Fair.

[1] Air-dry weight, equivalent to that of hay.
[2] Soil not in general agricultural use; average yields cannot be determined because soil is not used enough.
[3] Soil not in agricultural use and will probably never be used for agriculture.
[4] Cranberries and blueberries can be grown.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of weathering and soil development acting on the parent material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point depend on (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the plant and animal life in and on the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of development have acted on the 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 material and on the relief, which, in turn, strongly influences drainage, aeration, runoff, erosion, and exposure to sun and wind.

The soils of King County are formed from a number of different parent materials and under a fairly wide range of environmental conditions; as a result the soils are of variable character. Apparently, the soil-forming forces have not greatly modified the parent materials, which largely determine many of the outstanding characteristics of the soils. These parent materials differ considerably, but they consist largely of glacial deposits of various lithologic composition. The texture of the material and the manner in which it was laid down determine the physical characteristics of the soil—its porosity, permeability, drainage, and water-holding capacity. The principal factors effective in the development of the soils are given in table 8.

TABLE 8.—*Principal factors effective in the development of the soils in King County, Wash.*[1]

Parent or underlying material	Drainage	Soil series	
		Weakly podzolized [2]	Strongly podzolized [3]
UPLANDS			
Gravelly drift	Excessive	Everett	
Do	do	Barneston	Klaus.
Sandy mantle over drift	Good	Indianola	Ragnar.
Shallow drift mixed with shale and sandstone.	do	Cathcart	
Till over andesite and basalt	do	Oso [4]	
Cemented till	Moderate	Alderwood	Tokul.
Bouldery till	do	Stossel [4]	
TERRACELIKE POSITIONS			
Silty lake-laid sediments	Moderate	Kitsap	Ragnar fine sandy loam, terrace, gently sloping.
Glacial till (dark basic)	Imperfect	Enumclaw	
Glacial drift (dark basic)	Poor	Buckley	

See footnotes at end of table.

TABLE 8.—*Principal factors effective in the development of the soils in King County, Wash.*[1]—Continued

Parent or underlying material	Drainage	Soil series	
		Weakly podzolized [2]	Strongly podzolized [3]
TERRACES			
Stream-laid mixed sediments	Excessive	Snoqualmie [4]	Greenwater.
Glacial outwash	Good	Lynden	
Stream-laid micaceous sediments.	do	Salal	
BASINS, GENERALLY IN UPLANDS			
Sandy mantle over drift or lake sediments.	Poor	Norma	
Silty mantle over drift or lake sediments.	do	Bellingham	
BOTTOM LANDS			
Sandy alluvium (mixed)	Excessive	Pilchuck loamy fine sand, shallow.	
Sandy alluvium (granitic)	do	Edgewick sand	
Sandy alluvium (mixed)	Good	Puyallup	
Sandy alluvium (granitic)	do	Edgewick	
Silty alluvium (granitic)	do	Nooksack	
Silty alluvium (mixed)	Moderate	Sultan	
Sands and sandy clay alluvium (granitic).	Imperfect	Sammamish	
Sands and sandy clay alluvium (granitic).	Poor	Issaquah	
Silty alluvium (mixed)	do	Puget	
ORGANIC SOILS OR SOILS VERY HIGH IN ORGANIC MATTER IN DEPRESSIONS			
Woody accumulation	Poor	Carbondale muck, Rifle peat.	
Sedge accumulation	do	Mukilteo peat	
Moss accumulation	do	Greenwood peat.	
Mineral soil over organic material.	do	Snohomish	
Stratified mineral soil and organic materials.	do	Woodinville	

[1] Unclassified are Alluvial soils, undifferentiated, Gravel pits, Mine dumps, and Unclassified city land.
[2] Elevation, sea level to about 1,000 feet; precipitation, 30 to 55 inches; average temperature in January 34° to 39° F. and in July 61° to 65°; growing season, 170 to 255 days.
[3] Elevation, 1,000 feet or more; precipitation, 55 to 100 inches or more; average temperature in January 26° to 34° F. and in July 56° to 60°; growing season, 115 to 200 days.
[4] Moderately podzolized at higher elevations.

GEOLOGY OF THE AREA

According to Bretz (*2*), most of the glacial material was deposited by two continental glaciers—the Admiralty and the Vashon, the Vashon probably of Wisconsin age. An interglacial period of uplift and erosion followed by sinking of the land probably contributed the major glacial land features and regional drainage, inasmuch as conclusive evidence of deep excavation or of thick topographically significant deposits by the Admiralty glacier is lacking. In many places the deposits only thinly mantle the glacial-scoured Paleozoic, Miocene, and Eocene (coal-bearing) sedimentary strata and Miocene extrusives, which are largely andesite with some basalt (*3*). In a few soils these formations may appear as contributing parent soil material in residual soil profiles. The Miocene extrusives, together with intrusive Tertiary granodiorite parent materials, are largely in the undifferentiated soils of the mountains. Glaciers of the Cascade Mountains contributed some minor glacial deposits, the largest of which were laid down by the Osceola glacier (*17*) between the White and Green Rivers.

