SOIL SURVEY

Whatcom County Washington

Series 1941, No. 7

Issued August 1953

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with the
WASHINGTON AGRICULTURAL EXPERIMENT STATION
and the
STATE DEPARTMENT OF CONSERVATION AND DEVELOPMENT

How to Use THE SOIL SURVEY REPORT

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

SOILS OF A PARTICULAR FARM

The soil map is in the envelope inside the back cover. To find what soils are on any farm or other tract of land, locate the area on the map. This is easily done by finding the township the farm is known to be in and by using such landmarks as roads, streams, villages, dwellings, and other features that help to locate the boundaries.

Each kind of soil mapped within the farm or tract is marked on the map with a symbol. All the areas marked Bc are Barneston silt loam, rolling. The color with which the soil area is shown on the map will be the same as the color in the legend.

To find out what the soil is like, turn to the section on Soil Series, Types, and Phases and find Barneston silt loam, rolling. There will be found a statement of what the soil is like, what it is mainly used for, and some of the uses to which it is suited.

How productive is Barneston silt loam, rolling? Find this soil in the left-hand column of table 6 and read the yields given opposite it under the names of different crops. This table also gives estimated yields for all the other soils mapped in the county.

What are considered good uses and management practices for Barneston silt loam, rolling? Read what is said about this soil in the section on Soil Series, Types, and Phases. Look also at the section headed Soil Use and Management, where soils suited to the same general use and management practices are grouped together. Read what is said about crops, crop rotations, liming, fertilizing, drainage, erosion control methods, and other management practices on the group containing this soil. It will apply to Barneston silt loam, rolling.

SOILS OF THE COUNTY AS A WHOLE

A general idea of the soils of the county is given in the introductory part of the section on Soils of Whatcom County, which tells about the principal kinds of soils in the county, where they are found, and how they are related to one another. At the same time study the soil map and notice how the different kinds of soils tend to be arranged in different parts of the county. These patterns are likely to be associated with well-recognized differences in type of farming, land use, and land-use problems.

A newcomer to the county, especially if he considers purchasing a farm, will want to know about the climate; the types, sizes, and tenure of farms; the principal farm products and how they are marketed; churches, schools, roads, and railroads; the availability of telephone and electric services and water supplies; the industries of the county; and towns, villages, and population characteristics. Information about all these will be found in the sections on General Nature of the Area and on Agriculture.

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

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

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STATE DEPARTMENT OF CONSERVATION AND DEVELOPMENT

Series 1941, No. 7 Issued August 1953

SOIL SURVEY OF WHATCOM COUNTY, WASH.

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United States Department of Agriculture in Cooperation with the Washington Agricultural Experiment Station and the State Department of Conservation and Development

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[1] The Division of Soil Survey was transferred to the Soil Conservation Service Nov. 15, 1952.

LUMBERING and agriculture have been the leading industries in Whatcom County since settlement began in 1854. Agriculture, confined mostly to the Puget Sound Basin, developed as the dense stands of Douglas-fir, cedar, and hemlock were cut. Lumbering is now done chiefly in the more mountainous parts to the east. Agriculture is diversified, although the county leads the State in dairying and poultry raising. Small grains, vegetables, and fruits are among the principal crops, but hay occupies the largest acreage. Shipping, fishing, manufacturing, and some coal mining provide employment for part of the population. Dairies, creameries, canneries, hatcheries, lumber mills, furniture factories, shingle mills, and pulp and paper mills are among the manufacturing plants. To provide a basis for the best agricultural uses of the land this cooperative soil survey was made by the United States Department of Agriculture, the Washington Agricultural Experiment Station, and the State Department of Conservation and Development. Field work was completed in 1941, and, unless otherwise specifically mentioned, all statements in this report refer to conditions in the county at that time.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

Whatcom County borders Puget Sound and the Georgia Strait on the west and adjoins Canada on the north (fig. 1). Bellingham, the county seat, is 240 miles northwest of Spokane and 80 miles north of Seattle. The eastern two-thirds of the county lies within the Mount Baker National Forest, however, and is not included in the area surveyed. Lake Whatcom, Samish Lake, and many smaller lakes cover a considerable area. The 755 square miles, or 483,200 acres, surveyed include Lummi and Eliza Islands and Point Roberts, which is well out in the Georgia Strait and has road connections with the rest of the county only through Canada.

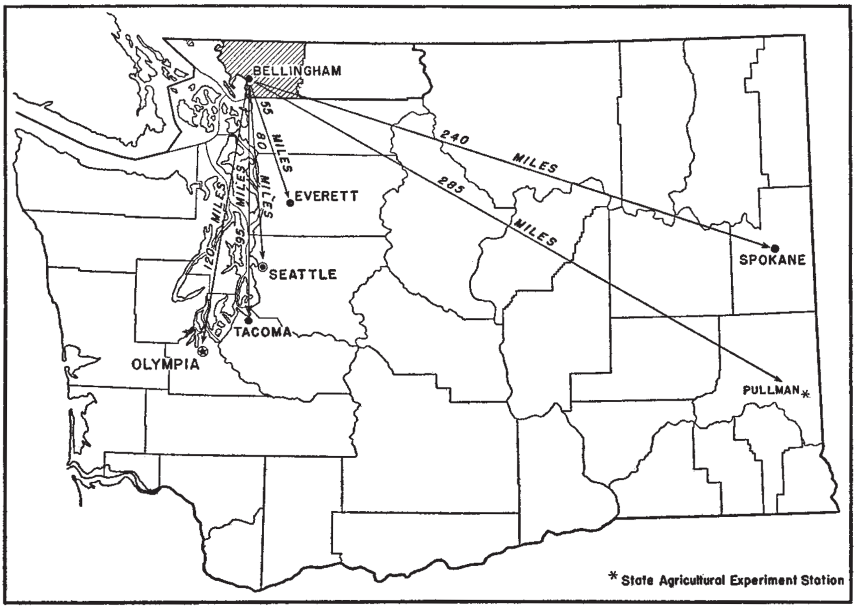

FIGURE 1.—Location of Whatcom County in Washington (eastern area in Mount Baker National Forest not covered in the soil survey).

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

The area surveyed lies largely in the Puget Sound Basin. Most of the agricultural lands are in the basin area at elevations ranging from near sea level to 300 or 400 feet (pl. 1, *A*). This basin area consists of extensive alluvial flats and low smooth glacial and postglacial fluvial or marine terraces, low rolling glacial ground-moraine plains flanking these flats and terraces, and occasional frontal recessional moraines of more pronounced relief.

The outlying foothills and spurs of the Cascade Mountains form a distinct and prominent front that joins the morainic drift plain (pl. 2) in a diagonal line that runs northeast from Bellingham to several miles east of Sumas at the Canadian border. Because of

A, Looking south along South Fork Nooksack River: Chiefly Pilchuck and Puyallup soils on flood plain; Barneston soils on low hills to left; Rough mountainous land in background. Elevation of plain, about 320 feet; of mountain peak, 3,500 feet.

B, Land-clearing operations on Bow silt loam, undulating.

Western Washington landscape: Well-managed pasture on cut-over land in foreground; intensively cultivated bottom lands in center; and Rough mountainous land in background.

both continental and alpine glacial scouring and the accumulation of drift, the relief of this piedmont region is somewhat subdued. Eastward, near the national forest boundary and beyond, is the higher, more rugged, eroded, and erupted Cascade peneplain, which has a summit level from about 6,000 to 8,000 feet above sea level. Many prominent peaks in the peneplain attain higher elevations. The highest is Mount Baker, with an altitude of 10,750 feet.

Immediately west of the national forest boundary, and within the area covered by this survey, the higher elevations range between 4,000 and 5,000 feet above sea level. Among the more prominent elevations in this area are Black Mountain, 4,990 feet; Bald Mountain, 4,550; Slide Mountain, 4,542; Bowman Mountain, 4,300; and Stewart Peak, 4,300. Near the morainic drift plain, 3,100 feet is the maximum elevation, and the lower foothills descend to only a few hundred feet above sea level.

Some of the lower hills have been scoured by glaciers, and Tertiary and Paleozoic (*2*)[1a] sedimentary rocks are exposed. Glacial drift mantles most of the hills, however, and the drift plain runs onto the mountainsides and extends as embayments into valley passes. Lobes of the main continental ice sheet were deflected southwestward along the trend of these foothills, and when they entered preglacial stream valleys they left heavy loads of glacial debris and disorganized the drainage pattern.

The largest deeply entrenched valley in the area surveyed runs southward from the international boundary into Skagit County on the south. This valley has been modified by glacial deposits and it separates the lower lying foothills and mountain ridges from the more elevated mountains to the east. The more conspicuous tributary valleys opening on the west side of this large valley are those occupied by Lake Whatcom and the main Nooksack River; to the east side are the deeply entrenched valleys drained by the three forks of the Nooksack River and the small valley occupied by Silver Lake.

Throughout the Puget Sound Basin, geologists (*1*) have found evidence of at least two continental glaciers, but they attribute the most impressive features of the relief to an interglacial period of land uplift. Of these Pleistocene glaciers the older is known as the Admiralty, and the other, thought to be of Wisconsin age, as the Vashon. Though drift deposits indicate there were many readvances of the oscillating Vashon glacier, the ground-moraine and glacial outwash accumulations are thinly laid over the deeply eroded relief of the interglacial period. Many of the major entrenched stream valleys, basins, and interstream areas therefore probably conform in large degree to the interglacial relief, and in the more mountainous sections, to relief that may have become well established in preglacial time.

With the exception of a few isolated high moraines and those skirting the foothills, the heavy clay till of the low drift-filled basin differs from the more sandy drift found elsewhere in the county and, in fact, from that in the whole Puget Sound Basin south of the extensive Cascade Mountain spur at Bellingham. This youthful clay till and the presence of intact recent marine shells suggest the re-

[1a] Italic numbers in parentheses refer to Literature Cited, p. 153.

advance of a later glacier. Geologists (*1*) ascribe this readvance to the late Vashon; they suggest the extensive outwash indicates that the glacier stood for a long time in this basin. Marine strata and beach ridges on the outwash plain also show that marine waters closely followed the retreat of the ice.

West of Mount Baker the drainage is mainly through the Nooksack River and its tributaries, though along the shore a number of small streams drain directly to Puget Sound and Georgia Strait. A small area drains to Lake Whatcom and Samish Lake, the waters of which empty through Whatcom Creek and the Samish River (in Skagit County), respectively. The land east of Mount Baker, outside the area surveyed, drains southward through the Skagit River and its tributaries.

In the mountain section, the dendritic drainage system of the Noosack River is deeply entrenched in Tertiary, Paleozoic, and Mesozoic sedimentary rocks. In the broad nearly level alluvial bottoms and deltas along the meandering lower course of the river, however, drainage is sluggish. The gradient in this lower lying glaciated section is not sufficient for effective drainage, and the bottom lands and adjacent terraces are mostly poorly or imperfectly drained. Dikes have been constructed to hold the river to its course during periods of high water.

The upland bordering this lower area has rolling and wavy to choppy morainic or kame and kettle topography, and drainage channels have not developed to the degree necessary to establish proper drainage relief. In addition, the massive clay till and marine strata prevalent throughout the basin cause slow internal and subdrainage. An intricate pattern of poor, imperfect, and moderately good drainage is the combined result of all these factors. Waterlogging may be permanent in this area, but it is often confined only to winter and spring.

Within the city limits of Bellingham, at the southern edge of the lower basin area, the altitude ranges from sea level to 640 feet. Marietta, at the mouth of the Nooksack River and northwest of Bellingham, is 10 feet above sea level. On alluvial flats and terraces along the Nooksack River northward and eastward of Marietta are: Ferndale, altitude 33 feet; Lynden, 95 feet; Everson, 83 feet; and Lawrence, 156 feet. Sumas and Blaine, on the Canadian border, have elevations of 48 and 57 feet, respectively. A prominent moraine east of Blaine has an elevation of nearly 500 feet, and one west of Ferndale, 350 feet. Elsewhere in the outlying basin the altitudes seldom exceed 300 feet.

Deming, located at the edge of the long interior valley where the three forks of the Nooksack River meet, has an elevation of 203 feet. Southward this flat-bottomed valley reaches an elevation of only 313 feet at Wickersham near the Skagit County line. To the north, on the Canadian border, Columbia Valley has an elevation of about 600 feet. Glacier, within the national forest boundary in the valley of the Nooksack River, has an altitude of 960 feet.

CLIMATE

Whatcom County has an equable, mild, somewhat modified oceanic climate, the result of the prevailing westerly winds from the Pacific

Ocean. The Rocky and the Cascade Mountains are barriers against the temperature extremes of the continental interior. The combined influence of winds and mountain barriers result in considerable precipitation, cool summers, and comparatively mild winters. Temperature and precipitation change from south to north but, because of the rapidly changing elevations of the Cascade Mountains on the east, vary more strikingly from west to east. Irregular relief further modifies the climate from place to place, especially in the eastern foothills and valleys.

Differences in altitude from place to place make climatic data for one location representative of only a limited area. Data for the United States Weather Bureau station 2 miles north of Bellingham are given in table 1.

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

[Elevation, 120 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year	Total for the wettest year	Average snowfall
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	38. 8	62	−4	5. 20	3. 94	5. 15	2. 4
January	36. 5	61	−4	4. 49	1. 56	4. 12	4. 2
February	39. 3	63	1	2. 89	1. 44	5. 72	2. 7
Winter	38. 2	63	−4	12. 58	6. 94	14. 99	9. 5
March	43. 2	72	15	3. 10	2. 77	7. 20	1. 1
April	48. 0	81	21	2. 41	1. 32	2. 88	. 1
May	52. 6	86	28	1. 81	1. 90	. 60	0
Spring	47. 9	86	15	7. 32	5. 99	10. 68	1. 2
June	57. 6	97	33	1. 80	. 60	2. 05	0
July	60. 8	93	35	. 94	. 11	3. 18	0
August	60. 8	89	31	1. 24	. 54	1. 34	0
Summer	59. 7	97	31	3. 98	1. 25	6. 57	0
September	56. 1	87	23	2. 05	1. 21	. 96	0
October	49. 9	80	10	3. 71	2. 17	5. 90	0
November	43. 2	69	10	4. 32	2. 38	9. 51	. 4
Fall	49. 7	87	10	10. 08	5. 76	16. 37	. 4
Year	48. 9	97	−4	33. 96	[1]19. 94	[2]48. 61	11. 1

[1] In 1929. [2] In 1932.

The mean annual temperature decreases with the distance inland, the distance north, and also with the increase in elevation. Precipitation and depth of snowfall usually increase markedly as elevation increases, but proximity of lower areas to mountains or other bold relief has an important influence on rain and snowfall.

Approximately 70 percent of the annual precipitation occurs from October 1 to March 31. July and August are the driest months, and December is usually the wettest. During the mild winters precipitation is largely in the form of rain at the lower altitudes, but in the colder mountainous region snow accumulates to considerable depths. Occasional snows occur near the coast, but they remain on the ground only a short time. In the foothills snow may remain on the ground for several weeks at a time; whereas in the mountains it may stay for the winter months or longer.

The moderating marine influence is especially significant at Marietta, where the lowest winter temperature is higher than elsewhere by almost 10° F., and the highest temperature is only 94°. Clearbrook, well inland on the large glacial plain north of Bellingham, has a low temperature record of −4° and a high of 97°. Here the average growing season of 138 days is more than a month shorter than near the coast. Cold currents of winter air from the Canadian interior apparently move down this low glacial plain, because it is considerably colder than areas to the south and those bordering the coast. Weather records at Clearbrook show summer temperatures consistently higher and winter temperatures similarly lower than those of other lowland sections where records have been kept. The average maximum of 58.9° at Clearbrook is about equal to the 59.0° at Marietta, but the average minimum for Clearbrook is 37.9°, as compared to 40.6° for Marietta. Killing frosts have been recorded at Clearbrook as late as July 6 and as early as August 5.

The average temperature is lower at higher altitudes, but the frost danger to crops is greater in low-lying valleys and depressions. Apparently, the cold air trapped in these low areas may bring frost in any month of the year. Fog helps to blanket the vegetation in low areas, however, and thus affords protection from late spring and early autumn frosts.

The average frost-free season and average annual snowfall, temperature and precipitation for various locations are given in table 2.

TABLE 2.—*Climatic summary to 1948, Whatcom County, Wash.*

Station	Approximate elevation	Mean annual temperature	Mean annual precipitation	Annual snowfall	Average annual frost-free period
	Feet	*°F*	*Inches*	*Inches*	*Days*
Bellingham (near)	120	48. 9	33. 96	11. 1	150
Marietta (near)	10	50. 0	31. 79	10. 3	176
Blaine	40	48. 8	40. 98	14. 2	170
Clearbrook	64	48. 8	47. 42	18. 5	138

WATER SUPPLY

Whatcom County possesses enormous water power resources, and several large dams, powerhouses, and reservoirs are located on the

Skagit River in the eastern part of the county, or east of the surveyed area. In the State, the Skagit River system is second only to the Columbia in potentiality for hydroelectric development. The domestic supply of water within the area surveyed is adequate and of good quality for both household use and livestock.

A number of scenic lakes and several beaches are in the county. The Mount Baker area is noted for its winter skiing and summer recreation.

VEGETATION

The virgin vegetation was an almost continuous dense growth of conifers that reached huge size at maturity. In the lower basin nearly all the merchantable timber has been removed, but in the mountainous area extensive logging for lumber and pulpwood still continues. Most of the logged area not in farms is restocking to timber types similar to those removed. The strongly competitive deciduous trees and brush, including alder, maple, and cottonwood, are rapidly invading unfarmed cut-over areas and retarding or excluding the more desirable trees, especially in severely burned areas. Little if any artificial reseeding or planting of timber is practiced. Farmed areas have been cleared of stumps to permit tillage or, where clearing has been delayed, generally have been seeded to grass and legumes for pasture.

Temperature and precipitation changes resulting from the wide range in altitude have a marked influence on vegetative growth. Temperature, precipitation, and soil and drainage conditions control vegetative growth. A few small areas of prairie and marsh occur as a result of soil and drainage conditions.

Douglas-fir, the most valuable timber type, grows more or less indiscriminately under a wide range of conditions throughout the area, but the other conifers thrive only within more clearly defined limits. Western redcedar, second in importance to Douglas-fir, covers a wide region, but it matures to large size only in low moist locations and seldom occurs on droughty soils. Scattered Sitka spruce and occasionally Pacific white fir are associated with cedar in the lower basin region. Western hemlock grows extensively in the western mountainous section, and scattered Western white pine is associated with the hemlock. Lodgepole pine grows occasionally on droughty gravelly soils or on soils with very compact subsoil.

Many trees and shrubs (*4*), mostly deciduous and commercially unimportant, are associated with the conifers throughout the area. Bigleaf maple is widely distributed and becomes prominent after the conifers are removed. Red alder spreads rapidly on cut-over lands, but after a number of years the conifers crowd it out in all except the wet depressions and streamways. Western paper birch grows abundantly with the alder in low moist places, and in these areas, scattered black cottonwood and quaking aspen are common. Willows and vine maple grow most abundantly in low wet areas but spread rapidly to the less favorable areas on cut-over lands. California filbert (hazelnut) and bitter cherry (wild cherry) are thinly scattered in a few areas.

Blueberry elder (elderberry), cascara buckthorn, and Pacific dogwood grow extensively in moist depressions and along drainageways. Scotch broom is in a few places near the coast. Ferns and shrubs form much of the understory in various parts throughout the area.

The most common cover includes salal, Oregon grape, oceanspray, trailing blackberry, cutleaf (evergreen) blackberry, salmonberry, whiteflowering raspberry (thimbleberry), red whortleberry (red huckleberry), snowberry, Nutka rose (wild rose), and wild strawberry.

Perhaps the most conspicuous on the forest floor are ferns (*3*) and mosses. Many of these grow over a wide range of moisture conditions, but some thrive only in moist dense woods or marshes. Bracken fern grows profusely under a wide range of conditions. It spreads extensively to open areas following logging operations or burning and forms a dense cover that may exclude nearly all other vegetation. Giant hollyfern (swordfern) grows in dense woods on wet soils, and toothed woodfern (triangular woodfern) occurs in dense shade. Lady fern grows in excessively wet marshy places. Maidenhair prefers rock seeps. The common polypody (licorice fern), deerfern, and the less common giant chainfern occur in various parts of the area. Horsetail fern frequently occupies seepy areas and depressions.

In wet depressions and in and around peat bogs are a number of shrubs that often contribute considerably to peat formation. The most widespread is Douglas spirea, which invades and often completely covers sedge-peat areas. Acid peat bogs of sphagnum moss usually support Labrador-tea, swamp laurel, small cranberry, and roundleaf sundew.

Water-tolerant grasses, sedges, rushes, tules, and cattails usually occur in open stream bottoms, wet depressions, and basins and contribute to the formation of sedge peat and muck. Saltgrass is common near the salty coastal marshes.

Scientific names for some of the more common trees, shrubs, ferns, and grasses of the area are listed as follows:

TREES AND SHRUBS

Scientific name	*Common name*
Abies grandis	Pacific white fir
Acer circinatum	Vine maple
A. macrophyllum	Bigleaf maple
Alnus rubra	Red alder
Berberis aquifolium	Oregon grape
Betula occidentalis	Western paper birch
Cornus nuttallii	Pacific dogwood
Corylus californica	California filbert
Cytisus scoparius	Scotch broom
Drosera rotundfolia	Roundleaf sundew
Fragaria spp.	Wild strawberry
Gaultheria shallon	Salal
Holodiscus discolor	Oceanspray
Kalmia polifolia var. *glauca*	Bog kalmia, swamp laurel
Ledum groenlandicum	Labrador-tea
Picea sitchensis	Sitka spruce
Pinus contorta	Lodgepole pine
P. monticola	Western white pine
Populus tremuloides aurea	Quaking aspen
P. trichocarpa	Black cottonwood
Prunus emarginata	Bitter cherry
Pseudotsuga taxifolia	Douglas-fir
Rhamnus purshiana	Cascara buckthorn
Rosa nutkana	Nutka rose

TREES AND SHRUBS—continued

Scientific name	*Common name*
Rubus laciniatus	Cutleaf blackberry
R. macropetalus	Trailing blackberry
R. parviflorus	Whiteflowering raspberry
R. spectabilis	Salmonberry
Salix spp.	Willow
Sambucus caerulea	Blueberry elder
Spiraea douglasii	Douglas spirea
Symphoricarpos albus	Snowberry
Thuja plicata	Western redcedar
Tsuga heterophylla	Western hemlock
Vaccinium parvifolium	Red whortleberry
V. oxycoccus	Small cranberry

FERNS AND WATER-TOLERANT GRASSES

Athyrium filixfemina	Lady fern
Distichlis spicata	Saltgrass
Dryopteris spinulosa	Toothed woodfern
Equisetum spp.	Horsetail
Polypodium vulgare	Common polypody
Polystichum munitum	Giant hollyfern
Pteridium aquilinum var. *lanuginosum*	Bracken
Struthiopteris spicant	Deerfern
Woodwardia fimbriata	Giant chainfern

ORGANIZATION AND POPULATION

Settlement in Whatcom County began in 1852 when several settlers staked out claims as power sites on Whatcom Creek. In 1854 coal was discovered nearby, and four towns, later incorporated into the city of Bellingham, sprang up on Bellingham Bay. Lumbering, coal mining, and salmon fishing became the principal industries, though many enterprising pioneers sought favorable homestead sites to engage in agriculture.

The creation of Whatcom County by the Territorial Legislature in 1854 marked the beginning of permanent settlement. Though the dense forests made travel by land difficult, the extensive coast line and the Nooksack River made the county fairly accessible. The fertile lands of the Nooksack River attracted the earliest settlers, who established homesteads at Ferndale in 1860, at Everson in 1867, and at Lynden in 1869. Blaine and Sumas on the Canadian border were settled in 1870 and 1872, respectively. Following 1890, when connections were made with transcontinental railroads, the lumbering industry flourished, and settlement of the interior became more rapid. The first settlers were largely from the Midwestern States, but the population has been drawn from many sources.

According to the 1950 census the population of the county was 66,733. Of this total, 48.9 percent was classed as rural.

Bellingham, the county seat, had a population of 34,112 in 1950. The population of other important towns in 1950 was Lynden, 2,161; Blaine, 1,693; Ferndale, 979; Sumas, 658; and Everson, 345. Other trading points and school centers are at Deming, Custer, Marietta, Nooksack, Lawrence, Van Zandt, Acme, Wickersham, Clearbrook, and Maple Falls.

INDUSTRIES

Lumber mills, pulp paper mills, furniture factories, shingle mills, canneries, dairies, and creameries are among the industrial plants represented in the county.

Lumbering and related industries are important. In 1933, exclusive of the national forest, there were 493,393 acres of privately owned and 51,530 acres of State- and county-owned land on which there was an estimated total of 9,330,061,000 board feet of lumber (*8*). Approximately 15 percent of the population is engaged in forest industries.

Douglas-fir supplies the largest number of lumber products, including plywood. Cedar is used largely for shingles. Hemlock, as well as cottonwood and white fir, is used extensively for wood pulp. Spruce is excellent for airplane stock and finishing and cabinet lumber. Maple, birch, and alder are used for furniture.

Bituminous coal occurs near Bellingham and elsewhere in the county, and anthracite has been found at Glacier, in the national forest. There is a coal mine just outside the city limits of Bellingham and another about 9 miles east. The deposits of lime, clay, and quartz sand are used in the manufacture of cement near Bellingham. Although undeveloped ore deposits of iron, chromium, nickel, copper, silver, lead, zinc, and gold exist, many occur where they are now inaccessible.

Bellingham, the largest city in the county and fourth largest seaport in the State, was once a leading canning center, but since the use of fish traps was abolished for salmon fishing, it has become a headquarters and warehouse center for salmon fishing and packing operations carried on in Alaska and elsewhere. A beet-sugar refinery is also located in Bellingham.

The county leads all others in the State in dairying and poultry production, and a number of large dairy-product plants and hatcheries are in the area. Manufacturing of cheese, powdered milk, butter, and ice cream is one of the chief industries. The most important dairy-product plants are in Lynden and Bellingham. Lynden is an important agricultural center for processing and shipping dairy, poultry, and fruit products. Blaine and Sumas are ports of entry from Canada and also important agricultural centers.

TRANSPORTATION AND PUBLIC FACILITIES

Three transcontinental railroads—the Northern Pacific Railway, the Great Northern Railway, and the Chicago, Milwaukee, St. Paul & Pacific Railroad—serve the county. A network of branch lines connects with agricultural and logging centers throughout the county. Steamship lines, operating both coastwise and abroad, serve Bellingham.

The county is well supplied with improved local public roads and paved State and Federal highways. In 1945, 4,705 farms were reported as being 0 to 0.2 mile from the nearest all-weather road; 66 farms, 0.3 to 0.5 mile; 13 farms, 0.6 to 0.9 mile; 11 farms, 1.0 to 1.9 miles; 1 farm, 2.0 to 4.9 miles; and 2 farms, 5 miles or more. United

States Highway No. 99 runs north and south near the coast line, and a number of State highways serve the other agricultural sections. Near the national forest, old logging roads and railroad grades are often improved and used as roads. Most of the foothill and mountainous section, embracing largely the national forest, is accessible only by logging railroads and trails.

Electric power and telephone service are available in all but the more remote sections. In 1945, 2,640 farms reported telephones and 4,563 reported electricity in the farmhouse. High schools and grade schools are located in towns and rural school districts. School bus service is available for outlying districts without schools. Students from the Point Roberts peninsula are transported daily through Canada and attend the schools at Blaine. The towns and local community centers have churches and assembly halls.

AGRICULTURE

The favorable natural setting and diversity of resources in Whatcom County have encouraged development of a large number of industries, but agriculture and lumbering have been of major importance since early settlement began. Agricultural development closely followed the rapidly expanding lumbering industry. Demand for agricultural products increased with the remarkable growth of lumbering, and as increasing areas of land were denuded of timber, they became available for agriculture. Farms were developed more rapidly on the broad stream-delta and valley lands because these were easier to clear, better supplied with moisture, and more fertile than the uplands. The less desirable lands were also farmed, however.

CROPS

The acreage of principal crops and number of fruit and nut trees in Whatcom County, Wash., are given in table 3 for stated years.

TABLE 3.—*Acreage of principal crops and number of bearing fruit and nut trees* [1] *in Whatcom County, Wash., in stated years*

Crop	1919	1929	1939	1944
	Acres	*Acres*	*Acres*	*Acres*
All hay	31, 412	36, 546	42, 981	50, 704
Clover and timothy mixed	24, 628	29, 479	32, 965	35, 789
Clover alone, all kinds	740	1, 114	140	(2)
Alfalfa	78	553	1, 954	2, 071
Small-grain hay	4, 693	3, 265	3, 838	2, 230
Annual legumes for hay	98	119	229	71
Other tame hay	939	1, 571	3, 261	10, 354
Wild hay	236	445	594	189
Silage crops	2, 081	399	1, 184	(2)
Forage crops	258	604	872	(2)
Root crops for forage	350	86	38	(2)
Cereals threshed:				
Oats	11, 338	10, 158	11, 791	11, 127
Wheat	2, 134	1, 724	860	511
Barley	852	1, 197	1, 263	567
Rye	222	81	30	56
Corn	48	23	53	3
Dry peas	2, 981	420	72	5
Potatoes	1, 449	1, 135	1, 971	1, 310
Vegetables for sale (potatoes excluded)	178	564	1, 094	1, 488
Sugar beets	(2)	645	98	(2)
Small fruits harvested:				
Strawberries	50	160	535	548
Raspberries (tame)	144	469	45	218
Boysenberries, loganberries, and youngberries	[3] 34	[3] 7	9	15
Blackberries and dewberries (tame)	19	113	4	9
	Number	*Number*	*Number*	*Number*
Apple trees	71, 517	44, 637	36, 729	34, 066
Cherry do	18, 779	22, 701	24, 884	18, 560
Plum and prune do	14, 336	13, 287	11, 432	10, 298
Pear do	13, 065	11, 698	9, 836	8, 514
All nut do	68	1, 408	16, 044	17, 288

[1] 1944 figures are for trees of all ages.
[2] Not reported.
[3] Loganberries only.

HAY, FORAGE, AND SILAGE CROPS

Hay and pasture crops are the most important in the county, and acreages of most hay crops have increased at a rate consistent with general agricultural expansion. The steady increase in hay acreages and corresponding increase in number of dairy cattle have occurred largely because climate and soil are more favorable to production of hay and pasture than to grain or vegetables.

The old practice of growing timothy or timothy and clover mixed on the wetter lands still persists in many sections, and this hay occupied a little less than three-fourths of the hay acreage in 1944. Many farmers prefer a mixture of clover and ryegrass or of clover and alta fescue. Both red and alsike clovers are used in hay mixtures, but the alsike is more suitable for wetter areas. Red clover is usually preferred on soils of the uplands and terraces, but it may be injured by lack of moisture if planted on more open porous soils of low moisture-holding capacity. Subterranean clover has also been found suitable for the drier uplands. Grains cut green have long been second to clover and timothy as hay crops, but acreages of other hay and forage crops are increasing.

Vetches are grown with small grains for hay and as green-manure crops. The fall-seeded green-manure crops are most satisfactory, and of these, rye or winter wheat with vetch is most often used. Wheat or oats mixed with field peas are considered best for spring-sown green-manure crops (*5*).

Alfalfa occupied only a small acreage in 1919, but by 1944 it had become an important crop. Most soils of the bottoms and upland flats and depressions are too wet for alfalfa; it is grown most successfully on the naturally well-drained but not excessively drained soils of the uplands and terraces. Alfalfa withstands summer droughts better than clover or grasses because its deep roots reach the moisture in the deeper subsoil and substratum. Unsuited to alfalfa are soils that overlie tight clay till and those with a cemented or consolidated subsoil and substratum, as they are often saturated in spring. Soils having a fine-textured subsoil that retains moisture well but does not become waterlogged during any part of the year are best suited. Though most of the agricultural soils are better for clover, alfalfa is popular in the county wherever it can be grown, because it gives high yields and has excellent feeding value.

Silage crops are not so important because the grazing season is long. Most of the corn is used for silage or forage. Green pea hulls and vines are also used as silage.

Where trench or other silos are not available, the ensilage from corn and other forage crops may be stacked and covered with soil. Hay covered with soil may have as much as one-third more feeding value than that cured in the field. Hay cured in the field is bleached by rains and is not of good quality if it is fed after being stored in barns.

CEREAL CROPS

The acreage of cereals has always been much less than that of hay crops, and in 1944 the hay acreage was more than four times as great. Much of the small-grain acreage is cut for hay, forage, or silage. Small-grain crops are often grown on newly cleared land where other hay is not established. Oats are more extensively used for hay, but winter wheat and rye produce early hay crops and are pastured in winter.

Oats have always exceeded the other small grains in acreage. The oat acreage has remained about the same since 1919, but that of wheat and barley has declined greatly. Oats produce high yields on the wet, cold, and more highly organic soils of the stream bottoms and upland depressions and, in addition, mature more rapidly than other small grains. This earlier maturity is important on wet soils that drain slowly in spring. Victory oats are the highest yielding and most satisfactory for this region. Federation and Bluestem are the best adapted and highest yielding wheat varieties.

VEGETABLES

Truck farming is of considerable importance in some sections, mainly in the alluvial bottoms, upland depressions, and like places where the soils are fertile and well supplied with moisture. A wide variety of truck crops and vegetables are grown, and higher yielding and better quality varieties are introduced as experiments prove them worthy. In descending order of importance, the crops are potatoes, green peas, snap beans, table beets, sweet corn, carrots, lettuce, cabbage, asparagus, cucumbers, and rhubarb.

The potatoes sold are grown mainly for certified seed and shipped to outside markets. Netted Gem, Irish Cobbler, and Early Rose are the most common varieties. Seed potatoes are grown largely on well-drained warm open soils of the uplands, where they mature rapidly and are comparatively free from disease. On the more fertile soils potatoes grow too large.

The acreage of vegetables harvested for sale, excluding potatoes, was about the same in 1944 as in 1939. In 1944, 741 acres of sweet corn, 389 acres of snap, string, or wax beans, 168 acres of cabbage, 54 acres of green peas, and 7 acres of tomatoes were harvested for sale. Most of the vegetables grown commercially are canned in local plants for shipment to outside markets, though some are shipped frozen.

FRUITS AND NUTS

The acreages of strawberries and filberts have increased significantly since 1919, but the number of fruit trees has decreased. Berries are most successfully grown on the better drained lighter textured soils of the stream bottoms and upland depressions and on many of the upland and terrace soils. Fruit trees yield best on soils that hold enough moisture within the root zone during the growing season but are not saturated or waterlogged in winter and spring. The soils shallowly underlain by tight clay or cemented or consolidated layers are oversaturated in spring and winter and are unfavorable for fruit trees. Deep open gravelly soils may not retain enough moisture to mature the fruit properly. Most orchards are therefore on the better drained soils of the uplands, terraces, and alluvial bottoms. Vetch, rye, or like cover crops are frequently planted in orchards to provide green manure.

Blackberries tolerate considerable moisture and are therefore grown on the less well drained soils. The principal varieties of blackberries are the Texas, Brainard, and Evergreen. The Evergreen spreads rapidly to uncultivated areas and abandoned fields. A native variety grows wild and supplies considerable fruit.

Strawberries are often grown successfully on the more droughty soils because they usually mature before the dry period in summer. Overhead sprinkling systems have been used successfully for strawberries on soils of low moisture-retaining properties. The Marshall variety is most popular and widely grown. It is common practice to plant the strawberries in spring and cut the blossoms the first year. The plants are usually plowed under after two seasons. Many of the berries grown are crushed, sweetened, and shipped in barrels, some are canned for shipment, and some are frozen and shipped.

The Montmorency variety of sour cherries is grown commercially. The sweet varieties grown are largely Royal Ann, Bing, and Lambert.

Apples are principally of the Golden Delicious and Spitzenberg varieties. Bartlett and Anjou are the most common varieties of pears. The filberts are mainly Du Chilly.

OTHER CROPS

Sugar-beet raising almost ceased following successful plantings in 1929, or thereabout, because of the ravages of the white-fly virus, but the introduction of virus-resistant varieties is reestablishing interest in this crop. Dry peas occupied almost 3,000 acres in 1919, but only 5 acres were reported in 1944.

ROTATIONS AND FERTILIZERS[2]

Crop rotation and fertilization vary according to the soils and crops grown. The better drained soils of the uplands and terraces are fairly low in organic matter and nitrogen, and these materials must be supplied before the lands can be farmed successfully. The cheapest and most satisfactory way is by use of legumes in crop rotations. It is best to use clover, alfalfa, or similar legumes for the equivalent of 1 year for each 2-year period the land is in intertilled crops or small grains. That is, if the legume remains 2 years, the other crops are grown for 3 or 4 years. This type of rotation is most successful if crop residues are conserved, all available manure is applied, and green manure is plowed under occasionally.

Many of the soils are deficient in phosphorus, and legumes are especially responsive to applications of phosphate fertilizer. If the legumes used in crop rotations are fertilized, they receive superphosphate (*9*, *11*). This application usually supplies enough phosphate for general field crops that follow the legumes in the rotation. Field crops properly rotated with legumes and supplemented with green-manure crops and barnyard manure usually do not require fertilizer, especially if superphosphate is applied to the legume.

Most of the commercial fertilizer and lime is used on special crops and on peat and muck soils. Soils used for truck crops are heavily fertilized and intensively farmed. Legumes are rotated with the truck crops, and both commercial fertilizer and barnyard manure are applied in large quantities. Practices vary considerably.

PERMANENT PASTURES

The permanent pastures of the county are important to the dairy and other livestock enterprises, and their total area is large. In 1944 there were 23,887 acres used only for pasture that could have been used for crops without additional clearing or draining. The total acreage of pastured land is unknown, but if woodland pasture and all other pastured land is included, it probably is about a third greater than that used for all cultivated crops.

A considerable part of the grazing is done on woodland pastures and partly cleared cut-over lands that remain in pasture for long periods. These pastures are hard to cultivate and manage properly and often revert to native plants of low carrying capacity. The

[2] For further information on rotations and fertilization, including rates of application for fertilizer, see the section on Soil Use and Management.

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plowable pastures, however, are kept well cultivated and free from weeds and are seeded to mixtures high in carrying capacity. In all pasture plantings effort is usually made to include low sod-forming and upright-growing grasses with the clovers to thicken the stand and add feeding value. Alta fescue, ryegrasses, orchard grass, Kentucky bluegrass, and white, alsike, and red clovers are among the favorite pasture plants (*6*).

LIVESTOCK AND LIVESTOCK PRODUCTS

Cattle are the most important livestock in the county, and the number has increased steadily since 1919. Dairy breeds predominate, as this is the leading dairy county in the State, but beef cattle, usually Hereford and Durham breeds, are raised in limited numbers. Dairy cattle are kept on most farms, but the greatest number are on lowland areas where the soils are especially suitable for pasture and hay. In such areas dairying usually dominates all other pursuits. The principal breeds are Holstein-Friesian and Guernsey, but Jerseys and Ayrshires are on many farms. Purebred bulls are usually kept, and many dairy herds are purebred.

Cooperative dairy associations and other companies operate fleets of trucks throughout the county. Most of the dairy products are processed in Bellingham, Lynden, Everson, and Ferndale. The processing plants include creameries, condenseries, and other establishments producing butter, cheese, buttermilk, ice cream, casein, and condensed milk. The largest markets for these products are the Pacific Coast, Alaska, and the Hawaiian Islands.

Poultry is second to cattle in importance, and the increase in number of chickens has been somewhat like that of cattle. Whatcom County leads all others in the State in poultry production, and of the poultry products sold, eggs bring the largest income. White Leghorns are the main breed of chickens kept for eggs; Rhode Island Reds and New Hampshire Reds are raised mainly for meat. Eggs and other poultry products are sold largely in the Pacific Coast States, in Alaska, and in the Hawaiian Islands. Fleets of trucks operated by cooperatives gather most of the poultry products and, in turn, deliver processed poultry feeds, which are in large part shipped in from outside points. The poultry cooperatives have their headquarters at Bellingham and Lynden. Some poultry is canned at Lynden.

Horses are the predominant work animals, but mules are kept on a few farms. Tractors and other power machinery have replaced work stock entirely, or in part, on all but the smaller farms. Horses are of a number of breeds; good sires are kept on some farms. Well-bred colts are raised on many farms, but not in numbers sufficient for replacement needs. The work stock is in excellent condition.

The number of swine decreased about half, following 1919, and has remained relatively stable since. Duroc and Chester White are the most popular breeds. The hogs are raised mainly for home consumption. The number of sheep in 1944 was less than a third of that reported for 1919; the small flocks are mostly of the Hampshire breed. The number of goats has ranged between 200 and 300 in the period 1919–44.

The number of livestock in the county in stated years is given in table 4.

TABLE 4.—*Number of livestock and beehives in Whatcom County, Wash., in stated years*

Livestock	1920	1930	1940	1945
	Number	*Number*	*Number*	*Number*
Cattle	30, 799	41, 490	[1] 44, 648	58, 537
Horses	5, 204	3, 741	[1] 3, 863	3, 044
Mules	34	117	[1] 78	42
Sheep	3, 645	3, 774	[2] 969	1, 110
Goats	204	299	[3] 182	239
Swine	6, 395	2, 939	[3] 2, 849	3, 065
Chickens	278, 806	781, 912	[3] 645, 880	810, 131
Turkeys	(4)	[5] 3, 058	[3] 2, 421	7, 927
Beehives	4, 013	1, 800	1, 355	(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.
[5] Turkeys raised in 1929.

TYPES, SIZES, AND TENURE OF FARMS

The types and sizes of farms vary considerably with location and kinds of products grown. Farms near population centers are often small and, if the soil permits, highly specialized. Those on the more remote cut-over areas may be of considerable size. The general trend is to smaller units that have larger acreages cleared and are more intensively farmed.

Of the 4,854 farms in the county in 1945, 91 were unclassified. The 4,763 classified farms were grouped according to type of farm products as follows: 2,263 dairy farms; 898 poultry; 865 producing primarily for own household use; 321 general; 127 livestock; 161 field crop; 75 fruit and nut; 30 vegetable; 15 horticultural specialty; and 8 forest-products farms.

Farms of the county range from less than 3 to more than 700 acres in size, but approximately 70 percent of them were less than 50 acres in size in 1945. In that year, about 21 percent of total number of farms were under 3 to 9 acres in size; about 30 percent, 10 to 29 acres; 20 percent, 30 to 49 acres; 23.6 percent, 50 to 139 acres; and 5.4 percent, 140 to 999 acres in size. In 1945, there were more farms in the 10- to 29-acre group than in any other, and this combined with the 30- to 49-acre group made up approximately half the farms in the county.

The number of farms has increased steadily since 1920, but the average acreage in farms has not always decreased correspondingly. There were 913 more farms in 1930 than in 1920, and in this period, the average size of farms decreased from 52.8 acres to 42.8 acres. In the period 1930–45, however, the average size of farms remained relatively stable—42.6 acres in 1945—though there was an increase of 572 farms. This increase in number of farms with little decrease in average size indicates that most of the new farms have been acquired from uncultivated areas of cut-over land.

In 1945, 88.3 percent of the farms were operated by owners or part owners, 11.5 percent by tenants, and 0.2 percent by managers. About 64 percent of the farms operated by tenants were rented for cash in 1945.

FARM EQUIPMENT, FACILITIES, AND EXPENDITURES

Tractors, trucks, and other power-driven machinery are on most of the larger farms. The smaller farms intensively cultivated to specialized crops are well equipped with machinery and implements. Farms in the more remote area, however, often lack adequate implements and other equipment. In 1945, 4,752 automobiles, 1,477 motortrucks, and 1,672 tractors were reported on farms.

About 54 percent of the farms reported cash expenditures for labor in 1944. The total spent was $1,448,639, or an average of $548.31 the farm. Most of the hired labor was employed on the dairy and poultry farms.

In 1945, 92.1 percent of the farms reported purchasing feeds; the total cost was $5,429,671, or $1,214.43 the farm reporting. Much of the poultry feed is purchased, and supplementary processed feeds are used on many dairy farms.

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, or horizons, which collectively are known as the soil profile. Each of these layers is studied carefully for the things about it that affect plant growth.

The color of each layer is noted. The darkness of the 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 poor aeration. Texture, or the content of sand, silt, and clay in each layer, is determined by the feel and is checked by mechanical analysis in the laboratory. Texture has much to do with the quantity of available moisture the soil will hold, whether plant nutrients or fertilizers will be held by the soil in forms available to plants or will be leached out, and how difficult the soil may be to cultivate.

Structure, or the way the soil granulates, and the quantity of pore or open space between particles indicate how easily plant roots can penetrate the soil and how easily water enters it. 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 rock from which the soil has been developed or its parent material, affects the quantity and kind of plant nutrients the soil may contain. Simple chemical tests show how acid the soil may be.[3] The depth to bedrock or to compact layers is determined.

[3] The reaction of a soil is its degree of acidity or alkalinity expressed mathematically as the pH value. The degree of acidity or alkalinity is expressed in words and pH values as follows:

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

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

Two or more soil types may have similar profiles, that is, the soil layers may be nearly the same, except that the texture, especially of the surface layer, 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 name of a place near where a soil series was first found is chosen as the name of the series. Thus, Lynden is the name of a well-drained soil series found on sandy glacial outwash deposits on the terraces in Whatcom County, Wash. Two types of the Lynden series are found—Lynden sandy loam and Lynden gravelly sandy loam. These differ in the quantity of gravel in the surface soil, as their names show. Lynden sandy loam is divided into three phases because some of it is undulating, some is rolling, and some is moderately steep. Lynden gravelly sandy loam is divided into undulating and rolling phases.

When very small areas of two or more kinds of soil are so intricately mixed that they cannot be shown separately on a map of the scale used, they are mapped together, and the areas of the mixture are called a soil complex. Bow-Bellingham silty clay loams is a complex of Bow silty clay loam and Bellingham silty clay loam in Whatcom County.

Areas such as bare rocky mountainsides, coastal beach, or dune sand that have little true soil are not designated with series and type names but are given descriptive names, such as Rough stony land, Rough mountainous land, Coastal beach, Fresh-water marsh, and Riverwash.

The soil type, or where the soil type is subdivided, the soil phase, is the unit of mapping in soil surveys. It is the unit or the kind of 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. One can say, for example, that soils of the Giles series are important agriculturally; but for Giles loam, gently undulating, it can be said that it has mild slopes, needs nitrogen and organic matter, and is suited to hay crops, small grains, and row crops. Likewise it can be stated that Giles silt loam, moderately steep, has slopes of 15 to 30 percent, has poor workability, and is used for woodland pasture and woodland. Both are included in the Giles series.

SOILS OF WHATCOM COUNTY

Whatcom County has a large number of soil units covering a wide range of soil characteristics. Perhaps nowhere else in the Puget Sound Basin is there such a great diversity of soils. This is mainly the result of the heterogeneous underlying glacial and stream deposits, which determine the physical make-up of the soil, the relief of the land, and drainage. The extreme variation in both surface and internal drainage has been an important factor in producing wide soil differences. The soils are very sensitive to drainage, and a small difference in microrelief is reflected not only in the soils but also in the crops produced.

However, the soils of the county have many characteristics in common. Probably one of the most noticeable in all or nearly all of them is the occurrence of aggregates or granules hard and durable in water. The soils are friable, they are easy to dig unless very stony, and vegetation grows rapidly on all of them. Because of the combination of water-stable granules and rapid plant growth, erosion is not a serious factor in soil management.

The steep road banks are not marred with the rills or deep fluted gullies so common on many slopes in drier regions. Soil on the road banks is loose and apparently absorbs water readily. There is less runoff than in regions where the soil bakes or is compact and plastic. Though leached, the soils retain considerable inherent mineral fertility. All have acid surface soil, and most have a less acid lower subsoil or substratum. This indicates a more healthful condition than if the acidity increased with depth. The soils respond well to fertilization and to good farming practices.

About 60 percent of the county consists of uplands and terraces from which all the virgin timber has been removed, and large areas of this land are farmed. Much of the remaining eastern upland area, or about 30 percent of the county, is mountainous, steeply sloping, and heavily forested with virgin timber. Highly fertile soils of the alluvial bottoms cover most of the remaining area. A considerable acreage, however, is covered by organic soils, which occur in basins and depressions in all parts of the county. Practically all stream-bottom and organic soils are cultivated.

Excluding differences in the lay of the land, the soils of both the uplands and terraces fall naturally into three classes of drainage; namely, well or moderately well drained (including some with excessive drainage), imperfectly drained, and poorly drained. Each of these groups is readily distinguished by surface color, which has resulted largely from the degree of leaching, oxidation, and incorporation of organic residues.

The well or moderately well drained soils are yellowish brown when wet. They are strongly acid, and most of them have a friable, mellow, water-stable granular silty surface soil, though sandy and gravelly textures are not uncommon. The soils are fairly low in nitrogen but not necessarily so in other plant nutrients. Application of lime alone does not benefit them significantly, but plants respond well to additions of phosphate or phosphate and lime. The subsoils and substrata vary from dense tight clay to open droughty gravelly material. Soils developed from clay till have a strongly rolling or knobby morainic relief and are generally free from surface stone and gravel, though a few gravelly areas do occur in some. Even on the steepest slopes the dense native vegetation and the water-stable granular surface soil promote rapid infiltration. Runoff is therefore small and erosion insignificant. On incorrectly cultivated steep hillsides, however, the silty surface soil becomes thin and the clay subsoil, when exposed, is more readily susceptible to accelerated erosion.

The imperfectly drained soils occupy smooth areas in association with those better drained. Slower surface drainage and retarded internal water movement have promoted a more luxuriant vegetation, and larger quantities of organic residues have become incorporated in the surface soil. The organic material, together with retarded oxidation, has created darker soils. The surface soil is weak brown when dry and dusky brown when wet, and the subsoil is pale brown and usually mottled with rusty iron. Iron concentration occurs in some soils as accretions and cementations, and ironpans are common. Being less leached, the imperfectly drained soils are generally less acid, have a higher mineral fertility, and retain more moisture than those better drained. This moisture relation is especially important because of the dry summers. These soils generally respond well to the same treatment as that given the better drained soils.

The soils of the stream bottoms are largely fine textured, deep, dark, and of high fertility. The highly organic ones are dark brown or nearly black, whereas those with lesser quantities of organic matter are brownish gray to light brownish gray or somewhat grayish olive. Stream-bottom soils are inherently fertile and have a plentiful supply of moisture. Moisture is commonly excessive where natural or artificial drainage is ineffective or incomplete.

The poorly drained soils of the uplands and terraces occupy nearly level basins and depressions and, not uncommonly, seepy areas on smooth steep slopes. Soils having this drainage support a luxuriant vegetation, including many deciduous trees, underbrush, and a ground cover of water-tolerant herbs and grasses. The conditions of drainage and vegetation have created a brownish-gray rather highly organic surface soil and a pale-brown discolored subsoil highly stained with rusty iron. In some soils iron cementations occur as fragments and plates, and dense ironpans are common. These soils have a higher inherent fertility than the associated better drained ones, but they are wet and cold in spring; even where drains are installed they may be suited to only a limited number of crops. The drains now used are largely open ditches. If tile were employed, a greater diversity of crops probably could be grown.

The organic soils are widely scattered in old lake basins, in depressions, on steep slopes, and in low bottoms of streams. Large bodies, often many square miles in extent, occupy old abandoned stream channels and areas adjacent to subsiding lakes. Peats and mucks of varied origin and composition are included. Organic soils form an important agricultural acreage and are highly productive when fertilized and properly drained. Moss peat growing on undrained uncultivated areas has a limited agricultural value, but it is dug and sold for commercial uses.

The first settlers recognized the value of bottom and upland depression soils, including the organic ones. Their fertility and supply of moisture were early appreciated and, as indicated by the density of farm population, these soils are still the most intensively used. The more concentrated population centers, including towns and smaller settlements, are in these areas.

Lands of the stream bottoms were from the first readily accessible by water, but those of upland depressions and other less favorable locations were difficult to reach and, therefore, largely unavailable until the lands were logged. These natural factors, together with greater ease of clearing, made expansion on the bottoms more rapid than elsewhere, and now little bottom land is uncleared. Railroads and the main arterial highways usually follow the easy grade of the stream valleys or terrace flats these soils occupy, and though power and telephone lines often have more direct courses, they naturally are directed to the more populated areas.

In the early period of settlement most of the stream-bottom land was cleared and farmed to meet the growing demand for agricultural products brought about by the rapid expansion of lumbering and other industries. There was not enough stream-bottom land to keep pace with industrial development, however, and soils of the upland depressions and wet terrace flats, including the organic soils, came into use as soon as they were logged. Expansion to these soils was later followed by movement to less desirable ones of the uplands and terraces, especially where an additional acreage was needed to round out a farm unit to satisfactory size.

Many of the soils of the uplands and terraces having naturally imperfect or poor drainage have become highly productive. Those that retain moisture well and do not waterlog at any time are now important fruit-producing soils because of their freedom from frosts.

The more droughty gravelly soil types have been largely abandoned because they do not retain enough moisture to mature crops satisfactorily. The early settlers frequently sought home sites around industrial and logging centers regardless of the kind of soil. Most logging operations have now moved to the more mountainous interior, but many people still remain on their farm holdings or retain them as a place for part-time employment. In many of the less desirable of these areas occupants change frequently, as the clearings are small and a patch type of part-time farming is practiced.

SOIL SERIES AND THEIR RELATIONS

The soils of the county can be placed in the following 10 groups according to similarities in drainage, position, and relief—the three factors that largely determine their agricultural use.

Soil group and series or land type:	*Parent or underlying material*
Well-drained and moderately well-drained soils of rolling uplands:	
Whatcom	Tight clay till
Squalicum	Sandy clay till
Kickerville	Gravel-mantled tight clay till
Indianola	Sand-mantled tight clay till
Alderwood	Gravelly cemented sandy loam to loam till
Barnhardt	Gravel-mantled compact cemented gravelly sandy till
Barneston	Gravelly drift of mixed origin
Schnorbush	Stony drift from arkose sandstone
Heisler	Shaly drift
Cathcart	Consolidated sandstone, shale, or both
Imperfectly drained soils of uplands:	
Labounty	Tight clay till
Cagey	Gravel-mantled tight clay till
Hale	Sand-mantled tight clay till
Poorly drained soils of uplands and terraces:	
McKenna	Tight clay to sandy clay till
Norma	Gravel-and-sand mantled tight clay till
Bellingham	Glacial lake and marine delta deposits
Custer, Edmonds	Sandy glacial outwash
Everson	Silty and clayey glacial outwash over sand
Woodlyn	Silty and clayey glacial outwash over gravel and sand
Well-drained soils of smooth terraces:	
Lynden	Sandy glacial outwash
Giles, Salal	Silty glacial outwash over sand
Smith Creek	Gravelly stream terrace
Moderately well drained to more slowly drained soils of terraces:	
Saxon	Laminated (varved) glacial lake deposits
Bow	Glacial lake or marine delta deposits
Imperfectly drained soils of terraces:	
Tromp	Sandy glacial outwash
Hemmi	Silty to clayey glacial outwash
Well-drained to moderately well-drained soils of alluvial bottoms and fans:	
Puyallup	Sandy stream alluvium
Nooksack	Silty and clayey deposits over sandy alluvium
Kline	Gravelly alluvial fans of mixed origin
Wickersham	Shaly alluvial fans
Poorly drained soils of alluvial bottoms, fans, and coastal lowlands:	
Skagit	Shaly clay alluvium
Sumas	Clay over sandy alluvium
Puget, Lummi	Clayey alluvium
Pilchuck, Clipper	Gravelly alluvium
Hovde	Coastal beach deposits
Neptune	Gravelly coastal beach deposits

Soil group and series or land type—Continued

Soil group and series or land type	*Parent or underlying material*
Organic soils:	
Rifle peat; Carbondale muck	Woody accumulations
Mukilteo peat; Semiahmoo muck	Sedge accumulations
Greenwood peat	Moss accumulations
Snohomish	Peats silted by mineral deposits
Miscellaneous land types:	
Rough mountainous land	Largely consolidated shale, schist, argillite, and sandstone, with occasional basic extrusives
Rough stony land	Largely isolated consolidated sedimentary rocks and stony glacial debris
Coastal beach	Coastal beach deposits
Riverwash	Stony, gravelly, and sandy alluvium
Made land	Man-made earth fills
Tidal marsh	Marine marshes along coast line
Fresh-water marsh	Shallow basins with standing fresh water

WELL-DRAINED AND MODERATELY WELL-DRAINED SOILS OF ROLLING UPLANDS

The well-drained and moderately well-drained soils of the uplands —occupying almost one-fourth of the area surveyed—are widely distributed, but the largest acreage is in the basin region west of the foothills and mountains. This soil group covers a wide range of relief— smooth outwash plains to rolling, ridgy, knobby, morainic, or erosional topography. The soils with slopes of 15 to 30 percent are classified as hilly phases, and those exceeding 30 percent slopes, as steep phases. The soils are light-colored, rather low in organic matter and nitrogen, and aside from variations in relief, differ from one another most significantly in drainage and texture of the subsoil.

Whatcom and Squalicum soils, both developed from clayey till, occupy more than half of the total acreage of this group. The Whatcom generally have the smoother relief because they developed on the low ground moraine in the low basin region, whereas the Squalicum are in the bordering higher foothill area and extend well into the more isolated mountain valleys.

The Kickerville soils, developed from gravelly drift, and the Indianola, from sandy drift, are closely associated with those of the Whatcom series and are underlain by the heavy clay till at depths ranging between 8 and 12 feet.

In this county the Alderwood soils are mapped only in complex with the Squalicum. They are underlain by cemented sandy gravelly till which lacks the clayeyness of the material underlying Squalicum soils.

The Barnhardt soils are somewhat similar to those of the Kickerville series, although their gravel mantle is usually coarser textured and their underlying drift, generally occurring at about 8 feet, is of cemented gravelly sandy material resembling that of the Squalicum soils.

The Barneston soils occupy an area about half as large as the Whatcom but, nonetheless, are the most extensive soils in the higher foothill area and the adjacent mountain valleys. They usually have an unfavorable morainic topography and are formed from an open gravelly drift of mixed origin that extends to undetermined depths. They are better suited to forestry than to farming.

The Schnorbush and Heisler, inextensive soils of irregular relief and low agricultural value, occur locally in the higher mountain valleys. They differ from the Barneston soils mainly in parent material. The Schnorbush are derived from sandstone drift; the Heisler, from shaly drift.

The Cathcart soils differ from all others of this group in being developed from glacially scoured consolidated rock formations. They are shallow, inextensive, unfavorable in relief, and little used for cultivated crops. Cathcart soils are largely from sandstone but include less permeable areas from shale and argillite.

IMPERFECTLY DRAINED SOILS OF UPLANDS

The imperfectly drained soils of the uplands include members of the Labounty, Cagey, and Hale series. These soils are intimately associated with the better drained ones of the uplands, but they do not cover so large an acreage.

Labounty soils, developed from dense clay till, make up more than half the total acreage in this group. Their internal drainage is slower than that of either the Cagey or Hale soils, but they are generally favorable to a wide variety of crops. The Cagey soils, developed from gravel-mantled clay till, and the Hale soils, from sand-mantled clay till, occur mainly on the same clayey ground moraine as the Labounty. They have relief similar to or smoother than the Labounty, but their porous subsoil permits more rapid internal drainage. The Cagey soils are associated with the better drained Kickerville, and the Hale soils have a similar relation to the Indianola.

POORLY DRAINED SOILS OF UPLANDS AND TERRACES

The poorly drained soils of both the uplands and the terraces occur in low flats, basins, or depressions where moisture accumulates. The ground is highly saturated in winter and spring, and, where drains have not been installed, frequently remains saturated into summer.

The McKenna and Norma soils of this group are widely distributed in the uplands and occur only in that area. Although they are not extensive, they form an important agricultural group, as more than half their combined area is cultivated. The McKenna soil, underlain by tight clay till mixed with gravel, drains more slowly than the Norma soils, which developed largely from sand-and-gravel drift usually overlying clay till.

The other soils of this group occupy similarly poorly drained places but occur on terraces rather than uplands. The Bellingham soil is associated with better drained soils and is developed from gravel-free clayey glacial lake and marine deposits. The Custer, Edmonds, Everson, and Woodlyn soils are associated with better drained soils and are derived from sandy or silty glacial or postglacial outwash. The Custer and Edmonds subsoils have ironpan concentrations and cementations in varying degree. The Everson subsoil contains only a band of sticky plastic orange or reddish iron-stained clay. The Woodlyn soil is more youthful than the others of this group, and though red is in the upper part of its sandy subsoil, the iron is not so highly concentrated and the underlying material is gravel instead of sand.

WELL-DRAINED SOILS OF SMOOTH TERRACES

The well-drained soils of the smooth terraces are confined largely to the extensive glacial terrace plain, which occupies about a third of the lower basin region. Areas on lesser stream terraces elsewhere in the basin and in the interior mountain valleys make up the rest of the acreage. Lynden, Giles, Salal, and Smith Creek soils make up this group.

Lynden soils, derived from sandy glacial outwash, usually have smooth relief but sometimes it is rolling or hummocky. The Giles soils are more productive than the Lynden or Smith Creek. They are associated with the Lynden in smoother lower areas where clayey materials have settled. Their silty surface soil and clayey upper subsoil materially increase moisture-holding capacity, yet the silty underlying substratum permits free underdrainage. The Salal soil is a prairie counterpart of the Giles. The droughty Smith Creek soils formed on smooth relief from deep gravelly materials deposited in postglacial stream terraces. Their moisture-retaining properties are sufficient to mature only early crops.

MODERATELY WELL DRAINED TO MORE SLOWLY DRAINED SOILS OF TERRACES

This group of moderately well drained to more slowly drained soils is not so extensive as the group of better drained terrace soils, but proportionately more of it is farmed because of the excellent moisture-retaining properties of its members. The soils are formed from clay strata confined largely to the low outer coastal rim of the extensive glacial outwash terrace and to other terraces where fresh or marine water, or both, may have been impounded during the glacial or postglacial period. The strata underlying the soils are largely of dense massive bluish-gray clay, which resembles the clay till of the adjacent ground moraines but is without gravel or stones.

The clay most often contains inconspicuous stratified seams or silt and sand but in places may be highly laminated. Where the materials become more definitely stratified as depth increases, soils of the Bow series develop. Differing significantly from these are the more highly laminated, more yellowish, clayey glacial lake strata containing many seams of silt and fine sand from which the inextensive Saxon soils are formed.

IMPERFECTLY DRAINED SOILS OF TERRACES

Imperfectly drained soils of the terraces occupy smooth areas of intermediate drainage lying between the better drained more elevated soils and the poorly drained ones of the many flats and depressions. They therefore have properties intermediate between those of soils in the higher and the lower locations.

Tromp soils are derived from sandy glacial outwash occurring on a smooth terrace plain in which the water table is relatively high. The subsoil is highly colored with rusty iron and cemented in varying degrees ranging up to ironpan hardness. Lynden, Custer, and Edmonds soils are from similar materials and are associated with the Tromp, but they differ in drainage. In the flats and basins Tromp soils are associated with the Everson soil.

The inextensive Hemmi soil, the other member of this group, developed from sandy postglacial outwash material containing some clay bands but is much like the Tromp in drainage, moisture capacity, and related characteristics.

WELL-DRAINED TO MODERATELY WELL-DRAINED SOILS OF ALLUVIAL BOTTOMS AND FANS

The well-drained to moderately well-drained soils of the alluvial bottoms and fans are developed from recent alluvium deposited along the streams throughout the area and are among the most fertile and productive soils in the county. Probably 90 percent or more of their acreage is cultivated, and most of the truck farms and many of the larger dairy and poultry farms are located on them. A little more than half the area covered by soils of this group is fairly well drained. All the soils have a porous subsoil or substratum, permitting relatively free underdrainage when spring floodwaters subside.

The highly productive Puyallup and Nooksack soils occupy most of the acreage of this group and occur mainly along the major streams. They occupy nearly level high bottoms where there is good natural drainage during the growing season. Both soils are well suited to cultivation and have high inherent fertility. They are developed from fine- and medium-textured stratified alluvium of mixed origin. The Puyallup alluvium is sandy, grayish or slightly olive, and somewhat darkened by a high content of very dark sand grains, probably from argillite. The alluvium for the Nooksack soils is more yellowish or olive gray and silty to somewhat clayey in the upper part. The mellow, readily cultivated surface soils of both series retain the color of the different alluviums, even though they have been darkened by organic accumulation.

Kline and Wickersham soils are developed on the better drained stream bottoms and alluvial fans in the foothill and mountainous areas. They are less productive than the Puyallup and Nooksack soils and not so extensively used. The alluvium of the Kline soils is a gravelly coarsely bedded assortment of materials laid down by streams flowing from areas of upland Vashon drift. This alluvium has the properties inherent in the glacial materials, which are largely of granitic and quartzitic origin. The Wickersham soil is derived from bluish-gray argillite and schist and has the dominant color of these materials.

POORLY DRAINED SOILS OF ALLUVIAL BOTTOMS, FANS, AND COASTAL LOWLANDS

Soils of the alluvial bottoms, fans, and coastal lowlands occur largely in low bottoms or back bottoms where there is not enough natural drainage to carry away surplus water, and, in consequence, about 40 percent of the area they cover is poorly drained. In winter and spring the soils become highly saturated and the water table is near the surface. Drains have been installed to remove excess water from most of these soils, but many of the drainage systems are inadequate because of insufficient gradient or lack of suitable outlet. The courses are meandering and gradients are low on the broad flat alluvial bottoms of the Nooksack and Sumas Rivers where a large part of these soils occurs. Also, the Nooksack River has frequently overflowed and dammed the open drains and outlets and clogged the tile, thus discouraging the use of tile. In many areas farmers rely almost entirely on open drains along the roads.

Though inherent fertility is relatively high for the Puget, Lummi, Sumas, and Skagit soils that make up most of this group, their productivity is modified by slow drainage. Their use is limited largely to forage crops, pasture, and small grains.

The Puget, Sumas, and Lummi soils occupy low poorly drained sites in back bottoms of the Nooksack and Sumas Rivers or the level delta along the coast. They formed from thickly bedded fine-textured alluvium of mixed origin. Their inherent color is strongly modified by the poor drainage that persisted during their development, and they are grayish and rusty-iron mottled. The Sumas soils differ from the Puget mainly in having a more permeable sandy lower subsoil and underlying stratum that promote more rapid internal drainage. The Lummi soil resembles the Puget and also has a clayey slowly permeable subsoil and underlying substratum, but it is younger, slightly more bluish, and bedded with sedge remains. It occurs on the lower delta and, until recent reclamation of some areas, contained considerable salt.

The Skagit, Clipper, Hovde, Pilchuck, and Neptune soils have gravelly porous underlying materials that drain freely when outlets are provided. The Skagit and Clipper soils occur on narrow alluvial bottoms and small fans and are widely scattered along streams of the uplands and in the foothills and mountain interior. The Skagit soil is darker and more highly organic than the Puget, Lummi, or Sumas and is used for a slightly wider range of crops. Though relatively high in mineral fertility, the Skagit and Clipper soils usually cannot be farmed effectively because the bodies are small and scattered.

The sandy gravelly Pilchuck and Hovde soils are of low agricultural value. The Pilchuck soils have excessive internal drainage but are subject to overflow and a high water table. The Hovde soil occurs in marshy fresh-water areas in the delta bottoms along the coast and has a matted dark surface soil bound by roots of sedges and coarse grasses.

The dark Neptune soil along the coast is developed on old narrow gravelly beach deposits filled with marine shells. It is rarely wet but lies where there is danger of wave and tidal overwash during storms. This soil is of low agricultural value.

ORGANIC SOILS

The widely distributed organic soils form an important agricultural acreage. They occur extensively throughout the depressions of the lower basin region, especially in old glacial lake basins and broad nearly level abandoned channels of glacial or postglacial streams. These soils are derived from plant remains in various stages of decomposition. Where conditions have inhibited decay, the plants are frequently in a high state of preservation. The succession of various plants growing during the accumulation has been important in determining the character of the profiles. Composition, depth of the organic materials, and degree of decay are important in determining use of these soils.

Peat soils are those in which the organic remains are partly decomposed, fibrous, and matted. In this area there are woody, sedge, and moss peats. The woody peat soil is identified as Rifle peat; the sedge peat is classified as Mukilteo peat; and moss peat is known as Greenwood peat. Moss peat is a highly acid organic soil formed of well-preserved sphagnum peat moss. The moss is sold commercially, but the soil is not farmed.

Muck consists of well-decomposed finely divided organic remains usually somewhat mixed with mineral soil material. The fibers of the organic materials are not recognizable, but the mucks can be identified by their vegetative cover or by their association with identified peats. Woody muck, classified as Carbondale muck, and a sedge muck, called Semiahmoo muck, have been mapped.

Soil of the Snohomish series—peat silted by mineral deposits—is included with these organic soils.

MISCELLANEOUS LAND TYPES

The miscellaneous land types include Rough mountainous land, Rough stony land, Riverwash, Coastal beach, Made land, Tidal marsh, and Fresh-water marsh. Rough mountainous land, the only miscellaneous land type of much importance, occupies more than a third of the land area in the eastern part of the survey. Though of no agricultural value, it was densely forested in the virgin state, and large revenue is still obtained from timber products.

SOIL SERIES, TYPES, AND PHASES

In the following pages the soils, identified by the same symbols as those on the soil map, are described in detail and their agricultural relations are discussed. Their location and distribution are shown on the accompanying map (cover page 3), and their acreage and proportionate extent are given in table 5.

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

Soil	Acres	Percent
Barneston silt loam:		
Gently undulating	6,660	1.4
Hilly	3,932	.8
Rolling	8,375	1.7
Barneston stony silt loam, rolling	751	.2
Barnhardt gravelly sandy loam:		
Gently undulating	992	.2
Rolling	199	[1]
Steep	150	[1]
Barnhardt gravelly silt loam:		
Hilly	251	.1
Rolling	1,792	.4
Bellingham silty clay loam	4,881	1.0
Bow-Bellingham silty clay loams	735	.2
Bow silt loam:		
Gravelly substratum, undulating	1,102	0.2
Undulating	1,586	.3
Bow silty clay loam:		
Rolling	1,041	.2
Undulating	905	.2
Cagey gravelly loam, undulating	319	.1
Cagey-Norma complex	665	.1
Cagey sandy loam, undulating	636	.1
Cagey silt loam:		
Sloping	1,971	.4
Undulating	1,068	.2
Carbondale muck	1,154	.2
Shallow	3,294	.7

See footnote at end of table.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in the surveyed area of Whatcom County, Wash.*—Continued

Soil	Acres	Per-cent	Soil	Acres	Per-cent
Cathcart loam:			Lynden gravelly sandy loam:		
Hilly	1, 181	0. 2	Rolling	764	0. 2
Rolling	1, 572	. 3	Undulating	2, 009	. 4
Clipper silty clay loam	1, 961	. 4	Lynden sandy loam:		
Coastal beach	214	(1)	Moderately steep	386	. 1
Custer sandy loam	496	. 1	Rolling	2, 954	. 6
Custer silt loam	8, 713	1. 8	Undulating	903	. 2
Edmonds silt loam	1, 485	. 3	McKenna silty clay loam	7, 951	1. 6
Edmonds-Tromp silt loams	929	. 2	Made land	311	. 1
Everson silt loam	2, 331	. 5	Mukilteo peat	673	. 1
Fresh-water marsh	51	(1)	Shallow	107	(1)
Giles loam:			Neptune gravelly sandy loam	1, 164	. 2
Gently undulating	5, 185	1. 1			
Moderately steep	325	. 1	Nooksack fine sandy loam	609	. 1
Rolling	522	. 1			
Giles silt loam:			Nooksack silt loam	4, 820	1. 0
Gently undulating	1, 792	. 4	High bottom	296	. 1
Gravelly subsoil, gently undulating	1, 353	. 3	Norma-Cagey complex	965	. 2
			Norma-Hale complex	359	. 1
Moderately steep	161	(1)	Norma silty clay loam	7, 480	1. 5
Giles-Tromp complex	615	. 1			
Greenwood peat	30	(1)	Pilchuck fine sandy loam	203	(1)
Hale-Norma complex	671	. 1			
Hale silt loam:			Pilchuck gravelly loamy sand	3, 924	. 8
Gently sloping	2, 628	. 5			
Moderately steep	184	(1)	Puget silt loam	2, 087	. 4
Heisler shaly loam:			Puget silty clay loam	4, 098	. 8
Hilly	584	. 1	Puyallup fine sandy loam	11, 019	2. 3
Rolling	754	. 2			
Hemmi silt loam	590	. 1	Puyallup loamy fine sand	783	. 2
Hovde silty clay loam	251	. 1	Puyallup silt loam	9, 241	1. 9
Indianola fine sandy loam, rolling	549	. 1	Puyallup very fine sandy loam	967	. 2
Indianola loamy fine sandy, rolling	914	. 2	Rifle peat	11, 147	2. 3
			Shallow	2, 121	. 4
Indianola silt loam, undulating	332	. 1	Rifle peat-Bellingham complex	57	(1)
Kickerville silt loam:			Riverwash	1, 869	. 4
Hilly	753	. 2	Rough mountainous land	198, 779	41. 5
Rolling	6, 942	1. 4			
Steep	362	. 1	Rough stony land	885	. 2
Undulating	5, 552	1. 1	Salal silt loam	369	. 1
Kline gravelly loam	1, 238	. 3	Saxon silt loam:		
Kline loam	581	. 1	Moderately steep	454	. 1
Labounty-McKenna complex	8, 993	1. 9	Rolling	614	. 1
			Schnorbush loam:		
Labounty silt loam:			Hilly	167	(1)
Moderately steep	106	(1)	Rolling	1, 275	. 3
Sloping	526	. 1	Schnorbush-Norma complex	262	. 1
Undulating	8, 504	1. 8			
Lummi silty clay loam	321	. 1	Semiahmoo muck	203	(1)
			Shallow	95	(1)

See footnote at end of table.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in the surveyed area of Whatcom County, Wash.*—Continued

Soil	Acres	Percent	Soil	Acres	Percent
Skagit silty clay loam	304	0.1	Sumas silt loam	982	0.2
Smith Creek gravelly loam:			Sumas silty clay loam	4,081	.8
Gently sloping	1,973	.4	Tidal marsh	430	.1
Steep	155	(1)	Tromp-Custer silt loams	1,879	.4
Snohomish silty clay loam	875	.2	Tromp-Edmonds silt loams	267	.1
Squalicum and Alderwood silt loams:			Tromp silt loam	5,100	1.1
Hilly	4,117	.9	Tromp silty clay loam	477	.1
Rolling	5,490	1.1	Tromp-Woodlyn silt loams	41	(1)
Squalicum and Alderwood stony silt loams, hilly	617	.1	Whatcom-McKenna complex	8,822	1.8
Squalicum silt loam:			Whatcom silt loam:		
Hilly	3,476	.7	Hilly	3,760	.8
Rolling	8,920	1.8	Hummocky	17,540	3.6
Steep	87	(1)	Steep	528	.1
Squalicum stony silt loam:			Undulating	12,279	2.5
Hilly	886	.2	Wickersham shaly loam	1,045	.2
Rolling	348	.1	Woodlyn silt loam	2,710	.6
Sumas fine sandy loam	931	.2	Total	483,200	100.0

[1] Less than 0.1 percent.

BARNESTON SERIES

Soils of the Barneston series are extensive in the higher morainic area bordering the foothills and mountains and extending well into the mountain valleys. In the areas of strong morainic relief they are developed on unassorted gravelly and stony drift, but in the areas of smoother relief, on assorted materials. In the interior mountain valleys postglacial stream erosion by the Nooksack River and its tributaries has significantly modified the drift deposits, and frequently only erosional remnants of the drift border the mountainsides.

The Barneston soils are frequently associated with and, in fact, merge almost imperceptibly with the Alderwood[4] and Squalicum, which are developed from softly cemented sandy and clayey till. They have more rapid internal drainage than soils of either associated series and a much lower moisture-holding capacity. They are favorably located in the belt of higher rainfall, however, and lack of moisture is less acute than it is in similar droughty soils. Considerable clay infiltration in the upper subsoil adds to the moisture-holding capacity.

[4] Because of its intricate association with Squalicum soils, the Alderwood soil (Alderwood silt loam) is mapped only in complex with units of Squalicum stony silt loam and silt loam.

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The soils are low in organic matter and nitrogen and deficient in phosphate, especially for leguminous crops. Some of the high moraines in the interior valleys contain stones in numbers sufficient to interfere with or prohibit cultivation. Relief is dominantly rolling but sometimes gently undulating or hilly. The smoother areas of fluvioglacial valley-train or postglacial-outwash nature occur at lower elevations than the more pronounced morainic areas. Surface drainage of the soils is complete, internal drainage is excessive, and moisture-holding capacity is low. Except in narrower valleys where seep areas occur, an all-year supply of domestic water can be obtained only at a considerable depth. In their native condition these soils supported excellent stands of Douglas-fir and considerable hemlock and cedar in the more mountainous areas.

A yellowish-brown mellow surface soil containing much shot and a yellowish-brown to yellowish-gray upper subsoil characterize Barneston soils. Below these layers there is some silt and clay infiltration, the material often resembling unconsolidated freshly poured coarse concrete. Rusty-brown and gray mottlings usually occur. The lower subsoil consists of open poorly assorted and stratified glacial drift in which there is no cementation or clay infiltration. The drift materials are chiefly quartzite, granite, and granodiorite; but basalt, andesite, rhyolite, argillite, schist, sandstone, and shale commonly occur. The proportionate content of the different materials varies considerably from place to place.

The series includes the gently undulating, hilly, and rolling phases of Barneston silt loam, and Barneston stony silt loam, rolling.

Barneston silt loam, rolling (Bc).—In the foothills bordering the lower basin region and the interior mountain valleys this is one of the more extensive soils. It is closely associated with the Alderwood and Squalicum soils but differs from them in having an open droughty subsoil and substratum. Slopes range from 6 to 15 percent.

Degree of leaching and soil development varies according to distance eastward and attendant increase in rainfall and rise in elevation. In progression west to east, the acidity increases slightly, clay content in the subsoil increases, decomposition is greater, and iron staining increases. At higher elevations the surface soil is usually a richer brown and has a thin gray leached layer at its top. The strongly acid humified organic layer overlying the surface soil promoted development of the irregular thin gray layer. In places where development is more advanced, the shot pellets usually in the surface soil may be absent, and instead there may be more localized enrichment of the brown color.

Profile in virgin areas under forest litter:

1½ to 0 inches, dark-brown partly decomposed organic layer forming a distinct mat over the mineral soil; material chiefly loose needles, acid, and 1½ to several inches thick.

0 to 12 inches, yellowish-brown moderately loose medium acid silt loam containing considerable shot (buckshot to pea size or larger); 8 to 15 inches thick; acidity may be reduced after land is logged over.

12 to 18 inches, subsurface layer; more yellowish-brown medium acid loam with a scattering of gravel or shot; 4 to 10 inches thick.

18 to 24 inches, yellowish-brown or olive medium acid gravelly silt loam or silty clay loam; moderately compact; 4 to 10 inches thick.

24 to 50 inches, light-brown or yellowish-gray, iron-stained sandy clay and clay-coated gravel of vesicular character; resembles unhardened freshly poured coarse concrete; medium to slightly acid; 10 to 30 inches thick.

50 inches +, light yellowish-brown or olive-tinted poorly assorted glacial drift consisting of slightly acid to neutral coarse porous salt-and-pepper colored sands; gravel and stones show some clay coating, rusty-brown iron staining, and occasional silica coating; materials attain a washed appearance with depth; boulders are common throughout the underlying materials, which are largely quartzite, granite, and granodiorite but include argillite, andesite, basalt, diorite, gneiss, schist, sandstone, and shale.

Use and management.—The virgin timber has been cut, but probably less than 10 percent of Barneston silt loam, rolling, has been cleared for home sites, farms, and pasture. A second growth of trees similar to the first is becoming established on the land not farmed. At lower elevations Douglas-fir is the principal growth; on more elevated areas to the east there is considerable hemlock and cedar and a scattering of white pine. In many areas the densest growth consists of such deciduous trees as alder and maple and an understory of willow, salal, Oregon grape, blackberry, red huckleberry, thimbleberry, salmonberry and bracken.

The most successful farms are adjacent to the lower basin region in areas where the silty surface soil is deep and the relief is smoother. Many of these farmers have part-time employment—logging, cutting cordwood, or working in lumber mills and other industries.

This soil is deficient in organic matter and nitrogen. In addition to use of regular rotations including legumes, it is advisable to conserve all crop residues and apply barnyard manure. A marked benefit results when superphosphate is added to legumes.