The compacted and partly cemented character of much of the glacial deposits suggests that these deposits may have been submerged for an extended period by both marine and glacial lake waters and possibly covered by more or less stagnant ice during crustal movements of the Pleistocene glacial period. This cementation has seriously retarded normal soil development and internal drainage over large areas.

The Vashon and Piedmont glaciations largely determined the present relief and drainage. They smoothed over older forms of relief and outcropping rock formations, gouged out minor valleys or filled others in, and dammed streams to form lakes or diverted them into new courses. Glacial moraines, though since considerably modified by subsequent outwash deposits, gave rise to a hilly, rolling, or hummocky relief with local lake basins and depressions. Outwash materials were deposited in the form of gravelly terraces and fans or flats of lake-laid silts and clays.

The Vashon drift from which most of the soils are developed covers a large part of the area surveyed. It is bluish gray, sandy, and filled with rounded fragments of rocks resembling stream cobbles and pebbles. Boulders are abundant in places, especially in the surface material. They are derived mainly from granite, gneiss, and schist, but considerable materials from quartzite, argillite, sandstone, shale, and other rocks are included. The Osceola drift is darker gray and contains more silt and clay than the Vashon. Though it contains a high percentage of similar material, it is darker and contains more minerals derived from andesite, basalt, and dark bluish-gray argillite and quartzite. The Osceola drift is confined to a relatively small area between the Green and White Rivers.

The Miocene and Eocene sedimentary rocks, which contribute considerable parent residual material to the soils developed from shallow drift material, occur largely in the higher situations in the east and central parts of the area surveyed. They consist of sandstone and shale, largely of buff, yellow, and gray. On Harris and Stossel Creeks they are highly colored heavy-textured argillaceous shale that ranges from yellow and brown to red, purple, and blue and is underlain at a shallow depth by andesite. Miocene andesite and basalt contribute to the residual material in small areas on Cherry Creek and the White and Tolt Rivers.

CLIMATE AND VEGETATION

The western part of the county borders Puget Sound, and a large part of the area surveyed lies within the Puget Sound Basin. The eastern boundary of the county follows the elevated summit of the Cascade Mountains. Outlying mountain spurs and foothills occur well within the basin and rise rapidly eastward to the crest of the range. This pronounced and variable relief has a marked influence on the climate, vegetation, and soils.

The climate is of a maritime or somewhat modified continental type, influenced by wind from the Pacific Ocean that brings characteristics of an oceanic climate, especially to the lower basin region. The mean annual precipitation ranges from about 34 inches along the coast line to more than 100 inches at higher elevations to the east. There is a protracted dry summer period; nearly 75 percent of the precipitation occurs from the first of October to the last of March. The relative humidity remains near 80 percent most of the year but may drop to nearly 50 percent in dry summer afternoons. Very little snow occurs near the coast, but it accumulates and often remains on the ground for several months at the higher elevations. The ground is frozen for extended periods at these higher levels, but in the lower basin region only occasionally is the ground frozen below a surface crust.

The predominant natural vegetation consists of a dense growth of conifers with a ground cover of ferns, mosses, and occasional shrubs in the more open areas. Deciduous trees, shrubs, vines, briers, and brush are in the stream valleys and depressions. Marshy flats are covered with sedges, reed, mosses, and other water-loving vegetation.

SOIL DEVELOPMENT

In this environment Brown Podzolic soils have developed throughout the uplands and terraces, and dark or gray soils on the flat lower lying stream bottoms and upland depressions. The soils of the uplands and terraces are characteristically low in organic matter. The layer of forest litter is comparatively low in content of bases, has decomposed slowly, and is mixed a little with the soil material. The layer of partly decomposed or humified organic matter below the undecomposed forest litter is feebly developed, though it increases in thickness at the higher elevations with greater rainfall and cooler temperature.

Although organic acids doubtless form, they may not become concentrated and strongly effective in leaching. The acidity of the organic matter may be neutralized by oxidation, especially in dry summer. Acidity is moderate at the lower elevations, rarely much below a pH of 5. At the highest elevations the organic matter is strongly acid, usually below a pH of 5 and generally not exceeding pH 4. The solum is relatively thin and distinctly less acid at shallow depth than the organic mat, even though all the parent materials are noncalcareous. In dry summer very little leaching takes place.

Wheeting (*15*) attributes the occurrence of the iron shot pellets in the normal soils of the lower part of the area to the dry period in which strong precipitation and dehydration of iron and aluminum compounds take place at focal points around sand grains or other nuclei. At higher elevations these shot pellets decrease in number or disappear in the more strongly podzolized soils under cooler temperature and higher rainfall. Instead are thin shallow horizons of imperfect orterde or ortsteinlike concentration of sesquioxides, occasionally with some humus. The shot pellets may represent an imperfect B horizon of scattered ortsteinlike concentrations of sesquioxides. They cannot be attributed to imperfect drainage, as they occur to some extent in the excessively drained droughty soils. There is a certain correlation with moisture, however, as they are significantly more densely massed in the soils of slow or restricted drainage.

SOIL GROUPS

Several important soil groups are apparently represented by one or more soil series in King County, but the soils have not been studied in sufficient detail to determine definitely to which great soil group they belong. In the following tabulation all the soil series mapped in the county are tentatively classified according to great soil groups:

- Zonal soils:
  - Brown Podzolic:
    - Alderwood
    - Barneston
    - Cathcart
    - Everett
    - Indianola
    - Kitsap
    - Lynden
    - Oso [1]
    - Stossel [1]
  - Podzols:
    - Greenwater [2]
    - Klaus
    - Ragnar
    - Snoqualmie [2]
    - Tokul
  - Prairie:
    - Enumclaw
    - Salal
- Intrazonal soils:
  - Weisenboden:
    - Bellingham
    - Norma
  - Weisenbodenlike:
    - Buckley
    - Issaquah
    - Sammamish
  - Bog:
    - Carbondale muck
    - Greenwood peat
    - Mukilteo peat
    - Rifle peat
  - Half Bog:
    - Snohomish
    - Woodinville
- Azonal soils:
  - Alluvial (well to moderately well drained):
    - Edgewick
    - Nooksack
    - Pilchuck
    - Puyallup
    - Sultan
  - Alluvial (poorly drained):
    - Puget

[1] At higher elevations have Podzol characteristics.
[2] Incipient Podzol characteristics.

Some of the soils now listed under one group may be changed to another group or the group name may be changed. There are often insufficient data with respect to certain series to determine absolutely their proper place in the grouping, but it is believed that reasonable accuracy has been attained. There may be some question about the Prairie grouping for the Enumclaw series and about the Wiesenbodenlike grouping of the Buckley series. Both soils are developed on impervious till of the relatively flat Osceola drift plain and are intimately associated with one another at nearly the same elevation, yet they apparently belong to different groups and have been separated for classification purposes.

ZONAL SOILS

The zonal soils include the Brown Podzolic soils, Podzols, and Prairie soils.

BROWN PODZOLIC SOILS

The Brown Podzolic soils are weakly podzolized, though local areas are included in which the podzolic character is more strongly developed. The more distinctly developed soils of this group are similar in appearance to the Brown Podzolic soils of New England (*10*), but they have not yet been investigated sufficiently to justify definitely their classification as such. Similar soils, though somewhat less distinctly developed, occur in northern Idaho (*8*). The less distinctly developed soils do not resemble the Brown Podzolic soils of New England to so great a degree, and probably are somewhat transitional to the Gray-Brown Podzolic soils.

The more weakly podzolized soils occur below an elevation of 1,000 feet and have 34 to 55 inches of rainfall and a mean annual temperature of 49° to 57° F. Owing to the rapidly changing climatic belts, the soils even within this group differ somewhat from west to east. They, however, have the following well-defined characteristics when developed from open permeable material under smooth relief and dominant external and internal drainage conditions: (1) Dark-brown organic layer; (2) brown to slightly reddish- or pale reddish-brown mineral material that grades to yellowish brown without an appreciable zone of enrichment in clay, organic colloids, or sesquioxides other than numerous scattered shot pellets ranging in size from peas to sand grains, which are most abundant below the brown surface soil; and (3) gray drift or residual bedrock material of variable color.

The more typical members of this group developed from porous glacial material under good drainage and on smooth relief include the Barneston, Everett, Indianola, and Lynden soils. The other series in this group are the Alderwood, Cathcart, Kitsap, Oso, and Stossel. The Oso and Stossel have Podzol characteristics at higher elevations. Soils of this group apparently have received the impress of the environmental forces throughout their period of development, but only a very youthful expression of the podzolic processes is evident. The inherent character of the parent material in the individual profiles dominates texturally, mineralogically, and chemically. With the exception of the Cathcart and Kitsap series these soils are all developed from Vashon drift material and do not differ essentially from each other in morphological character but do differ in textural character of drift, in topographic position, and in relief.

The Everett and Barneston soils are developed from similar gravelly and stony drift material. Owing to the higher rainfall under which the Barneston occurs, however, the comparable horizons are a little thicker in the Barneston, and gravel and stone are clay coated and show some iron staining (pl. 4). The Everett soils occupy terraces of relatively smooth level relief, whereas the Barneston include areas of similar but more pronounced morainic relief with hummocks and kettle holes. Drift material or surface boulders are more frequent. The Indianola and Lynden soils are developed from sandy modified drift and glacial outwash. The Indianola soils are on kamelike deposits, eskers, and eroded deltas in which a scattering of gravel and boulders may occur, and the Lynden is on smooth terraces of stratified sand in which gravel is infrequent. The Lynden is somewhat more youthful than the Indianola and contains fewer shot pellets. The Indianola horizons are similar in thickness to the Everett. The Kitsap soils are on old glacial lake deposits of silty texture. The Cathcart soils are derived from sandstone and shale and the Alderwood from cemented Vashon till.