Hay, small grains, and pasture occupy the largest area, but potatoes, fruits, and vegetables are grown successfully. The most satisfactory hay crops are red clover planted with ryegrass, alta fescue, or timothy. These mixtures produce 1½ to 2 tons of hay an acre. Farmers say it is difficult to obtain or properly maintain satisfactory stands of alfalfa. Small grains are used mainly as nurse crops for legumes and yield less than a ton an acre when cut for hay. Grain-and-vetch mixtures produce much higher yields of hay. When harvested for grain, oats yield 25 to 45 bushels an acre; barley, 15 to 30; and wheat, 10 to 20. Potatoes yield 150 to 200 bushels an acre on the better areas of deep soil, and various other vegetables produce well in such locations.

The soil provides good pasture in spring if it is seeded to mixtures of alta fescue, English and Italian ryegrasses, tall meadow oatgrass, orchard grass, Kentucky bluegrass, common white, alsike, subterranean, and red clovers, or like pasture plants. The grazing season may be short because of the summer dry period. Recently burned-over stump lands produce fair pasture if they are seeded to mixtures of white clover, ryegrass, and orchard grass and competing vegetation is kept under control. In general, the uncleared less desirable and more remotely located parts of this soil are probably more suitable for reforestation than for cultivated crops, and their use for forest should be encouraged.

Barneston silt loam, gently undulating (Ba).—Except for its gently undulating topography this soil is very similar to Barneston silt loam, rolling. Its maximum slope of 6 percent is the minimum slope for the rolling phase. The soil is developed mainly on the smooth glacial valley-train deposits in the large flat Columbia Valley and other adjacent mountain valleys.

Use and management.—Probably about 10 percent of Barneston silt loam, gently undulating, is cleared. Farms are confined largely to the favorably located areas having deep surface soil, especially those near the main highways. The crops grown are similar to those on the rolling phase, and yields are about the same.

The more remotely located areas are largely in forest. In the higher interior valleys the valuable virgin growth of Douglas-fir and scattering hemlock has been removed. The forests are restocking to similar timber trees and other conifers, among which are rather thick stands of deciduous trees and brush. The cover is now highly diversified and includes Douglas-fir, hemlock, spruce, Western white and lodgepole pines, alder, birch, aspen, willow, vine maple, cascara, hazelnut, salal, bracken, red huckleberry, and grasses. This cover indicates that rainfall is sufficient for a good forest growth even though the soil has relatively low moisture-holding capacity. If the restocking of more valuable timber trees were encouraged, the timber could be materially improved.

Barneston silt loam, hilly (Bb).—This phase occurs in association with the other Barneston soils. It occupies hilly slopes or ridges, largely in the strongly rolling upland adjacent to the foothill section and in the interior mountain valleys. Gradients range between 15 and 30 percent. A smaller acreage occurs on steep slopes along drainageways and at the outer margins of moraines and terraces. Drainage is rapid, but accelerated erosion is held to a minimum because the soil rapidly absorbs moisture and because the native vegetation, forest litter, and organic mat afford excellent protection. In other characteristics this soil resembles Barneston silt loam, rolling.

Use and management.—Little of Barneston silt loam, hilly, is farmed; it is not readily worked with farm machinery. The surface soil is thinner than that of Barneston silt loam, rolling; gravel and stones may be concentrated at or near the surface. Though this phase is largely nonagricultural, it is good for timber, and its use for forest should be encouraged. The forested areas have been logged and are now in second-growth timber.

Barneston stony silt loam, rolling (Bd).—This inextensive soil occurs in association with other Barneston soils in the interior mountain valleys. From Barneston silt loam, rolling, it differs principally in its greater content of stone. Much of it occupies strongly rolling morainic areas and ridges adjacent to the foothills and mountains where the drift deposits are more frequently morainic and stony. In such areas the slopes range from 6 to 15 percent. In the smaller areas of smoother relief that occur adjacent to the Nooksack River, differential erosion in the early postglacial period left huge boulders that cover the surface.

Use and management.—The stones and boulders throughout Barneston stony silt loam, rolling, prohibit cultivation but do not limit tree growth. The virgin timber has been removed, and a second growth, largely Douglas-fir and scattering hemlock, is becoming established. The potential value of the timber stand could be increased by reseeding or replanting to conifers, as deciduous trees and brush now form a dense growth inhibiting development of desirable species.

BARNHARDT SERIES

Soils of the Barnhardt series occur on several conspicuous moraines that rise high above the lower drift plains of the mainland and form conspicuous sea cliffs at Point Roberts and Point Frances. Unlike the lower lying ground moraines of heavy clay till near them, these high moraines consist of compact softly cemented sandy till, which probably was deposited at the end of the Vashon glacial period. On the high moraine east of Blaine, Barnhardt gravelly silt loam soils are associated with Alderwood soil, which lies on the highest part. On this moraine the loose porous gravelly mantle of material parent to the Barnhardt soils may have been deposited by readvancing ice lobes, as the soils are not directly related to the underlying cemented drift.

The relief generally is undulating to rolling or morainic, but large areas are smoother. The soils have rapid surface drainage. Internal drainage is excessive, even though moisture movement is somewhat restricted by the deeper lying cemented drift usually occurring at a depth of about 8 feet. The natural vegetation is largely coniferous and deciduous trees, with a sparse undergrowth of brush and shrubs.

Soils of the Barnhardt series are characterized by incipient podzol development. They have a reddish-brown or brown gravelly but mellow shot-filled surface soil over a yellowish-brown to olive-gray open porous gravelly subsoil stained with rusty iron in the lower part. The bluish-gray gravelly and sandy softly cemented till characteristically occurring in the substratum is usually at a depth of about 8 feet. The organic mat on the forest floor is strongly acid, the surface soil is medium to more strongly acid, and the subsoil is medium acid. The underlying till is neutral to mildly alkaline.

The series includes the rolling and hilly phases of Barnhardt gravelly silt loam and the gently undulating, rolling, and steep phases of Barnhardt gravelly sandy loam.

Barnhardt gravelly silt loam, rolling (Bk).—Large bodies of this soil are on the high moraine east of Blaine, and there is one area at Point Frances. The virgin timber of Douglas-fir, cedar, and a scattering of spruce has been removed. A second growth of similar conifers is becoming established on unfarmed areas, but willow, alder, maple, and birch make strongly competing growth. Salal, ferns, Oregon grape, and red huckleberry form a thick ground cover.

The relief is rolling to strongly rolling or morainic, and slopes range from 6 to 15 percent. Surface drainage is rapid, but infiltration is good because of the thick forest cover and the permeable open character of the soil. Accelerated erosion has not developed. Internal percolation is free, but moisture is held by the substratum of compact till, which retards water movement in the lower part.

Profile description of virgin areas under forest litter:

2 to 0 inches, dark-brown partly decomposed organic mat, principally of loose needles.

0 to 1 inch, light-gray single-grained silty material; ranges from a thin film to about an inch thick; like above layer, usually strongly acid following logging.

1 to 13 inches, brown gravelly silt loam; contains a large quantity of impure iron of buckshot to pea size; medium to rather strongly acid; 8 to 12 inches thick.
13 to 28 inches, light yellowish-brown or moderate yellowish-brown gravelly shotty silt loam; pieces of gravel are coated with clay; acidity is slightly less than in the layer above; 8 to 20 inches thick; gradual transition to underlying material.
28 inches to 8 feet, light yellowish-brown loose gravel and sand, clay-coated in the upper part and increasingly marked with rusty-iron staining in the lower; 30 to 70 inches thick.
8 feet +, bluish-gray softly cemented gravelly sandy till; lower subsoil medium acid, and the till substratum neutral.

The depth to the compact softly cemented substratum is somewhat variable but less so than the depth to the clay till under the Kickerville soils. In some areas the surface soil contains more sand than is typical. At a high point on the moraine on which most of this soil occurs, the gravel content is high, and in places the pieces are the size of small cobblestones.

Use and management.—A small part of Barnhardt gravelly silt loam, rolling, has been cleared for farming. Satisfactory crops are produced on the less gravelly areas under management suitable for other Barnhardt soils. Such management includes use of crop rotations that include legumes, conservation of crop residues, and application of manure. Legumes respond well to phosphate. Lime may benefit some crops, for the soil is more acid than those at lower elevations. Crops are similar to those grown on the Kickerville soils, but yields are slightly lower. This is a good soil for timber and under most conditions is best suited to forestry.

Barnhardt gravelly silt loam, hilly (BH).—Most of this soil occurs on the steep sides of the moraine east of Blaine in association with Barnhardt gravelly silt loam, rolling. It differs from that soil mainly in having stronger relief (15 to 30 percent).

Use and management.—Barnhardt gravelly silt loam, hilly, is unsuited to farming; accelerated erosion probably would result even under good farming methods. The slopes are difficult to work with farm machinery, and the surface soil is usually thinner and more gravelly than elsewhere. Little of the land is cleared for cultivated crops or pasture.

Trees grow about as well as on areas of smoother relief, and production of timber should be encouraged. All of the land has been logged, and though most areas are restocking fairly well to the valuable timber species, less valuable deciduous trees now form much of the cover.

Barnhardt gravelly sandy loam, rolling (BF).—The small areas of this inextensive soil occur only at Point Roberts and Point Frances. The soil occurs on moraines that do not rise so high as the one upon which the phases of Barnhardt gravelly silt loam developed, and its profile is not so distinctly formed, even though the material is sandy. The native cover—mainly Douglas-fir, cedar, and a scattering of spruce—has been removed, but a second growth of similar trees is becoming established. Willow, alder, maple, birch, and other deciduous trees strongly compete with the conifers.

The relief is rolling, with slopes of 6 to 15 percent. Surface drainage is rapid, but infiltration of moisture is promoted by the vegetative cover and the permeability of the soil. Though internal moisture percolates freely, the compact substratum checks excessive drainage, and moisture for plant growth is therefore well retained.

The medium acid surface soil, a reddish-brown gravelly sandy loam, contains a scattering of shot pellets and, inclusive of the overlying organic mat, extends to a depth of about 8 inches. Under the forest mat there is a thin light-gray layer rarely more than an inch thick. There is a tendency toward iron staining in the surface soil. Bands or tongues of stain penetrate downward from the surface. The yellowish-brown upper subsoil of medium to slightly acid gravelly sandy loam contains some shot and extends from a depth of 12 to about 24 inches. This layer is replaced by loose gravel and sand. The olive-gray pepper-and-salt colored sand is stained with iron and held in cluster masses where it contacts the neutral till substratum. Light-gray to bluish-gray softly cemented gravelly sandy till of the substratum usually occurs at depths of 8 to 12 feet.

Use and management.—Only a small part of Barnhardt gravelly sandy loam, rolling, has been cleared for pasture and cultivated crops. Crops are similar to those grown on Barnhardt gravelly silt loam, rolling, and yields are similar or somewhat lower. A small area of this phase is strewn with large glacial boulders and is therefore best suited to trees or pasture.

Barnhardt gravelly sandy loam, gently undulating (Be).—Aside from its gently undulating relief (slopes of 3 to 6 percent) the characteristics of this soil are essentially the same as those of Barnhardt gravelly sandy loam, rolling. It is associated with that soil at Point Roberts but is much more extensive.

Use and management.—Little of Barnhardt gravelly sandy loam, gently undulating, is farmed, and crop yields are similar to those obtained on the rolling soil. All the merchantable timber has been removed, and a second-growth of similar trees, largely Douglas-fir, is becoming established in thicker growths of less valuable deciduous trees and brush.

Barnhardt gravelly sandy loam, steep (Bg).—Bodies of this inextensive soil occupy narrow steep moraine fronts along the shore line at Point Roberts and Point Frances. Slopes exceed 30 percent, and the subsoil and substratum are exposed in places along precipitous sea cliffs. Otherwise, this soil is much like Barnhardt gravelly sandy loam, rolling.

Use and management.—Most areas of Barnhardt gravelly sandy loam, steep, are well covered with vegetation, including valuable second-growth timber, that effectively checks accelerated erosion. This soil has little value other than for forestry, and its use for that purpose should be encouraged.

BELLINGHAM SERIES

The Bellingham series is represented in the area surveyed by only one type, Bellingham silty clay loam, which is mapped alone and in complex with Bow silty clay loam. It is confined chiefly to terraces along or near the coast line, where it occupies flats, basins, and drainage depressions in association with the better drained Bow soils.

Bellingham silty clay loam (Bl).—Most of this soil occurs in small widely distributed bodies near the coast line. It is associated with the better drained Bow soils and occupies flats, basins, or depressions where relief ranges from 1 to 4 percent. Though developed from stratified clayey marine-delta materials similar to those of the Bow soils, it is poorly drained. Many areas are in closed or nearly closed basins, and in other places drainageways are poorly defined or lacking. Waterlogging is common in winter and spring, and some areas remain wet throughout the year. In areas of more irregular microrelief, this soil forms a complex soil pattern with those of the Bow series. Like the McKenna and Norma soils, this soil originally had a dense forest cover, largely Douglas-fir and cedar.

Profile description of a virgin area:

1 to ½ inch, litter of forest debris.

½ to 0 inch, partly decomposed organic surface layer; 0 to 1 inch thick when combined with layer of litter above.

0 to 8 inches, dark grayish-brown slightly acid highly organic granular silty clay loam; 6 to 12 inches thick; material in this layer and the two above becomes nearly black when wet.

8 to 17 inches, somewhat lighter grayish-brown slightly acid silty clay loam with a slight bluish cast; blocky fractures are discernible; contains many roots and worm casts; 6 to 12 inches thick.

17 to 39 inches, light bluish-gray or steel-gray silty clay loam on sandy clay mottled with yellowish and rusty iron stains; contains thin seams of sand or silt; blocky particles ¼ to ½ inch across are outlined by colloidal cementation; slightly acid; 18 to 24 inches thick.

39 inches +, blue-gray or steel-gray iron-mottled thick-bedded silty clay loam of dense massive structure; broken by occasional fracture planes; and in lower part marine shells in many places cause a mildly alkaline reaction; shells indicate material may have been laid down, at least in part, in marine waters.

The surface soil is of rather uniform depth throughout the densely wooded areas, but in basins where sedges and water-tolerant grasses flourished, it may be considerably deeper and mucky or peaty.

Use and management.—In the virgin condition Bellingham silty clay loam is highly saturated and waterlogged. Some form of drainage is necessary before it can be used satisfactorily for cultivated crops or permanent pasture. Open drains are most often used and must be spaced closely for satisfactory drainage. Many areas could be materially improved by use of tile drains. Some of the low basins often remain permanently wet and are used only for pasture.

Probably three-fourths of this land is cleared and used for cultivated crops or pasture. The rest is in second-growth conifers with which deciduous trees and brush are in most places prominently admixed. More land is being brought into cultivation as soon as it is cleared and drained.

Under cultivation this soil responds well if crop rotations include legumes and applications of superphosphate are made. Because the soil is inherently fertile, a high level of productivity can be maintained on it more readily than on the associated Bow soils. Applications of phosphate are usually made to legumes only, as crops following them in the rotation are sufficiently benefited by such treatment. On newly cleared lands or those depleted of organic matter, barnyard manure is especially beneficial in promoting a healthy growth of legumes. Manure and complete fertilizers are commonly applied for truck and other specialized crops. For legumes, 300 pounds of superphosphate are applied the first year and 200 pounds each succeeding year. A 3–10–7[5] mixture is usually used for leafy vegetables, and a 4–10–10 mixture for root vegetables. These mixtures are applied at the rate of about 800 pounds an acre.

This soil is used largely for hay, pasture, oats, and to a less extent for other cereals and truck crops. It is too wet for tree fruits. For hay, either red or alsike clover is used in mixture with ryegrass, alta fescue, or timothy. Mixed hay yields 2½ to 4 tons an acre; clover alone yields less. The second growth of hay is pastured if it is not cut. Oats and other small grains yield 1 to 2 tons of hay an acre when used as a nurse crop for legumes. Oats planted with vetch yield considerably more hay, and oats harvested for grain yield 60 to 90 bushels an acre. Barley usually yields well, but the soil is too wet and cold for wheat. Threshed vetch yields 1 ton or more an acre. Truck crops and berries can be grown successfully on the sites with better natural drainage or where effective drains have been built. Intensive methods are employed where the land is used for these specialized crops.

Permanent and woodland pastures are seeded to the same mixtures as those used on the McKenna and Norma soils, and carrying capacities are about the same as on the McKenna. Low wet areas can be used successfully for both pasture and hay without drainage if seeded to reed canarygrass or a mixture of meadow foxtail and big trefoil. Wet areas planted to such crops yield 3 to 5 tons of hay an acre or, if pastured, grazing throughout the year.

BOW SERIES

Although soils of the Bow series are widely distributed on terraces along the coast line and inland on the low terraces skirting the delta bottoms of the Nooksack River, their largest development is on the terraces of California and Dakota Creeks.

Characteristically, Bow soils are smoothly undulating or rolling—the relief to be expected where geologically eroded terraces are composed of sediments that yield readily to erosion. Main streams are deeply incised, but their tributaries do not branch enough to establish complete drainage relief on the terraces. Elongated ridges and paralleling shallow incomplete drainageways are common. Some areas along terrace fronts and drainageways have stronger relief.

The partly eroded glacial lake or marine-delta terraces on which Bow soils occur are made up of laminated or interstratified massive dense clays, silts, and occasional fine sands. The clays closely resemble those in the clay till of the adjacent ground moraines but are without gravel and stone and are stratified. The terrace sediments of clay, silt, and fine sand are slowly permeable to water, and, in direct relation to the completeness of the relief, surface drainage is only fair to good.

Bow soils warm slowly in spring but hold moisture well during the protracted dry summer. They were heavily forested with Douglas-fir, cedar, and occasional spruce, and there was a scattering understory of alder, bigleaf maple, vine maple, birch, cottonwood, and willow.

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

The soils represented in this series are Bow-Bellingham silty clay loams; the rolling and undulating Bow silty clay loam; and the undulating and the gravelly substratum, undulating, Bow silt loam.

Bow-Bellingham silty clay loams (BM).—In areas where shallow incomplete drainage channels have led to development of complex relief and diverse drainage, Bow silty clay loam and the darker poorly drained Bellingham silty clay loam of the depressions have formed such an intricate soil pattern that it was necessary to map them together as a complex. The Bow soil makes up about 60 to 70 percent of the complex; the Bellingham, about 30 to 40 percent.

Use and management.—This complex of Bow and Bellingham silty clay loams presents a drainage condition and soil association difficult to manage. It is impossible to cultivate or use sizeable areas of either soil separately; therefore, crops and cultural practices most nearly meeting the requirements of both are necessary. Hay and pasture crops meet these requirements most satisfactorily and are most widely used. Hay yields are the same or slightly better than on the undulating phase of Bow silty clay loam, and the carrying capacity of pastures probably is a little greater. About half of this complex is cleared. The rest has a cover of second-growth conifers and deciduous trees and brush similar to that on Bow silt loam, undulating.

Bow silty clay loam, rolling (BP).—This inextensive soil occurs in several bodies on low terraces along California Creek. The relief is more youthful and not so deeply impressed as on the related Saxon silt loam, rolling; and drainage is not so complete. Also, the surface soil is not so silty or so deep, and oxidation is not so far advanced. This soil is rolling or somewhat ridgy, with paralleling ill-defined channels. The topography may have resulted in part from the erosive action of floodwaters in the postglacial period. Slopes range from 6 to 15 percent. The influence of slow internal drainage and slow oxidation is reflected in the dull or grayish color of the soil. This soil is cold and wet in spring but holds moisture well into summer.

All the merchantable timber has been removed, but in much the same way as on the rolling unit of Saxon silt loam, second-growth timber of Douglas-fir and cedar is becoming established in the thick stands of deciduous trees and brush on unfarmed areas.

Profile description of virgin areas:

1 to 0 inch, thin dark-brown acid organic mat; 0 to 2 inches thick.

0 to 9 inches, light yellowish-brown shot-filled granular silty clay loam; medium acid; 6 to 12 inches thick; lower part somewhat grayer and more granular than the upper.

9 to 17 inches, light yellowish-gray somewhat granular but dense and compact medium acid silty clay loam with rusty-iron staining; 7 to 10 inches thick; a few shotlike pellets and horizontal iron-stained seams or bands mark the contact with the unmodified stratified materials below.

17 to 74 inches, light yellowish-gray or steel-gray iron-stained laminated clays and silts with occasional seams of fine sand; strata become thickly bedded and have colloid-stained blocky fractures toward the bottom; roots follow the laminations and fractures downward.

The substratum materials are similar to or more massive than those of the 17- to 74-inch layer, but darker. These substratum layers are neutral or mildly alkaline and in places contain marine shells. Domestic water from these shallower layers of the substratum is brackish, and good water is obtained only at a depth of 400 feet or more.

Use and management.—Probably three-fourths of Bow silty clay loam, rolling, is cleared for cultivated crops and pasture. The soil responds well to the same rotation, cultivation, and fertilization treatments as those given other soils of the Bow series. Mixtures of clover and ryegrass or of clover and timothy yield 2½ to 4 tons an acre. Small grains cut for hay yield about 1 to 1½ tons an acre. When harvested for grain, oats yield about 40 to 70 bushels an acre; barley, 30 to 45; and wheat, 20 to 30. Pastures have about the same carrying capacity as those on Saxon silt loam, rolling.

Bow silty clay loam, undulating (Br).—This soil is closely associated with the rolling phase. It occurs in areas of similar but somewhat less pronounced relief where slopes do not exceed 6 percent and usually has somewhat slower surface and internal drainage.

The slower drainage promotes development of a shallower soil of duller and grayer color. Depressions and incomplete drainage channels give rise to a diverse drainage pattern, which, in turn, causes considerable difference in color. The soil may range from dull reddish brown to a yellowish gray within short distances. The grayer soil often grades into darker poorly drained soils of the depressions and basins, and where separation is impractical, the area of association is mapped as a complex.

Use and management.—Bow silty clay loam, undulating, is wet in spring and warms up slowly. Farmers have found the land more suitable for hay and pasture than small grains. Planting of grain crops is usually delayed because of high moisture content and uneven saturation. During the warmer weather in the dry summer, the soil cracks badly and allows rapid loss of moisture. This loss may prevent satisfactory heading and maturing of grain. The hay crops are similar to those grown on Bow silty clay loam, rolling. Yields from hay and small grain are about the same as on that soil, and so are crop rotations and cultural practices.

Probably about a fourth of this land is in second-growth timber. Thick growths of deciduous trees and brush are competing strongly with the conifers, and methods should be initiated to improve the stand of more valuable timber trees.

Bow silt loam, gravelly substratum, undulating (Bn).—Most of this soil occurs on a low terrace along Squalicum Creek and on a higher old delta terrace at Bellingham. Its undulating to strongly undulating relief of 6 to 12 percent does not permit surface drainage so rapid as that of Saxon silt loam, rolling; but internal drainage is usually more rapid because this soil has a deep gravelly substratum and gravelly lenses imbedded throughout its profile.

In areas where the clay strata are rather shallow over the gravelly substratum this soil has more rapid underdrainage and, in consequence, is brighter and more deeply oxidized than elsewhere. In the vicinity of Bellingham much of it shows these characteristics of the better drained Bow soils. On the lower terraces, however, the surface soil is a duller moderate brown or grayish brown and the subsoil is gray and mottled because of slower internal drainage. In such places this soil often grades into the darker poorly drained Bellingham soil.

Use and management.—Most of Bow silt loam, gravelly substratum, undulating, is farmed, and to crops like those grown on Saxon silt loam, rolling. Similar yields are obtained.

Bow silt loam, undulating (Bo).—Areas of this soil are widely distributed in association with Saxon silt loam, rolling. The relief is undulating or strongly undulating and sloping, the dominant slope range being 3 to 6 percent. The slopes are not so steep as those of the Saxon soil and they do not promote surface and internal drainage so effectively. The soil is therefore less deeply oxidized, and because of this, has a variable duller brown to yellowish-brown or yellowish-gray surface soil. Areas of this soil adjacent to deeply incised drainageways are more effectively drained and more deeply oxidized.

Use and management.—Owing to slower surface and internal drainage, Bow silt loam, undulating, retains moisture longer than Saxon silt loam, rolling, and also remains cold and wet longer in spring; otherwise, the two are much alike. Slower drainage makes this soil more desirable for hay, pasture, and grain crops than the Saxon, and a wide variety of other crops are also grown successfully. In general, crop yields are very similar to those of the rolling Saxon silt loam under similar management, and about the same acreage is cleared (pl. 1, *B*). The rest has a similar cover consisting of second-growth conifers and a luxuriant growth of deciduous trees and brush.

CAGEY SERIES

Soils of the Cagey series occur chiefly in the low basin region near the coast where extensive gravel deposits thinly mantle the dense clay till ground moraine of irregular topography. They occupy smoother parts of the rolling wavy morainic or kame and kettle topography where gravel deposits are usually 3 to 5 feet deep. They are associated with the Kickerville soils, which developed from deeper gravel deposits in areas of stronger relief and better drainage, and form a complex association with the Norma soils, derived from similar or thinner gravel deposits occurring in the depressions and basins. In places the gravel mantle under the Cagey soils lies on less clayey till that is usually more permeable but softly cemented. In several areas in the interior mountain valleys, imperfect drainage results from other impediments that deflect or impound ground water. Originally, the soils were heavily forested, mainly with Douglas-fir, cedar, and some spruce.

In the more typical locations, soils of the Cagey series have a rich-brown to moderately dark-brown surface soil, an upper subsoil of brown open porous gravelly material, and a substratum of brownish-gray, iron-mottled stratified drift lying abruptly on dense clay till at a depth of about 3 to 5 feet. Elsewhere the substratum may consist of less clayey compact softly cemented drift. The underlying till prevents free percolation of moisture; water is therefore held in the porous gravelly subsoil, and, as a result, that part of the profile shows the considerable iron discoloration attending poor drainage. The surface soil contains considerable shot. Though large glacial erratics (transported masses of rocks and gravel) are common, they rarely interfere with cultivation.

The extensive Cagey soils are important in the agriculture of the areas where they occur. They have more rapid internal drainage than the Labounty soils but may not hold moisture so well during the dry summer. If it is desired, Cagey soils can be drained by open ditches, as water moves rather freely over their compact substratum.

The series includes the undulating and sloping units of Cagey silt loam; Cagey-Norma complex; Cagey gravelly loam, undulating; and Cagey sandy loam, undulating.

Cagey silt loam, undulating (Ce).—This important agricultural soil is widely distributed in the lower basin region and to a less extent on Lummi Island and in the interior mountain valleys. It most characteristically occurs where the drainage pattern is complex and incomplete because of the rolling to somewhat ridgy kame and kettle topography. On such relief it is more typically associated with the better drained Kickerville soils and the not so well-drained Norma soils. The soil occupies smoothly undulating areas with slopes of less than 6 percent, and, in these, free movement of water is retarded. In winter and spring the soil is highly saturated, and for the rest of the year drainage is relatively more free but still imperfect.

In comparable locations, this phase drains more readily than Labounty silt loam, undulating, because its gravelly subsoil permits rather free lateral movement of water over the clay till. However, moisture is not retained so well as in the undulating Labounty soil.

The merchantable timber has been cut from this soil, and in unfarmed areas a second-growth of conifers—mostly Douglas-fir and cedar with a few spruce or white fir—is growing in the thick stands of deciduous trees, brush, and shrubs that normally flourish after logging. Among other types of vegetation present are alder, bigleaf maple, vine maple, willow, birch, cottonwood, bracken, blackberry, salmonberry, thimbleberry, and red huckleberry.

Profile description of a virgin area:

1½ to 0 inches or more, acid organic mat littered with forest debris.

0 to 14 inches, moderately dark-brown or rich-brown floury mellow very fine granular silt loam; contains fine shot pellets; layer with the organic mat included is 6 to 16 inches thick; medium acid.

14 to 20 inches, lighter medium-brown subsurface layer of floury silt loam; contains more shot and is more compact than layer above; 4 to 10 inches thick; medium acid; abruptly underlain by the next layer.

20 to 48 inches, grayish-brown or grayish-yellow highly iron-stained porous gravelly sands; medium acid; material slightly coated with clay; 20 to 30 inches thick.

48 inches +, steel-gray or bluish-gray rusty or iron-stained dense clay till fractured into massive blocks; fracture planes darkened by brown colloidal matter; neutral or mildly alkaline.

Use and management.—Probably two-thirds or more of Cagey silt loam, undulating, has been cleared for crops and pasture. Because it has a moisture supply lasting far into the dry summer, it is very productive when proper rotations and good management practices are employed. Good management requires use of crop rotations including legumes and the incorporation of crop residues and manure to increase or maintain the supplies of organic matter and nitrogen in which the soil is deficient. Open drains are an effective means of carrying off excess moisture in winter and spring, and crops can be planted earlier if drains are used.

Legumes respond well to applications of 300 pounds of superphosphate the first year and 250 pounds thereafter. Crops following in the rotation profit by this application and need no other fertilizer treatment unless they are special crops.

A great variety of crops, including fruit, is grown; but hay, small grains, and pasture occupy the largest acreage. A mixture of red clover and ryegrass or timothy yields 2 to 3½ tons of hay an acre; red clover sown alone, considerably less. A small second cutting of hay or some pasture is usually obtained. Small grains, frequently used as nurse crops for legumes, yield 1 to 1½ tons of hay an acre. Vetch sown with oats or other grains yields more heavily and is often used for hay. Hayfields are invaded by less valuable native hay plants after a few years, and lower yields result. If a proper rotation is used, invasion by native hay plants does not become a problem.

If harvested for grain, oats yield about 50 to 70 bushels an acre; barley, 35 to 55; and wheat, 20 to 30. Threshed vetch yields about 1 ton an acre.

Permanent pastures planted to recommended mixtures of such pasture plants as alta fescue, English and Italian ryegrasses, tall meadow oatgrass, Kentucky bluegrass, and common white, alsike, and red clovers have a good carrying capacity, but the grazing season usually is a little shorter than on Labounty silt loam, undulating. Stump lands and other partly cleared woodland pastures have a high carrying capacity if good stands of grass are obtained and competing natural vegetation is kept under control. The best pastures are gained by seeding mixtures of ryegrasses, orchard grass, and white clover on recently burned-over land.

Berries and fruits are grown successfully on better drained places or on areas that have open drains. Strawberries yield 2 to 2½ tons an acre; blackberries and raspberries yield well. Some sour cherries are grown commercially, but apples, pears, plums, and prunes are grown mainly for home use. Most farms have gardens in which a wide variety of vegetables are grown.

Cagey silt loam, sloping (Cd).—Although it resembles the undulating unit of Cagey silt loam with which it is closely associated, this soil occupies more sloping or rolling areas where slopes range from 6 to 15 percent. It usually has a surface soil thinner than that of the undulating soil—a surface soil that may be somewhat gravelly and of variable color. The till substratum is not at a uniform depth, and this creates uneven internal saturation. The variation in moisture content is often reflected in uneven growth or maturity of crops, especially where the microrelief is irregular.

Use and management—About half of Cagey silt loam, sloping, is cleared. Present use is rather similar to that of the undulating soil, but yields may be somewhat lower.

Cagey-Norma complex (Cc).—In some areas small bodies of Cagey silt loam and Norma silty clay loam are so intimately associated it is impossible to delineate them separately on a map of the scale used. They are therefore mapped as a complex consisting in most places of about 60 to 70 percent of Cagey silt loam and 30 to 40 percent of Norma silty clay loam. At Point Roberts are a few small areas in which Cagey sandy loam occurs, and these are included in mapping.

Most of the complex occurs on parts of the smoother ground moraines or similar tracts where there is an irregular microrelief of mounds, knobs, or sags and swells, chiefly in the low basin region. Drainage relief is shallow or undeveloped, and because of incomplete runoff, high saturation results in winter and spring. Under natural conditions the areas drain very slowly. The basins and depressions of Norma soil remain wet for extended periods. Open drains promote more rapid surface runoff and facilitate internal drainage because the water moves laterally through the porous gravel lying over the clay till. Nonetheless, it is difficult or impossible to obtain uniform moisture conditions in both soils, even with artificial drainage, and plantings are delayed and crops ripen unevenly.

Use and management.—Probably less than half the Cagey-Norma complex is cleared for cultivated crops and pasture; the rest is covered with second-growth mixed conifers and the thick stands of deciduous trees, brush, and shrubs that become established after logging. Owing to variable moisture conditions in the associated soils, cleared areas are used largely for hay and pasture and are well adapted to that use. Hay yields are about the same as on the Labounty-McKenna complex, but the grazing season for pastures is usually a little shorter.

Cagey gravelly loam, undulating (CB).—Nearly all of this inextensive soil occurs in association with the Barnhardt soils on the high moraine east of Blaine. It occupies depressions and smooth slopes where underlying compact drift causes imperfect drainage. The slope range is 3 to 6 percent. The sandy drift is more permeable than that under most of the Cagey soils, and this soil does not become so highly saturated nor remain wet and cold so long in spring as others of the series. Its freer drainage permits earlier planting, but moisture is not retained so long.

Profile description of virgin areas:

½ to 0 inch, slightly acid decomposing organic mat; up to 1 inch thick.

0 to 12 inches, light yellowish-brown medium acid gravelly loam; contains scattering pellets or shot; 8 to 14 inches thick.

12 to 18 inches, mellow medium acid gravelly sandy loam similar to layer above in color; 4 to 8 inches thick.

18 to 50 inches, grayish-brown loose porous gravelly sand highly stained with yellow and rusty brown; 24 to 36 inches thick.

50 to 72 inches or less, steel-gray softly cemented sandy till resembling that underlying the Alderwood soil but differing from clayey till under the more typical soils of the Cagey series; depth to the substratum varies somewhat but is usually less than 6 feet.

Use and management.—Less than half of Cagey gravelly loam, undulating, is cleared for farming. The forested area is covered by a second growth, largely of Douglas-fir and cedar and deciduous trees, brush, and shrubs similar to those on Cagey silt loam, undulating. Home gardens and plots for berries and fruit trees occupy a small part of the cleared area, but most of the land is used for hay, small grains, and pasture. Yields are the same or slightly lower than on Cagey silt loam, undulating. Pastures have a good carrying capacity, but the grazing season is shorter because of the more rapid drainage.

Cagey sandy loam, undulating (CA).—Found at Point Roberts, this soil occupies smooth flats, slightly depressed areas, and long gentle slopes. The soil is not waterlogged, but saturation is rather high in winter and spring. This phase is associated with Barnhardt gravelly sandy loam, rolling, and is underlain by similar compact softly cemented drift. Like Cagey gravelly loam, undulating, it differs from the more typical Cagey soils, which are underlain by clayey till. Except for its surface soil—a sandy loam usually containing no gravel—it very closely resembles the Cagey soils on clayey till. It drains more freely than Cagey silt loam, undulating.

Use and management.—Probably less than one-third of Cagey sandy loam, undulating, is cleared for cultivated crops and pasture. A small part is used for home sites, usually with accompanying gardens and small plantings of berries and fruit trees. Most of the land is used for hay, small grains, and pasture. Crop yields and the carrying capacity of pastures are about the same as on Cagey gravelly loam, undulating, and forested areas are covered by similar second-growth timber.

CARBONDALE MUCK

Bodies of Carbondale muck (Cf) are widely distributed in wet basins and depressions on the uplands, terraces, and stream bottoms. In many of these sites this muck is associated with Rifle peat and other highly organic mineral soils. Such areas are wet and often flooded in winter and early spring unless artificially drained.

The woody muck varies considerably throughout the area, and where it is less than 2 feet deep over mineral layers, Carbondale muck, shallow, is mapped. The surface soil of both this and the shallow phase ranges from dark-brown to grayish-black well-decomposed peaty muck to a material having a mineral content intermediate between that of highly organic mineral soil and that of woody peat. Deeper layers may show variation in color or mineral content similar to that in the surface soil, but they are usually well decomposed. In usual succession, layers containing woody fibers and fragments overlie those containing sedge fibers, and the sedge-fiber layers are underlain by sedimentary and mineral muck. Thin layers of white or yellow diatomaceous earth often occur near the surface. This soil always lacks the consistency and plasticity of mineral soils.

Profile description:

0 to 12 inches, very dark-brown or nearly black greasy granular medium acid muck; contains roots and a few wood fragments; 6 to 16 inches thick.

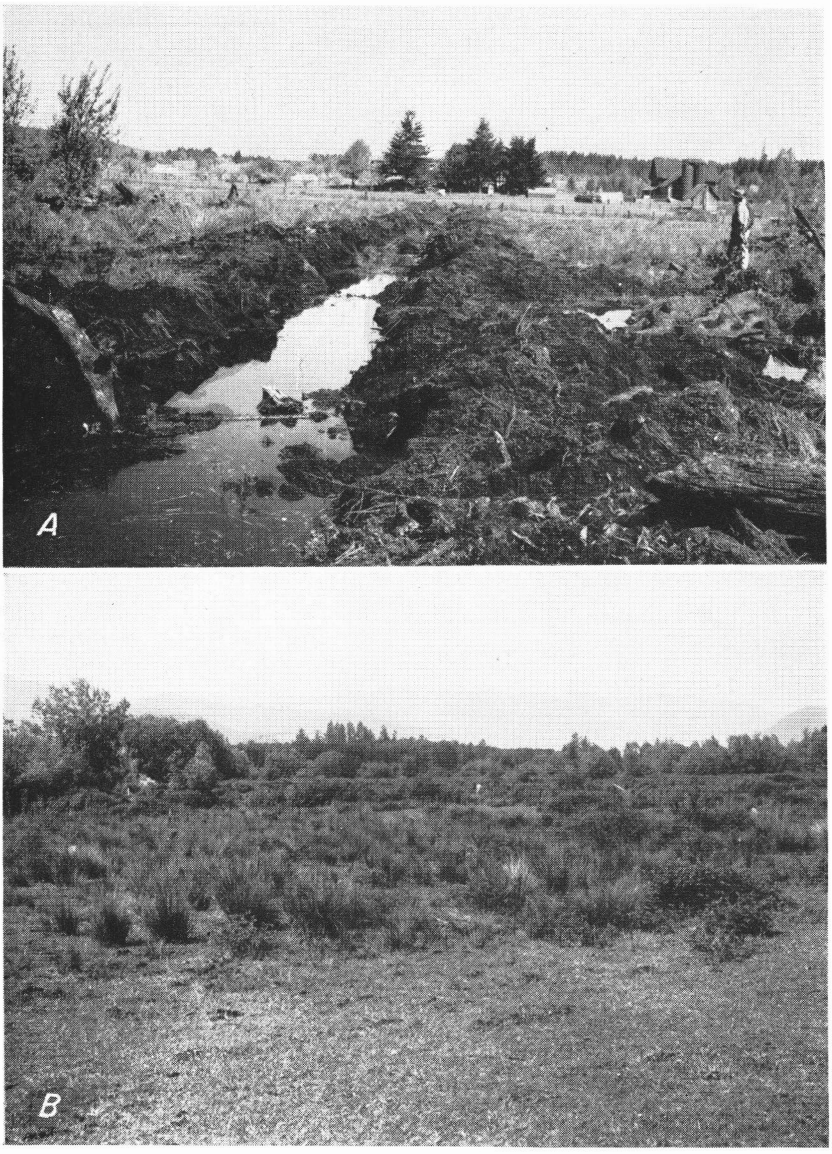
12 to 40 inches, dark-brown greasy woody muck; contains wood fragments, fibers, and silty mineral material; 20 to 30 inches (average about 24 inches) thick; medium acid.

40 inches to 6 feet, dark bluish or gray-brown medium acid muck; 20 to 40 inches thick.

5 or 6 feet +, bluish-gray mineral muck or dark sedimentary peat in contact with the underlying mineral soil; substratum at variable depths but usually in excess of 5 or 6 feet.

Use and management.—Artificial drainage is necessary for successful growth of most crops on Carbondale muck (pl. 3, *A*), and, if satisfactory outlets are available, can usually be accomplished by using intercepting and central drains. Drains should be installed so as to hold water at a definite depth below the surface. If this is done, a supply of moisture is held available during the growing season.

The small part of this soil remaining uncleared has a vegetative cover similar to that on Rifle peat—cedar, Douglas-fir, some hemlock,



A, Artificial drainage on Carbondale muck.
B, Sedges and wild blackberries invading partly cleared woodland pasture on Labounty soils.

Strawberries on Lynden sandy loam, undulating, near Lynden, yielded 5.5 tons an acre the second year after planting.

and scattering spruce. Crop yields usually exceed those on Rifle peat because this soil has a surface layer of more compact finely divided or colloidal character and a higher mineral content. It is more frequently used for pasture than Rifle peat because mineral deficiency in the peat causes reduction in milk production. The soil works into an excellent seedbed, and the well-decomposed organic matter provides nitrogen more readily than peat. Balanced fertilizers high in potash and phosphate are used, particularly for special crops.

CARBONDALE MUCK, SHALLOW

Carbondale muck, shallow (Cg), is much more extensive than Carbondale muck. The individual tracts have similar wide distribution, however, and aside from the shallower depth of muck resting on mineral layers, this soil is very similar. The depth ranges from 8 to 24 inches, and the shallower parts usually contain larger quantities of mineral soil than elsewhere. This soil equals Carbondale muck in productivity when properly drained. Much of the land is farmed, the proportionate acreage being about the same as for Carbondale muck.

CATHCART SERIES

Soils of the Cathcart series are shallow over bedrock of sandstone and shale and are developed from glacially scoured consolidated sandstone. They typically contain little or no glacial gravel. However, a considerable total area having a thin glacial mantle is included in mapping because the individual mantled bodies are too intricately associated to allow separate delineation on a map of the scale used. Cathcart soils occur on low, elongated, glacially scoured ridges bordering the lower basin area and on more prominent foothills in the interior. In the high mountainous part large areas of very shallow ill-defined soils are mapped as Rough mountainous land, though they are from sandstone, some shale, and other rocks giving rise to Cathcart soils at lower elevations.

Steep relief makes surface drainage rapid, but accelerated erosion is prevented by a thick forest cover and a good undergrowth and organic mat. These soils absorb moisture well and hold it available to plants for extended periods. The native forest trees were largely Douglas-fir, cedar, hemlock, and an occasional spruce.

Cathcart soils are characterized by a gritty very light moderate-brown shot-filled surface soil over a gritty to sandy yellowish-brown or olive-gray and gray iron-stained subsoil. Decomposing sandstone fragments usually occur throughout the subsoil. The substratum is consolidated decomposing olive-gray or gray sandstone, often of arkose character. The series is represented by the rolling and hilly phases of Cathcart loam.

Cathcart loam, rolling (Ck).—Areas of this soil occur largely on the more prominent ridges adjacent to and in the city of Bellingham. A considerable part occurs as scattering bodies in the nearby foothills. The relief is strongly rolling or ridgy on slopes of 6 to 15 percent, and surface drainage is rapid. Though the merchantable timber has been cut, second-growth conifers mixed with thick stands of deciduous trees and brush remain on uncleared areas and effectively check accelerated erosion.

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In places this soil varies considerably because debris was left by the scouring glacier. The more completely scoured ridges and hills are relatively free from glacial deposits, but elsewhere glacial erratics of gravel and stone may mantle the surface or be embedded at variable depths in the subsoil.

Profile description of a virgin area:

1½ to 0 inch, dark-brown partly decomposed medium acid organic mat up to 1½ inches thick.

0 to 10 inches, moderately light-brown gritty but very mellow slightly granular loam; contains much shot; medium acid; 6 to 12 inches thick.

10 to 20 inches, yellowish-brown medium acid gritty loam or sandy loam; contains shot pellets and fragments of sandstone; 8 to 12 inches thick.

20 to 50 inches, yellowish-brown or pepper-and-salt colored sandy loam; contains decomposing sandstone fragments and horizontal reddish iron stains and bands; medium acid; 20 to 40 inches thick.

50 inches +, olive-gray or pepper-and-salt flecked yellowish-gray consolidated arkose sandstone considerably iron stained at the top.

Use and management.—Probably about one-third of Cathcart loam, rolling, is cleared and used for home sites or farms. Various crops, including fruits and vegetables, are grown where the lay of the land permits cultivation, as the soil has good moisture-holding properties. It has the same deficiencies as other soils of the uplands and responds well to the same crop rotations and cultural practices.

Cathcart loam, hilly (CH).—This soil differs from Cathcart loam, rolling, mainly in steepness. Slopes usually range from 15 to 30 percent, though a few small areas of steeper relief are included. The soil occupies hilly slopes along drainageways and the sides of ridges and hills and is closely associated with the rolling phase.

Use and management.—All of Cathcart loam, hilly, has been logged, but because of unfavorable relief, none is used for farming. A few small areas are used for home sites. A second-growth of Douglas-fir and cedar is becoming established, but the stands probably would be improved by artificial methods.

CLIPPER SERIES

The Clipper series is represented in this area by only one type, Clipper silty clay loam. The soil occupies low areas, is poorly drained, and in some places has a scattering of stones. The subsoil and substratum favor artificial drainage.

Clipper silty clay loam (CL).—Small bodies of this soil are widely distributed in poorly drained sites on alluvial fans and on very gently sloping alluvial flats along well-defined drainageways. Characteristically, relief is smooth and nearly level to very gently sloping (1 to 4 percent), with few undulations or sags and swells. Especially in fan positions, the land may be crossed by many abandoned stream channels. High saturation occurs in winter and spring when streams are up, but because of the open subsoil and substratum, artificial drainage is fairly free if there is a satisfactory outlet. Open drains are used to facilitate underdrainage, and some areas are protected against overflow.

Profile description of a virgin area:

1 to 0 inch, dark-brown grass-matted slightly acid organic layer including forest litter; up to 2 inches thick.

0 to 11 inches, dark-brown or dark grayish-brown very granular silty clay loam; 8 to 14 inches thick with organic layer included; slightly acid.
11 to 17 inches, yellowish-brown or slightly reddish dark-brown highly iron-stained gravelly loam; 4 to 10 inches thick; rests abruptly on material below.
17 to 39 inches, grayish-brown highly iron-stained stratified gravel and sand; 20 to 24 inches thick.
39 inches +, steey-gray or pepper-and-salt colored loosely stratified washed gravel and sand; slightly acid to neutral.

In some areas the surface soil has a slightly reddish cast; in others it ranges from medium grayish-brown to nearly black. The soil in the wetter locations is usually darker and more highly organic. In the lower basin thin clay lenses or strata occur in the substratum. A few small areas with a scattering of stone are shown on the map by stone symbols.

Use and management.—Probably less than half of Clipper silty clay loam is farmed. Uncleared areas—covered by second-growth forest similar to that on the other lowlands—provide some woodland pasture and browse. Most of the cultivated land is used for hay, pasture, and oats, though vegetables and berries are important in some areas. The soil responds well to the same cultural and fertilizer practices as those employed on Bellingham silty clay loam, and crop yields are similar or slightly lower.

COASTAL BEACH

Coastal beach (Cm) consists of narrow elongated areas of shore-washed sand, gravel, and stone that parallel the coast. These areas range from less than a rod in width to about one-fourth mile in the widest part. They are often covered with driftwood and other debris, including marine shells. In places the bodies occur as low narrow ridges or successive ridges behind which may be trapped areas of fresh- or salt-water marsh. Coastal beach is usually barren of vegetation but may support short-lived grasses or shrubs on the inner margins.

CUSTER SERIES

In the Custer series are poorly drained soils of the sandy terraces that form a considerable part of the smoother basin region. They occupy large continuous flats and depressions where the water table is high most of the year. Surface water moves off slowly because the surface is nearly level and clearly defined drainage channels are lacking. Custer soils are associated with the Lynden and Tromp soils and in places form a complex soil pattern with the better drained Tromp soils.

Like soils of the Tromp series, the Custer have a hardpan of variable concentration. It is massive, platy, or fragmental in some places and in others not so highly cemented or concentrated. Iron and other cementing materials have apparently precipitated from solution under the influence of a seasonally fluctuating water table and caused the induration. Drainage waters are highly colored with iron and organic matter. The surface soil is leached to a grayish color, and an ash-gray layer usually occurs over the iron concentration.

Drains must be installed before these soils can be farmed satisfactorily. In most places the indurated layer does not seriously restrict internal water movement or the root penetration of the hay, pasture, and small-grain crops commonly grown. The nearly continuous leaching probably causes considerable impoverishment in readily available plant nutrients. In virgin areas Custer soils were heavily forested with valuable trees, largely cedar, Douglas-fir, and a few spruce.

Two soil types are represented in the series—Custer silt loam and Custer sandy loam.

Custer silt loam (Co).—This widely distributed soil is more extensive than Custer sandy loam, the other member of the series occurring in the area surveyed. Areas are scattered in the flat basins and depressions over the sandy glacial outwash terrace and are in most places associated with the more extensive, higher, and better drained Lynden and Tromp soils. In some locations they form a complex pattern with the Tromp.

The slope range is 1 to 3 percent, and surface runoff is slow. Open drains facilitate surface drainage and aid in lowering the water table, and through their use spring plantings can be made without serious delay. Though crops are planted late, the soil holds moisture effectively during summer and assures a plentiful supply for late-maturing crops.

Uncleared areas are in second-growth Douglas-fir and cedar, but in places deciduous trees and brush outnumber and crowd out the more valuable trees. Alder, hazelnut, aspen, willow, bigleaf maple, vine maple, cascara, and dogwood are among the deciduous growth. In most places the thick understory consists of bracken, salal, rosebush, snowberry, Oregon grape, oceanspray, blackberry, salmonberry, and thimbleberry.

Profile description in an uncleared area:

3 to 0 inches, dark forest litter and acid organic mat; 1 to 4 inches thick.

0 to 2 inches, grayish-brown or dark grayish-brown somewhat granular silt loam; medium acid; 2 to 4 inches thick.

2 to 8 inches, light-gray or grayish-white highly podzolized iron-stained material; strongly acid; 4 to 8 inches thick.

8 to 15 inches, rust-colored strongly acid ironpan in which there are localized dark metallic-like zones; contains shotlike material; fragmental or rounded accretionary stones are embedded in the rusty brownish-red sand; 6 to 12 inches thick.

15 to 23 inches, yellowish-brown or orange medium acid sand; contains a few iron accretions or localized rusty areas; 6 to 12 inches thick.

23 to 69 inches +, steel-gray pepper-and-salt colored sand of washed appearance; sands usually saturated with water and thickly bedded and medium acid.

The silty surface soil above the gray layer is variable in depth; it may be 1 to 4 inches thick in some places, and a foot or more deep in exceptional basins where organic residues accumulate. The deeper areas are usually darker. Most plowed fields are gray. The iron concentration is likewise extremely variable. In some locations there is a dense massive ironpan of stonelike hardness; in others the iron concentrations occur in less definite zones and are more widely dispersed. In such areas of less iron concentration there may be only a scattering of gravel-sized accretions. Where the accretions occur, the gray layer is usually not so well marked and may be absent, but even in these places the whole surface soil is grayer than that of the often closely associated Edmonds soil.

Use and management.—All of Custer silt loam has been logged, and probably half has been cleared for cultivated crops and pasture. If the land is effectively drained, hay, small grains, and pasture crops do well. Only the better drained sites are suitable for other crops, and even then the deeper rooted crops may not penetrate the ironpan. Artificial drains are required before this soil can be successfully farmed. The organic-matter content is low, and owing to nearly continuous leaching, mineral fertility is lower than in most associated soils. Barnyard manure aids in getting satisfactory stands of legumes and is beneficial or essential for other crops. The plowing under of crop residues and green cover crops is important in keeping the organic-matter content at a satisfactory level. Legumes are needed frequently in the rotation. About 300 pounds an acre of superphosphate the first year and 250 pounds thereafter are recommended to assure good yields of legumes. It may be necessary in some places to apply phosphate to other common crops and possibly more complete fertilizer for special crops.

The most common hay crops are mixtures of either red or alsike clover with ryegrass or timothy. These mixtures yield 2 to 3 tons or more an acre under good management. Nurse crops for legumes (usually oats) yield about 1 to 2.5 tons an acre when cut for hay. Oats and vetch grown together yield 1½ tons or more of hay. When harvested for grain, oats produce about 35 to 70 bushels an acre; vetch may yield nearly a ton.

Permanent and woodland pastures have a relatively high carrying capacity, and grazing lasts through most of the summer. The most satisfactory pasture mixtures include such plants as alta fescue, English and Italian ryegrasses, tall meadow oatgrass, Kentucky bluegrass, and common white, alsike, and red clovers. Good pasture stands usually can be obtained on partly cleared stump lands if they are seeded shortly after burning. These stands will provide good grazing if competing natural vegetation is kept under control.

Custer sandy loam (Cn).—This soil usually occurs on positions slightly higher than those occupied by the associated Custer silt loam, but the slope range is also 1 to 3 percent. Drainage is similar, and the native vegetation was much the same. Some form of artificial drainage is necessary before this soil can be cropped satisfactorily.

In virgin areas, forest litter lies over a thin, acid, decomposing organic mat several inches thick. The mineral surface soil, to a depth of about 3½ inches, is acid highly organic finely granular dark grayish-brown sandy loam. Below this and continuing to a depth of 9 inches is a podzolized, rather strongly acid, grayish-white or whitish-gray sand or loamy sand in which there are iron-stained bands. This layer lies directly over a strongly acid rusty reddish-brown ironpan of stonelike hardness that is embedded in reddish-brown compact sand. This iron-cemented hardpan has a metallic slaglike appearance in places. Between depths of about 21 and 40 inches is a yellowish-brown iron-stained medium acid compact sand in which localized areas of iron cementation occur. Below this are slightly acid bluish-gray or steel-gray sands having a uniform washed appearance resembling that of beach sand.

Use and management.—Owing to the sandiness of the surface soil, the organic and mineral fertility of Custer sandy loam is lower than that of Custer silt loam. Careful management similar to that for the silt loam is necessary to keep this soil at a high level of productivity. With more intensive management, however, a somewhat wider variety of crops can be grown because this soil usually can be drained more rapidly in spring. For the most part, the crops grown are similar to those on the silt loam, and about the same proportion of the land remains uncleared.

EDMONDS SERIES

In the area surveyed, the Edmonds series is represented by only one type, Edmonds silt loam. The Edmonds soil is associated with the Custer soils on the glacial outwash terrace of the lower basin region. More than half of it is mapped in complex with Tromp silt loam, which occupies slightly higher better drained sites. The Edmonds soil is usually in lower flats or depressions where considerable organic matter accumulates from thick stands of deciduous growth, sedges, and water-tolerant grasses.

Edmonds silt loam (Ea).—Small bodies of this soil are widely distributed over the broad sandy glacial outwash terrace in association with soils of the Custer, Tromp, and Lynden series. It differs from Custer soils in having a deeper, darker, more highly organic surface soil and in the absence of an ash-gray layer above the indurated hardpan. The organic and mineral fertility is higher than in Custer soil; the slope range is the same, 1 to 3 percent.

The basins and depressions in which this soil occurs are highly saturated and waterlogged in their natural condition, especially in winter and early spring. If not drained, they may remain wet all year. Moisture is available for plant growth through the growing season. The ironpan does not impede internal drainage seriously, and the water table subsides in summer. The ironpan may restrict root penetration somewhat, but the shallow-rooted crops commonly grown are not much affected. Native vegetation was much like that on the Custer soils, but deciduous trees and brush are now dominant, and sedges and water-tolerant grasses may form a considerable part of the ground cover.

Profile description in a virgin area:

3 to 0 inches, dark well-decomposed acid organic mat; greasy and granular in the lower part; 2 to 3 inches thick.

0 to 9 inches, very dark grayish-brown medium acid highly organic granular silt loam; contains many roots; 8 to 14 inches thick.

9 to 15 inches, rust-brown platy medium acid ironpan embedded in reddish and orange-brown sand; dark slaglike areas with reddish-brown concentrations are common; 5 to 10 inches thick.

15 to 33 inches, yellowish-brown or orange-brown rust-stained sand; contains a few iron-cemented accretions; 16 to 20 inches thick.

33 inches +, steel-gray or pepper-and-salt colored thick-bedded sands that appear to have been washed; somewhat saturated or waterlogged.

The surface soil is of somewhat variable depth, and in lower basins it is often deep and peaty or mucky at the surface. The indurated layer varies from more massive concentrations to fragmental plates or localized accretions more thinly dispersed.

Use and management.—On Edmonds silt loam some form of artificial drainage is essential to the successful growth of crops. Open drains are used, and by their use the drainage necessary for cultivation and planting of the crops most commonly grown (hay, small grains, and pasture) usually can be established without serious seasonal delay. On many low-lying or seepy areas the drainage system could be improved by tile drains.

The use of legumes in regular rotation with other crops aids in maintaining the organic and nitrogen fertility of the soil. If superphosphate is applied to legumes at the rate of 300 pounds an acre the first year and 250 pounds each succeeding year, hay yields and carrying capacities of pastures will be materially higher. Crops following the legume in rotation usually are sufficiently benefited by this treatment to require no direct application. Hay fields are usually invaded by native vegetation after several years, and the yield and feeding value of the hay is materially reduced. Farmers usually use a short rotation to prevent the establishment of native vegetation.

All the land has been logged, and probably three-fourths is cleared for cultivated crops and pasture. Much of the remaining area is used for woodland pasture. The hay crops generally are red or alsike clover mixed with ryegrass or timothy and yield 2½ to 4 tons an acre. Oats used as a nurse crop for legumes yield a ton or more an acre when cut for hay; and oat and vetch mixtures, 1½ tons or more. Oats harvested for grain produce 40 to 80 bushels an acre; and vetch, probably a ton or more. Pastures have a rather high carrying capacity, and the grazing period is long because there is an abundant supply of moisture. Pastures are seeded to the same mixtures as those used on Custer silt loam.

Edmonds-Tromp silt loams (Eb).—In this complex are bodies of Edmonds and Tromp silt loams so intricately associated they cannot be shown individually on the map of the scale used. Approximately 60 to 70 percent of this association is Edmonds soil, and about 40 to 30 percent is Tromp. This differs from the complex of Tromp-Edmonds silt loams, for in that association Tromp silt loam is dominant.

Bodies of Edmonds-Tromp silt loams are scattered on the smooth glacial terrace plain on which Lynden soils occur. The lighter colored and better drained Tromp silt loam is on slightly elevated islandlike areas rising above the more continuous bodies of dark Edmonds silt loam, which are in basins and depressions where drainage is poor. The range in slope for the complex is 1 to 4 percent.

Use and management.—Most of the complex of Edmonds-Tromp silt loams is cleared for farming. Open ditches provide enough drainage for cultivated crops and pasture, but uniform moisture conditions cannot be obtained in sizable areas for both soils. Use of the complex is therefore limited largely to hay and pasture, though considerable grain is also grown. Grain crops usually ripen unevenly because the two soils differ in drainage and moisture-retaining properties. Hay yields are slightly less than on typical Edmonds silt loam, and the carrying capacities of pastures are lower.

EVERSON SERIES

The Everson series is represented in the area surveyed by only one type, Everson silt loam. Like the Edmonds soils, it occupies basins and depressions in the glacial outwash plain of the lower basin region.

Drainage conditions are similar, though internal movement of moisture is somewhat slower because of a tight plastic clay layer occupying a position in the profile similar to that of the more pervious ironpan in Edmonds soils. The native forest cover was much like that on the Edmonds.

Everson silt loam (Ec).—Small bodies of this soil are widely distributed in the low basins, depressions, and back-terrace positions on the glacial outwash plain on which the town of Lynden is located. Slopes do not exceed 3 percent.

Profile description in virgin areas:

2 to 0 inches, dark-brown or dark brownish-gray medium acid well-decomposed granular organic mat; 1 to 3 inches thick.

0 to 5 inches, dark brownish-gray granular heavy silt loam matted with roots and high in organic matter; becomes dark grayish brown or brownish black when wet; 3 to 8 inches thick and strongly acid.

5 to 11 inches, light brownish-gray strongly acid silty clay loam; breaks into blocky particles that are readily crushed into single grains when dry; 5 to 6 inches thick; somewhat bluish gray when wet.

11 to 17 inches, very pale-brown highly mottled slightly acid sandy clay or clay loam; 6 to 8 inches thick.

17 to 25 inches, bright orange-yellow iron-mottled very sticky plastic clay having angular fractures; 6 to 12 inches thick; slightly acid or neutral.

25 inches +, steel-gray pepper-and-salt colored thick-bedded sand; bluish gray when wet; loose; almost devoid of organic matter; neutral or mildly alkaline.

Use and management.—Probably less than a fourth of Everson silt loam is still uncleared. Wooded areas have been logged and now have a cover similar to that on Edmonds silt loam. Some form of drainage is necessary before this soil can be used successfully. Most of the low basins and depressions can be drained successfully because the subsoil and substrata are sandy. The tight clay layer impedes downward percolation of moisture, however, and the soil is wet and cold in spring and plantings are delayed. Open drains are used for the most part. Drainage of lower lying areas could be improved by closer spacing of these open drains and by use of tile where water moves very slowly.

Hay and pasture are better suited than most crops because drainage is poor and because deep-rooting crops penetrate the clay layer with difficulty. The abundant moisture supply promotes good growth of hay, and pastures have a high carrying capacity for an extended period. This soil responds well to the same management and cultural practices as used on Edmonds silt loam, and under such management crop yields are about the same.

FRESH-WATER MARSH

Fresh-water marsh (Fa) occurs in low depressions or basins where fresh water stands at the surface all year. Such areas support a luxuriant vegetation of sedges, cattails, and other water-tolerant plants and usually lie too low for artificial drainage.

GILES SERIES

Soils of the Giles series are inextensive but important agriculturally. They are usually associated with the Lynden soils and occupy smooth nearly level or slightly undulating positions on the glacial outwash terrace. Some areas along drainageways and terrace fronts have steeper slopes. In the smooth nearly level places, finer silty and clayey sediments characteristically overlie the sandier layers. The sediments materially add to the moisture-holding properties of the soils, and the underlying sandy deposits permit free underdrainage. Since these soils are in lower positions than the Lynden, ground water is nearer the surface but still at a depth where it does not create imperfect or poor drainage. The virgin cover consisted of thick stands of valuable conifers, scattering deciduous trees, and an understory of brush, ferns, and herbaceous plants.

Giles soils are characterized by a smooth mellow shot-filled brown surface soil over an upper subsoil of laminated and interstratified yellowish-brown to yellowish-gray silt, clay, and fine sand. The material in the upper subsoil shows some compaction and usually is stained rusty brown in the lower part. The lower subsoil is formed of pepper-and-salt colored stratified sands similar to those under the Lynden.

The soils included in the Giles series are the gently undulating, rolling, and moderately steep phases of Giles loam; the gently undulating, moderately steep, and gravelly subsoil, gently undulating phases of Giles silt loam; and Giles-Tromp complex.

Giles loam, gently undulating (Ga).—This soil is associated with Lynden sandy loam, undulating, and occupies areas of smoother relief throughout the lower basin region and in the valley of the Nooksack River near Van Zandt. The usual topography is relatively level to gently sloping or undulating, most slopes being considerably less than 6 percent. Surface drainage is good, and internal drainage is moderate to excessive. The deep silty surface soil absorbs moisture readily and holds it effectively for plant growth, but the porous sandy subsoil and substratum are rather droughty, though not so much so as those of Lynden sandy loam, undulating, which is developed from coarser-textured sands. This soil is more desirable for agriculture than the associated Lynden soil, and the cultivated acreage is much greater. It has better moisture-retaining properties and a higher productive capacity.

On unfarmed areas the virgin coniferous timber, largely Douglas-fir with occasional cedars, has been logged and a second growth of similar timber trees has attained considerable size. The deciduous trees and brush that flourish after logging are competing strongly with the timber trees for space. A more systematic program of revegetating these lands with more valuable trees would add materially to the potential timber wealth.

In virgin areas there is an acid organic mat one to several inches thick over the mineral surface soil. To a depth of about 11 inches, inclusive of the organic mat, the surface soil is a medium acid brown floury silt loam containing a large quantity of fine shot pellets. Under this and continuing to a depth of about 20 inches is a subsurface layer of medium acid lighter moderate-brown mellow silt loam or loam in which there is considerable shot. The subsoil below this is slightly acid yellowish-brown or olive loamy fine sand with reddish mottling and some slight compaction. It extends to a depth of about 40 inches, where it is replaced by slightly acid loose grayish-olive pepper-and-salt colored sands with rusty-iron mottlings. These loose stratified sands of the substratum have a washed grayish pepper-and-salt colored appearance and are sometimes gravelly in the deeper parts.

At undetermined depths are layers of clay till or clay that restrict free percolation, and because of these, a suspended water table results. The water table fluctuates considerably with the season but throughout the year contributes materially to saturation of the substratum. The degree of saturation, indicated by the extent of iron mottling and soft cementation in the subsoil and substratum, may be considerable where this soil adjoins those of more restricted drainage. Trees and deep-rooted crops profit materially by this proximity to underground water.

Use and management.—Probably three-fourths of Giles loam, gently undulating, has been cleared for cultivation or permanent pasture. A large part is in hay crops, pasture, and small grains, but certified seed potatoes, strawberries, and such special crops are frequently grown. Vegetables and fruits are produced, but largely for home use.

There is a considerable deficiency in organic matter and nitrogen in this soil, and therefore management should include rotating legumes with other crops, plowing under of manure crops and crop residues, and using barnyard manure. Superphosphate applied to legumes at the rate of about 300 pounds an acre per year increases hay yields and materially benefits crops following in the rotation.

Hay crops are largely red clover mixed with ryegrass or timothy and yield 2 to 3¼ tons an acre, or more than clover would yield alone. Small grains commonly used as nurse crops for seedings of hay yield a little more than 1 ton an acre when cut for hay. Oat-and-vetch mixtures yield 1½ to 2 tons an acre or more. Alfalfa is an excellent hay crop, but farmers complain of difficulty in getting a good stand. Oats harvested for grain yield 40 to 60 bushels an acre; barley, 30 to 45; and wheat, 25 to 35. Certified seed potatoes do well, especially where the silty surface soil is deep; yields range from 225 to 325 bushels an acre. Strawberries yield 1½ to 3 tons an acre. Sour cherries also are grown in commercial quantities.

The carrying capacity of pastures is greater on this soil than on the sandier members of the same series, and the length of the season is longer. Permanent pastures have the best grazing value if seeded to mixtures of the following pasture plants: English and Italian ryegrasses, alta fescue, tall meadow oatgrass, orchard grass, Kentucky bluegrass, and common white, red, subterranean, and alsike clovers. Partly cleared stump lands or open woodland pastures generally have good carrying capacities if good stands are obtained and competing natural vegetation is controlled. Such pastures are most successfully sown shortly after the land has been burned over, and the best seed mixtures are those including the ryegrasses, orchard grass, and white clover.

Giles loam, rolling (Gc).—This soil resembles soils of the Lynden series but is a little more silty. It is inextensive and occupies rolling areas where slopes range from 6 to 15 percent. Surface drainage is rapid, but accelerated erosion is checked by the thick forest cover and the good water-stable granulation of the soil.

Use and management.—The merchantable timber has been removed from Giles silt loam, rolling, but in comparison with the gently undulating phase considerably less of the land is cleared and crop yields are lower. The second-growth coniferous timber is largely Douglas-fir. Deciduous trees and brush form a thick understory that competes with the more valuable timber trees.

Giles loam, moderately steep (GB).—This soil occupies moderately steep areas where slopes range from 15 to 30 percent. Small elongated bodies are widely distributed, usually along drainageways and terrace fronts. In most features other than relief and resultant differences in moisture relations and workability, this resembles the associated Lynden soils.

Use and management.—Giles loam, moderately steep, is not suitable for cultivated crops, because it has steep slopes. It is a good soil for forest and supports a fair second growth of Douglas-fir, some cedar, and thick stands of deciduous trees and brush. The vegetative cover, forest litter, and organic mat prevent accelerated erosion.

Giles silt loam, gently undulating (GD).—Most of this soil occurs southeast of Barrett Lake, and the rest is in widely scattered small bodies associated with Lynden soils. Relief is gently undulating (3 to 6 percent). Surface drainage is adequate, and the soil absorbs moisture readily and holds it well for plant growth. Underdrainage is very effective, yet not excessive. In some places southeast of Barrett Lake, water occasionally rises in shallow wells to within 8 to 12 feet of the surface.

The small uncleared area is in second-growth conifers, largely Douglas-fir with a scattering of cedar. Much of the cover is made up of alder, vine maple, bigleaf maple, birch, willow, and other deciduous trees, and there is an understory of ferns, salal, Oregon grape, ocean-spray, blackberry, red huckleberry, salmonberry, and thimbleberry.

Profile description in a virgin area:

2 to 0 inches, dark-brown medium acid organic mat; layer 0 to 3 inches thick but averages 2 inches; acidity usually lower in logged areas.

0 to 9 inches, moderate-brown softly granular medium acid silt loam; contains a large quantity of fine shot; 8 to 14 inches thick.

9 to 16 inches, yellowish-brown or lighter moderate-brown slightly more compact but friable heavy silt loam; medium acid; contains considerable shot; 6 to 12 inches thick.

16 to 46 inches, yellowish-brown or olive friable laminated or stratified silty clay loam; 20 to 30 inches thick; slightly acid.

46 to 63 inches, pepper-and-salt colored highly iron-stained or mottled stratified fine sand; 15 to 30 inches thick.

63 inches +, olive-gray and pepper-and-salt colored stratified sands with bands of rusty brown and yellow; depth is variable.

At a variable depth below 65 inches is light yellowish-gray clay till or other clay layers that restrict free percolation of moisture, and therefore a suspended water table results. The water table fluctuates considerably with the season, but throughout the year it contributes materially to saturation of the substratum. The degree of wetness in the subsoil and substratum is indicated by iron mottling and soft cementation, and where this soil adjoins those of more restricted drainage, this mottling and cementation may be considerable. Trees and deep-rooted crops profit by the proximity to underground water.

Use and management.—Giles silt loam, gently undulating, is excellent for farming and in most places is used in a highly diversified agriculture. A considerable area is used for home sites and adjoining small orchards and gardens.

The soil is deficient in organic matter and nitrogen, and legume crops, especially, respond well to phosphate. These deficiencies are partly corrected by rotating intertilled crops with legumes and by applying superphosphate to the legumes at the rate of about 300 pounds an acre annually. In short rotations—those in which intertilled crops occupy the land about 2 years—a high level of productivity is maintained in this manner, especially if considerable manure is also applied. If longer rotations are practiced, it may become necessary to use green-manure crops and apply barnyard manure more frequently.

The largest acreage is used for hay, permanent pasture, and small grains. Oats are the most extensively grown small grain. Hay mixtures of clover and ryegrass or timothy yield 2½ to 3½ tons an acre; yields of clover alone are smaller. Small grains used as nurse crops for legumes yield more than a ton of hay an acre. Small grains, as oats, yield 2 or more tons an acre when grown with vetch. When harvested for grain, oats yield 45 to 70 bushels an acre; barley, 35 to 50; and wheat, 25 to 40. Strawberries are grown successfully and yield 2 to 3½ tons an acre; other berries and fruits yield well. Vegetables are grown extensively for home use, and under proper management yields are excellent and quality is good. Permanent pastures have a good carrying capacity, and the grazing season is longer than on other soils of this kind. The usual pasture mixtures are used.

Giles silt loam, gravelly subsoil, gently undulating (GE).—From the gently undulating Giles silt loam this soil differs principally in its lower subsoil, which is loose open stratified gravel instead of sand. The gravel promotes rapid to excessive underdrainage and somewhat reduces moisture-holding capacity. The silty surface soil and upper subsoil are of stratified silts, clays, and fine sands, however, and they retain sufficient moisture for good plant growth. Areas of this phase occur on terraces along the Nooksack River from the vicinity of Goshen northward. The slope range is 3 to 6 percent.

Use and management.—About half of Giles silt loam, gravelly subsoil, gently undulating, is cleared and cultivated; the rest remains in second-growth timber. The cleared area is used for the same crops as those grown on the gravel-free gently undulating Giles silt loam, but yields are generally somewhat smaller because the moisture-holding capacity is lower.

Giles silt loam, moderately steep (GF).—Long narrow bodies of this soil occur along streamways and terrace fronts. Steeper relief (15 to 30 percent) and differences in moisture relations and workability resulting from steeper relief differentiate this from Giles silt loam, gently undulating. The steep slopes are covered with vegetation, and accelerated erosion rarely occurs. A considerable part of the phase is underlain by gravel.

Use and management.—Giles silt loam, moderately steep, is not cultivated, but some of it is used for woodland pasture. The larger part is in second-growth conifers, with which thick stands of deciduous trees and brush are mixed.

Giles-Tromp complex (GG).—In lower more nearly level areas of Giles silt loam where surface and internal drainage are incomplete, there are small depressions in the microrelief containing imperfectly drained Tromp silt loam. In such areas the two soils occur in a pattern so complex that separation on the map is impractical and they are mapped as a complex. The proportion is usually about 70 percent of Giles silt loam to 30 percent of Tromp silt loam, though some areas have a greater percentage of the Tromp soil. Slopes range from 1 to 4 percent.

In areas of this complex the water table is considerably nearer the surface than in typical Giles silt loam soils, and the subsoil is stained or iron mottled. The staining or mottling is especially pronounced adjacent to Tromp soil areas, and there may be considerable cementation. The moisture condition is complex, and although the increased moisture is a benefit to plant growth in summer, it delays spring plantings. Likewise, uniform growth is impossible, and uneven ripening of crops usually results. For most crops other than grain, however, the uneven ripening is not so important as the increase in available moisture.

Use and management.—A large part of the Giles-Tromp complex is farmed. Uncleared areas are in second-growth timber, but cleared ones are used extensively for all crops grown in the county. Crop yields are intermediate between those of Giles silt loam soils and Tromp silt loam.

GREENWOOD PEAT

Greenwood peat (Gh) is a well-preserved moss peat formed largely from sphagnum moss. All of it occurs near Mosquito Lake in a deep bog with a poorly defined sluggish outlet. Water rises in winter and spring and later subsides, but a well-regulated drainage system controls the level fairly well most of the year. Mats of green or pale-green sphagnum, hypnum, and other mosses up to 10 inches or more thick grow almost continuously on virgin areas. Protruding above these are stiff bushy growths of Labrador-tea and scattering cranberries, and around the border of the bogs are thick growths of invading spirea.

The upper 8 inches of Greenwood peat is very strongly acid, dark yellowish-brown decomposing moss peat containing twigs and roots. Between depths of 8 and 70 inches it is very strongly acid, raw spongy felted fibrous light yellowish-brown or brownish-yellow moss peat, mostly from remains of sphagnum moss but containing hypnum and other mosses. Below this and continuing downward to undetermined depths, the moss is moderate yellowish brown, slightly decomposed but fibrous and felted, and bedded into layers. Woody particles, roots, fibers of other vegetation, and, in places, buried logs are present.

Use and management.—All of Greenwood peat has been drained and developed for the commercial sale of baled peat moss, which is used for packing, chicken bedding, and organic dressing for lawns.

HALE SERIES

Soils of the Hale series are sandy counterparts of the Cagey soils. They are developed from sand-mantled clay till and occur almost entirely near the coast. They occupy gently sloping to moderately steep areas of imperfect drainage in association with soils of more irregular morainic topography.

Hale soils have brown surface soil over an upper subsoil of highly iron-stained yellowish or olive-gray porous sand. The sand frequently shows considerable compaction or soft iron cementation.

The lower subsoil and substratum of dense clay till usually occur at 3 to 5 feet.

Included in this series are the gently sloping and moderately steep phases of Hale silt loam and the Hale-Norma complex.

Hale silt loam, gently sloping (HB).—Except for a small area at Point Roberts, all of this soil occurs in the low basin region. The relief generally is gently sloping and in few places exceeds 6 percent. Probably less than one-fourth of the soil remains uncleared. All the merchantable timber has been removed, and a second growth, largely Douglas-fir and cedar, is becoming established in dense stands of deciduous trees and brush.

The shallow underlying clay till limits downward percolation of moisture, and imperfect drainage results. Water moves laterally through the porous upper subsoil, but saturation results in winter and spring. The soil is wetter and colder early in spring than the associated soils of better drainage, but a higher moisture content is retained during the dry summer. Open drains facilitate lateral drainage and are usually employed where more rapid drainage is desired in spring.

Profile description:

3 to 1½ inches, under virgin conditions the surface is littered with strongly acid forest debris that may be up to 3 inches thick.

1½ to 0 inches partly decomposed organic mat; 1½ to several inches thick.

0 to 5 inches, brown friable finely granular medium acid loam; contains fine shot pellets; 5 to 10 inches thick.

5 to 17 inches, medium-brown friable medium acid silt loam; contains shot; 10 to 14 inches thick.

17 to 47 inches, light yellowish-brown iron-stained sand; under certain shades of light, material has a faint olive color; contains localized compact or softly cemented lumps; 24 to 30 inches thick.

47 to 77 inches, light yellowish-brown dense clay till; becomes moderate yellowish-brown when wet; contains rounded gravel and stones; clay till occurs at variable depths but is usually 3 to 5 feet from the surface and continues downward to undetermined depths; clay till becomes bluish gray with depth; in some lower areas near the coast where marine shells are present the till is alkaline.

Use and management.—Under proper management and drainage Hale silt loam, gently sloping, is excellent for a wide variety of crops. Crop rotations that include legumes are necessary to build up and maintain organic matter and nitrogen, unless these materials are supplied by barnyard manure or by other means. Superphosphate applied to legumes will increase hay yields; the usual application is about 300 pounds an acre a year. Crops that follow the legumes in rotation profit from this application and do not need further additions of superphosphate.

This soil is used for vegetables, fruits, berries, hay, small grains, and pasture. Hay mixtures of red clover and ryegrass or timothy yield 2½ to 3½ tons an acre. Yields of red clover alone are considerably lower. Fields usually are pastured after the hay is cut, but a second cutting is sometimes made, especially in wetter years. Small grains used as nurse crops for legumes yield 1 to 1½ tons of hay an acre. Vetch with oats or other grains yields more heavily and is often used for hay. With proper rotations, less valuable native hay plants do not become established, and higher yields of more palatable hay are obtained.

Permanent pastures that include alta fescue, English and Italian ryegrasses, tall meadow oatgrass, Kentucky bluegrass, and common white, alsike, and red clovers have the highest carrying capacity. The grazing period usually is longer than on Cagey silt loam, undulating, because this soil has somewhat better moisture-retaining properties. Stump lands and other partly cleared woodland pastures have a high carrying capacity when good stands become established and invading natural vegetation is kept under control. The best pastures are obtained by seeding mixtures of ryegrasses, orchard grass, and white clover shortly after the land is burned over.

When harvested for grain, oats yield about 55 to 75 bushels an acre; barley, 35 to 55; and wheat, 25 to 35. Threshed vetch yields about 1 ton or more an acre. On better drained locations or on areas with adequate open drains, berries and fruits grow successfully. Strawberries yield 2 to 2½ tons or more an acre, and blackberries and raspberries yield well. Only the sour varieties of cherries are raised commercially. Apples, pears, plums, and prunes are among the fruits grown mainly for home use. A great variety of vegetables are grown in farm gardens.

Hale silt loam, moderately steep (Hc).—This soil occurs in close association with the gently sloping phase of Hale silt loam, largely along drainageways and terrace fronts where the slope is greater than 15 but rarely in excess of 30 percent. The areas generally are unsuited to agriculture because they are difficult to work with farm machinery. In addition, the surface layer is thinner than on the gently sloping soil and would erode under careless management. None of the land is now cleared, and the second-growth trees and thick undergrowth prevent accelerated erosion. Restocking to valuable forest trees should be encouraged.

Hale-Norma complex (Ha).—In this complex are areas of Hale silt loam and Norma silty clay loam so intricately associated it would be impractical to delineate them separately on a map of the scale used. Usually about 60 to 70 percent of the association is Hale silt loam, and 30 to 40 percent is Norma silty clay loam. Slopes range from 1 to 4 percent.

A small area of this complex lies near the coast at Point Roberts, but most of it is in the low basin region. It occupies relatively smooth places on low ground moraines where an irregular microrelief of mounds, knobs, or sags and swells creates an intricate pattern of imperfect and poor drainage. Drainage relief is shallow or undeveloped, and incomplete runoff results in high saturation during winter and spring. The areas naturally drain very slowly. More rapid drainage is promoted by use of open drains, as they facilitate more rapid surface runoff and the lateral movement of water through the sand overlying the clay till.

Use and management.—Probably two-thirds of the Hale-Norma complex is cleared for cultivated crops and pasture. The uncleared part is covered by second-growth timber and a thick understory of deciduous trees and brush. Drains bring about moisture relations more favorable for growth of cultivated crops and pasture, but it is difficult or impossible to establish uniform moisture conditions in both soils at one time, and, in consequence, plantings are delayed and crops ripen unevenly. Because of variable moisture conditions in the two associated soils, areas of this complex are used largely for hay and pasture. Hay yields are probably about the same or slightly greater than on the Cagey-Norma complex, and the grazing period for pasture is a little longer.