The following description of a Barneston gravelly fine sandy loam represents the stronger profile development that takes place in the Brown Podzolic soils. This profile occurs near Lake Retreat. The cover is mixed conifers with a scattering of shrubs and ferns. The decaying forest litter, including logs, limbs, and twigs, is covered with a continuous growth of moss.

1. 2 to 0 inches, moderately acid dark-brown matter organic layer partly decomposed and humified; black, greasy, and mixed with mineral matter at contact point with mineral soil.
2. 0 to 14 inches, friable and moderately acid rich medium-brown or reddish-brown gravelly fine sandy loam; contains a scattering of rust-iron accretionary shotlike pellets, mostly in lower part.
3. 14 to 28 inches, moderately acid yellowish-brown gravelly gritty sandy loam with scattering of shot pellets in upper part.
4. 28 to 60 inches, slightly to very slightly acid light yellowish-brown to light yellowish-gray poorly assorted glacial drift; consists of porous open sands, gravel, and stone coated with infiltrated clay, rust-brown iron stains, and occasionally silica on under sides at lower depth.
5. 60 inches +, poorly assorted grayish Vashon drift of washed appearance; very slightly acid to neutral.

The Kitsap soils are developed from bluish-gray stratified and laminated lacustrine silt and clay of glacial lake origin. These strata occur largely as terrace remnants of sloping to undulating relief, though flat areas are common. Surface drainage is fairly rapid but internal drainage slow; consequently, the soils are more immature or less perfectly developed than the usual soils developed from open porous drift deposits. They have relatively shallow profiles with abundant shot pellets in which oxidation and soil development have not progressed to any appreciable depth. The surface soil is brown on the better drained situations and frequently grayish brown on the lower areas. The drab mottled grayish-brown to highly iron-mottled yellowish-gray, reddish-gray, and brownish-gray subsoil is over the unmodified bluish sediments.

The Lynden soil occurs on relatively level outwash plains and is derived from sand deposits with a distinct salt-and-pepper appearance. It generally has a shallow profile and is characterized by being rich brown in the upper part. Since it possesses a low water-holding capacity, it dries out excessively late in summer and the vigorous oxidation of the iron compounds no doubt is the cause of the rich-brown color.

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The Cathcart soils are developed almost entirely from interstratified buff, yellow, and gray shale and sandstone of Miocene or Eocene age. Glacial gravel and stone are embedded in the surface soil. The soil retains certain characteristics of these rock materials, and in some cases the normal development has been somewhat modified by slow drainage. Areas in which the soils are derived from sandstone are browner, more loamy and friable, and more permeable than those from shale. Those from shale are frequently clayey and are grayish or darker, owing to retarded drainage. Accretionary shot pellets are more abundant than in the Everett soils.

The following profile description of an Alderwood gravelly sandy loam soil is near Renton on a smooth rolling till plain. Mixed conifers with a scattering of deciduous trees, shrubs, and ferns form the principal vegetation. Forest litter, including rotten logs, is covered by green moss.

1. 2½ to 0 inches, very dark-brown decomposing humified organic mat; becomes black and greasy and mixed with some mineral matter at the sharply defined contact with the mineral soil; reaction, medium acid.
2. 0 to 12 inches, moderately acid brown to pale reddish-brown friable gravelly sandy loam, containing considerable accretionary rust-brown shot pellets, largely of buckshot to pea size.
3. 12 to 26 inches, slightly acid yellowish-brown gravelly sandy loam with a scattering of shot pellets.
4. 26 to 31 inches, slightly acid light yellowish-gray gravelly loam with some brown iron mottling and horizontally matted small roots.
5. 31 inches +, slightly acid light yellowish-gray gravelly loam with some brown iron mottling and horizontally matted small roots; rests on bluish-gray arenaceous gravelly stony drift, slightly indurated by siliceous cementation and containing successive thin wavy fragmental plates with glazed dense surfaces in the upper part; rust-brown iron staining common; a few roots penetrate into the more softly cemented material below; cemented noncalcareous neutral drift continues to undetermined depth.

The Stossel soils are developed from boulder till underlain by highly colored gravelly and stony interbedded clay and shale materials ranging from yellowish brown and red to blue and purple. They have a shallow imperfectly developed profile in which drainage is retarded. The reaction is slightly to very slightly acid.

The Oso soils are developed from a thin mantle of glacial drift over purplish andesite with some dark basalt. Where the weathered rock material occurs only in the deeper subsoil, the profile is more nearly normal, but where it occurs near the surface, the soil is darker, the subsoil influenced by character of the underlying rock, and retarded drainage frequent. Shot pellets are abundant in the surface soil and upper subsoil. The reaction is slightly to very slightly acid.

PODZOLS

The more strongly podzolized soils of this area, or those tentatively classified as Podzols, occur largely between elevations of 1,000 and 1,500 feet. Within short distances these soils range from those with incipient Podzol development to those of more definite Podzol character. The mean annual precipitation probably ranges from 60 to 100 inches or more, and the mean annual temperature from about 47.0° to 48.5° F. Snow occurs frequently in winter and may stay on the ground for several weeks. The ground is more often frozen and to greater depth than at lower elevations.