HEISLER SERIES

Soils of the Heisler series are inextensive and occur high in the mountain valleys east of Acme. They have formed on glacial moraines developed from argillite, schist, and shale. Apparently these materials were accumulated by alpine as well as Vashon glaciation. The strongly rolling to hilly morainic relief promotes rapid runoff, but the dense forest cover prevents accelerated erosion. The soils receive and retain large supplies of moisture, but their open character permits free internal drainage. They were once densely wooded with excellent growths of Douglas-fir, cedar, and hemlock.

Heisler soils are characterized by a strongly acid organic mat, which has promoted the development of an ashy-gray layer that rests upon a moderate-brown shaly surface soil. The subsoil is strong yellowish brown, orange stained, and shaly. It grades to light yellowish brown and then to weak yellow near the substratum, which is bluish or steel-gray argillite and schist.

The rolling and hilly units of Heisler shaly loam are included in the series.

Heisler shaly loam, rolling (HE).—Except for a small area southeast of Saxon Bridge on the South Fork of the Nooksack River, this soil occurs in a fairly continuous body in the high mountain valley of Hutchinson Creek east of Acme. It is a valuable soil for forest but is not well suited to cultivated crops, because of its irregular topography and shaliness. The relief is of strongly rolling morainic character, and there are many sharp slopes, especially along drainageways. The slope range is 6 to 15 percent, but most of the areas approach the steeper grade. Surface runoff is rapid, but the dense vegetation and organic mat prevent accelerated erosion. Moisture is absorbed readily and held moderately well for plant growth even though the lower subsoil and substratum are open and shaly.

Profile description in a virgin area:

2 to 0 inches, very dark partly decomposed organic mat; strongly acid; 1 to 2 inches thick.

0 to 1 inch, light brownish-gray or ashy-gray smooth silty shaly loam; strongly acid; 2 to 3 inches thick.

1 to 6 inches, moderate-brown shaly loam in which tongues extend irregularly downward; strongly acid; 3 to 5 inches thick.

6 to 16 inches, strong yellowish-brown shaly loam; 10 to 12 inches thick; strongly acid.

16 to 48 inches, light yellowish-brown moderately compact shaly and stony heavy loam or clay loam; 25 to 36 inches thick; strongly acid.

48 to 63 inches, light olive-yellow looser and lighter textured shaly and stony loam; slightly acid; 12 to 20 inches thick; merges gradually into layer below.

63 inches +, bluish-gray or steel-gray drift consisting principally of argillite and graphitic and sericitic schist.

Use and management.—Heisler shaly loam, rolling, is not farmed. The valuable timber trees—largely Douglas-fir, hemlock, and cedar, but also some spruce—have been cut. In recently logged areas the cover is principally alder, maple, and willow, with an understory of bracken and other ferns, blackberry, salmonberry, and thimbleberry. Where some time has elapsed since logging, the growth includes valuable stands of second-growth conifers.

Heisler shaly loam, hilly (HD).—This inextensive soil occurs on 15- to 30-percent slopes in close association with the rolling phase of Heisler shaly loam. For the most part it lies on hilly areas along deeply incised streams, steep mountainsides, and sharply rising moraines. Other than in relief, this soil resembles the associated rolling phase.

Use and management.—Heisler shaly loam, hilly, is steeper than the rolling phase, but trees grow about as well and produce excellent timber. Practically all of the merchantable timber has been removed, and a second-growth of similar trees is becoming established in thick stands of deciduous trees that remain after logging. The forest cover, litter, and organic mat protect the slopes from accelerated erosion. Rainfall is heavy, and though internal drainage is free, the soil absorbs and holds large quantities of moisture.

HEMMI SERIES

Soils of the Hemmi series are represented in this area by one inextensive type—Hemmi silt loam. The soil occurs in low smooth imperfectly drained terrace positions similar to those occupied by Tromp soils. The water table is relatively high, especially in winter and early spring, and as a result the subsoil material is highly iron stained, especially the plastic tight clay in the upper part. Internal drainage is slow. Water and roots are retarded by the clay layer but do penetrate to the porous sand underneath. Runoff is also slow, and a high saturation results in winter and early spring.

Hemmi silt loam (HF).—Small bodies of this soil occur on the smooth glacial terrace plain in the lower basin region. The acreage is small, but this is an important agricultural soil. Most of it is farmed. In greater part it has slopes of less than 3 percent, but a few small more sloping areas occur along terrace fronts. The nearly level to very gently undulating relief is favorable to farming, and the soil retains moisture well. The land was formerly forested, mainly with Douglas-fir and cedar.

Profile in virgin areas:

3 to 0 inches, dark-brown medium acid organic mat; 0 to 4 inches thick.
0 to 8 inches, moderate-brown, somewhat reddish-brown, or grayish-brown friable fine granular loam; contains shot; 6 to 9 inches thick.
8 to 15 inches, yellowish-brown slightly mottled somewhat compact medium acid silt loam; contains fine shot; 6 to 8 inches thick.
15 to 27 inches, rusty yellowish-brown or ocherous sticky plastic clay with bluish-gray inclusions; slightly acid; 8 to 16 inches thick.
27 to 37 inches, yellow, brown, and gray transitional layer of sand and clay; 8 to 14 inches thick.
37 inches +, pepper-and-salt colored or steel-gray sand containing rusty iron-colored bands.

Included in mapping is a small area where Everson silty clay loam occurs in complex association with this soil. The location of this area is NW¼ sec. 1, T. 40 N, R. 2 E.

Use and management.—All of Hemmi silt loam is in farms, and most of it is cleared. It is used mainly for hay, small grains, and pasture. Crop yields are about the same or slightly higher than on Tromp silt loam, and management practices are similar. This soil is deficient in organic matter and nitrogen, and legume crops are especially benefited by applications of superphosphate. Spring planting is sometimes delayed, but moisture is held into the dry summer for late crops. The water table subsides during the growing season; open drains like those used on lower lying lands are seldom necessary.

HOVDE SERIES

The Hovde series, represented in the area surveyed by Hovde silty clay loam, is developed where fine thin sediments have settled over the gravelly beach materials in fresh-water marshes. A thin highly organic root-bound surface soil lies over open porous beach gravel and sand. The vegetation is largely sedges and coarse water-tolerant grasses. Scattering willows and alders invade along the edges of the low wet basins.

Hovde silty clay loam (Hg).—This inextensive soil occurs in fresh-water marshes lying behind coastal beach deposits along the Nooksack delta, near Birch Bay, and at Point Roberts and Point Frances. Surface water usually remains until the dry summer.

The surface soil, to a depth of about 12 inches, is dark-brown rather highly organic silty clay loam bound into a tough root mat. The mat can be lifted sharply off the coarse coastal beach deposit below. These beach-deposit subsoil and substrata materials are slightly iron-stained washed-appearing poorly assorted sand and gravel, mainly of quartzitic and grantic origin.

Use and management.—The vegetation on Hovde silty clay loam is largely sedges and coarse water-tolerant grasses. These provide some grazing after the surface water subsides in dry summer, but pasture is of low quality.

INDIANOLA SERIES

Soils of the Indianola series are developed from a sand mantle deposited over clay till. They are associated with soils shallower over clay till and more slowly drained. Characteristically, the mantle is laid down in the same manner as the gravelly capping from which the Kickerville soils are formed, and the soils are associated with the Kickerville in the lower basin region. The relief of the Indianola soils is most characteristically undulating to rolling and generally smoother than that of the Kickerville.

Soils of the Indianola series have light yellowish-brown surface soil over gravel-sprinkled sandy subsoil. The subsoil grades into olive-gray pepper-and-salt colored sands that usually contain a scattering of gravel. The material immediately over the clay till is mottled throughout with rusty-brown bands and is commonly compacted or softly cemented. The clay till, usually occurring at a depth of 8 to 15 feet, sometimes restricts internal water movement in the layer immediately above it, and, in consequence, there is localized iron and silica cementation in that layer. Because of the restrictive action of the clay till, more moisture for plant growth is retained than is usual in open sandy soils.

The soils included in the series are Indianola fine sandy loam, rolling; Indianola loamy fine sand, rolling; and Indianola silt loam, undulating.

Indianola fine sandy loam, rolling (IB).—This soil occupies a relatively small acreage, largely near Goshen. A small part is on the Lummi Indian Reservation. Relief generally is rolling, with slopes ranging up to 15 percent, but in some smoother areas near Lummi, slopes do not exceed 6 percent. Less than one-third of the total area has the smoother relief. The soil absorbs water rapidly and retains it fairly well for crops. Appreciable accelerated erosion does not occur, even under cultivation. The virgin timber has been removed. On areas not cleared for farming, the principal cover is a thick growth of deciduous trees and brush in which a smaller proportion of Douglas-fir and cedar is becoming established.

Profile description in undisturbed areas:

1 to 0 inch, thin dark-colored mat of organic matter and forest litter; mat is up to 1½ inches thick but is obliterated with cultivation.
0 to 9 inches, light yellowish-brown medium acid friable fine sandy loam; contains shot; 8 to 10 inches thick.
9 to 19 inches, subsurface layer of yellowish-brown loose friable fine sandy loam or loamy sand; 8 to 12 inches thick.
19 to 29 inches, light yellowish-brown or, in places, pepper-and-salt colored sand with some iron-stained bands and a scattering of gravel; 8 to 12 inches thick.
29 inches to 8 feet or more, dark yellowish-brown or pepper-and-salt colored sands having a slight olive tint when wet; usually contain some gravel; slightly acid or neutral; 4 to 8 feet thick and may lie 8 to 14 feet beneath the surface.
8 feet or more and to unknown depths, light olive-gray or light bluish-gray dense compact clay till; neutral to mildly alkaline.

Use and management.—Probably 60 percent of Indianola fine sandy loam, rolling, is used for cultivated crops; the rest is in woodland pasture or forest. The cultivated crops are similar to those grown on the rolling phase of Kickerville silt loam, but yields are slightly greater. The soil responds well to the same rotations, fertilization, and cultural practices.

Indianola loamy fine sand, rolling (IA).—This soil differs from other Indianola soils in being formed on wind-blown sand ridges. According to geologists (*1*), the ridges formed along the marine beaches of an ancient, now extinct, shore line that existed after glacial time. Most of these ridges are scattered along the border line between the uplands and terraces, but they also occur well out on the terraces. The soil has very uneven topography because the ridges rise sharply and are extremely duned and rolling at the crests. The dominant slope range is 6 to 15 percent, but a few areas of steeper relief are included.

Runoff is rapid, but the thick forest cover promotes effective penetration of moisture, and accelerated erosion has not developed. Internal drainage is free, but moisture enough for good forest growth is retained. The surface soil is influenced by silt deposits. The subsoil is characteristically without any clay concentration.

In virgin areas the soil is covered by an acid organic mat less than 2 inches thick. The surface soil below this mat is moderately light-brown slightly acid smooth and friable loamy fine sand to a depth of about 10 inches. Between depths of 10 and 20 inches the upper subsoil is yellowish-brown or olive partly oxidized smooth loose loamy fine sand. Between depths of 20 and 40 inches are yellowish-gray or pepper-and-salt colored olive-tinted smooth sands containing thin compacted wavy rusty-iron colored and yellow bands.

Use and management.—The unfavorable topography and rather low moisture-holding capacity of Indianola loamy fine sand, rolling, limit its agricultural value, but it is a good soil for forest. The virgin stand of conifers, largely Douglas-fir, has been logged, but none of the land is cleared for farming.

Indianola silt loam, undulating (Ic).—This inextensive soil is important agriculturally because most of it is used for cultivated crops. It occurs near Pangborn Lake and on Lummi Indian Reservation. It developed from material similar to those forming Indianola fine sandy loam, rolling. Relief is smoother. About half the land is gently undulating with slopes of less than 6 percent, and the rest is more strongly undulating.

In virgin areas the surface soil is light yellowish-brown or rusty-brown friable shotty silt loam. The thin organic mat over the surface soil becomes incorporated with it during cultivation but adds little valuable organic matter. A more yellow friable loam underlies the surface soil at a depth of about 13 inches, and this changes to yellowish brown or olive-brown sandy loam at about 24 inches. Down to this depth the mineral soil is medium acid. The upper subsoil is pepper-and-salt colored or olive iron-stained sand between depths of about 30 and 50 inches. Below this are olive-gray pepper-and-salt colored sands containing rusty-iron colored, sometimes softly cemented or compacted, bands. The sands contain a sprinkling of gravel and continue to the light olive-gray or bluish-gray clay till that usually lies 8 to 15 feet below the surface. The lower subsoil is slightly acid to neutral.

Use and management.—Less than a third of Indianola silt loam, undulating, remains uncultivated. The uncleared part supports a second growth of conifers in dense stands of deciduous trees and brush. This soil is managed in the same way as Indianola fine sandy loam, rolling, but because of its deep silty mantle, yields from most crops, particularly from the specialized ones, are greater. On areas having the deeper silty mantle, seed-potato yields of 250 to 350 bushels an acre have been reported in wetter years.

KICKERVILLE SERIES

Soils of the Kickerville series occupy an extensive area, principally in the vicinity of Lake Terrell near the coast and in the northwestern part of the lower basin region. They are formed on a gravel mantle 8 to 12 feet or more thick. In places this mantle covers the rolling to knobby ground moraine of clay till occupying much of the lower basin region. The occurrence of clay till in the substratum has an important influence. It retards the free movement of water and tends to conserve moisture for deep-rooted crops. Because of this, the soils are less droughty than gravelly ones without such impediment. Also important is the depth of the gravelly mantle. These soils have more complete drainage than lower lying ones with which they are associated because they have a deeper gravelly mantle.

Like the associated Whatcom soils, these occupy areas of pronounced relief. Relief is wavy to ridgy over about half their area, and for the rest, undulating, hilly, or steep. Like the Whatcom, they have retarded or poor drainage because drainways on the rolling wavy morainic kame and kettle topography have not developed enough to establish proper drainage. Similarly, there are areas in which Kickerville soils are in complex association with more poorly drained soils of the smoother areas and basins.

Soils of the Kickerville series have brown friable surface soil containing scattered shot. The yellowish-brown porous gravelly subsoil is in many places iron stained and mottled with concentrated zones of yellow and reddish brown. Localized soft iron and silica cementation and compaction often occur in the finer textured strata. Discoloration and cementation in the subsoil have resulted because drainage was restricted during the period of soil development. Bluish-gray gravelly and stony neutral clay till similar to that from which the Whatcom soils developed occurs at depths of 8 to 12 feet or more.

Included in the series are the rolling, hilly, steep, and undulating phases of Kickerville silt loam.

Kickerville silt loam, rolling (Kb).—The thickness of the silty surface mantle and the depth to the substratum of clay till are the most variable features of this phase, and to a large extent they determine its use and productivity under cultivation. Areas on more pronounced ridges or undulations usually have the shallowest surface soil and the deepest gravel mantle and are therefore less valuable for cultivated crops than those elsewhere. These ridgy areas have the most rapid surface drainage and more rapid internal drainage, and consequently less moisture remains available for plant growth.

The virgin coniferous cover was largely Douglas-fir with scattering cedar. All merchantable timber has been cut, but second-growth timber is becoming established in the heavy growth of alder, maple, and willow that flourished after the conifers were removed.

Profile under virgin cover:

1½ to 0 inches, dark-brown loose rather strongly acid organic mat, 1 to several inches thick; mat distinctly apart from the shot-filled soil below.

0 to 10 inches, brown friable silt loam; contains shot; 8 to 9 inches thick; under cultivation this and the above mat become mixed and form a medium acid soil; the acidity of the organic layer may be extremely variable following logging operations.

10 to 20 inches, light yellowish-brown or yellowish-gray subsurface layer of compact gravelly loam; 8 to 12 inches thick.

20 to 30 inches, pale-brown or light yellowish-brown compact gravelly loam; 8 to 14 inches thick.

30 inches to 8 feet, light yellowish-brown loose sand; contains a very large quantity of rust-stained gravel; localized soft iron and silica cementation or compaction occurs in many areas of fine material; 6 to 10 feet thick; rests on dense clay.

8 to 12 feet, or to undetermined depths, medium-gray dense gravelly and stony clay till of undetermined thickness; dark gray when wet, and near the coast may contain marine shells.

The upper subsoil usually is medium to slightly acid; the lower subsoil, slightly acid to neutral. The degree of rusty mottling and cementation occurring in the subsoil and substratum indicates to what extent internal moisture movement is retarded. This mottling and cementation is a valuable index to moisture-retaining properties, and areas lacking the higher discoloration should be avoided for cultivated crops unless they are deeply mantled with fine material. The mantle of fine material, like that on the Whatcom soils, is extremely variable, but it is usually deeper on the smoother areas and generally uniformly deep adjacent to stream and delta flood plains. Gravel rarely occurs in quantities sufficient to interfere with cultivation, even where the surface soil is shallow.

Use and management.—Though only about one-fourth of Kickerville silt loam, rolling, is farmed, it forms a considerable part of many farm units in the vicinity of Lake Terrell, Lake Pangborn, and on Lummi Island. Most of this soil remains in forest, however, and it is apparently better for trees than cultivated crops. Artificial seeding and replanting would increase the stand of more valuable trees and provide a more satisfactory growth of timber.

The cultivated land is used largely for hay, pasture, and small grains, but growing seed potatoes is important in some areas. Garden vegetables, berries, and fruits are commonly grown for home use. Red clover mixed with ryegrasses or timothy produces the highest yields of hay (2 to 3 tons an acre). Grain nurse crops cut for hay yield about 1 ton an acre. Grain-and-vetch mixtures for hay yield 1½ to 2 tons. Oats harvested for grain yield 40 to 60 bushels an acre; barley, 25 to 40; and wheat, 20 to 30. Seed potatoes yield 180 to 300 bushels an acre. This soil seems suitable for alfalfa, but farmers report difficulty in obtaining good stands. This difficulty is less commonly encountered on Whatcom soils.

Pastures have good carrying capacity in spring, but the grazing season is short. Permanent pastures seeded to some mixture of alta fescue, English and Italian ryegrasses, tall meadow oatgrass, orchard grass, Kentucky bluegrass, and common white, alsike, subterranean, and red clovers have the highest carrying capacity. For woodland pastures or those on partly cleared land, ryegrasses, orchard grass, and white clover are probably the best pasture crops. They can be seeded successfully before natural vegetation gets a foothold on lands that have been recently burned over.

This soil, like the other phases of Kickerville silt loam, is deficient in organic matter and nitrogen. To obtain satisfactory yields, legumes are necessary in crop rotations and additions of crop residues and barnyard manure are needed. Superphosphate should be applied to legumes at the rate of about 300 pounds an acre per year.

Kickerville silt loam, hilly (Ka).—This hilly soil occurs in association with the other Kickerville soils. It occupies 15- to 30-percent slopes along drainageways and along the margins of drift plains. In most features other than relief it resembles other phases of Kickerville silt loam.

Use and management.—Kickerville silt loam, hilly, is not suited to cultivated crops, for it would be difficult to work such hilly areas with farm machinery and accelerated erosion would increase under careless farming. Probably it could be used satisfactorily for woodland pasture, but under most conditions it is best for timber. The surface soil on the hilly slopes usually is shallower than on the smoother locations, but trees do well. All of this soil has been logged. A second growth of conifers similar to the original is becoming established, though deciduous trees and brush strongly compete. Forestry practices to promote a more rapid revegetation and growth of the conifers would increase the potential value of the land for timber.

Kickerville silt loam, steep (Kc).—This soil occurs principally on steep escarpments along the main shore line and along the shores of

Lummi Island. Slopes are more than 30 percent, and some are precipitous with frequent exposures of the underlying clay till substratum. A good vegetative cover is on the less steep slopes, and coniferous trees do well. The virgin timber has been removed, and a mixed growth of conifers and deciduous trees is now the principal cover.

Kickerville silt loam, undulating (KD).—Though closely associated with the rolling phase of Kickerville silt loam and almost as extensive, this soil is somewhat different. It occupies smoother areas where slopes do not exceed 6 percent. In general, the silty surface soil is deeper and the clay till substratum occurs at shallower depths; such conditions contribute to greater retention of moisture.

Use and management.—The cultivated area of Kickerville silt loam, undulating, is greater than that of Kickerville silt loam, rolling, but probably more than half its acreage still remains in trees and woodland pasture. The crops grown are similar to those on the rolling soil, but yields are about a fourth greater. All the merchantable timber has been removed, and conifers are restocking somewhat slowly in competition with deciduous trees and brush.

KLINE SERIES

Soils of the Kline series occupy about 3 square miles and are derived from coarse, gravelly alluvium originating from the glaciated uplands. Their material comes mostly from granite and quartzite. The soils have smooth relief, but their moisture-holding properties and inherent fertility are rather low.

Kline soils are characterized by a light grayish-brown surface soil underlain by a stratified yellowish-gray or olive-gray sandy and gravelly subsoil. Cobbles and stones may be scattered throughout the profile and occasionally occur on the surface in fairly large quantities.

Two types are in this series—Kline loam and Kline gravelly loam.

Kline loam (KF).—Though less extensive than Kline gravelly loam, this soil is more important agriculturally. Probably three-fourths of its total area is farmed. It occurs mainly on alluvial fans along the foothills and mountainous area skirting the lower basin region, but minor areas are scattered throughout the valleys of the mountainous interior. The relief is generally smooth to gently sloping (1 to 4 percent) but may be traversed by abandoned drainage channels. Surface drainage is rapid, and internal drainage is good. In winter and spring underground water may rise in the substratum gravel.

All of the land has been logged, and second-growth timber occurs on uncleared areas. Douglas-fir, cedar, and hemlock strongly compete with alder, vine maple, bigleaf maple, birch, willow, dogwood, cascara, and hazelnut. In many places there is a thick undercover of spirea, oceanspray, blackberry, salmonberry, thimbleberry, rosebush, snowberry, and bracken.

Profile description:

0 to 6 inches, light brownish-gray slightly acid friable loam; contains a scattering of gravel; 5 to 7 inches thick.

6 to 16 inches, slightly acid loam similar in color to layer above or slightly yellowish brown or light olive gray; contains a moderate quantity of gravel; 8 to 12 inches thick.

16 inches +, yellowish-gray or light olive-gray, pepper-and-salt colored slightly rusty-brown mottled coarsely stratified sands and rounded gravel, largely of quartzitic and granitic origin.

Use and management.—Much of the uncleared area of Kline loam is used for woodland pasture. Farmed areas are used chiefly for hay, pasture, and small grains, though better areas are used for gardens, berries, and fruits. Hay mixtures, as red clover with ryegrass or timothy, yield about 2 to 3 tons an acre. Small grains used as a nurse crop for hay and pasture seedings yield about 1 ton an acre. When cut for grain, oats produce 50 to 60 bushels an acre; barley, 30 to 40; and winter wheat, 20 to 30. Pastures provide fair to good grazing, but the grazing period may be short in dry years. Pasture mixtures are those usually recommended for soils of the lowlands.

This soil is deficient in organic matter and nitrogen, and frequent rotation of legumes with other crops and the incorporation of crop residues and barnyard manure are necessary to maintain the supply at a satisfactory level. In addition, superphosphate applied at the rate of about 300 pounds an acre per year gives larger yields of hay and greater grazing capacity to pastures. The residual effect of the superphosphate applications is usually sufficient for other crops following in the rotation.

Kline gravelly loam (Ke).—Areas of this soil occupy sites on alluvial fans and stream bottoms where very gravelly and sometimes stony alluvium occurs. These areas are often cut by active and abandoned stream channels, and erosion or decomposition of material is common when streams overflow.

The surface soil is dull grayish-brown friable slightly acid gravelly loam to a depth of about 8 inches. Between depths of 8 and 18 inches is lighter grayish-brown slightly acid gravelly loam or sandy loam with a yellowish or olive cast. Below this are open porous poorly assorted stratified yellowish-gray or olive-gray sands and gravel that contain scattering cobbles and stones. In areas of stream overflow the surface texture is extremely variable, and fresh deposits of gravel and sand are common. Some tracts covered by scattering cobbles and stones are shown on the map by stone symbols.

Use and management.—Kline gravelly loam is not well suited to cultivated crops but does provide considerable pasture under careful management. The grazing period is relatively short, however, as the soil is droughty. Probably about one-fourth of the land is cleared for farming, and the rest is partly cleared stump land or in second-growth timber. The uncleared tracts provide considerable pasture and browse. The cleared land is used for crops similar to those grown on Kline loam, but yields are considerably lower.

LABOUNTY SERIES

Soils of the Labounty series, the most extensive of the imperfectly drained soils of the uplands, occur almost entirely in the low basin region. They occupy relatively smooth, undulating, sloping, and moderately steep areas on the extensive clay till ground moraine where there is no gravel or sand mantle. On this clay till they form a complex soil pattern with the associated better drained Whatcom soils of the more strongly morainic areas and with the poorly drained McKenna of the depressions and basins. Where mounds, knobs, or sags and swells occur, small areas of dark soils may be included, but if bodies of these form a substantial part of the soil association, a Labounty-McKenna complex is mapped. On the more typical locations, surface drainage of Labounty soils is relatively slow, and the internal drainage is retarded or restricted by the dense clay till. These soils had a dense forest cover under virgin conditions. In the wetter places many partly cleared areas are growing up in sedges and blackberries (pl. 3, *B*).

The Labounty soils have a dark-brown or grayish-brown very fine granular silty surface soil in which there is considerable shot and an iron-stained yellowish or olive-gray subsoil overlying clay till similar to that from which the Whatcom soils are developed. The subsoil is of fractured angular clay. Brown colloidal coatings occur on the fractures, and masses of roots are matted in the fracture planes. The lower subsoil and substratum grade into bluish- or steel-gray till and, with increased depth, contain an increasing quantity of gravel, stones, and boulders. Marine shells are common in the substratum of low-lying areas. Glacial erratics occur in places on the surface but rarely interferes with farming. Areas associated with the Squalicum soils do not have so dense a clay till in the substratum as those occurring elsewhere.

The series includes the undulating, sloping, and moderately steep phases of Labounty silt loam and the Labounty-McKenna complex.

Labounty silt loam, undulating (Ld).—This is the most extensive and important Labounty soil in the area surveyed. It occurs mostly on the low irregular ground moraine of the lower basin region where drainage is incomplete. The areas of less pronounced relief become highly saturated during winter. The relatively smooth topography (slopes not exceeding 6 percent) and the siltiness of the surface layer promote rapid absorption. Large quantities of moisture are absorbed and held for extended periods. The heavy clay till retards moisture movement, and the soil remains rather wet and cold early in spring. The delay in spring planting is compensated for because moisture is held effectively for plant growth during the dry period in summer. Delay in tillage and planting appears to be a better practice than attempted drainage of the tight clay. Open surface drains are commonly used to drain enclosed basins.

Uncleared areas of this phase are in second-growth conifers—mainly Douglas-fir, cedar, and scattering spruce—and a heavy growth of deciduous trees, brush, and shrubs.

Representative profile:

1½ to 0 inches, dark-brown medium acid organic mat, 1½ to several inches thick; acidity usually lower in logged areas.

0 to 10 inches, dark-brown or grayish-brown friable very fine granular silt loam; high in content of shot, which ranges from the size of a pinhead to that of a pea; medium acid; 5 to 12 inches thick.

10 to 18 inches, brownish-gray very fine granular silty clay loam; contains a large quantity of shot; 6 to 10 inches thick.

18 to 36 inches, yellowish-gray or olive-gray iron-stained or mottled clay loam; contains some gravel; shows horizontal yellow and rusty bands over tight clay till; medium to slightly acid; 16 to 20 inches thick.

36 to 48 inches, light brownish-gray slightly acid clay fractured into angular somewhat blocky pieces ⅛ to ½ inch across; contains embedded gravel and stones; colloid stained; matted roots along fracture plane; 10 to 14 inches thick.

48 inches +, yellowish-gray compact highly fractured clay till in which gravel, stones, and occasional boulders are embedded; becomes light brownish gray with a somewhat bluish shade when wet; dark-brown stains occur in the larger fracture planes; fractures decrease with depth.

The silt loam surface soil, as in the associated Whatcom soils, varies somewhat in depth. The deeper areas of surface soil are adjacent to the delta flood plain of the Nooksack River where silty loessal material may have originated and been blown to the surrounding region. In such places this phase is most productive. In areas of irregular microrelief, the surface soil is thinner and extremely variable in both depth and color. The color grades to lighter grayish brown in the more poorly drained places. The lower subsoil and substrata materials of this phase are neutral or mildly alkaline. A few small areas with excessive stones and boulders are shown on the map by stone symbols.

Use and management.—Probably two-thirds of Labounty silt loam, undulating, has been cleared for crops and pasture. The soil responds well to the same rotation, cultural, and fertilizer treatments as those given the associated better drained soils. Legumes grown for 3 years and followed by intertilled crops for 2 years seem to form a rotation satisfactory for maintaining the organic-matter and nitrogen contents of this soil at a level adequate for continuous crop production. If superphosphate is added to legumes at the rate of 300 pounds each year its residual effect is sufficient to maintain good production of crops following. Barnyard manure, crop residues, and green manures are especially beneficial where the rotation period is extended.

The land is used for a wide variety of crops, but the principal ones are hay, small grains, and pasture. The hay crops are largely mixtures of red clover and ryegrass or timothy. The mixtures produce more than clover alone, yields being 2 to 3½ tons an acre. The yields given are usually from one cutting, though a second cutting or a good crop of pasture is possible in most years. Small grains, frequently used as nurse crops for legume seedings, yield 1 to 1½ tons or more of hay an acre. Small grains produce heavy yields of hay when sown with vetch.

Oats harvested for grain yield about 55 to 75 bushels an acre; barley, 35 to 60; and wheat, 25 to 40. Threshed vetch yields about 1 ton an acre. A small acreage is used for strawberries, and yields are 2 to 2½ tons an acre. Blackberries and raspberries are also grown commercially. Cherries do well, but sour cherries are the only ones grown in commercial quantities. Apples, pears, plums, and prunes are grown mostly for home use. Farm gardens supply a wide variety of vegetables for home consumption.

Labounty silt loam, sloping (Lc).—This inextensive soil differs from the undulating phase of Labounty silt loam mainly in its more sloping relief and its consequent lower favorability for farming. Drainage is more rapid, however, and the soil warms earlier in spring. It is associated with other Labounty soils and occupies areas where slopes exceed 6 percent but are rarely greater than 10. The surface soil usually varies in color and thickness. Proportionately, the total area farmed is about the same as that of the undulating phase. It is used for crops, and yields are about the same or slightly lower.

Labounty silt loam, moderately steep (Lb).—Steeper slopes of 15 to 30 percent are the main difference between this soil and Labounty silt loam, undulating. This soil occupies moderately steep slopes in association with the other Labounty soils, usually along drainageways or on sharp breaks in the ground moraine. The slopes are unfavorable for farming but well suited to trees. The cover is second-growth conifers and thick stands of deciduous trees, brush, shrubs, and ferns. Under cultivation such areas would be extremely susceptible to accelerated erosion, but erosion is now held in check by the vegetative cover.

Labounty-McKenna complex (La).—In this separation are areas of Labounty silt loam and McKenna silty clay loam so intricately associated that satisfactory delineation of each soil could not be made on a map of the scale used. The complex usually consists of 60 to 70 percent Labounty silt loam and 30 to 40 percent McKenna silty clay loam. The complex occupies low rather level or gently sloping areas of ground moraine where drainage is slow and incomplete and mounds and knobs or sags and swells are prominent.

Areas of this complex become highly saturated during winter and drain very slowly in spring. The basins and depressions of McKenna silty clay loam remain wet far into summer. Runoff can be promoted somewhat by open drains, but it is almost impossible to create in the two members of the complex the uniform moisture conditions that would permit planting and harvesting of crops on both soils at the same time. Clearing and development for cropping have therefore been slower than on more typical Labounty soils, and farmed areas are used chiefly for hay and pasture.

Most of the complex is in the low basin region, though a considerable part occurs at Point Roberts and scattered areas are associated with the Squalicum soils on the higher moraines adjacent to the foothills and mountains. A few small areas containing many boulders are shown on the map by stone symbols.

Second-growth Douglas-fir, cedar, and occasional spruce grow on uncleared areas. Deciduous trees, especially alder, vine maple, and willow, have flourished since the lands were logged, and these, together with brush, shrubs, and bracken, make such areas almost impenetrable.

Use and management.—Probably less than half of the Labounty-McKenna complex has been cleared for cultivated crops and pasture. Cleared and partly cleared woodland tracts make excellent permanent pasture, and a large area is used for this purpose. The carrying capacity is high, and the grazing season is long when the usually recommended mixtures are used and native vegetation is held in check. The yields from such hay crops as clover mixed with ryegrass or timothy are 2 to 3½ tons an acre. Improving the conifer stands on uncleared areas would materially increase the potential timber value of the land.

LUMMI SERIES

Soils of the Lummi series are represented in this area by only one type, Lummi silty clay loam, which occurs mainly adjacent to the tidal flats on the delta of the Nooksack River. This is a fertile soil when reclaimed but salty in the virgin condition, and the ground water is highly charged with salts and unfit for domestic purposes.

Lummi silty clay loam (Le).—Most of this soil occurs adjacent to the tidal flats on the delta of the Nooksack River, though other areas are near Birch Bay and on Sandy Point. Until recently, the low basins and flats it occupies were periodically inundated by salt waters, especially when storms carried salty water inland. Natural drainage was very poor. The native vegetation is largely sedges and water-tolerant grasses, including some saltgrass. In the better drained or reclaimed areas, willow, cottonwood, alder, and other deciduous trees and brush are becoming established. The water beneath all the soils of the delta remains salty even after reclamation.

Profile description:

0 to 6 inches, light brownish-gray rust-stained or iron-mottled silty clay loam, very granular and high in content of organic matter; strongly acid; 5 to 7 inches thick.

6 to 20 inches, light-gray profusely iron-mottled strongly acid silty clay loam; like the layer above, dark brownish gray when wet; 12 to 16 inches thick.

20 inches +, light-gray laminated plastic clays interbedded with flattened sedge remains in various stages of decomposition; thin seams of dark sand, increasing in thickness with depth, occur in the lower subsoil and substratum; very strongly acid; virgin areas retain considerable salt in the lower subsoil and substratum.

Use and management.—About half of Lummi silty clay loam has been reclaimed by building storm dikes across the tidal flats at the edge of the Nooksack River delta and digging an extensive system of open drains. The storm dikes along Puget Sound broke after the soil had been reclaimed for some time, and as a result the underground water was somewhat recharged with salt. This salt affected other soils on the delta, as those of the Puget and Sumas series. Now, however, all but the continually waterlogged areas in the low basins along the tidal flats are relatively free of salt and produce good crops of hay and pasture. Hay and pasture are the principal crops grown on the lands suitable for farming. The sedges and coarse grass growing on unreclaimed areas provide considerable pasture. The inherent fertility of this soil is high; and under continuous reclamation and cropping with legumes, hay crops, and pasture, its productivity is increasing.

LYNDEN SERIES

Soils of the Lynden series are the most extensive of those formed from the sandy glacial outwash deposits of the large glacial terrace plain. This plain occupies the central part of the lower basin region of the county, and Lynden soils occupy the better drained parts. They are associated, nonetheless, with soils of imperfect and poor drainage lying in the many flats and basins. The variable drainage of soils of the extensive terrace plain results from a fluctuating high water table created by the clay substratum underlying all of them. Though for the greater part the water table is deep under Lynden soils, they may be somewhat affected in lower lying areas by restricted drainage. The influence of restricted drainage is indicated by reddish iron staining and sometimes soft cementation in the lower subsoil and substratum. In such areas of Lynden soils, trees and deep-rooted crops may be benefited by the increased moisture. Lynden soils were heavily forested with conifers, largely Douglas-fir, and an understory of deciduous trees and brush.

Under a thin dark-brown organic mat the Lynden soils have a moderate yellowish-brown friable surface soil that grades to more yellowish brown over the subsoil. The pepper-and-salt colored olive to olive-gray subsoil is of loose uniform sandy character, typically without gravel. Relief ranges from nearly level to rolling or moderately steep, and smoother areas have better moisture-retaining properties than those more rolling or hummocky. The areas of stronger relief are, in fact, droughty and may not retain enough moisture to mature crops.

Represented in this series are the undulating and rolling phases of Lynden gravelly sandy loam and the undulating, rolling, and moderately steep phases of Lynden sandy loam.

Lynden sandy loam, undulating (Ll).—This soil occurs largely on the more elevated parts of the glacial outwash terrace in the lower basin region. A few small bodies are south of Van Zandt in the valley of the South Fork Nooksack River and east of Van Zandt along the Middle Fork Nooksack River. The original timber cover, largely Douglas-fir, has been logged, and a second growth of Douglas-fir and denser growths of alder, willow, bigleaf maple, vine maple, and scattering birch have become established. There is a thick understory characteristic of the region.

The smooth glacial outwash plains on which this soil lies are relatively level in places but are more characteristically gently to more strongly undulating. Most slopes do not exceed 6 percent. The smooth relief and open character of the soil promote rapid absorption of water, but the moisture is not held effectively for plant growth, and cultivated crops may be injured during the protracted dry period in summer.

Gravel rarely occurs at the surface of this soil, but it is common in the deeper substratum. In lower places where the water table occurs in the substratum there may be considerable iron staining and frequent compaction or soft cementation in the lower subsoil. Deep-rooted crops and trees profit by this moisture condition. Most of the surface soil contains significant quantities of silt but little clay. As with the other soils of this area, considerable variation exists in the content and depth of the loesslike silt. Where the silt content is high (usually on the smoother areas), the moisture-holding properties are materially increased.

Profile description:

1½ to 0 inches or more, dark acid organic mat, 1 to 2 inches thick.

0 to 11 inches, moderate yellowish-brown friable sandy loam; somewhat silty but gritty in places, with some coarse sand grains; moderate brown when wet; medium acid; 8 to 10 inches thick.

11 to 20 inches, light yellowish-brown medium acid loamy sand with very slight compaction; 8 to 12 inches thick.

20 to 50 inches, light yellowish-brown or pepper-and-salt colored incoherent sand with occasional wavy yellow or rusty-brown bands more firmly compacted; 24 to 36 inches thick.

50 inches +, lighter pepper-and-salt colored clean loose sands; sands continue to variable depths, where they rest on clay till or other clay strata that effectively hold water.

Use and management.—Less than half of Lynden sandy loam, undulating, is cleared for cultivated crops and permanent pasture. All merchantable timber has been cut from uncleared areas, and the less valuable deciduous trees and brush that flourish after logging retard the second growth of conifers. Methods of improving the coniferous stands could well be initiated to improve the timber on the uncleared land.

Although a wide variety of crops are grown, only the quick-growing ones that mature before the summer dry period can be grown profitably from year to year. On more favorable smooth or low tracts, where surface soils are deeper, or where deep-rooted crops reach the substratum, the moisture problem may become critical only in times of drought. The coarseness of the soil materials makes necessary intensive rotation of legumes with other crops, conservation of crop residues, and frequent application of barnyard manure. Plowing under green-manure crops is especially beneficial where legumes are used less frequently in crop rotations. Legumes are much benefited by applications of 300 pounds of superphosphate an acre yearly. This application will be sufficient to meet the needs of other crops in the rotation.

Red clover and other legumes yield more hay when grown with ryegrass or timothy. Yields from such mixtures are usually 1½ to 2½ tons an acre. Alfalfa probably would be a valuable hay crop if good stands could be obtained. Small grains used as nurse crops for hay seedings usually yield about ¾ ton an acre, but small grains grown with vetch yield much higher. When harvested for grain, oats yield about 30 to 50 bushels an acre; barley, 20 to 30; and wheat, 12 to 20. Potatoes for certified commercial seed are grown successfully, and yields range from 150 to 250 bushels an acre, depending on the character and depth of the surface soil. Strawberries also do well (pl. 4).

When correct pasture mixtures are used, good grazing is available during spring. The best mixtures include alta fescue, Italian and English ryegrasses, orchard grass, tall meadow oatgrass, Kentucky bluegrass, and common white, red, subterranean, and alsike clovers.

On partly cleared stump lands or woodland pastures a successful stand of pasture mixtures can usually be obtained following burns. Suitable pasture plants seeded at such times receive minimum interference from native vegetation, and once the stand is established, pasture is good if competing vegetation is kept under control.

Lynden sandy loam, rolling (Lk).—In most features other than relief this soil resembles the associated Lynden sandy loam, undulating. It occupies areas of rolling or hummocky relief where the slope range is 6 to 15 percent and is therefore more limited in use. The surface soil, especially in the areas of strongest relief, is usually somewhat shallower and less influenced by silt than that of the undulating phase. The moisture-holding capacity of the soil is less because its surface layer is shallower and less silty.