This group includes the more strongly podzolized Klaus, Tokul, and Ragnar soils and the more weakly to moderately podzolized Greenwater and Snoqualmie soils. These soils are developed from material derived largely from Vashon drift. The Greenwater soil is developed more generally on drift from local Piedmont glaciation. In character of parent drift material, relief, and drainage the Klaus soils are similar to the Barneston; the Tokul is similar to the Alderwood; and the Ragnar similar to the Indianola. Logging operations have destroyed profiles of incipient podzolization, but they can usually be found well-preserved under the protecting radiating roots of larger trees. The soils of this group have more continuous and distinct podzolic development at the higher elevations having more rain and snowfall and lower temperature and in cool moist valley depressions.

A Klaus gravelly loam soil was observed northwest of Lake Hancock on the North Fork of the Snoqualmie River. It was developed under mixed conifers of Douglas-fir, hemlock, and redcedar with little undercover other than ferns and mosses. It occurs on the smoother part of a rolling upland drift plain adjacent to a steep mountain ridge. The ground is covered with a litter of decaying needles, twigs, logs, and rotten wood clothed in a green mat of mosses and ferns. The following is a description of a well-developed profile of this soil occurring in an undisturbed virgin situation:

1. 3 to 0 inches, very dark-brown partly decomposed and humified strongly acid organic mat; thin black greasy layer, containing considerable mineral soil; contacts with the mineral soil.
2. 0 to 1½ inches, leached light-gray sand from ½ to 2 inches or more where it penetrates downward in tonguelike projections or along old animal burrows or root channels; strongly acid.
3. 1½ to 8 inches, strongly acid rust-brown or rich reddish-brown firm compacted gravelly gritty loam with some staining or mottling from iron and dark organic infiltration; irregular development as in horizon above.
4. 8 to 28 inches, moderately acid yellowish-brown heavy gravelly gritty loam with considerable rust-iron staining.
5. 28 to 90 inches, moderately acid yellowish-gray clay-coated and iron-stained coarse gravelly and stony drift with embedded boulders; clay coating and iron staining diminishes with depth; silica coatings are on the under side of gravel and stone, and the materials are frequently bound in firmly clustered masses or layers of silica cementation.

The Ragnar soils, developed from sandy drift, have similar or less strongly developed podzolized profiles than the Klaus soils. They occur at somewhat lower elevations and are often intermediate in stage of development between the soils of the lower and the higher elevations. Shot pellets are frequent, and the gray layer is often thin. Ragnar fine sandy loam, terrace, gently sloping, is at a higher elevation, on smoother relief, and in more sheltered mountain valleys that have a higher humidity most of the year. It is more acid and more strongly podzolized, and coffee-brown orterde or soft ortsteinlike horizons frequently occur. Areas are largely in the Snoqualmie National Forest.

The Tokul soil has a podzolized development as indicated by an A_2 horizon over softly cemented till resembling that of the Alderwood soils. This indurated drift usually occurs at slightly greater depth than that of the Alderwood and does not have the fragmental plates at the surface. It is of till character and for the most part is less deeply, firmly, and continuously cemented. In many places it is highly iron-stained and appears to have been cemented by underground percolating solutions.

Within the region of the more strongly podzolized soils, the young Greenwater soil has not received the full impress of the environment because of the shorter period the parent material has been acted upon by the soil-developing forces. It occurs on narrow stream terraces, mostly in mountain valleys at an elevation slightly above 1,500 feet. The virgin forest is of dense conifers with little undergrowth other than ferns and mosses, except where the terraces are crossed by seepage areas from tributary streams or springs. The parent material is predominantly dark basic andesitic and basaltic subangular thickly stratified sand, coarse sand, and fine gravel. The organic mat and surface soil is strongly acid and the subsoil and substratum slightly acid. In the more strongly podzolized areas, a brownish light-gray or gray layer less than 1 inch thick is developed under the organic mat. This layer is most distinct when the soil is dry. In places the upper subsoil is bound or cemented in clustered masses by infiltrated material.

Development of the incipient podzolic character of the Greenwater soil on such youthful material is promoted by the high rainfall, cool temperature, and dense coniferous forest with the consequent deep forest litter. Leaching is active because of the flat position that is favorable for the accumulation of snow and moisture. In low wetter areas the coniferous forest and the vegetation is largely replaced by deciduous shrubs, and a darker colored soil without the incipient podzolized character is developed.

The Snoqualmie soils are forested light-colored open porous soils intermediate in stage of development between the youthful stream bottom soils and the more mature Everett soils of the upland terraces. Typically they have supported more deciduous trees, brush, and shrubs than the Everett soils, and the surface few inches are darker from incorporated organic residues. They are widely developed throughout the area and include frequent minor differences in profile. Where they occur at higher elevations, a thin ash-gray film under the surface organic mat is common. Accretionary iron shot pellets have not developed.

PRAIRIE SOILS

The Prairie soils are represented by two series, the Salal and Enumclaw. Salal soils are developed on older alluvial material occupying slightly elevated terrace positions. They have developed under grass or bracken fern or both with localized deciduous tree and brush associations. They are unusual in that they have strongly acid surface soils but slightly acid to neutral subsoils. Apparently they have been subjected to wet subsoil conditions but less frequently to flooding and sedimentation. The soot-black surface soil containing finely divided nonfibrous organic matter resembles that of the Prairie soils occurring in Pierce County.

The Enumclaw soil is developed in the area occupied by the relatively local Osceola drift plain. This impervious drift undoubtedly limited root development of the forest trees of the region and favored the grass-bracken fern plant association, thus contributing to the accumulation of large quantities of organic matter in the surface. Since the Enumclaw soil occupies low swells or undulations where natural drainage is more effective, the deciduous and water-tolerant vegetation has been less vigorous and the soils are consequently not so dark or so highly organic as the associated Buckley soils. Unlike the Buckley, this soil has a rich-brown layer lying between the dark-colored surface soil and the impervious gray till beneath.

INTRAZONAL SOILS

The intrazonal soils are developed largely under excessive moisture conditions on low-lying areas of the stream bottoms and upland depressions. The moisture is largely responsible for the retarded development, and the regional profile is therefore wanting or is not appreciably impressed upon the soil material. Unlike the brown soils developed under a coniferous forest these darker or grayer soils have developed principally under cover of mixed conifers, deciduous trees, brush, grass, and water-tolerant vegetation, which has contributed a large quantity of organic residues of high base content.

WIESENBODEN SOILS

The soils tentatively classified as Wiesenboden in this area include the Bellingham and Norma series. In these dark-colored soils the surface horizon of organic accumulation is a distinct profile feature. The subsoil and substratum are of variable stratified texture. They are dominantly gray or greenish gray but are somewhat stained or mottled with red, rust brown, yellow, green, or blue. These colors result from changes in moisture conditions and successive reduction, oxidation, and hydration attending such changes.

The Norma and Bellingham soils in the upland depressions, including local flat stream bottoms, have dark-colored highly organic surface soils as they have developed on waterlogged material supporting flourishing growths of deciduous trees, brush, shrubs, and water-tolerant vegetation, including coarse grasses, reeds, and sedges. Occasionally they have thin peaty or mucky organic accumulations at the surface. These accumulations are more common in the Bellingham soil, which is developed on tight laminated or stratified clay. The Norma soils have a more sandy subsoil of bluish gray that is highly discolored by iron mottling brought about by alternate oxidation and reduction.

WIESENBODENLIKE SOILS

The Wiesenbodenlike soils include the Issaquah, Sammamish, and Buckley series. The Issaquah and Sammamish soils are developed on interstratified sand, clayey sand, and sandy clay. They occupy smooth gently sloping wet valley floors with slowly moving underdrainage. The Issaquah soil occurs in lower positions and is wetter, darker, and more highly organic than the Sammamish soil. The subsurface layer of the Issaquah soil is yellow or reddish brown, which contrasts conspicuously with the darker surface soil and blue-gray iron-mottled subsoil. This apparently is not a leached layer of a Ground-Water Podzol but rather a contact point between acid organic-surface solutions and the nearly neutral or slightly alkaline ground water. Before being drained, the water table evidently remained fairly constant at this level, which also marks a textural change between the surface soil and subsoil. A considerable quantity of iron is precipitated from solution at this point. The deeper underlying Sammamish horizons resemble those under the Issaquah soil.

Buckley soils are underlain by Osceola drift and developed under restricted or poor drainage resulting from the flat relief and slowly permeable parent material. They are closely associated with the Enumclaw soil on flat areas between ridges or benches on which the Alderwood soils are developed. In some of the low basins occupied by Buckley soils, a thin gray layer, probably diatomaceous earth, occurs in the surface soil. Owing to the continuous wet condition, hydration and reduction processes are active. The highly discolored gray clay material is gritty, gravelly, and stony with sharp angular fragments of disintegrating rocks.

BOG SOILS

The Bog soils are Carbondale muck and Greenwood, Mukilteo, and Rifle peats. Peat and muck soils have the characteristic properties of organic soils developed in the northern region of the United States. They occupy low basins or low areas of the stream valleys and uplands and have developed from remains of aquatic vegetation in open water, from sedges and reeds in marshes, and from trees, brush, shrubs, and water-tolerant vegetation in the swamp forest.

Peat soils represent the accumulation of organic remains from plant successions, and in the field various degrees of preservation or decomposition of the fibrous or spongy remains are recognizable. In this area sedimentary peat from the first stage in development is largely buried by remains of the subsequent plant successions so that the surface peat consists of woody material or sedges and mosses. Mukilteo peat is representative of the sedge type, while Rifle peat represents the woody type. When decomposition has proceeded under conditions of better drainage, Carbondale muck is developed. It has a somewhat granular black or dark-brown surface soil with undecomposed organic material of sedge or woody origin beneath. The vegetative origin of the Mukilteo and Rifle peats can be readily determined since the plants from which they were derived remain relatively undecomposed. The strongly acid Greenwood peat is derived mainly from sphagnum mosses, usually in pot holes without adequate drainage. Lack of available minerals in the bog water excludes most plant species except Labrador-tea, swamp laurel, and mosses.