Use and management.—Only about one-fourth of Lynden sandy loam, rolling, is used for cultivated crops. The crops grown are similar to those on Lynden sandy loam, undulating, but yields may be somewhat smaller. Part of this soil is used for woodland pasture, and the rest is in second-growth timber, largely Douglas-fir. Deciduous trees and brush form a considerable part of the cover. The conifer stands should be improved to obtain better timber yields.

Lynden sandy loam, moderately steep (Lh).—Steep terrace fronts and moderately steep areas along drainageways make up most of this phase. Slopes are in excess of 15 percent and range up to 30 percent. In most features other than relief this soil resembles the undulating phase of Lynden sandy loam. It is not farmed, and its slopes are well covered with vegetation. Accelerated erosion has not developed. The virgin timber has been cut, and a second growth of similar trees is becoming established in thick stands of deciduous trees and brush.

Lynden gravelly sandy loam, undulating (Lg).—This soil characteristically occupies slightly more elevated areas in association with Lynden sandy loam, undulating. It is formed from slightly gravelly glacial outwash deposits of sand, somewhat coarser than those of the undulating phase of Lynden sandy loam. In development it resembles that undulating phase closely, but it contains a scattering of gravel throughout the surface soil and an increasing quantity in the subsoil and substratum. The subsoil sands are usually of coarser texture, and the deeper substratum commonly contains considerable gravel.

This soil occurs on elongated sometimes ridgelike swells or undulations. The slopes are smooth and nowhere exceed 6 percent. Surface drainage is good, and internal drainage is excessive. In moisture-holding capacity this soil is inferior to Lynden sandy loam, undulating, but where the surface soil contains a considerable quantity of silt and is deeper than average, early maturing and deeper rooted crops grow successfully.

Use and management.—Probably less than one-fourth of Lynden gravelly sandy loam, undulating, is used for cultivated crops and pasture. Fair hay and pasture crops grow on the more desirable areas. Early maturing crops and certified seed potatoes are also grown successfully on the better parts. Crop rotations and cultural practices are the same as for Lynden sandy loam, undulating.

In general, this soil is better for forest than for farming. The virgin timber was largely Douglas-fir, all of which has been cut. A second growth of similar trees is established in many places, but stands could be improved by partly removing thick growths of less desirable deciduous trees and brush and seeding or planting more valuable conifers.

Lynden gravelly sandy loam, rolling (Lf).—This soil occupies rolling to strongly sloping areas (6 to 15 percent). It is associated with Lynden gravelly sandy loam, undulating, and resembles that soil in most features other than relief and the resultant differences in moisture relations. The surface soil is usually shallower and contains more gravel than the undulating soil, and the gravel content also is proportionately greater in the subsoil and substratum.

Use and management.—The moisture-holding capacity of Lynden gravelly sandy loam, rolling, is low. It is less desirable for cultivated crops than the undulating phase, but just as good for forest. Timber production should be encouraged. A second growth of conifers, largely Douglas-fir, occupies much of the land, but this is strongly competing with deciduous trees and brush. A systematic program for improving stands would increase the potential value of the timber crop.

McKENNA SERIES

The McKenna series is represented in the area by one type, McKenna silty clay loam. The McKenna is the most extensive of the poorly drained soils of the uplands. It occurs almost entirely in the low basin region, where it forms an important part of the agricultural acreage. Drainage relief is poorly developed or lacking, and the dense clay till restricts downward percolation of moisture. McKenna soil requires some form of artificial drainage before it can be farmed satisfactorily. In areas of more irregular microrelief this soil may form a very complex soil pattern with soils of imperfect or better drainage, as for example, the Labounty. There was formerly a dense forest cover, mainly Douglas-fir and cedar with a scattering of spruce and white fir, and a thick understory.

McKenna silty clay loam (MB).—This soil occurs largely in association with the Whatcom and Labounty soils in the low basin region and at Point Roberts. A smaller acreage is scattered throughout various areas of the Squalicum soils in the more elevated interior region. In some of the low-lying areas near the coast line marine shells are in the substratum; here the till is mildly alkaline. Glacial erratics occur on or in the surface soil in places and occasionally interfere with cultivation. A few boulder-strewn areas are shown on the soil map by stone symbols.

The soil has a smooth or relatively level relief in contrast to the more irregular rolling morainic or knobby topography of the better drained soils with which it is associated. As only a few slopes exceed 3 percent, farm machinery can be used efficiently. Internal drainage is slow, and moisture is retained for extended periods. The high moisture content during winter and spring delays cultivation and planting. Open drains are used in places to remove excess water, but tile drains are common only in seep areas, which have a tendency to remain wet. Closed basins without outlets may remain waterlogged throughout the year, and such areas are suitable for pasture only.

Probably less than a third of this soil remains in forest. The merchantable timber, largely Douglas-fir and cedar with scattered spruce and white fir, has been removed from the uncleared areas, and a second growth is fairly well established. Deciduous trees and underbrush have thickened considerably since logging and are now in strong competition with the conifers. Dense mixed growths of alder, bigleaf maple, vine maple, willow, birch, cascara, and dogwood are common, and cottonwood occurs in places. The understory is largely bracken, rosebush, snowberry, spirea, blackberry, salmonberry, thimbleberry, red huckleberry, sedges, and water-tolerant grasses.

Profile in a virgin area:

2 to 0 inches, very dark brownish-gray medium acid spongy decaying organic layer; fibrous and woody at the surface but mull-like below; brownish black when wet; 1 to 3 inches thick.

0 to 4 inches, dark brownish-gray granular slightly acid silty clay loam rather high in organic matter; 3 to 6 inches thick.

4 to 10 inches, slightly acid colloid-stained silty clay loam or silty clay showing irregular angular fractures; contains fine roots, many cavities and worm casts, and a few pieces of gravel; 4 to 10 inches thick.

10 to 28 inches, light brownish-gray slightly acid clay loam or loam with rusty-brown or light yellowish-brown mottlings; contains rounded gravel and stones; 15 to 20 inches thick.

28 to 58 inches, light olive-brown colloid-coated angularly fractured silty clay loam; contains embedded gravel and stones; brownish colloidal coating decreases with depth; grades to underlying layer; 2 to 4 feet thick.

58 to 70 inches +, bluish-gray dense silty clay loam till; fractures into angular blocks which are cut in places by tilted or oblique planes.

The surface soil is of fairly uniform depth in wooded areas but may be deeper in basins where sedges and water-tolerant grasses grow luxuriantly. In flat basins a light-gray friable subsurface layer is distinct when the soil is dry.

Use and management.—Much of McKenna silty clay loam is used for cultivated crops and pasture. Pastures have a high carrying capacity. Under cultivation the soil responds well to rotation of legumes with other crops and applications of superphosphate. It inherently has more nitrogen and organic matter than associated lighter colored better drained soils, and therefore the content of these materials can be maintained with less frequent use of legumes. Where phosphate is used, it is usually applied only to legumes, as the residual effect seems sufficient for crops following in the rotation. On newly cleared lands barnyard manure is effective in getting legumes started, and marked benefits result from its application to other crops.

Hay, small grains, and pasture are most often grown, but most crops of the area can be grown where an effective drainage system is installed. Some form of artificial drainage is required before this soil can be farmed satisfactorily. Red clover or alsike clover mixed with ryegrass and timothy is the most common hay crop, and yields are 2½ to 4 tons an acre. Clover alone yields considerably less. The soil holds moisture well for extended periods, and fields usually can be pastured after the hay is harvested or a second crop can be cut. Fields left in hay more than 3 years are usually invaded by white clover and native grasses that produce lower yields of inferior quality. Small grains used as nurse crops for legumes yield 1 to 2 tons an acre of hay. Vetch sown with such grains as oats yields considerably higher. Threshed vetch yields 1 ton or more an acre. Oats, the most commonly grown cereal crop, yields 60 to 90 bushels or more an acre; barley yields fairly well. The soil is usually too wet and cold for wheat.

Other crops, especially vegetables and berries, produce well on better drained sites. On such areas 250 to 400 bushels of potatoes an acre are reported, but the cold wet soil harbors diseases and insect pests. Vegetable yields are high under good management, but the soil is usually too wet for tree fruits.

MADE LAND

Made land (Ma) consists of areas artificially built up from miscellaneous soil materials, and its total acreage is relatively small. The largest area is along the Bellingham water front where there has been scraping and filling to form extensive sites for manufacturing and shipping plants. Along Squalicum Creek in the city of Bellingham slack coal deposits are included in mapping.

MUKILTEO PEAT

Mukilteo peat (Mc) occupies a small total acreage, though individual bodies are widely scattered throughout the area. Several of the larger bodies occur at Point Roberts and in the vicinity of Mosquito Lake. Though predominantly of sedge and tule origin, this peat soil contains remains of many other plants. Trees and brush, including spirea, commonly occur along the outer margin of bogs, and remains of these may be incorporated in the soil. Where the woody deposits do not exceed 10 to 12 inches in depth, the peat is considered to be of sedge origin and is mapped as Mukilteo peat. Areas having deeper deposits of woody peat are mapped as Rifle peat.

Sedge-peat bogs are usually more swampy and open than the woody-peat areas and in the virgin state are usually inundated a considerable part of the year. Usually there is a gradual transition from more

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open sedge, cattail, and marsh-grass vegetation to brush and tree growths similar to those on woody peat.

Profile description:

0 to 10 inches, moderately dark-brown medium acid granular sedge peat matted with roots and fibers; 8 to 12 inches thick.

10 to 40 inches, moderate-brown or yellowish-brown medium acid fibrous sedge peat; contains embedded flattened remains of partly decomposed sedges and coarse grasses; 24 to 36 inches thick.

40 to 50 inches or more, darker brown somewhat mucky peat; contains black preserved roots and stems; 10 inches to 2 feet or more thick.

50 inches +, bluish-gray sedimentary peat and muck; overlies mineral soil at extremely variable depths.

Use and management.—About half of Mukilteo peat is farmed, but artificial drainage is necessary before the land can be properly used for cultivated crops or permanent pasture (pl. 5, *A*). Open ditches similar to those used for draining Rifle peat are employed, but some areas are difficult or impossible to drain and therefore remain in the virgin condition. The largest reclaimed areas are at Point Roberts and adjacent to Lake Terrell. The reclaimed peat is now fairly well decomposed, finely divided, and compacted. In most places it is a little more acid and raw than Rifle peat and less productive of most crops. The crops grown are similar to those on Rifle peat, but yields are usually lower. The two soils show similar deficiencies and are managed in the same way.

MUKILTEO PEAT, SHALLOW

Mukilteo peat, shallow (MD), covers areas where the sedge peat over the mineral soil is less than 2 feet thick. Much of it occurs on the outer margin of bogs containing deeper peats, but scattered areas are widely distributed in shallow basins or depressions. About half the land is farmed. In virgin areas the drainage and the cover are the same as on Mukilteo peat. Crops grown and yields obtained are also much the same.

NEPTUNE SERIES

The Neptune series is represented in the area by one type—Neptune gravelly sandy loam. This soil developed from coastal beach deposits thickly littered with marine shells. It is well drained and droughty but may include marshy areas where the water table is high. The darkness of the surface soil is due to limy shell accumulations. The vegetation is sparse grasses and scattered brush and deciduous trees.

Neptune gravelly sandy loam (NA).—Widely scattered bodies of this soil occur on long narrow beach ridges, on low terraces along the coast, and near the outer margin of the Nooksack River delta. The soil is above high tide and usually well drained or droughty, but areas may be included in which the water table is high.

Profile description:

0 to 5 inches, very dark brownish-gray or nearly black loose incoherent shell-littered gravelly sandy loam; 4 to 6 inches thick.

5 to 20 inches, brownish-gray gravelly coarse sand much littered with fragments of clam shells that constitute a considerable part of the soil mass; 12 to 18 inches thick.

20 inches +, brownish-gray sands and gravel; decreasing quantities of shell fragments in the lower part.

Use and management.—The droughtiness of Neptune gravelly sandy loam limits growth of shallow-rooted vegetation, but sparse grass and brush afford some pasture and browse. The roots of scattering deciduous trees tap the supply of moisture in the lower subsoil and substratum. The soil is generally unsuitable for cultivated crops and permanent pasture and along the coast may be overwashed by high waves.

NOOKSACK SERIES

The Nooksack soils occur largely on the broad fertile intensively farmed alluvial flood plains of the Nooksack and Sumas Rivers from Ferndale to the Canadian border. The original vegetation was like that on the associated Puyallup soils, but little remains, as almost all areas are now cleared and farmed. Soils of this series are especially extensive in the vicinity of Everson, where they are among the most important of those used for truck crops and berries. Though the Puyallup may excel for certain types of crops and fruits that do best on sandy soil, the Nooksack are probably more productive when all crops are considered.

Nooksack soils occupy positions somewhat similar to the Puyallup and have much the same relief, but they more commonly occur in the higher bottom locations backward from the natural levees. They drain a little more slowly and consequently retain moisture better during dry summers. The moisture-holding capacity is increased by their siltiness throughout. A few lower lying areas have been improved by the use of open drains. Good moisture properties, smooth relief, and friable consistence make these soils easy to work over a wide range of moisture conditions. Though they are inherently fertile, the supply of organic matter and nitrogen is deficient and needs replenishment.

Soils of this series have a pale-brown or light yellowish-brown smooth friable surface soil over a lighter, light yellowish-brown or pale-brown upper subsoil of smooth silty texture but slight plasticity. The lower subsoil—pale-brown or olive-tinted pale-brown smooth friable thick-bedded clay and silt marked with rusty-brown and gray mottlings—contains thin layers of sand at lower depths. The clayey materials are friable and cheesy and lack any appreciable plasticity until they are worked into a moist mass.

Represented in the series are Nooksack silt loam; Nooksack silt loam, high bottom; and Nooksack fine sandy loam.

Nooksack silt loam (Nc).—A large part of this soil occurs on the broad alluvial bottoms near Everson. It occupies smooth alluvial flats of wavy sag-and-swell relief and is the most extensive of the Nooksack soils. Both surface and internal drainage are generally good, though flats or basins may remain wet longer than adjacent areas of more wavy or undulating relief. Slopes range up to 3 percent. Open drains are used on the areas of more pronounced relief to promote more effective runoff and more rapid internal drainage. The excess moisture is not sufficient to retard spring plantings, and it proves valuable during dry summers. Since the diking of the Nooksack River, this soil has rarely been flooded.

Representative profile:

0 to 10 inches, pale-brown to light yellowish-brown (pale olive when wet) smooth friable slightly acid silt loam; 8 to 12 inches thick.

10 to 30 inches, lighter yellowish-brown or pale-brown (somewhat olive colored when wet) friable slightly acid silt loam or silty clay loam; low in plasticity; 18 to 24 inches thick.

30 to 50 inches, silty clay loam similar to layer above in color but slightly rust mottled; somewhat olive colored when wet; slightly acid; 8 to 30 inches thick.

50 inches +, rusty-brown and gray-mottled thickly bedded silty clay of a color similar to that of the layer above; interstratified with thin lenses of silt and fine sand that in places become thicker and dominant in the substratum; reaction, about neutral.

The soil materials are highly silty throughout and have rather low plasticity. The surface soil is somewhat variable. In higher lying areas it is more yellowish or olive and the lower more nearly level ones, definitely grayer. In the low areas the subsoil is also grayer and more mottled.

Use and management.—Most of Nooksack silt loam is farmed, and a variety of crops are grown. Its general productivity is greater than that of the other bottom soils, even though some of those may excel for crops of specific soil requirements. Probably 75 percent of the land is used for hay, pasture, and small grains in conjunction with dairy and poultry enterprises; the rest is used largely for truck crops and berries, though some tree fruits are grown where underdrainage is adequate.

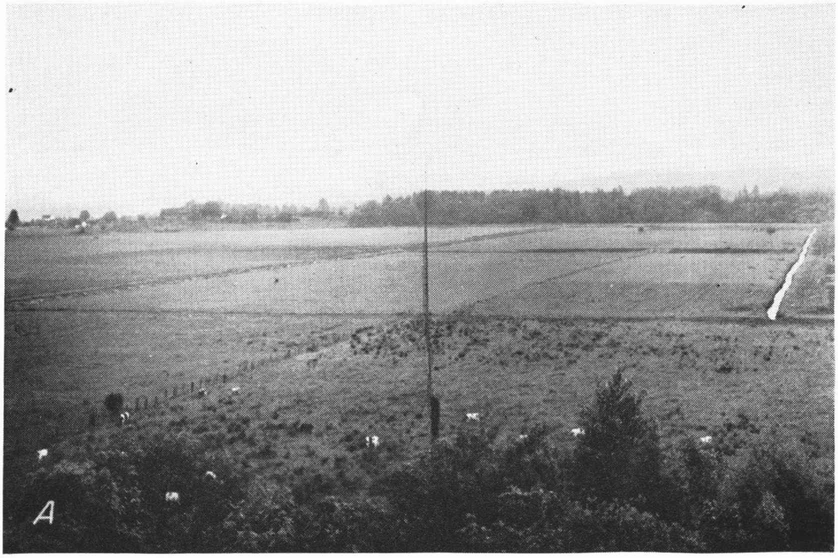
Mixtures of red clover and ryegrass or timothy are most popular for hay, though alsike clover is also used. Such mixtures yield 3 to 4½ tons an acre. Alfalfa is grown on the more elevated sites, and yields are high. Small grains, sown as nurse crops for hay and pasture mixtures, yield more than 1½ tons an acre as hay. Vetch sown with small grains may yield 4 tons or more an acre. Field corn, grown largely for silage, usually yields 12 to 18 tons an acre, though larger yields are reported.

Oats produce 60 to 95 bushels or more an acre; barley, 40 to 50; and winter wheat, about 25 to 35. Spring wheat is attacked by weevil and seldom grown. Vetch yields about 1 to 1½ tons an acre, and shelled dry peas, nearly the same. Pasture mixtures are similar to those used on the Puyallup soils, but because of the high moisture-retaining properties of this soil, their carrying capacity is greater and they can usually be grazed longer.

Truck crops and berries (pl. 6, *A*) are grown about as extensively as on the Puyallup soils, and yields of most of these crops average higher because moisture is held in the soil more effectively during dry seasons. A yield of 4½ tons of strawberries has been reported under intensive management. This soil responds well to the same management and fertilization practices as those used on the Puyallup soils.

Nooksack silt loam, high bottom (Nd).—This inextensive soil occupies high bottom positions in the South Fork Nooksack River Valley near Van Zandt. The small scattered areas have the appearance of a former terrace remnant and commonly are underlain by gravel at shallow depths. A reddish cast not common in Nooksack silt loam is usually evident throughout the surface soil and subsoil. This coloration is probably due to the slightly greater age. Where this soil is deep, crop yields are similar to those of the silt loam, but elsewhere they are considerably smaller.

Nooksack fine sandy loam (Nb).—Most of this soil occurs on smooth natural levees of the Nooksack River between Ferndale and



A, Permanent pasture on Mukilteo peat following adequate drainage.
B, Pole beans on Puyallup fine sandy loam.

A, Strawberries on Nooksack silt loam.
B, Landscape showing gently rolling uplands of Whatcom silt loam soils.
C, Corn planted on Whatcom silt loam, undulating.

Everson. Surface drainage is more rapid than on Nooksack silt loam, but internal drainage is similar. The sandy surface mantle probably was laid down in times of flood before the Nooksack River was diked.

The surface soil, to a depth of about 10 inches, is pale-brown or light yellowish-brown friable slightly acid fine sandy loam of somewhat olive or grayish cast. Below this is slightly acid more yellowish or olive smooth friable silty clay loam. Between depths of 18 and 60 inches the subsoil is light yellowish-brown or olive-gray very slightly mottled and slightly acid compact but friable smooth silty clay loam of slight plasticity. Below this is a thickly bedded nearly neutral silty clay loam, which is more plastic and mottled than that above but is stratified with silt and sand. The proportion of silt and sand increases in the substratum.

Use and management.—Though Nooksack fine sandy loam is well suited to crops that do better on sandy soils, farmers ordinarily use it for the same crops as those grown on Nooksack silt loam. It responds well to the treatment given that soil, and yields of most crops are about the same.

NORMA SERIES

Soils of the Norma series are sometimes associated with and usually adjacent to McKenna soil. In areas of association they occur where gravel and sand thinly mantle a heavy clay till similar to that from which both McKenna and Whatcom soils developed. Where associated with or adjacent to those soils, the Norma occupy flats, depressions, and basins in the morainic or kame and kettle topography, and the clay mantle is usually about 3 to 5 feet deep. Elsewhere in the basin region the sand and gravel mantle is over a less clayey and usually more permeable but cemented type of drift. Seepy areas and poorly drained basins in the interior mountain valleys result from other impediments that restrict or deflect ground water near the surface.

In the lower basin region Norma soils form a complex soil pattern with the imperfectly drained Cagey and Hale soils and are also associated with the better drained Kickerville soils, all of which lie upon similar heavy clay till. As in the associated soils, the clayey or compact till under the Norma soils prevents free percolation of moisture, and water is therefore held in the upper subsoil of porous gravel and sand. Surface drainage is as slow as in the McKenna soil, but internal drainage is more rapid, and open drains facilitate lateral movement of water over the underlying clayey or compact till.

In the more typical locations, Norma soils have a dark grayish-brown or nearly black rather highly organic surface soil over a sandy and gravelly iron-mottled brownish-gray or gray subsoil. The subsoil lies on a substratum of dense steel-gray clay till at a depth of 3 to 5 feet. In other places the substratum may be a less clayey or sandy drift of compact softly cemented character.

Norma soils are wet and cold in spring and require some form of drainage before they can be farmed satisfactorily. Excellent yields are obtained, however, if proper rotation of legumes with other crops is carried out and management and fertilizer practices of maximum benefit to soils of this group are used. Drainage is effected more readily than in the McKenna soil because the subsoil is more porous. Greater ease of drainage often makes the growing season longer and permits wider latitude in choice of crops than on the McKenna and Bellingham soils.

Norma silty clay loam, Norma-Cagey complex, and Norma-Hale complex make up the series.

Norma silty clay loam (NG).—Areas of this soil are associated chiefly with Kickerville and Cagey soils in the lower basin region near the coast and at Point Roberts. Minor bodies are scattered throughout the soils of the higher moraines and interior mountain valleys. Slopes do not exceed 4 percent. Efficient use of farm machinery is facilitated by the smooth relief, but the soil has a high moisture content in winter and spring that delays early plantings, even where drains are installed. Open drains that penetrate the sandy and gravelly strata are used to facilitate surface runoff and to provide outlets for the water moving laterally over the clay substratum. Internal drainage is more rapid than in the McKenna soil, but moisture may not be held as well for late-maturing crops. Because this soil drains more rapidly than the McKenna, it warms up sooner in spring and earlier plantings generally can be made. The better drainage may also permit a wider choice of crops.

Profile description of a virgin area:

2 to 0 inches, dark brownish-gray fibrous granular highly organic root-matted layer; black when wet; medium acid; friable; 1½ to 3 inches thick.

0 to 5 inches, dark brownish-gray granular slightly acid silty clay loam having a high content of organic matter; nearly black when wet; 4 to 6 inches thick.

5 to 18 inches, light brownish-gray silty clay loam having a ½-inch blocky structure; dark brown when wet; 10 to 15 inches thick.

18 to 58 inches, light yellowish-brown slightly acid somewhat compact but open and porous iron-stained gravelly sand; 36 to 48 inches thick.

58 to 78 inches, light olive-gray dense clay till; shows angular fractures and is embedded with gravel, stones, and boulders; varies considerably in thickness; neutral or slightly alkaline; in some areas along the coast contains marine shells.

On the higher moraines the substratum is of more sandy drift, and in the interior valleys it is open and porous. The dark surface soil is of fairly uniform depth in wooded areas but is deeper and more highly organic in basins supporting luxuriant growths of sedges and water-tolerant grasses. In such basins a thin light-gray surface layer, probably diatomaceous earth or material of ground-water origin, is common.

Use and management.—Probably less than one-third of Norma silty clay loam is in second-growth forest, mainly Douglas-fir with scattering cedar and thick stands of deciduous trees and brush. The cleared land is important agriculturally, though usually widely distributed with other soils of better drainage. A wide variety of crops are grown, but the high moisture content and slow drainage are more favorable for hay, pasture, and small grains—the principal crops.

Use of crop rotations that include legumes and application of superphosphate keep this soil at a high level of productivity, but these practices are not so essential as on the associated lighter colored soils of the uplands. Where phosphate is used, it is usually applied only to legumes; the residual effect is considered sufficient for crops following in rotation. Barnyard manure aids in getting legumes started, and other crops make significant responses to it, especially on newly cleared land. Clover usually is fertilized with a 300-pound application of superphosphate the first year and 200 pounds an acre each succeeding year. An 800-pound application of 3–10–7 is made for leafy vegetables and of 4–10–10 for root vegetables.

Red clover or alsike clover mixed with ryegrass or timothy are the most common hay crops; they yield 2 to 3½ tons an acre. Clover alone yields much less. Hayfields generally are pastured after the hay is harvested, especially where a second cutting is not made. Older hayfields are invaded by white clover and native grasses, and lower yields of inferior hay result.

Permanent and woodland pastures have a high carrying capacity, and the grazing season is nearly as long as on McKenna silty clay loam. The better permanent pastures are of alsike and white clovers mixed with alta fescue, Italian and English ryegrasses, orchard grass, and Kentucky bluegrass. If similar mixtures are seeded on stump lands shortly after they have burned over, and, if natural competing vegetation is then kept under control, satisfactory pasture can be obtained. Permanently wet low areas are often seeded to reed canarygrass, which provides good all-year pasture and produces 3 to 5 tons an acre when cut for hay. A mixture of meadow foxtail and big trefoil also has proved satisfactory on wet land.

Small grains, sometimes used as nurse crops for hay seedings, yield about 1½ tons an acre when cut for hay. Oats sown with vetch produce considerably more hay than oats grown alone. Threshed vetch yields 1 ton or more an acre. Oats produce high yields of grain, 60 to 80 bushels an acre being common. Only fairly good yields of barley are obtained, and the soil is considered too cold and wet for wheat. On the better drained sites or on those where drains are employed successfully, vegetables and berries produce well. Potatoes do well on the better drained areas if diseases and insects are controlled. The soil usually is too wet for tree fruits.

The soil is wet and cold in spring and requires some form of artificial drainage before it can be farmed satisfactorily. Because the subsoil is porous, the soil is easier to drain than McKenna silty clay loam. Open ditches usually are sufficient, though the additional use of tile drains would increase water movement materially. As the soil is friable and granular, it can be worked under a wide range of moisture conditions if drainage is effective.

Norma-Cagey complex (Ne).—In this complex are bodies of Norma silty clay loam and Cagey silt loam so intricately associated they cannot be satisfactorily shown separately on a map of the scale used. As it most commonly occurs, the complex is about 60 to 70 percent Norma and 30 to 40 percent Cagey soil, but the proportion varies. This differs from the Cagey-Norma complex, because in that complex Cagey silt loam is dominant.

Most of this complex is widely distributed in the lower basin region. It occurs on areas of relatively smooth ground moraine where many mounds, knobs, and swells interrupt the more continuous nearly level basins or depressions. The basins or depressions are without appreciable relief or developed drainageways, and the Norma soil occupying these places has a high moisture content and remains wet for extended periods. The less extensive areas of Cagey silt loam are on higher ground and better drained. Artificial drainage tends to promote a more uniform moisture condition in the complex.

Use and management.—Probably not more than half of the Norma-Cagey complex is farmed, though a large part is used for woodland pasture. The uncleared land is in mixed second-growth conifers and accompanying dense growths of deciduous trees and brush. Hay yields and the carrying capacity of pastures are greater than on the Cagey-Norma complex, providing good drainage can be effected, but they are not so high as on the typical Norma silty clay loam. Adequate artificial drainage is important, and plantings may be delayed and crops may ripen unevenly if it is insufficient.

Norma-Hale complex (NF).—This complex occupies areas of sand-mantled ground moraine in the lower basin region in association with the Hale soils. It consists of areas of Norma silty clay loam and Hale silt loam, and the proportion of the Norma soil is about 60 to 70 percent. Because the subsoil of Hale silt loam is sandy, the difference in moisture content of the two soils is not so great as that in the Norma-Cagey association.

Use and management.—Perhaps two-thirds of the Norma-Hale complex is cleared. The uncleared part is in second-growth timber and the accompanying thick stands of deciduous trees and brush that flourish after logging. Open ditches promote fairly rapid drainage, as the water moves laterally through the sand covering the clay till. The Norma soil remains more highly saturated than the Hale, however, and uniform moisture conditions are difficult to obtain. Plantings usually are delayed, and grain crops ripen unevenly. The large quantity of moisture retained is conducive to high yields of hay and a long grazing period for pastures. Farmers prefer to use the land for hay and grain, though other crops can be grown successfully on the better drained sites.

PILCHUCK SERIES

Soils of the Pilchuck series, of little agricultural importance, are widely distributed along the Nooksack River and its tributaries near Everson. The elongated bodies lie along the river channel and are closely associated with Riverwash, a miscellaneous land type. They are formed from sandy and gravelly alluvium, and gravel bars are common. They are crossed by many channels that are often shifting, and most areas are flooded periodically. Surface materials are moved and redeposited, and the surface soil is therefore unstable. The soils are usually highly saturated during periods of high water in winter and spring but become droughty as water subsides.

Soils of this series are characterized by light to medium brownish-gray loose sandy surface soil over open porous coarsely stratified sand and gravel, largely from granite and quartzite but also from substantial quantities of darker materials, chiefly argillite. The Pilchuck soils lie adjacent to those of the Puyallup series and are derived from materials of similar origin. In places they are gravelly and stony at the surface.

Pilchuck gravelly loamy sand and Pilchuck fine sandy loam represent this series.

Pilchuck gravelly loamy sand (PA).—The somewhat elongated bodies of this soil are widely scattered in areas adjacent to the Nooksack River and its tributaries near Everson. Slopes do not exceed 3 percent. Because of its low position, the soil is periodically flooded during high water, and the surface soil is unstable and shifting. The soil consists of sandy and gravelly alluvium, and gravel bars are common. It is droughty except in wet seasons.

Profile description:

0 to 14 inches, brownish-gray loose nearly neutral gravelly loamy sand; 8 to 16 inches thick.

14 inches +, brownish-gray or pepper-and-salt colored coarsely stratified sand and gravel.

The soil materials are coarser with depth. The lighter colored particles are largely granite and quartzite; the darker ones, argillite and some basic igneous materials. A few areas having stones and boulders at the surface are shown on the map by stone symbols.

Use and management.—Little of Pilchuck gravelly loamy sand is farmed, because it is periodically flooded, and erosion or deposition of materials frequently accompanies the flooding. Most areas are crossed by active and abandoned channels. A few small bodies on slightly elevated positions away from the river are used for pasture and hay. Hay yields are low and so are the carrying capacities of pastures. Thick growths of willow, alder, cottonwood, and scattering conifers are the common native vegetation. Dense undergrowths of brush and scattering areas of grass also are common, and these provide some browse and grazing.

Pilchuck fine sandy loam (PB).—This soil occurs mainly near Acme. It occupies slightly higher positions than Pilchuck gravelly loamy sand, but slopes do not exceed 3 percent. To a depth of about 8 inches the surface soil is brownish-gray slightly acid moderately friable fine sandy loam. Below this is lighter brownish-gray slightly acid loose or mellow pepper-and-salt colored loamy fine sand containing a few pieces of gravel. At a depth of about 20 inches this overlies loose coarsely stratified sand and gravel, largely of light-colored quartzite and granite. The sand derives its pepper-and-salt color from inclusions of dark argillite and other dark materials.

Use and management.—Probably one-third of Pilchuck fine sandy loam remains uncleared. The mixed vegetation on uncleared areas, similar to that on Pilchuck gravelly loamy sand, provides some pasture and browse. The farmed area is used chiefly for hay and permanent pasture. Hay yields are low, and the grazing period on pastures is short.

PUGET SERIES

Soils of the Puget series are widely distributed in low flats and basins in the back bottoms of the Sumas and Nooksack Rivers and on the delta of the Nooksack River. They are associated with and cover almost the same total area as the Sumas soils. The native forest was mainly cedar and Douglas-fir; a few marshy areas probably had a cover of sedges and coarse water-tolerant grasses. In such marshy places the surface soil is usually more brownish because of organic accumulation. Organic matter and nitrogen are generally deficient in Puget soils.

The soils are characterized by a rusty-iron mottled light yellowish-gray or medium slate-gray surface soil over an upper subsoil of yellow-and-brown mottled light slate-gray laminated and stratified silty clay and clay. The lower subsoil is of medium bluish-gray clays showing much rusty-iron mottling.

Artificial drainage is necessary before these soils can be used successfully for cultivated crops. Open drains are used for the most part, but many areas could be much improved by the use of tile drains, as water moves slowly through the clay subsoil and substratum. In the past, farmers reported difficulty in keeping tile open because deposits from floodwaters had a tendency to impair free flow. Open drainage ditches can be easily reopened and repaired. The more recent installation of more complete dikes and levees along the Nooksack River has materially lessened the danger of overflows.

Puget silty clay loam and Puget silt loam are the soil types of this series.

Puget silty clay loam (PD).—This soil is widely distributed in back-bottom areas along the Sumas and Nooksack Rivers and on the delta of the Nooksack River. Slopes do not exceed 3 percent. Except for Lummi silty clay loam, this is the most poorly drained soil of those occurring in the back-bottom and delta areas.

Profile description:

0 to 8 inches, pale-brown or light brownish-gray granular slightly acid or neutral silty clay loam; shows faint rusty-iron stains; becomes weak brown when wet; 6 to 10 inches thick.

8 to 22 inches, slightly acid to neutral highly iron-stained silty clay loam or silty clay of a color similar to layer above; shows irregular angular fractures; 12 to 15 inches thick.

22 to 75 inches, light-gray or steel-gray very plastic stratified or laminated clay or silty clay; breaks into medium blocky structure; nearly neutral in reaction; rusty-iron mottlings increase with depth.

In low basins where organic remains from sedges and grasses accumulate, the surface soil is darker and more highly organic at the immediate surface.

Use and management.—Puget silty clay loam is highly saturated and often inundated in winter and early spring. It remains permanently wet and waterlogged unless artificially drained. In most areas open drains now furnish slow but adequate drainage for the hay, pasture, and small-grain crops commonly grown. On many areas closer spacing of open drains and the use of tile drains in the more waterlogged places would be of marked benefit.

Nearly all of this soil has been cleared for farming and permanent pasture. One large area about a mile northeast of Acme is still occupied by deciduous forest because it has an especially tight subsoil and presents a particularly difficult drainage problem. In some respects this area resembles Bellingham soil.

The hay crops most commonly grown are mixtures of red and alsike clovers with ryegrass or timothy. Alsike clover is preferred for more poorly drained areas. White clover usually appears in hayfields through natural revegetation. Some farmers harvest one cutting of hay and then pasture the fields the rest of the season. Fields not pastured yield 2½ to 3½ tons or more an acre of hay. Permanently wet areas usually can be seeded to reed canarygrass, which supplies pasture throughout the year and yields 3 to 5 tons of hay an acre. Oats sown as a nurse crop for hay or pasture mixtures yield about 1½ tons an acre as hay. When harvested for grain, oats produce 60 to 85 bushels an acre, and barley, 35 to 45.

Permanent pasture mixtures usually include red, alsike, and white clovers mixed with ryegrasses, but the carrying capacity can be increased by including orchard grass, alta fescue, and Kentucky bluegrass. Pastures provide grazing for a long period but cannot be grazed during the wet winter season.

General farming practices, which include frequent rotation of legumes with other crops, usually keep this soil at a fairly high productive level. Superphosphate, applied to legumes at the rate of about 300 pounds an acre per year, increases hay yields and improves the grazing capacity of pastures.

Puget silt loam (Pc).—Bodies of this soil are almost as widely distributed as those of Puget silty clay loam, but the total acreage is about half as large. Though slopes do not exceed 3 percent, this soil lies slightly higher than the silty clay loam, and it has a sag-and-swell microrelief that promotes more effective drainage.

The surface soil, to a depth of about 8 inches, is yellowish-gray granular slightly acid to neutral heavy silt loam. Below this is yellowish-gray slightly acid to neutral highly iron-stained medium blocky silty clay loam. Below a depth of about 24 inches are interstratified and laminated plastic rusty-iron mottled clay and silty clay, neutral in reaction.

Use and management.—In general, Puget silt loam is more readily drained than Puget silty clay loam, and a somewhat wider range of crops can be grown. The larger part is used for hay, small grains, and pasture, and some is used to produce seed potatoes (pl. 7). Crop yields and carrying capacities of pastures are slightly higher than on Puget silty clay loam but about the same as on Sumas silty clay loam. The soil responds well to cultivation and fertilization like that employed on Sumas and Puget silty clay loams.

PUYALLUP SERIES

Soils of the Puyallup series form an important part of the cultivated acreage in the broad smooth alluvial bottoms along the Nooksack and Sumas Rivers. The Nooksack River—an aggrading stream—has built up broad natural levees and higher bottoms that slope away from the channel. These smooth very gently sloping areas, often marked with sags and swells or gentle undulations, have sufficient natural drainage to permit their use for a wide variety of crops, and they retain a supply of moisture adequate to mature all crops or assure long seasonal grazing on pastures.

The Nooksack River is confined to its course by dikes and levees through the most important agricultural areas, and flooding outside the levees takes place only during exceptional periods of high water. During winter and spring the water table rises, but in most instances only the lower poorly drained spots become waterlogged. Where Puyallup soils have a tendency to become highly saturated, open drains are sufficient to facilitate drainage.

Before they were logged, these soils supported a wide variety of trees, but the deciduous types are now dominant. Conifers are largely Douglas-fir and cedar, but there is a scattering of white fir and spruce. The deciduous trees are the same as on the other bottom-land soils, and there is also a dense undercover of shrubs, ferns, and vines.

Soils of this series have a friable mellow brownish-gray surface soil over a stratified medium brownish-gray sandy upper subsoil. The upper subsoil is slightly compacted and faintly iron-mottled and grades to a lower subsoil of open porous brownish-gray pepper-and-salt colored thickly bedded sand of washed appearance. The sand is of mixed origin; glacial outwash and darker material, probably derived in large part from dark argillites, are included.

In this series are Puyallup fine sandy loam, Puyallup silt loam, Puyallup very fine sandy loam, and Puyallup loamy fine sand.

Puyallup fine sandy loam (Pe).—This soil is widely distributed throughout the valleys of the Nooksack and Sumas Rivers. It occupies more elevated sites on the stream bottoms, including the natural levees. The lay of the land is usually nearly level to very gently sloping (0 to 3 percent), but areas of sags and swells or gentle undulations are common in some places. Surface and internal drainage are usually good. A few lower areas may have only fair drainage, but these can be improved by open drains. Since construction of dikes along the river, the soil is rarely overflowed except in periods of exceptional floods.

Profile description:

0 to 12 inches, light brownish-gray friable fine sandy loam; brownish-gray when moist; slightly acid; 10 to 14 inches thick.

12 to 24 inches, light brownish-gray faintly iron-mottled slightly compacted loamy fine sand; slightly acid; 10 to 14 inches thick.

24 to 70 inches, brown loose fine sand containing dark- and light-colored grains, probably largely argillite, that impart a dark pepper-and-salt appearance; underlying sands are slightly acid or neutral.

Use and management.—Puyallup fine sandy loam is inherently fertile, fairly high in organic matter, and well supplied with moisture. These factors and the friable surface soil make it well suited to a wide variety of crops, including truck crops and berries. Probably 95 percent of the land is cultivated, and much of this is used for hay, small grains, and pasture.

The hay crops are largely mixtures of red clover and ryegrass or timothy, but alsike clover is also used with red clover or as a substitute. A second cutting is made if fields are not pastured, and yields range from 2½ to 4 tons or more an acre. Alfalfa does well on the more elevated areas and yields more than other hay crops. Small grains sown as nurse crops for legumes yield 1½ tons or more an acre when cut for hay, but if they are grown with vetch, up to 4 tons of hay may be obtained. Corn, grown largely for silage, normally produces 11 to 18 tons or more an acre, though 25 tons an acre have been reported.

Pastures have a high carrying capacity, and because moisture is available throughout the summer, provide grazing for a relatively long period. 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. When harvested for grain, oats yield 60 to 80 bushels. Shelled vetch yields 1 to 1½ tons an acre, and dry shelled peas yield about the same.