HALF BOG SOILS

The Half Bog soils of this area are not very well defined and include only the Woodinville and the Snohomish series. The Woodinville soil occupies low basins in back bottom positions subject to overflow yet favorable for peat formation. The profile indicates that peat has formed intermittently with accumulation of mineral sediments. The surface soil material is silty and highly organic or peaty and is underlain by a blue-gray gley iron-mottled subsoil of laminated clay sediments. The Snohomish soil differs from the Woodinville in that the subsoil is composed of peat and the surface soil of silty sediments of recent alluvial origin.

AZONAL SOILS

The azonal soils of the county are chiefly the alluvial soils of the river flood plains. Owing to wide differences in drainage conditions, two groups have been established: (1) Well to moderately well drained and (2) poorly drained.

ALLUVIAL SOILS (WELL TO MODERATELY WELL DRAINED)

Soils of the Edgewick, Nooksack, Pilchuck, Puyallup, and Sultan series are the Alluvial soils (well to moderately well drained). In periods of heavy runoff these soils may be temporarily covered by floodwater; nevertheless, the color profiles indicate that good internal drainage conditions usually prevail.

Pilchuck soils are of recent origin—in most places representing stream sediments deposited within the last few years. They occur on hummocky topography or as natural levees adjacent to recent or current stream channels. There is no profile development, and the soil is really a geologic deposit consisting of a wide variety of rock fragments. Since most of the rivers are fed by mountain glaciers, a high proportion of rock flour is present in the sediments. The predominant color is grayish brown throughout the entire soil, and the predominant texture is sandy.

Puyallup soils have developed from sandy alluvial sediments of mixed lithological origin and usually occupy the more elevated positions in the stream valleys. They are subject to less annual spring flooding than the associated Pilchuck soils but may be modified from time to time by depositions of river sediments. They have fair to good drainage and support mainly a moderately dense growth of deciduous trees, brush, shrubs, and other ground cover. The soil environment has produced deep soils with light-brown surface soil and gray subsoil, sometimes slightly mottled below 3 feet. The light-brown upper soil is evidence of the beginning of soil formation processes.

The Edgewick soils occupy similar positions and have drainage similar to the Pilchuck, but the alluvial sediments are highly micaceous and are derived mainly from granites or granodiorites. They have been subjected to more turbulent water action and deeper and more frequent sedimentation. These soils occur mainly in the upper reaches of the rivers, particularly along those rivers not fed from mountain glaciers. Sandy textures predominate and the sediments have a distinct olive cast.

The Nooksack soil is similar to the Edgewick in color, but it is derived from finer textured more silty sediments. It has developed under slightly better drainage conditions and is relatively free from mottling in the lower layers. It is related to the Edgewick soils in much the same manner as the Puyallup soils are related to the Pilchuck.

Sultan soils occupy slightly elevated positions in the river flood plains and are similar to Puyallup soils in surface aspect. They differ from Puyallup soils in having a heavy-textured subsoil with appreciable mottling. They are related to the Puget series in the same manner as Puyallup soils are related to Pilchuck; that is, Sultan soils are older sediments showing the faint beginning of soil formation processes. Like Puyallup soils, they are flooded infrequently.

ALLUVIAL SOILS (POORLY DRAINED)

The Alluvial soils (poorly drained) are represented by the Puget soils. They are developed from fine-textured sediments mainly of gray glacial flour derived from mountain glaciers. Most of this material settles out in the ponded waters and probably produces the heaviest textured alluvial soil in the county. Areas occur in low back bottoms in the flood plains and are subject to annual flooding. Owing to the fluctuating drainage conditions and recurrent deposition of fine-textured sediments, the soils are usually heavy textured and mottled in the surface soil. Normal vegetation has been somewhat inhibited, and areas have a swampy appearance and are often covered with sedges and willow. Because of the small quantity of organic matter incorporated and because of poor oxidation, the soils are predominantly gray and highly mottled throughout.

LABORATORY STUDIES

The results of mechanical analyses and pH determinations of certain soils in the county are given in table 9.