The land can be plowed and an excellent seedbed prepared under a wide range of moisture conditions because the surface soil is friable. This probably is one of the best drained soils of the stream bottoms. It warms early in spring and is therefore valuable for truck crops and fruits. The principal truck crops grown in commercial quantities are pole beans (pl. 5, *B*), carrots, and beets. Beans yield 7 to 10 tons or more an acre; carrots, 20 to 30 tons; and beets, 12 to 18 tons. Sweet corn also is grown. Potatoes grow too large to sell well commercially. Interest in sugar beets has revived since the introduction of virus-resistant varieties. Sugar beets commonly yield 8 to 15 tons an acre, and some seed has been grown. This is an excellent soil for root crops but for leafy vegetables it is not so productive as the more highly organic soils of the bottoms.

Strawberries and raspberries are grown commercially, and yields range from about 2½ to 4 tons an acre. Of the tree fruits, only sour cherries are grown for market, and these yield about 12 tons an acre. Filberts do well, are grown fairly extensively, and yields of about a ton an acre have been obtained.

For general farm crops the organic and nitrogen fertility can be maintained by regular use of legumes in crop rotations and the addition of superphosphate. Annual applications of superphosphate made to the legumes at the rate of about 300 pounds an acre promote vigorous growth of hay, and the residual effect is usually sufficient for crops following in the rotation. For truck and other special crops, barnyard manure and green crops are plowed under. Some farmers find 10 to 15 tons of manure an acre supplemented by 100 to 300 pounds of superphosphate satisfactory. Others add 3–10–7 or 4–10–4 fertilizer at the rate of 100 to 300 pounds or more an acre. Some farmers report increased yields of root crops when side dressings of muriate of potash are applied at the rate of 150 pounds an acre, but this is not a common practice. A 3–10–10 fertilizer applied at the rate of about 250 to 300 pounds an acre seems satisfactory for strawberries.

Puyallup silt loam (Pg).—This soil covers an area almost as large as Puyallup fine sandy loam and has similar wide distribution throughout the bottoms of the Nooksack and Sumas Rivers. It occurs on more elevated parts of the stream bottoms, usually well back from stream channels where underdrainage is somewhat slower. The areas have slightly smoother relief than the fine sandy loam, but they are occasionally traversed by abandoned stream channels, and sags and swells are common. Both surface and internal drainage are adequate, though nearly level or basin areas may remain wet longer than adjacent ones of more undulating relief. In low areas the subsoil is usually more mottled and the surface soil darker. Open drains speed surface and internal drainage.

The surface soil, about 12 inches thick, is light brownish-gray friable slightly acid silt loam somewhat darker than that of other soils in this series. The upper subsoil is slightly acid loam or fine sandy loam of a color similar or slightly lighter. It shows slight compaction and some iron mottling. Below 20 inches are gray slightly acid to neutral loose stratified sands considerably darkened by grains from argillite and basic rocks, which impart a definite pepper-and-salt color. Slight iron mottling is common, and a faint olive cast is noticeable in most profiles.

This soil is grayer on the delta of the Nooksack River than it is farther inland, where the yellowish-brown or olive cast is more pronounced. Gravel is uncommon, but a few shallow areas near the river have inclusions from underlying gravel bars, and these are shown on the map by gravel symbols.

Use and management.—Nearly all of Puyallup silt loam is farmed. The same crops are grown as on Puyallup fine sandy loam, but proportionately, a larger acreage is used for hay, pasture, and small grains. These crops yield slightly more than they do on the fine sandy loam, but yields from others are about the same. Hay crops yield 2½ to 4½ tons an acre; oats, 60 to 90 bushels; barley, 35 to 50 bushels; and winter wheat, which is not attacked by the weevil, 25 or more bushels. The carrying capacity of pastures is greater, especially in dry years, because this soil has better moisture-holding capacity.

Puyallup very fine sandy loam (PH).—Most of this inextensive soil occurs in elongated narrow bodies on the natural levees along the Sumas River or on higher areas elsewhere in the valley of the Sumas River. The relief (0 to 3 percent) is similar to that of Puyallup fine sandy loam, and drainage conditions are about the same.

The 10-inch surface soil is light brownish-gray slightly yellowish or light olive-brown smooth friable very fine sandy loam. The upper subsoil between depths of 10 and 20 inches is slightly more olive light brownish-gray very fine sandy loam or loamy very fine sand without appreciable compaction. Below this are pale olive-gray stratified pepper-and-salt colored sands rather thickly bedded and loose. The surface soil and upper subsoil are slightly acid, and the sands are slightly acid or neutral.

Use and management.—Puyallup very fine sandy loam is for the most part cleared, and the crops grown are similar to those on Puyallup fine sandy loam. Yields are intermediate between those on Puyallup fine sandy loam and Puyallup silt loam.

Puyallup loamy fine sand (PF).—Narrow elongated bodies of this inextensive soil are widely distributed along the upper course of the Nooksack River. The more typical areas are on natural levees adjacent to the stream channel where surface and internal drainage are good. In these positions, however, the soil is subjected to flooding in times of exceptionally high water and may be injured by erosion or deposition where not protected by dikes.

To a depth of about 10 inches the surface soil is light brownish-gray uniformly fine-textured friable slightly acid loamy fine sand. The upper subsoil between depths of 10 and 36 inches is lighter brownish-gray slightly acid or neutral stratified loamy fine sand with slight iron mottling. Below this are gray or pepper-and-salt colored loosely stratified slightly acid or neutral sands faintly mottled in places.

The texture of the surface soil is somewhat variable, and in about one-fourth of the area it is rather loose open sand. These sandier areas usually occur near the river and may be subject to overflow in times of high water. In a few scattered areas gravel occurs in significant quantities, and these are shown on the soil map by gravel symbols.

Use and management.—Probably a third of Puyallup loamy fine sand is still uncleared, though all of it has been logged. Forested areas have a scattering of second-growth conifers and thick stands of deciduous trees and brush, and they afford some pasture and browse. More than half of the cleared area is in permanent pasture; the rest is largely in hay and general farm crops. Hay crops are the usual mixtures of legumes and grasses from which 1½ to 3 tons an acre are obtained. Small grains used as nurse crops for hay and pasture mixtures yield about 1 ton or more an acre. Grain yields are considerably lower than on the other Puyallup soils. Pasture mixtures are the same as those used on similar lowland areas, but the carrying capacity of pasture is lower and the grazing season shorter than on Puyallup fine sandy loam.

This soil is deficient in organic matter and nitrogen, and frequent use of legumes in crop rotations and the plowing under of crop residues, green cover crops, and barnyard manure are necessary for satisfactory yields. Other management and fertilizer practices are similar to those for the other Puyallup soils.

RIFLE PEAT

Areas of Rifle peat (RA) are widely distributed in depressions and basins throughout the uplands, terraces, and stream valleys. Broad belts several miles long and many square miles in extent occupy wide nearly level abandoned channels of glacial and postglacial streams. Similar belts that occur on the glacial terrace flats and depressions and along the outer margin of the terraces are subject to seeps; surface water has accumulated because the clay underlying all the lower basin region is penetrated with difficulty. Other areas are along the margins of lakes, in old glacial lake basins, in marshy depressions, and in the back bottoms of streams.

This land originally supported cedar, Douglas-fir, some hemlock, and scattering spruce, but the timber has been cut. A second growth is becoming established on unfarmed areas, but dense growths of alder and other deciduous trees, brush, and shrubs have become dominant since the land was logged.

In representative areas the surface layer is very dark-brown medium acid granular decaying peat having incorporated fibrous roots and a woody litter on the surface. Replacing the surface layer at a depth of about 4 inches and continuing downward to approximately 40 inches is dark reddish-brown more strongly acid granular woody peat bound together by woody fibrous material, twigs, and woody fragments. Between depths of 40 and 60 inches is dark-brown medium acid somewhat more colloidal peat. This is more highly decomposed than the layer above but is still bedded with woody fragments, twigs, and a few matted flattened stems of sedge. This layer continues to extremely variable depths and grades into a layer in which the flattened remains of well-preserved stems are embedded. This layer continues to extremely variable depths and grades into the highly colloidal materials, largely sedimentary peat, that overlie the mineral substratum.

The above profile description gives the usual succession of layers, but considerable variation occurs in the total depth of the soil and in the thickness of the various layers. This variation occurs in some of the individual areas and nearly always between different areas. Areas having at least a foot of woody peat over other peaty materials from sedges, tules, or similar plants are included with Rifle peat because they are managed similarly when cultivated.

Use and management.—Virgin areas of Rifle peat are highly saturated and swampy, and artificial drainage is necessary before the land can be utilized satisfactorily for cultivated crops or pasture. The water table must be lowered, yet retained at a depth of several feet where it will provide the peat with sufficient moisture for plant growth. The peat sometimes sinks several feet when drained. Most of the land is drained by open ditches, and intercepting ditches are usually necessary along the outer margins to make drainage uniform.

Probably 80 percent or more of this important agricultural soil is cleared for cultivated crops and pasture. The rest, now in second-growth timber, is gradually being cleared and placed under cultivation or in permanent pasture. The wooded and stump-land areas, which occur largely in the more remote upland depressions and other places where proper drainage is difficult to establish, provide some pasture and browse.

Hay, pasture, and oats occupy the largest acreage. The hay crops most frequently grown are usually mixtures of alsike clover or red clover with timothy, and the yield is about 2½ to 3½ tons an acre. Oats yield 2 to 3 tons an acre when cut for hay and 80 to 100 bushels or more when harvested for grain.

A few areas are used for truck and garden crops, and, of these, the leafy vegetables are highest yielding. Peas, lettuce, cabbage, cauliflower, and spinach are the main truck crops. Peas yield about 1½ to 2½ tons when shelled green for frozen pack. The other truck crops produce about 300 to 400 crates an acre.

This land improves with tillage, as the surface peat becomes more finely divided and compacted. The improved consistency allows for better seedbeds and greater ease of cultivation. The soil is most deficient in phosphorus and potash, which are usually applied in some form for most satisfactory yields. Truck farmers apply manure supplemented with fertilizers high in phosphorus and potash. The fertilizer combination used is about equivalent to a 3–7–10 or 4–10–10 mixture. Lime is not always necessary but is beneficial on the more acid areas.

RIFLE PEAT, SHALLOW

Rifle peat, shallow (Rb), consists of areas where the peaty material is less than 2 feet thick. It has the same wide distribution as the normal soil, but its acreage is much smaller. The succession of layers is also the same, but the lower sedge and sedimentary layers are thin. In some of the shallower places the entire peaty part of the soil is woody peat. These shallower areas usually occur at the outer margins of peat bogs, in shallow depressions, in seep areas, and in small stream bottoms relatively free from overflow but continuously saturated. The native vegetation is similar to that on Rifle peat.

Use and management.—About 80 percent of Rifle peat, shallow, is cleared and drained for cultivation, and crop yields are much like those on the normal soil. Deep-rooted crops probably reach the mineral soil.

RIFLE PEAT-BELLINGHAM COMPLEX

Rifle peat-Bellingham complex (Rc) occurs in a few small areas west of Willey Lake where Rifle peat is broken by many islandlike bodies of Bellingham silty clay loam that cannot be delineated satisfactorily on a map of the scale used. The total acreage is small. Areas are farmed in association with Rifle peat, but yields are slightly lower.

Certified seed potatoes on Puget silt loam.

Experimental grass plots at Soil Conservation Service nurseries near Bellingham on morainic topography characteristic of Whatcom silt loam soils.

RIVERWASH

Riverwash (RD) consists chiefly of washed sand, gravel, and stones occurring in abandoned river channels or in somewhat barren overflowed areas adjacent to active streams. In places this land type supports a sparse vegetation of trees, brush, shrubs, and grasses that provides some grazing and browse, but otherwise it has no agricultural value. Nearly all of the Riverwash occurs as narrow elongated bodies along the Nooksack River.

ROUGH MOUNTAINOUS LAND

Rough mountainous land (RE) occupies a great expanse of foothills and bordering mountain spurs in the eastern part of the area surveyed and on Lummi Island. Its total acreage is more than 40 percent of the surveyed area. The slope range is 30 to 45 percent. The steep relief promotes rapid runoff and drainage, but the dense forest cover protects most slopes from accelerated erosion.

There is considerable variation in topography. Somewhat smooth glacial-debris mantled hills and low mountain spurs descend to altitudes of about 500 feet or less, and more rugged mountainous areas attain an altitude of 5,000 feet or more. Adjoining areas of steep canyon walls or steep areas along streams are usually included. Extensive tracts, especially those at higher elevations, are rough and broken or stony and outcropped by bedrock. These higher areas may have been modified by alpine glaciation, but the glacial mantles are thin and obscure. In the widely scattered areas of smoother relief a great variety of soils occur.

The mountainous areas of this land type are traversed by many low passes and stream valleys that may have been occupied by lakes of the continental glacier. Along the lower smoother borders of the mountainous areas considerable glacial debris mantles the bedrock slopes, but as elevation increases the mantling is thinner, and above several thousand feet it is absent in most places.

Sedimentary bedrock materials of Tertiary to Paleozoic age—as sandstone, shale, argillite, schist, and occasionally limestone—are dominant in this mountainous area, but in the eastern part there are places where basic volcanic extrusives and even more basic intrusives of a probably similar age are prominent.

For a width of about two townships east of a southwest-northeast line between Bellingham and Sumas, the bedrock materials are mainly sandstone and shale, but included in the more northern part of this belt there are areas in the vicinity of Sumas and Black Mountains where there is considerable argillite and basic volcanic rock (*2*).

On the scattered areas of smoother relief, soils derived principally from the sandstone and shale bedrock develop into members of the Cathcart soils series, but because of their small extent they are not differentiated on the map. Similarly, Cathcartlike or Heislerlike soils develop from the Paleozoic to Mesozoic argillites (*2*) and sericitic and graphitic schist materials occurring east of the sandstone and shale. All the soils in the steep mountainous areas making up this land type are variable and thinly developed, and in many places soil is entirely lacking. The soils often have a varied origin and a considerable color and textural range within short distances, and complex

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associations of the various soils frequently occur. Gravel, stones, and boulders are prominent. Small narrow areas of darker soils are common along minor streams.

Use and management.—The greater part of Rough mountainous land is best suited to forestry. Rainfall probably exceeds 60 inches, and in the cool environment, this abundant moisture promotes growth of valuable timber trees, largely Douglas-fir, hemlock, and cedar. Probably less than a third of this valuable timber remains uncut. The logged part is restocking to trees similar to the original growth, but revegetation is slow on the more carelessly logged areas or where burns have been severe. There is urgent need for systematic reforestation of the valuable timber lands and for the careful logging that will permit sustained yields and insure a profitable income. The scattered smoother areas might be farmed, though most of them are inaccessible.

ROUGH STONY LAND

Rough stony land (Rf) occupies a small total acreage of widely scattered bodies in the lower basin region and the interior mountain valleys. These bodies are low lying, isolated, and of broken relief. Bedrock, thinly clad or almost barren of vegetation, makes up a considerable part of the land surface. This shale, sandstone, or sandstone conglomerate bedrock has weathered to only shallow depths, and only thin soils or soil materials have formed. Rough stony land has been glacially scoured, and considerable glacial debris mantles the surface. The soils or soil material are deeper in areas where the glacial debris occurs. Along the Nooksack River south of Kendall boulders litter the surface.

Use and management.—The thin soil layer and steep irregular relief of Rough stony land make it unfavorable for agriculture. None of it is cleared for farming, but woodland pastures do provide some grazing and browse. The land is valuable for timber, but it has been logged, and little reforestation has been attempted.

SALAL SERIES

The Salal series is represented by Salal silt loam. In its virgin state this dark soil supported a prairie vegetation of grasses and ferns.

Salal silt loam (Sa).—Only one small body of this soil, which is adjacent to Bertrand Creek, is mapped. It is associated with Giles soils, has formed from similar glacial outwash, has similar relief and drainage, and occupies a like terrace position.

Profile description:

0 to 10 inches, very dark-brown or nearly black medium acid silt loam; light in weight; floury or sootlike; 10 to 14 inches thick.

10 to 20 inches, light yellowish-brown granular slightly heavy silt loam; becomes weak brown or brighter brown when wet; 10 to 14 inches thick.

20 to 36 inches, light yellowish-brown or somewhat olive-colored stratified or laminated layers of silty clay loam, silt loam, or very fine sandy loam; slightly acid.

The above layers abruptly overlie olive-gray or pepper-and-salt colored slightly acid sands in which there are bands of rusty brown and yellow.

Use and management.—All of Salal silt loam is cultivated, and the crops grown and yields obtained are much like those on gently undulating Giles silt loam.

SAXON SERIES

Soils of the Saxon series typically have moderately brown or somewhat yellowish-brown surface soil, but in the better drained areas of more pronounced relief this layer is slightly reddish brown. The subsoil consists of iron-mottled, or iron-stained, laminated or interstratified yellowish or olive-gray and gray heavy clay, silt, and some fine sand. The substratum is similar but bluish gray. Virgin areas are covered by a dark-brown organic mat. Many iron shot pellets are in the surface soil and, to a lesser extent, in the upper subsoil.

In the series are the rolling and moderately steep phases of Saxon silt loam.

Saxon silt loam, rolling (Sc).—Most of this soil occurs in small scattered bodies along or near the coast. Though the total area is small, this is an important agricultural soil, and nearly all of it is farmed. The wooded part is in second-growth Douglas-fir and cedar, strongly pressed for space by thick growths of less valuable deciduous trees and brush. Dense undergrowths are common, and cascara, wild cherry, and grasses are evident in wetter areas.

The relief is strongly rolling or ridgelike with slopes of 3 to 8 percent. The soil is not excessively shallow, but under careless cultivation it may become shallower through erosion. In the virgin state the soil is well stabilized against erosion, even on the steeper slopes, by a thick vegetative cover and organic mat. Surface drainage is sufficient, but internal drainage is moderate to slow. The soil warms slowly in spring. The moisture-retaining properties exceed those of most of the better drained soils of the uplands and terraces, therefore moisture is held well during the summer dry period.

Representative profile:

½ to 0 inch, dark-brown medium to strongly acid organic mat; in logged areas organic mat may be considerably less acid; 0 to 1½ inches thick.

0 to 16 inches, moderate-brown or yellowish-brown friable slightly acid silt loam; contains a large quantity of shot; somewhat reddish brown when wet; 12 to 18 inches thick.

16 to 30 inches, light yellowish-brown iron-stained medium acid silty clay loam of fragmental character; contains some shot; 12 to 20 inches thick.

30 to 45 inches, light yellowish-gray medium acid silty clay loam of irregular fragmental or fine blocky structure; silt and fine sand seams or laminations common; 15 to 20 inches thick.

45 to 60 inches, light yellowish-gray or blue-gray neutral to mildly alkaline laminated and highly fractured clays and silts with iron-stained seams; depth varies, the range being 10 to 40 inches.

60 inches +, more massive dense thickly bedded deposits, but in color similar to layer above; contains marine shells in places.

On the crests of slopes the silty surface soil is more deeply oxidized, thicker, and a richer brown; in others, it may be of a more variable duller or grayish color than the usual brown.

Use and management.—All of Saxon silt loam, rolling, has been logged, and only a small part remains uncleared. Use of legumes in crop rotations is necessary to bring the land up to a good productive level. Fortunately, the farmed areas respond well to rotations that include legumes, and use of these tends to alleviate the deficiencies in organic matter and nitrogen. Applications of manure and superphosphate significantly increase productivity and seem essential to sustained high yields.

All crops and fruits of the area are grown, but hay, pasture, and small grains occupy the largest acreage. Hay crops are usually mixtures of clover and ryegrass or timothy and yield 2½ to 4 tons an acre. Yields of clover alone are smaller. Small grains used as nurse crops for legumes yield about 1½ tons an acre as hay. Vetch grown with oats or other small grains yield 2 to 2½ tons of hay an acre. When cut for grain, oats yield about 50 to 80 bushels an acre; barley, 40 to 55; and wheat, 25 to 40.

Because of the excellent moisture-retaining properties of the soil, permanent pastures have a high carrying capacity that extends well into the summer. Best for pasture mixtures are alta fescue, English and Italian ryegrasses, tall meadow oatgrass, orchard grass, Kentucky bluegrass, and common white, red, and alsike clovers. Partly cleared woodlands or stump lands can be successfully seeded to pasture shortly after they have burned over. Mixtures containing ryegrasses, orchard grass, and white clover should be seeded, and if competing natural vegetation is then kept under control, the pasture will maintain itself well.

Saxon silt loam, moderately steep (Sb).—Except for steeper relief of 15 to 30 percent and resultant differences in surface runoff and workability, this soil resembles rolling Saxon silt loam in all characteristics. It occupies steep slopes, largely along drainageways and terrace fronts, in close association with the rolling phase. A few areas having greater than 30-percent slopes are included.

This soil has a typical erosional relief, and if it were not for the dense vegetation, accelerated erosion would be active. Though the surface layer is shallower and more variable than in the rolling phase, probably because of past erosion, the soil is stabilized on all but the steeper slopes where natural vegetation is thin or where the land has been cleared for cultivation or pasture.

Use and management.—Probably about one-third of Saxon silt loam, moderately steep, has been cleared even though the soil is shallow and the slopes are unfavorable to the use of most farm machinery. The cleared land is usually adjacent to areas of Saxon silt loam, rolling, which has more favorable relief, and it is used for the same crops or pasture. Crop yields are lower than on that soil, but the carrying capacity of pasture is nearly the same. Crops providing good cover or pasture should be grown because the soil is readily injured by erosion. Most of the land is better suited to forest, and the stands of second-growth timber on uncleared areas should be improved and protected to assure a future crop of good timber.

SCHNORBUSH SERIES

Soils of the Schnorbush series are confined to the valley of the South Fork Nooksack River, where they extend from Van Zandt to Acme. They are derived from arkose sandstone drift materials that border steep mountainsides. Talus rubble and former alpine glaciers may have contributed considerably to this stony unassorted drift of till character.

Most areas have a strongly rolling morainic or knobby pitted relief, but some are hilly. For the most part huge sandstone boulders litter the surface and make cultivation impossible. Surface drainage is rapid except in kettle holes and basins where dark poorly drained soils develop. The soils in the holes and basins are of such mixed association that they must be mapped as a complex. Scattered smooth areas without boulders, largely erosional remnants along the steep valley sides, are farmed and produce good crops. Schnorbush soils retain moisture well for crops and trees, but they are deficient in nitrogen and organic matter. The virgin forest was mainly Douglas-fir and cedar with some spruce.

The virgin soils are covered by a dark-brown acid partly decomposed organic mat that gives way abruptly to the mineral soil. The surface soil is moderate brown to orange brown and gritty because of its content of angular grains. The subsoil is yellowish gray to grayish yellow and mottled with rusty iron. It is plastic but contains considerable sand or other angular gritty material. Clayey and sandy layers or lenses and pockets are common in Schnorbush soils, and sandstone fragments are scattered throughout their profile.

Included in the series are rolling and hilly phases of Schnorbush loam and Schnorbush-Norma complex.

Schnorbush loam, rolling (Se).—Most of this soil occurs northeast of Van Zandt, where the relief is strongly rolling, morainic, or knobby and pitted with kettle holes. The slope range is 6 to 15 percent. On probably more than 80 percent of the soil huge boulders are scattered on the surface and throughout the profile. These boulder-strewn tracts are not suited to agriculture, but on scattered smoother areas of moderate slope agriculture is practicable. The soil retains moisture well.

Profile description:

1½ to 0 inches, thin dark-brown granular partly decomposed rather strongly acid organic mat.

0 to 8 inches, brown or orange-brown medium acid gritty loam with scattering shot pellets; varies somewhat in color according to the irregular microrelief, being grayer where it adjoins dark poorly drained soils of the basins; 6 to 8 inches thick.

8 to 16 inches, light yellowish-brown granular heavy gritty loam or clay loam; contains some shot and fragments of decomposing sandstone; medium acid; 8 to 10 inches thick.

16 to 30 inches, material similar to that of overlying layer but stained with rusty-iron mottlings and contains scattering fragments of sandstone; 12 to 16 inches thick.

30 to 60 inches, light yellowish-brown or slightly olive clay, clay loam, or sandy loam; shows variegated rusty-iron staining and occurs in irregular pockets or lenses; subangular arkose sandstone gravel, stone, and boulders are embedded throughout; 24 to 36 inches thick.

60 inches +, sands containing a large quantity of sandstone rubble; color similar to that of layer above or a pepper-and-salt color.

Use and management.—All of Schnorbush loam, rolling, has been logged, but less than a fifth has been cleared for farms or pasture. The virgin timber, largely Douglas-fir and cedar, grew to large size. The land is restocking to similar forest, but deciduous trees grew unrestrained after logging and now form a thick cover that may retard growth of the more valuable timber.

Regular use of legumes in crop rotations and applications of barnyard manure are necessary for satisfactory crop production because the soil is low in organic matter and nitrogen. Increased yields, especially of legumes, are obtained when superphosphate is applied.

The principal crops are hay, pasture, and small grains, though most farmers grow vegetables, fruits, and such crops for home use. Red clover usually is grown with ryegrass or timothy mixtures because yields are much heavier than from clover alone. Under good management 2 to 3 tons an acre are obtained from such hay mixtures. Small grains sown with vetch produce considerably more. Oats cut for grain yield about 35 to 55 bushels an acre; barley, 25 to 40; and wheat, 15 to 30.

Permanent pastures have a good carrying capacity in spring and early summer, as the soil retains moisture well. Woodlands and stump lands can be successfully seeded to pasture after they have burned over. The best pasture mixtures include white clover, alta fescue, ryegrasses, and orchard grass.

Schnorbush loam, hilly (SD).—This inextensive soil differs from Schnorbush loam, rolling, principally in its steeper slope (15 to 30 percent). It occurs along the outer border of the drift plain occupied by the rolling soil and is marginal to the steep mountainsides that bound the valley.

Use and management.—Schnorbush loam, hilly, is too steep for cultivated crops but good for forest. The virgin timber has been cut, but a second growth of similar species is now established in denser growths of deciduous trees and brush. The thick cover checks runoff, and accelerated erosion has not developed.

Schnorbush-Norma complex (SF).—The more stony irregularly knobby and pitted area north of Van Zandt is occupied by this complex. The many kettle holes and basins contain small dark poorly drained bodies of Norma silty clay loam in such intricate association with the better drained Schnorbush loam that the two cannot be separated on a map of the scale used. On its outer margin this complex merges with recent alluvial soils of the stream bottoms, and some of the basins contain alluvial deposits laid down by high floodwaters. There also is evidence of scouring. In places waters have moved finer materials, exposed huge boulders, and left a relatively larger quantity of stone and boulders.

Use and management.—The Schnorbush-Norma complex is difficult or impossible to farm because of varied drainage conditions, intricate association of the two member soils, and high content of stones and boulders. Both soils of the complex are good for forest, however, and they produce a diversified cover of conifers and deciduous trees.

SEMIAHMOO MUCK

Semiahmoo muck (SG) is widely scattered in the low wet depressions of the stream valleys and uplands or adjacent to small lakes and ponds. The soil developed in marshes, is flooded at least part of the year, and under natural conditions has a high water table all year. The native vegetation of sedges, tules, marsh grasses, and other water-loving plants was similar to that on Mukilteo peat.

The surface soil to a depth of about 12 inches is very dark-brown medium to strongly acid granular but greasy sedge muck containing a small quantity of mineral soil. In this layer are many fibrous roots from the present sedge vegetation. Between depths of about 12 to 36 inches is dark reddish-brown greasy strongly acid colloidal muck containing more silty mineral material than the above layer. Next occurs a medium acid dark grayish-brown somewhat bluish sedge muck in which flattened brown sedge fibers and roots are embedded. Bluish-gray colloidal mucky material mixed with considerable mineral soil lies over the substratum, which occurs at extremely variable depths.

This muck varies considerably in proportionate content of mineral and organic materials. At one extreme are highly decomposed colloidal peaty sedge materials low in mineral content, and at the other are more mucky materials in which there is considerable silty mineral. The color ranges from dark reddish brown to grayish black. The surface soil lacks the plasticity and consistency of highly organic mineral soils, and thin layers of white or yellowish-gray diatomaceous deposits are common at the surface.

Use and management.—Artificial drainage is necessary before Semiahmoo muck can be used for farm crops or pasture. Probably half of it is drained and used for hay, small grains, and permanent pasture. The farmed area is managed in the same manner as Carbondale muck, but crop yields are usually somewhat lower.

SEMIAHMOO MUCK, SHALLOW

Semiahmoo muck, shallow (Sh), covers a small total acreage, but the small areas are widely scattered in small depressions or adjacent to deeper areas of Semiahmoo muck. This shallow soil is about 8 to 24 inches deep to the mineral substratum. Usually a higher proportion of silty mineral material is incorporated with the organic matter than there is in the normal soil. The drainage and vegetative cover of both soils are similar.

Use and management.—About half of Semiahmoo muck, shallow, is drained for farming, and the crops grown are similar to those grown on Semiahmoo muck. Yields are about the same when similar management practices are used. Forage on this soil may have a higher mineral content than that growing on the more highly organic soils.

SKAGIT SERIES

The Skagit series is represented in this area by Skagit silty clay loam. The soil occurs on stream bottoms and alluvial fans in the foothill and mountainous areas where there is shaly alluvium. It occupies low poorly drained areas and is associated in many places with the better drained Wickersham soil, which is formed from similar alluvium. It is highly saturated in the virgin state, and the water table is high all the year. With installation of open drains, water moves off more freely, but many areas remain waterlogged and are suitable for pasture only.

Skagit silty clay loam (Sk).—This soil is widely distributed on the stream bottoms and alluvial fans in the eastern mountainous region. Most areas are very gently sloping (0 to 3 percent) but usually have a microrelief of sags and swells. In the slower drained lower depressions the surface soil is peaty or mucky in the upper part. Near Wickersham the soil material is largely from graphitic schist, and the soil is greasy and shiny with flaky schistose fragments.

Profile description:

0 to 12 inches, gray or dark-gray highly organic granular but greasy-feeling medium acid silty clay loam in which shiny flakes or fragments of schist and shale are prominent; 10 to 14 inches thick.

12 to 24 inches, bluish-gray or silver-gray iron-stained silty clay high in content of shale and schist fragments; medium acid; 10 to 14 inches thick.

24 to 36 inches, material similar to that in layer above but higher in content of shale; 10 to 14 inches thick.

36 inches +, light brownish-gray porous stratified layers of platy or flaky subangular shale, schist, and argillite.

Use and management.—More than half of Skagit silty clay loam is cleared, and much of the cleared area is used for hay and pasture. Wooded areas support the second-growth timber and other vegetation typical of other soils of the lowlands. The wooded areas provide some pasture and browse. The soil is managed in the same manner as Clipper silty clay loam, and yields are similar. Artificial drainage is necessary for successful cropping, and in most areas this can be accomplished satisfactorily by using open drains.

SMITH CREEK SERIES

Soils of the Smith Creek series are of low agricultural value. They are developed on low-lying smooth gently sloping postglacial gravelly stream terraces and on steeper areas along terrace fronts and drainageways. They are somewhat droughty and of low moisture-holding capacity, except where clay and silt lenses occur in the substratum. They are good soils for forest and, under virgin conditions, supported good stands of conifers, largely Douglas-fir.

These soils have strong yellowish-brown or moderate yellowish-brown gravelly surface soil over light yellowish-brown porous gravelly upper subsoil. The upper subsoil grades to a more open grayish-brown gravelly or stony lower subsoil and substratum. Gravel in the upper subsoil shows a slight coating from infiltrated clay; considerable iron staining occurs in the lower subsoil. Interbedding layers of dense clay and silt are common in the substratum on the delta terrace near Bellingham.

The gently sloping and steep phases of Smith Creek gravelly loam are represented.

Smith Creek gravelly loam, gently sloping (Sl).—Large continuous bodies of this soil occur on the terraces of Squalicum Creek near Bellingham and along the Nooksack River near Lawrence and Goshen. These smooth gently sloping (3- to 6-percent slopes) stream terraces consist of outwash deposits resembling those from the Vashon glacier. They contain much light-colored quartzite, granite, and related rock. Considerable dark argillite and minor quantities of basalt, andesite, and rhyolite are present.

Surface drainage is sufficient because internal drainage is rapid or excessive. Moisture is not held effectively, and only quick-growing crops mature before lack of moisture becomes critical during the summer. In Bellingham and vicinity, irrigation is resorted to for gardens and other plantings. The clay and silt beddings in the substratum of the areas near Bellingham aid in moisture retention when they lie relatively near the surface.

Profile description in a virgin area:

1½ to 0 inches, nearly black medium acid partly decomposed organic mat; 0 to 2 inches thick.

0 to 12 inches, strong yellowish-brown or moderate yellowish-brown medium acid gravelly loam; 10 to 12 inches thick.

12 to 24 inches, light yellowish-brown slightly acid gravelly sand; infiltrated clay coats the gravel and holds the sand in fragile clusters; 8 to 20 inches thick.

24 inches +, light yellowish-brown or pepper-and-salt colored slightly acid loose open porous sand and gravel.

The thickly stratified deposits become increasingly lighter colored, porous, and stony with depth. Interstratified beds of clay and silt are common in terrace deposits near Bellingham.

Use and management.—About half of Smith Creek gravelly loam, gently sloping, is cleared for home sites, farming, and pasture. Uncleared areas are in second-growth timber. A considerable part of the stand is Douglas-fir, though alder, bigleaf maple, vine maple, bracken, snowberry, rosebush, blackberry, and other deciduous trees and brush are well established. The main crops are hay, small grains, and pasture, though a considerable acreage in the vicinity of Bellingham is used for gardens and fruits. There the droughtiness of the soil is overcome by sprinkling during the dry summer. Elsewhere, crops are injured by lack of moisture in dry years. Crop yields are usually lower than on the Kickerville soils that occur in the same general rainfall belt.

Smith Creek gravelly loam, steep (Sm).—The narrow elongated bodies of this soil occur largely in steep areas along terrace fronts and incised drainageways. Slopes range from 15 to 30 percent. The soil is too steep for agriculture but supports good forest. It differs from gently sloping Smith Creek gravelly loam mainly in relief and workability. All of the land has been logged, and a second growth of trees is becoming established.

SNOHOMISH SERIES

Soils of the Snohomish series consist of peats silted by mineral deposits. In this area they are represented by Snohomish silty clay loam.

Snohomish silty clay loam (Sn).—Most of this soil occurs in a few small areas in back-bottom positions along the Nooksack River near Lynden. It consists of woody peat covered by an overflow deposit of silty clay loam sediment that resembles a Puget surface soil. The deposit is a few inches to about 20 inches deep. In other counties the surface layer of Snohomish soils is darker and more highly organic.

Use and management.—Most of Snohomish silty clay loam is cleared and used for hay, pasture, and small grains. Yields are about the same as or slightly lower than those on Carbondale muck.

SQUALICUM SERIES

Soils of the Squalicum series occupy high drift plains of strongly morainic relief. They skirt the lower basin region occupied by the Whatcom soils and extend into the interior foothills and mountain valleys. The drift on which the soils developed is shallow over a glacially scoured bedrock of consolidated Eocene shale and sandstone. Occasionally the bedrock crops out. The glacial drift deposits were probably laid in the early Vashon period when the continental glacier was at a higher elevation than it was in the later part of that period. The drift materials are noticeably modified by the underlying shale and sandstone.

Squalicum soils are characterized by a light yellowish-brown smooth mellow silty surface soil over an upper subsoil marked by iron-stained thin, horizontal, cemented laminar plates. These layers overlie a softly cemented till, which is more compact and sandy than that under the Whatcom soils but more clayey and not so compact as that under typical Alderwood soils. The till is bedded with gravel, stone, and boulders in a manner somewhat like that of the Alderwood and Whatcom. Boulders are common and conspicuous in the more strongly morainic areas.

Soils of this series are widely distributed in the foothill and mountain valley areas. About half the total area has slopes of 6 to 15 percent, and the rest has hilly or steep relief. Surface drainage is rapid, but internal drainage is somewhat retarded. The soils were heavily forested.

The soils of this series are the rolling and hilly phases of Squalicum silt loam, Squalicum stony silt loam, and Squalicum and Alderwood silt loams; Squalicum silt loam, steep; and Squalicum and Alderwood stony silt loams, hilly.

Squalicum silt loam, rolling (ST).—This is one of the more extensive soils in the higher upland region adjacent to the foothills and in the mountain valleys. Much of it occurs on high moraines somewhat remotely located. Owing to irregular morainic relief (6- to 15-percent slopes), the soil has rapid surface drainage. Internal moisture movement is only moderate, however, because the underlying compact softly cemented clay till retards free percolation. The drainage relief and drainage channels are usually more completely developed than on Whatcom soils, and the soil associations are not so complex. There is a tendency toward waterlogging above the clay till in winter and spring. The moisture-holding capacity is high, and trees grow to large size. Moisture is retained well for crop growth in the few areas farmed.

Representative profile:

2 to 0 inches, dark-brown strongly acid decomposing organic mat; ½ to 3 inches thick.

0 to 10 inches, moderate yellowish-brown friable floury silt loam; contains many shotlike pellets ranging from a pinhead to a pea in size; strongly acid; 10 to 12 inches thick.

10 to 22 inches, yellowish-brown friable silty clay loam or silt loam; contains a few shot; medium acid; 10 to 20 inches thick.

22 to 28 inches, light yellowish-brown strongly acid loam or sandy loam mottled with gray and yellow and matted with roots; 4 to 15 inches thick.

28 to 38 inches, pale-yellow compact or softly cemented clay loam or loam with laminar horizontal bands of light brownish gray and rusty yellow; roots are matted above this layer but some penetrate through fractures; embedded gravel is prominent; 8 to 40 inches thick.

38 to 78 inches +, pale-yellow compact softly cemented light sandy clay till embedded with gravel, stone, and boulders; this layer forms the lower subsoil and substratum.

The upper part of the profile is somewhat modified by development of yellowish brown, but the lower part has the bluish gray of the original till. Stone and boulders usually become more prominent with depth but may end abruptly on bedrock of sandstone or shale. The soil is variable from place to place in color and character of subsoil and underlying till. Areas overlying shale usually are more clayey and less deeply oxidized than those over sandstone. In general, areas bordering the foothill region are more stony and gravelly than are those in the higher interior.

In the high interior mountain valleys the softly cemented till is somewhat deeper and the soil material is a little more yellow. Here the characteristic relief is strongly morainic, though smoother areas are not uncommon. Surface drainage is rapid, but internal drainage is retarded by the compact till.

An area of this soil covering about 2 square miles on a high morainic terrace adjacent to and south of Lake Whatcom has strongly rolling relief with slopes generally less than 15 percent. In that location the phase is extremely variable and in places includes soils derived from residual materials. Sandstone and shale and, in places, considerable rubble may mantle the older compact till. In most parts of this area, however, less gravel and stone are embedded in the till than is usual in Squalicum soils. Only scattered smoother bodies in this variable tract are farmed, and the results are about the same as on other areas of this soil.

Use and management.—Scattered small areas of Squalicum silt loam, rolling, are farmed, but the total area cultivated is a small part of the entire acreage. A considerable acreage in and near Bellingham is used for home sites. Farmed areas are used largely for hay, pasture, home gardens, and fruit. The yields obtained are less than those on Whatcom silt loam soils but larger than on the associated Alderwood silt loam. This soil responds well to the same rotations and cultural practices as those used on the Whatcom soils.

Because the soil is extremely variable in relief and in large part remotely located, it will likely continue to be used primarily for timber production. It is good soil for forest, but most of the merchantable timber has been removed. Most cut-over areas are restocking to good timber trees, but stands could be materially improved by artificial seeding and planting.

Squalicum silt loam, hilly (Ss).—Steep elongated bodies of this soil are widely distributed along drainageways and in areas of strongly rolling to hilly relief (15- to 30-percent slopes). It occurs in association with Squalicum silt loam, rolling, and except for stronger relief, resembles it.

Use and management.—Squalicum silt loam, hilly, is generally unsuited to farming but is good for forest. None of it is now farmed. The areas are difficult to work with farm machinery, and under cultivation, most of them would probably yield readily to accelerated erosion. All of the merchantable timber has been removed, and a second growth of Douglas-fir, cedar, and some hemlock is becoming established. Less valuable deciduous trees and underbrush have a strong foothold, however, and systematic seeding and replanting would be valuable aids in restocking to more valuable timber species.

Under the dense cover that now prevails there is little accelerated erosion, even though runoff is more rapid than on rolling Squalicum silt loam. Usually, the surface soil is thinner than that of the rolling soil, but owing to the good moisture-retaining properties of the subsoil and substratum, there is a plentiful supply of moisture for luxuriant tree growth.

Squalicum silt loam, steep (Su).—This inextensive soil occupies long narrow bodies on steep escarpments and other steep areas of irregular relief where slopes exceed 30 percent. It differs from other phases of Squalicum silt loam mainly in its steeper relief and in resultant characteristics.