TABLE 9.—*Mechanical analyses and pH determinations of certain soils in King County, Wash.*

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	pH
Bellingham silty clay:	*Inches*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	
552132	0–10	0.2	0.4	0.5	2.3	3.5	46.9	46.2	5.3
552133	10–30	.1	.2	.5	5.7	8.8	57.8	26.9	6.6
552134	30+	.1	.3	1.4	10.2	16.2	58.4	13.4	7.0
5521191	0–5	.6	.8	.7	2.7	3.9	50.2	41.1	5.0
5521192	5–18	.5	1.0	1.0	3.7	4.4	48.5	40.9	5.5
5521193	18+	1.2	3.5	3.9	7.4	9.5	54.5	20.0	5.9
Lynden loamy sand:									
552141	0–2	11.5	50.1	13.0	5.4	3.4	10.9	5.7	5.5
552142	2–10	9.9	51.2	14.1	5.8	3.5	10.9	4.6	6.0
552143	10–30	4.4	51.8	23.2	6.2	2.5	7.8	4.1	5.7
552144	30–80+	2.8	56.7	29.7	7.1	.7	1.8	1.2	6.0
Puget silty clay loam:									
552157	0–3	.3	.2	.2	.8	1.5	69.4	27.6	4.9
552158	3–14	.1	.2	.3	.8	1.8	65.8	31.0	4.9
552159	14–60+	.1	0	.1	.2	.2	62.1	37.3	5.3
Greenwater sand:									
5521220 [1]	1½–0	-----	-----	-----	-----	-----	-----	-----	4.8
5521221	0–1	6.8	28.6	21.6	24.2	6.9	9.6	2.3	5.0
5521222	1–7	4.6	24.0	23.2	29.7	7.5	8.9	2.1	5.3
5521223	7–22	6.3	28.9	26.4	25.1	2.5	9.5	1.3	5.7
5521224	22–68+	13.5	33.8	19.3	18.4	5.7	7.7	1.6	6.0

[1] Mechanical analyses not made; this layer largely organic matter.

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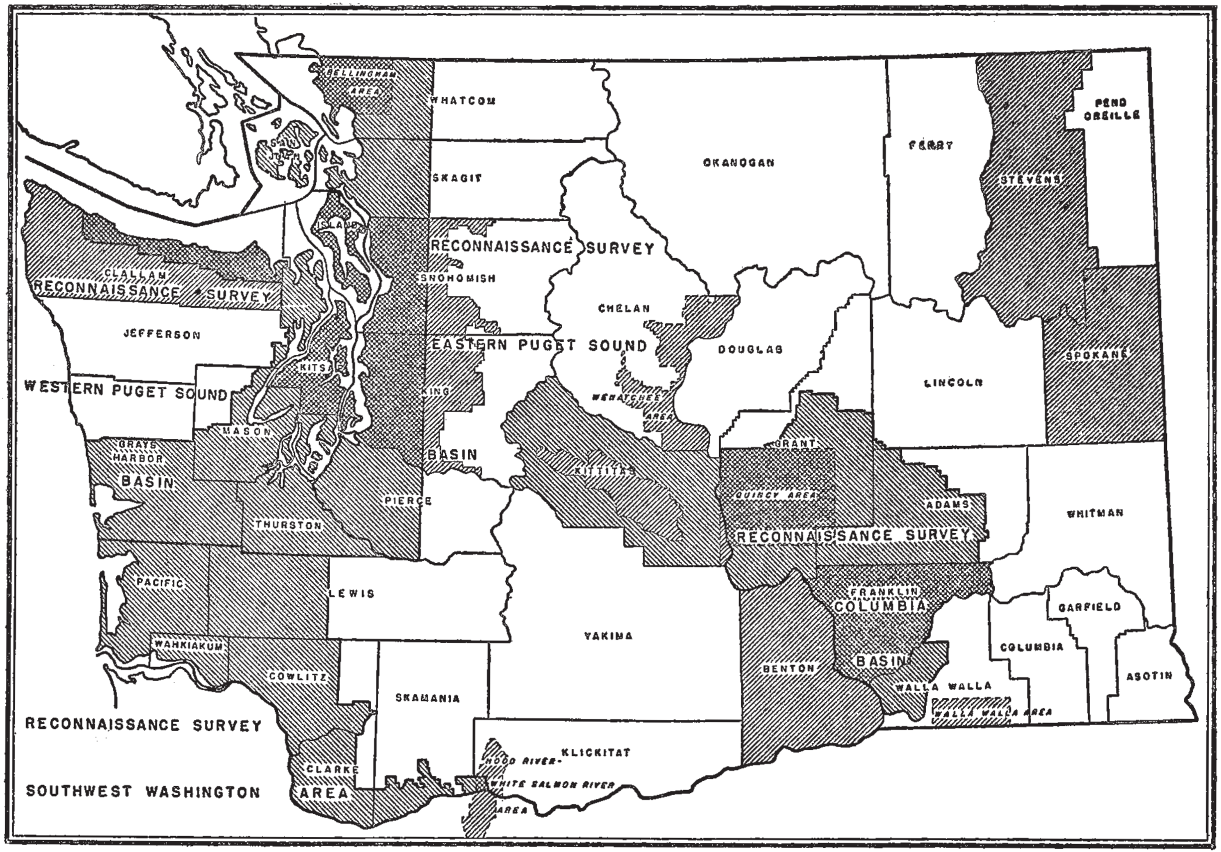

Areas surveyed in Washington shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys by northwest-southeast hatching; cross hatching indicates areas covered both ways.

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