Use and management.—Squalicum silt loam, steep, produces good timber but is unsuitable for other uses. All the good timber has been removed, but a fair stand of second-growth conifers is becoming established. Deciduous trees and dense undercover hold erosion to a minimum, and only in scattered areas on nearly vertical banks is accelerated erosion appreciable.

Squalicum stony silt loam, rolling (Sw).—Except for the scattering of stone and huge boulders on the surface, this soil is not essentially different from Squalicum silt loam, rolling. In general, its relief is somewhat more irregular, and slopes average a little steeper in most areas. Nearly all of this soil occurs in the high uplands surrounding Squalicum Mountain.

Use and management.—Some of the areas of Squalicum stony silt loam, rolling, having more favorable relief and greater freedom from boulders have been cleared for farming, and crop yields are slightly less than on Squalicum silt loam, rolling, which is without stones. Boulders that cannot be removed are scattered over the surface, however, and in places tillage is difficult. When cleared, most areas are more satisfactory for pasture than for other crops, and for the most part, the soil is better for timber than for cultivated crops. A second-growth of timber—Douglas-fir, cedar, and some hemlock—now covers this cut-over land. The stand probably could be improved by artificial seeding and planting, which would insure a good future revenue from the land.

Squalicum stony silt loam, hilly (Sv).—Steep areas of this soil are along drainageways or on steep slopes adjacent to Squalicum Mountain. The 15- to 30-percent slopes and the scattering stone and boulders make the land unsuitable for anything but timber production. As on the other Squalicum soils, the valuable timber has been removed, and a fair stand of similar trees is gradully becoming established.

Squalicum and Alderwood silt loams, rolling (Sp).—Some Alderwood silt loam, rolling, occurs on high moraines in the lower basin region, but it is so closely associated with soil of the Squalicum series that consistent separation is not feasible, and the two are therefore mapped as a complex. The associated soils occur in the higher region adjacent to the foothills and in the interior mountain valleys.

The strongly rolling morainic topography (6- to 15-percent slopes) permits rapid surface drainage even though the complex has slow internal drainage. The soils are oversaturated during winter and early spring. Though they are cold in early spring, moisture is retained better for plant growth during the dry summer than in soils of more open character. Erosion is at a minimum because cultivated areas are on the smoother relief and uncleared areas are well protected by the dense vegetation and forest litter.

The till of the Squalicum soils is appreciably modified by the clayeyness of the underlying materials, but that under the Alderwood lacks for the most part any appreciable clay incorporation, as the consolidated layers are deeply buried or absent. In general, however, the drift under the Alderwood is probably less firmly cemented and lacks much of the coarser gravel and stone it has in counties to the south.

Soils of the Squalicum series are described in the preceding pages, but the Alderwood are mapped only in complex with the Squalicum. Alderwood soils have strongly to moderately yellowish-brown silty surface soil over light yellowish-brown upper subsoil in which there are cemented wavy laminated layers characteristically marked by rusty brown and usually showing glazed surfaces. The upper subsoil grades downward into the light yellowish-gray compact softly cemented sandy gravelly till. The till occurs at variable depths, usually within 28 to 40 inches of the surface. Roots tend to become matted at the surface of the compact layers of this till, and brown and yellow mottlings suggest high water saturation during winter and spring, even though the morainic relief promotes rapid runoff. Embedded stone and boulders are common but rarely occur at the surface.

Use and management.—On better areas that have been farmed, Squalicum and Alderwood silt loams, rolling, have produced satisfactory crops under the same treatment given other soils of the uplands. Both members of the complex excel as forest soils, however, and they probably should be restocked with a better stand of timber trees where the present growth is not satisfactory. The cultivated acreage is very small, but there are scattered farms, and some areas near Bellingham are used for home sites.

The principal crops are hay, pasture, and small grains. Mixtures of red clover and ryegrass or timothy are common, and the yield is 1½ to 2 tons an acre. Small grains yield ¾ to 1 ton an acre when cut for hay. If they are sown with vetch, yields are considerably higher. When threshed, oats yield about 30 to 45 bushels an acre; barley, 20 to 35; and wheat, 10 to 25. A considerable part is used for woodland pasture or partly cleared stump-land pasture. The better pastures have fairly good carrying capacity if they are seeded to mixtures of such plants as alta fescue, English and Italian ryegrasses, tall meadow oatgrass, orchard grass, Kentucky bluegrass, and common white, alsike, subterranean, and red clovers.

Squalicum and Alderwood silt loams, hilly (So).—This complex occupies hilly areas with slopes of 15 to 30 percent, usually along streams or margins of drift plains and on the more rolling uplands. Drainage is more rapid than on smoother areas, but the surface soil is not significantly thinner because the tangled native vegetation and forest litter hold erosion at a minimum.

Use and management.—Squalicum and Alderwood silt loams, hilly, are not farmed. Use of farm machinery on such hilly land would be difficult, and yields probably would be low. Erosion would become accelerated under careless farming methods. All areas have been logged, and a second growth of timber is becoming established. Artificial reseeding and replanting would be of material benefit in establishing a good stand of timber types more valuable than the thick deciduous growths that become established following logging.

Squalicum and Alderwood stony silt loams, hilly (Sr).—This inextensive complex occurs largely east of Maple Falls. The land is of hilly relief (15- to 30-percent slopes), and huge boulders and stone litter the surface. The many boulders and stones distinguish it from Squalicum and Alderwood silt loams, hilly; otherwise, there is close resemblance. The stones generally cannot be removed, and both member soils of this separation are best suited to forestry.

SUMAS SERIES

Soils of the Sumas series are closely associated with the Puget soils in back-bottom positions along the Nooksack and Sumas Rivers and on the delta of the Nooksack River. They occupy similar or slightly more elevated positions, and this slightly greater relief, together with more rapid internal drainage resulting from their open sandy lower subsoil and substratum, make them better suited than the Puget soils to a somewhat wider range of crops. The high winter and spring saturation of Sumas soils and an accompanying high water table make installation of drains essential for satisfactory crop production. Because of the open character of the lower subsoil, open drains are usually sufficient. The soils were naturally heavily forested, mainly with cedar and Douglas-fir. A few low basins on the delta are covered with sedges and coarse grasses, including some saltgrass.

Soils of this series are characterized by light brownish-gray iron-mottled surface soil that becomes weak brown when wet and light brownish-gray mottled clayey upper subsoil abruptly overlying stratified sands of yellowish-brown or pepper-and-salt color. Sumas soils have the deficiency in organic matter and nitrogen that lighter colored members of this poorly drained group usually possess.

Three soil types are in the series—Sumas silty clay loam, Sumas silt loam, and Sumas fine sandy loam.

Sumas silty clay loam (Sz).—Areas of this soil are widely distributed in the broad flat bottoms of the Nooksack and Sumas Rivers where drainage is poor.

Representative profile:

0 to 10 inches, light brownish-gray rusty-iron stained granular silty clay loam; becomes brown when wet and under certain shades of light material has a somewhat bluish hue; medium acid; 4 to 14 inches thick.

10 to 28 inches, lighter colored light brownish-gray or somewhat bluish-gray rusty-mottled plastic angularly fractured silty clay loam; weak brown and distinctly mottled when wet; medium acid; 12 to 20 inches thick.

28 inches +, yellowish-brown or pepper-and-salt colored strongly acid sands of washed appearance; stained or mottled with rusty brown.

In the lower delta region the surface soil and upper subsoil have a more bluish-gray cast, and in the vicinity of Sumas the surface soil and upper subsoil are more yellowish or olive than typical.

Use and management.—Low-lying areas of Sumas silty clay loam are highly saturated during winter and early spring, and artificial drainage is essential for satisfactory crop production. Open drains carry off surface accumulations, adequately reduce internal saturation, and lower the water table to such extent that spring plantings are not seriously delayed. Even when this soil is diked and reclaimed, the substratum contains considerable salt, but this rarely retards plant growth. Water in wells is too brackish and salty for domestic use.

This soil does not contain enough organic matter and nitrogen to support sustained yields under continuous cropping. Under a good cropping system—usually one including hay, small grains, and pasture much of the time—the legumes in the rotation maintain a satisfactory level of fertility. Superphosphate substantially increases both yields of hay and the grazing capacity of pastures, and its residual effect is usually sufficient for crops following in the rotation. Superphosphate is applied at the rate of about 300 pounds per acre a year.

The hay crops are largely red clover mixed with ryegrass or timothy, though alsike clover is often used with or substituted for the red clover. A second cutting of hay is obtained if fields are not pastured. The second crop of clover is sometimes harvested for seed. Hay yields 3 to 4 tons an acre. Oats or barley used as nurse crops for seedings of hay and pasture plants yield 1½ tons or more an acre as hay. Mixtures of oats and vetch yield up to 4 tons an acre. Oats produce 70 to 90 bushels or more an acre when harvested for grain, and barley, 40 to 50 bushels. Yields of both these crops are declining. Pasture mixtures are similar to those used on the Puyallup and other soils of the bottoms, but the grazing period is probably longer than on the Puyallup because there is abundant moisture in this soil throughout the growing season.

Sumas silt loam (Sʏ).—This inextensive soil occurs in slightly elevated sites or on elongated ridges. It differs from Sumas silty clay loam chiefly in having variously interstratified layers of silt, clay, and sand throughout the subsoil and substratum. Layers of sand usually predominate, though thick beddings of silty clay, silty clay loam, and clay are common. In places on the more elevated sites the surface soil is more shallow than elsewhere.

Use and management.—Surface drainage of Sumas silt loam is usually moderate, and internal saturation is reduced readily when drains are provided. The soil therefore does not remain wet and cold so long in spring as Sumas silty clay loam, and crop selection is less limited. The main crops are hay, small grains, and pasture, and yields are about the same as on the silty clay loam. All the land is farmed.

Sumas fine sandy loam (Sx).—Areas of this soil are on low smooth elongated ridges in the delta of the Nooksack River. It is closely associated with other Sumas soils and with Puget soils, and though its total extent is small, all the land is cleared and forms an important agricultural acreage.

The sandiness of the surface soil and the interbeddings of silt and clay in the more sandy materials of the subsoil and substratum differentiate this soil from Sumas silty clay loam. Owing to its general sandiness and its more elevated position, natural drainage is more rapid and effective in this soil than in the silty clay loam, and in places it drains satisfactorily without use of artificial means.

Use and management.—Where sizable areas of Sumas fine sandy loam occur, they are generally used for more specialized crops than those grown on Puyallup soils. More often, however, this soil is used for hay, small grains, and pasture. Crop yields are intermediate between those obtained on Sumas silty clay loam and Puyallup fine sandy loam.

TIDAL MARSH

Tidal marsh (TA) lies within the overflow or saturation limits of high tide. The largest areas are on the delta of the Nooksack River. The soil materials consist of alluvial or shore deposits having a slate-gray iron-mottled appearance and a wide range in texture. No true soil has developed. At high tide the materials are completely submerged, and they remain marshy at low tide. Areas of Tidal marsh usually support sedges, cattails, and salt-tolerant vegetation.

TROMP SERIES

Soils of the Tromp series occur on the large glacial outwash plain in association with the more extensive Lynden. They occupy lower lying areas and border places where imperfect drainage results from a high water table that fluctuates with the seasons. Iron and other cementing materials precipitated from solution have created indurated layers of variable intensity in the soil. These layers range from platy ironpan to fragmental or compact zones. The concentration of cementing materials occurs at sufficient depth and is penetrable enough not to restrict movement of roots and water. The high saturation of winter and early spring often retards early plantings, but moisture is held far into the dry summer. The retained moisture is a valuable asset, and because the water table usually subsides sufficiently, the drainage established for the adjacent lower lying poorly drained soils is adequate for these soils also. Under virgin conditions there was a heavy forest of valuable timber, especially Douglas-fir, cedar, and occasional spruce.

Under a thin dark-brown organic mat soils of the Tromp series have brown or grayish-brown surface soil over compact cemented platy or fragmental ortsteinlike light yellowish-brown to highly iron-mottled or iron-stained sandy upper subsoil. The lower subsoil is light yellowish-brown highly iron-mottled pepper-and-salt colored sand, and the substratum is gray or pepper-and-salt colored sand, in which scattered gravel may occur. The occurrence of gravel, however, is not typical.

The soils of this series are Tromp silt loam, Tromp silty clay loam, Tromp-Custer silt loams, Tromp-Edmonds silt loams, and Tromp-Woodlyn silt loams.

Tromp silt loam (TD).—On the smoother part of the glacial outwash terrace in the lower basin region small widely scattered bodies of this soil occur in association with the more extensive Lynden soils. Relief is almost level to very gently undulating or sloping. Almost all of the slopes are less than 3 percent, but a few small more sloping areas are included. Surface runoff is relatively slow, and internal drainage is retarded. The soil is usually wet in spring but dries out later as the water table subsides. Moisture is well retained throughout the season, and this is an asset because of the dry summers. Open drains are used in some places to carry off excess water, but the more common practice is to use such ditches only on the adjacent soils of the low basins and depressions.

All of this soil is used in farming, but probably a fourth is uncleared. The forested part is in second-growth Douglas-fir and cedar, strongly pressed for space by the thick stands of deciduous trees, brush, and shrubs that flourish after logging.

The surface soil is somewhat variable in color because of the range in drainage conditions. Where the soil adjoins the Lynden soils or is more elevated, it is usually a brighter brown. Adjacent to poorly drained flats in which occur Custer or Edmonds soils, it usually is more brownish gray. The subsoil is likewise more highly iron-stained and ortsteinlike where this soil grades into those of poorer drainage. Adjoining the Lynden, this soil is frequently without ortstein concentration yet highly iron-stained and softly cemented. The soil is youthful, however, and no appreciable cementation has occurred to impede the growth of roots or the free movement of water. Typically no gravel occurs in the subsoil or substratum unless the soil adjoins others developed from gravelly alluvium.

Profile description in the virgin, or forested, condition:

1½ to 0 inches, dark-brown partly decomposed forest litter; 1 to 2 inches thick.

0 to 12 inches, brown friable fine granular silt loam of medium acid reaction; contains a few fine shot; 10 to 12 inches thick.

12 to 20 inches, light yellowish-brown iron-stained medium acid silt loam; contains a small quantity of fine shot; 6 to 10 inches thick.

20 to 40 inches, moderate yellowish-brown medium acid sand and sandy loam; contains iron concretions and localized cemented ortsteinlike lumps, plates, or flat fragments; 18 to 24 inches thick.

40 to 60 inches, strong yellowish-brown medium acid sand; contains particles of dark-gray sand; 18 to 24 inches thick.

60 inches +, pepper-and-salt colored loose sand; under certain degrees of moisture and favorable shades of light color is somewhat olive gray or bluish gray; slightly acid to neutral.

Some areas of this soil, particularly one covering about one-third of a square mile on the low terrace along Tenmile Creek, are seasonally saturated. When the water table subsides in summer, precipitated iron is left, and in the better drained spots this imparts a somewhat hematite-red, rusty, or ocherous color to the subsoil.

Use and management.—Tromp silt loam is a good agricultural soil and forms an important cultivated acreage in association with the less valuable Lynden soils of lower moisture content. Planting may be delayed in spring because of excessive moisture, but the season is long enough for the maturing of most crops.

The farmed areas respond well to rotation of legumes with other crops for the purpose of correcting organic-matter and nitrogen deficiencies. Application of barnyard manure and superphosphate increase yields significantly and seem essential to sustained high production. When 250 to 300 pounds of superphosphate are applied annually to legumes, the residual effect is sufficient for crops following in the rotation.

All crops, including fruits of the area, are grown on this soil, but hay, pasture, and small grains occupy the largest acreage. Mixed hay crops of red clover and ryegrass or timothy are the most common, and yields of 2½ to 4 tons an acre are obtained. Yields of clover alone are considerably smaller. Where small grains are used as nurse crops for legumes, they yield about 1¼ tons of hay an acre. Vetch and oats sown together yield about 2 tons of hay an acre. Oats threshed for grain produce 45 to 70 bushels an acre; barley, 35 to 50; and wheat, 20 to 35.

Permanent pastures have a high carrying capacity and provide forage well into summer. The most satisfactory pasture mixtrues include alta fescue, English and Italian ryegrasses, tall meadow oatgrass, Kentucky bluegrass, and common white, alsike, and red clovers. Stump lands and partly cleared woodland pastures have a good carrying capacity if good stands become established and invading natural vegetation is kept under control. Good pasture stands can be had by seeding mixtures of ryegrass, orchard grass, and white clover in the woodlands or stump lands shortly after they have burned over.

A number of special crops, including certified seed potatoes, flower bulbs, strawberries, and truck crops, are grown in some areas. Potatoes yield about 250 to 350 bushels an acre; strawberries, 2 to 3 tons or more. Sour cherries are the only tree fruit grown commercially. Blackberries and raspberries are grown on a considerable acreage, and good yields are obtained. Farm gardens supply a wide variety of vegetables.

Tromp silty clay loam (Te).—Parts of low-terrace areas, mostly near Keefe Lake, are occupied by this soil. Before dikes were built along the Nooksack River these areas were periodically overflowed, and therefore the surface soil is grayer and the subsoil is less bright brown than typical of Tromp silt loam. However, the intense rusty brown in the subsoil indicates a high concentration of iron. The lower subsoil and substratum are stratified highly iron-stained gravel. Profile characteristics of this soil are not so clearly defined as in Tromp silt loam, and a wider range of soil characteristics is included in mapping. The slope range is 1 to 4 percent.

Use and management.—Tromp silty clay loam has a smooth relief favorable to farming but usually dries out slowly in spring because of its low position. Most of the land is cleared and in use, principally for hay and pasture. Hay yields and the carrying capacity of pastures are about the same as on Tromp silt loam. Where gravel occurs at shallow depths, the land may be considerably less valuable.

Tromp-Custer silt loams (Tb).—In places where relief is diversified and the drainage pattern is variable, Tromp silt loam and Custer silt loam are so intricately associated that delineation of individual areas is impracticable on a map of the scale used. They are therefore mapped together as a complex. The darker poorly drained Custer soil occupies the basins or depressions in the shallow incomplete drainage relief, and Tromp silt loam is on the many more elevated areas. This association usually consists of 60 to 70 percent of Tromp silt loam and 30 to 40 percent of Custer silt loam.

Use and management.—The intimate mixture of imperfectly and poorly drained soils in this complex of Tromp-Custer silt loams makes the use and management of fields difficult. Crops suitable for the diverse soil and moisture conditions are limited, hay and pasture being most used. Hay yields and the carrying capacity of pastures are usually about the same as on Tromp silt loam. About three-fourths of the land is cleared for farming; the rest is in second-growth coniferous timber, deciduous trees, and brush.

Tromp-Edmonds silt loams (Tc).—This inextensive complex occupies areas similar to those in which the Tromp-Custer silt loams occur. It differs from the complex of Edmonds-Tromp silt loams in that Tromp silt loam predominates. Most of the land is cleared and in use, largely for hay and pasture. Yields are about the same as on the Tromp-Custer silt loams.

Tromp-Woodlyn silt loams (TF).—This complex occurs on the terrace plain along Tenmile Creek near Laurel where basins, sags, and swells are prominent and the pattern of imperfect and poor drainage is extremely complex. In this area Tromp and Woodlyn silt loams are so intricately associated that individual areas of each are not delineated on the map. The complex is usually made up of 60 to 70 percent of Tromp silt loam and 30 to 40 percent of Woodlyn silt loam.

Surface runoff is slow, and the depressions occupied by Woodlyn silt loam become saturated in winter and early spring. Plantings are delayed, even where surface drains are used, and uniform moisture conditions for both soils are difficult to obtain. Crops have a tendency to ripen unevenly, and therefore hay and pasture crops are the most satisfactory. Yields of hay crops and the grazing capacity of pastures are much the same as on Tromp silt loam. Yields from other crops are usually smaller.

WHATCOM SERIES

Soils of the Whatcom series have developed on the better drained parts of a low ground moraine having rolling to knobby or intricate moundlike kame and kettle topography. This moraine occupies the part of the lower basin region smoothed by glacial and postglacial outwash and recent stream alluvium. For the most part the soils have rolling or hummocky relief with slopes of 6 to 15 percent (pl. 6, *B*). Others have undulating, hilly, or steep relief. All retain moisture well, but they may remain wet and cold longer in spring than those of more open character.

These soils are intimately associated with those in which imperfect and poor drainage has been created by the dense, pitted, heavy clay till and a youthful incomplete drainage relief. The drainage is complete only in places of more pronounced relief, and it may be only moderate in the smoother parts of a soil area. So intricate is the soil pattern that very small basins having imperfect or poor drainage are included with the Whatcom. Where the soil associations resulting are very intricate and cannot be delineated on a map of the scale used, soil complexes are indicated. The natural forest cover consisted largely of Douglas-fir and cedar and a scattering of spruce.

In virgin areas Whatcom soils are covered with several inches of forest litter. Abruptly below the litter is brown or yellowish-brown friable silty surface soil containing considerable shot. This layer overlies a light yellowish-brown upper subsoil more friable than that of the lower clay subsoil. The underlying clay till parent to this soil is bluish-gray highly fractured dense boulder clay, often shalelike, and frequently embedded with stones and boulders. In some places marine shells indicate the clay till may be partly of marine origin. According to geologists (*1*), the clay till was laid down during the latter part of the Vashon glacial period.

In this series are the undulating, hummocky, hilly, and steep phases of Whatcom silt loam and the Whatcom-McKenna complex.

Whatcom silt loam, undulating (WE).—This is one of the more extensive soils in the area and the most productive of the better drained upland soils. It occurs in the low basin region where it is readily accessible for agricultural development. It is also a good soil for forest, but all merchantable timber—largely Douglas-fir and cedar—has been removed. Probably one-third of the land has been cleared for farms; the rest is restocking, mainly to Douglas-fir and some cedar, though alder, maple, birch, some cottonwood, other deciduous trees, and a brushy understory are prominent.

This soil is a part of the extensive drift plain. Most of it occurs on a low undulating to rolling or knobby ground moraine (4- to 12-percent slopes) that covers most of the upland area in the basin region adjacent to the coast (pl. 8). The glacial till is largely dense shale-like dark bluish-gray clay till in which gravel, stones, and occasional boulders are embedded. These rock materials are mainly of quartzitic and granitic origin, which is characteristic of Vashon drift. Pockets of more sandy and gravelly clay till frequently occur.

Surface drainage is sufficient, but the heavy clay subsoil and substratum retard internal movement of water. In many places the soil is highly saturated at the surface of the underlying tight clay during winter and early spring. Where this occurs, the soil may be colder and warm more slowly in spring. In respect to drainage and its influence on time of planting and tillage, this soil is intermediate between the more porous permeable soils of the upland and those of more restricted drainage. Aside from delay in spring planting, the moisture is an asset, as it is held longer in dry summer when the deficiency might otherwise be critical.

Water for domestic use usually can be reached in shallow wells during winter and spring, but deep wells are necessary for a satisfactory year-round supply. The tight clay till is not water-bearing; strata that hold water are usually not less than 80 feet from the surface and, more often, are down 400 feet or more. The depth to a continuous water supply depends on elevation. Water at lower elevations may be brackish if drawn from strata containing marine shells.

Accelerated erosion has not occurred or is held to a minimum by the forest litter and organic mat that covers the soil even after it is logged. The deep silty surface soil is of very stable structure and promotes rapid infiltration. Under cultivation the steeper and knobby areas have eroded slightly during heavy downpours, as the surface soil in such places is usually thinner, especially at the crests. This thin surface soil may result from a thinner natural soil cover in such positions, or it may be that part was removed during early geologic time. On burned areas or on abandoned farms, bracken and other native vegetation rapidly form a dense tangled cover.

Virgin profile description:

1½ to 0 inches, dark-brown strongly acid partly decomposed organic mat; 1 to 2½ inches thick.

0 to 12 inches, moderate-brown or moderate yellowish-brown friable floury silt loam; contains a few round shotlike concretions of impure iron and probably some manganese; under cultivation the strongly acid organic mat is mixed with this layer to form a medium acid surface soil; 8 to 14 inches thick.

12 to 20 inches, light yellowish-brown very friable, heavier, medium acid silt loam; contains a somewhat larger quantity of shot than layer above; 10 to 12 inches thick.

20 to 28 inches, light yellowish-brown highly mottled somewhat vesicular gritty silt loam or loam; horizontal yellowish iron-stained bands; medium acid; 4 to 14 inches thick.

28 to 50 inches, light yellowish-gray dense silty clay loam; breaks into angular blocky fragments ¼ to ½ inch across that have brown and gray colloidal

coatings; fibrous roots are matted in the fracture planes; slightly acid in the upper part and neutral in the lower; 20 to 24 inches thick.

50 inches +, a little modified gray silty clay loam till cut by fracture planes having a dark-brown coating on their surfaces; embedded gravel and boulders are common throughout the subsoil and substratum; clay till is neutral to slightly alkaline and in places contains marine shells.

Use and management.—Probably less than one-fourth of Whatcom silt loam, undulating, is used for intensive farming. Most crops yield fairly well where topography is favorable and proper methods are employed. Hay, pasture, corn (pl. 6, *C*), and small grains are the crops most satisfactory. The soil is deficient in organic matter and nitrogen, and if cultivated, requires use of barnyard manure, crop residues, and proper rotation of legumes with other crops to keep productivity at a satisfactory level. Crops, especially legumes, respond materially to applications of superphosphate but are not appreciably benefited by other commercial fertilizer or amendments like lime. In better management practices, legumes usually receive about 300 pounds an acre per year of superphosphate. This application is usually sufficient for crops following in the rotation.

The main crops are hay, pasture, and small grains, but most farmers produce a variety of crops, mainly vegetables and fruits, for home use. The hay crops are largely mixtures of red clover with ryegrass and timothy. Small grains, principally oats, are used as nurse crops in seeding the hay mixture. The nurse crops are usually cut for hay and yield about 1 to 1½ tons an acre. The mixed hay crops yield 1½ to 3 tons an acre, and of these, most farmers find that mixtures of clover, alta fescue, and ryegrass give the highest yields. Clover alone yields somewhat less and is not commonly used.

In wet years it is sometimes possible to get a small second cutting of hay, but the more common practice is to pasture fields after the first cutting. The grazing period following the first cutting is short because summer rains are lacking, but some pasture later becomes available when fall rains begin. Older hayfields are invaded by white clover and other grasses through natural revegetation and are more efficiently pastured than cut for hay. Some farmers prefer to reseed such old fields to better hay mixtures or to pasture mixtures having higher carrying capacity than the native plants. A pasture mixture for soils of the uplands recommended by the State Extension Service includes alta fescue, English and Italian ryegrasses, tall meadow oatgrass, orchard grass, Kentucky bluegrass, and common white, red, subterranean, and alsike clovers.

The logged lands intended to supply pasture and occasionally hay can be seeded successfully only after they have burned over. At other times competition with the natural vegetation, especially bracken, is too severe. Once a stand is established on uncleared logged-over lands, it will provide good pasture if competing vegetation is kept under control. The ryegrasses, orchard grass, and white clover are probably best for use under these circumstances. The dry summers may limit the grazing period to 3 or 4 months.

Alfalfa is not so important as other hay crops on this soil but it grows successfully on areas having effective surface drainage and sufficient internal drainage during winter and spring. Most farmers find it difficult to get a good stand of alfalfa, however, and to maintain the stand after it is established. Most alfalfa is plowed up at the end of the second or third year because by that time grasses and weeds are difficult to keep out by cultivation and their invading growth has made the hay of low quality. The acreage of alfalfa is increasing, however, as its culture becomes better understood. Under better management 4 tons or more of alfalfa hay to the acre have been grown from 2 or 3 cuttings, and this exceeds the yield of other hay crops in both tonnage and feeding value.

Small grains are less frequently grown on this soil than on those of the upland depressions and bottoms because yields are lower and fall rains often make harvesting difficult. Oats, the small grain most commonly grown, yield 50 to 65 bushels an acre. Wheat yields 20 to 35 bushels an acre, and barley 30 to 55.

Cherries, strawberries, raspberries, and blackberries are the fruits and berries most frequently grown. Sour cherries produce about 1 to 3 tons an acre and are preferred because wet weather causes other varieties to crack badly. On very favorable locations 2 tons of strawberries an acre are reported in good seasons. Apples, pears, plums, prunes, and other fruits are grown mostly for home use. The yield from these fruits is small and of poor quality because methods of controlling diseases and insects have not been worked out satisfactorily. Farm gardens supply a wide variety of vegetables for home use.

Whatcom silt loam, hummocky (Wc).—This soil is widely distributed in association with Whatcom silt loam, undulating, and characteristically occupies areas on the lower ground moraine where there are many low hummocks, knobs, or low moundlike elevations. In these lower areas the irregular microrelief and general absence of drainageways contribute to slow runoff, and the soil is highly saturated during winter and spring. Owing to slow surface and internal drainage, the soil is characteristically grayer than the undulating phase, especially in the many depressions. The sharp-pitched crests and slopes apparently were more subject to erosion, particularly during the early geologic period.

The silty surface soil on steeper slopes is considerably shallower over the tight clay till than it is in the undulating phase. In virgin areas only slight erosion now occurs because a dense forest cover holds the soil, but on cultivated tracts erosion might become accelerated under careless management. In characteristics other than those just mentioned, this soil is much like Whatcom silt loam, undulating.

Use and management.—Whatcom silt loam, hummocky, warms up slowly in spring and has uneven relief that makes it difficult to obtain uniform moisture conditions over an entire field. The soil is therefore used chiefly for hay and pasture, but a considerable acreage of small grains is also grown. A much smaller part of this soil is farmed than of the undulating soil, and yields are about the same or somewhat smaller.

Whatcom silt loam, hilly (Wb).—Areas of hilly relief considered unfavorable for cultivated crops comprise this soil. The land would be difficult to work with farm machinery, and though erosion is at a minimum under the native cover, the soil probably would be affected by accelerated erosion if cultivated. The soil is made up of strongly rolling ridgy or hilly upland areas and slopes bordering drainageways or along ascending or descending drift plains. The slopes have an approximate range of 15 to 30 percent, though steeper areas may be included. This soil has wide distribution among others of the Whatcom series, but the larger bodies occur on the more prominent moraines in the lower drift plain and on steep areas skirting the foothills and mountains.

Surface drainage is more rapid than on Whatcom silt loam, undulating; internal saturation is not so great as in areas of smoother relief. The silty surface soil generally is not so deep as on the smoother, undulating phase, but apparently this does not affect tree growth. Where steeper areas adjoin flood plains, some silt may have blown onto the soil from the plain, and the silt surface layer may be deeper than on smoother areas less favorably located for such deposition. Apparently there is no definite correlation between the depth of surface soil and the steepness of slope, but higher crests of sharp relief are usually the most thinly mantled. In characteristics other than those just discussed, this soil is similar to Whatcom silt loam, undulating.

Use and management.—Whatcom silt loam, hilly, has extremely limited value for agriculture and under most conditions should be used only for forestry. Deciduous trees and brush rapidly invade cut-over areas. Even burned areas rapidly acquire a protective covering of prolific bracken, which is followed by a more permanent growth of trees and brush. Timber trees are restocking most areas rather slowly because they must compete with deciduous trees and brush of little or no commercial value. A more systematic reforestation program, including reseeding or replanting of valuable timber trees, would increase the potential value of this land and lay the foundation for increased revenue.

Whatcom silt loam, steep (WD).—Narrow elongated areas of this soil are widely distributed in the low basin region. They occur largely on very steep slopes and escarpments, usually along the deeper incised drainageways, and on steep areas adjacent to the foothill area. The steeper tracts have slopes of more than 30 percent. The surface soil is thinner than on Whatcom silt loam, undulating, and occasional exposures of clay subsoil are common on the excessively steep areas. In most places, however, the slopes have a dense undercover that almost totally prohibits or, at most, permits only slight accelerated erosion. In other characteristics this soil is similar to Whatcom silt loam, undulating.

Use and management.—Steep slopes make Whatcom silt loam, steep, definitely unsuitable for cultivated crops, but it will produce excellent timber. The merchantable timber, largely Douglas-fir and cedar, has been removed, and a scattered second growth of similar trees is now competing with thick stands of quick-growing deciduous trees and brush. Restocking to valuable timber trees should be encouraged.

Whatcom-McKenna complex (WA).—In this complex are bodies of Whatcom silt loam and McKenna silty clay loam so intricately associated that separate delineation of individual areas was impractical on a map of the scale used. Whatcom silt loam occupies approximately 60 to 70 percent of the total area, though a higher percentage of McKenna silty clay loam occurs in some places.

The complex occurs in the lower basin region where the relief, though relatively subdued, is made up largely of choppy, knobby, or moundlike areas having short slopes that do not exceed 15 percent. The McKenna silty clay loam part of the complex occupies the kettles and basins where slopes are less than 6 percent. Probably more than one-fourth of the total area of Whatcom silt loam also has slopes no greater than 6 percent. The incomplete drainage relief, or absence of well-defined drainage channels, causes high saturation in the basins and depressions and permits only moderate drainage on the more elevated areas occupied by the Whatcom soil. In the imperfectly drained parts of the complex transitional between the basins and slopes the soils probably resemble more closely those of the Labounty series, but the bodies are too small to be shown separately.

Use and management.—Only a small part of the Whatcom-McKenna complex is used for cultivated crops, as the diversity of soil and drainage conditions within short distances is too great. Even where drainage can be established, it is difficult to find crops tolerant of all the variations in soil and moisture. It is questionable that satisfactory tillage can be accomplished, and crops will probably always mature unevenly. Hay and pasture are the principal crops, for they are least affected by the diversity of soils and drainage. Pastures have a good carrying capacity because moisture is abundant, and good hay yields are obtained.

WICKERSHAM SERIES

The Wickersham series is represented in this area by only one type, Wickersham shaly loam. The Wickersham soil developed on alluvial deposits derived largely from argillite and schist, which have been brought down by the streams flowing across consolidated rock formations of such materials. The deposits are open and porous and retain their shaly angular flaky character. The deeper soil materials vary considerably and may be shaly, graphitic, flaky, or schistose.

Wickersham shaly loam (Wf).—This inextensive soil occurs largely on alluvial fans along the foothills and mountains skirting the lower basin region and in the more mountainous interior. The gently sloping relief (2- to 6-percent slopes) is broken in places by active or abandoned drainage channels. Drainage is good to excessive, but flash floods occasionally bring fresh deposits of shaly debris.

Profile description:

0 to 8 inches, light brownish-gray strongly acid shaly loam high in schistose materials; under certain shades of light has a bluish cast when moist; 6 to 10 inches thick.

8 to 24 inches, light olive-gray medium acid very shaly loam; 12 to 18 inches thick.

24 to 70 inches +, dark bluish-gray medium acid loosely stratified angular highly schistose shaly material.

Use and management.—The relief of Wickersham shaly loam is well suited to farming, but the soil is deficient in organic matter and nitrogen and low in moisture-holding capacity. It responds to management and fertilizing practices similar to those used on Kline loam. Much the same crops are grown, and yields are equal or a little lower. The uncleared part—about half the total area—has a cover of second-growth forest similar to that on the Kline soil and provides some grazing and browse.

WOODLYN SERIES

The Woodlyn series is represented in this area by Woodlyn silt loam. The soil occupies poorly drained flats and depressions and has poor surface and underdrainage. It responds well to artificial drainage, however, as the lower subsoil and substratum are gravelly and there is no iron hardpan.

Woodlyn silt loam (WG).—Large continuous bodies of this soil are associated with Edmonds silt loam north of Lynden on the poorly drained flats and depressions of the glacial terrace plain. Slopes do not exceed 3 percent. The soil occurs in an area where intensive farming is practiced, and an effective system of drains has been installed. Open drains provide adequate outlets, and favorable moisture conditions are possible in spring and throughout the growing season because the subsoil is porous and gravelly. The organic and mineral fertility, though still relatively high, has been somewhat depleted.

Profile description of a cultivated area:

0 to 12 inches, dark brownish-gray granular highly organic heavy silt loam; 10 to 14 inches thick.

12 to 20 inches, gray iron-mottled or spotted plastic silty clay loam.

20 to 40 inches, gray gravelly sand highly mottled with yellow and rusty brown; contains some localized areas showing cementation; 18 to 24 inches thick.

40 inches +, brownish-gray open stratified gravel and sand highly mottled with yellow and rusty brown.

The surface soil varies in depth and organic-matter content. Shallower areas are gray, especially when the soil is dry. Many areas of this soil once highly organic are now more definitely mineral because they have been cultivated a long time.

Use and management.—Woodlyn silt loam becomes highly saturated in winter and spring because it has nearly level relief and a high water table. Efficient use of drains reduces moisture content to a level assuring maximum growth during the growing season. Underground water moves fairly freely in the porous gravelly subsoil and substratum.

Much of this soil is used for dairy farming, and most of it is kept at a fairly productive level by applying manure and superphosphate and by regularly rotating legumes with other crops. Farmers have used complete fertilizers with excellent results on vegetables, berries, and such specialized crops. The fertilizer is applied at a rate similar to that for soils with which this one is associated. General farm crops do not require commercial fertilizer.

All the land is cleared, and 95 percent or more of it is used for hay, small grains, and pasture. Red clover or alsike clover mixed with ryegrass or timothy are considered the highest yielding hay crops, the return being 3 to 4 tons or more an acre. Small grains sown as nurse crops for legumes yield 1½ tons an acre when cut for hay. Oat-and-vetch mixtures yield 2 tons or more an acre. Oats harvested for grain produce 60 to 90 bushels or more an acre, and yields of barley are also high. The soil is too wet and cold for wheat; furthermore, the crop is injured by weevil infestation. Such crops as vegetables and berries produce well, but the soil is not very satisfactory for tree fruits, and most farms with this soil have only small orchards for home use.

Pastures have high carrying capacity, and because there is usually abundant moisture in the dry summer, can be grazed a long time. Pasture mixtures including alta fescue, English and Italian ryegrasses, tall meadow oatgrass, Kentucky bluegrass, and clovers have the highest carrying capacity and produce forage of high quality.

SOIL USE AND MANAGEMENT

Use and management for individual soils are suggested in the section on Soil Series, Types, and Phases, and therefore only more generally applicable information is considered here. Although a number of fertilizer experiments have been conducted on soils in Washington, no specific information on the fertilizer requirements of individual soils has been worked out. Nonetheless, general information gained from these experiments and a knowledge of the demands that certain plants or groups of plants make upon soils has led to general recommendations (*9*) by the State College of Washington Extension Service, and these are usually adhered to. In brief, lime and commercial fertilizer are used on peat and muck soils; general field crops grown on mineral soils in rotation with legumes and supplemented with green-manure crops or barnyard manure generally receive no fertilizer; legumes receive superphosphate; and truck crops are heavily fertilized.

Where general field crops are grown on mineral soils in rotation with clover, alfalfa, and such legumes, satisfactory results are obtained when the ratio is 1 year of legume to 2 of intertilled or small-grain crops. In other words, 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 is plowed under. Superphosphate applied to the legumes usually assures enough phosphorus for the other crops that follow in the rotation.

Legumes used in crop rotations receive superphosphate (about 16 to 18 percent available phosphoric acid) at the rate of 300 pounds an acre the first year and 250 pounds each succeeding year (*9, 11*). Red, subterranean, and alsike clovers are the legumes most commonly used in crop rotations, but alfalfa is also used to a small extent. Alsike clover is used mostly on the wettest part of the drained areas along the stream bottoms and in upland depressions. Alfalfa does not tolerate poor drainage and is therefore grown only on well-drained soils of the stream valleys and uplands.

When legumes are not regularly rotated with them, small grains may require nitrogen, phosphorus, or both. Usually satisfactory is an application of 100 to 200 pounds an acre of sulfate of ammonia and 200 pounds of superphosphate. 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 of these in other fertilizer.

The green-manure crops most used are mixtures of vetches and small grains. Small grains sown alone are not very efficient in supplying the much needed nitrogen. A mixture of Rosen rye and hairy vetch makes the best green-manure crop for this area. Hairy vetch is better than common vetch because it is winter hardy and grows in cool weather. Rye is better than wheat because it is less subject to winter injury and is still better than winter oats, a crop even more readily injured than the wheat.

Fall-sown manure crops are most satisfactory. In seeding, 30 pounds an acre of hairy vetch and 90 pounds of either Rosen rye or winter wheat are commonly used. If common vetch is used, 50 pounds an acre are needed. Fall seeding is usually done between September 15 and October 15.

Seeding late in February or early March is best for spring manure crops on well-drained soils, but this may have to be delayed on wet soils. It is recommended that green-manure crops be plowed under when the grain begins to head. Because summers are dry, green manure may not decompose satisfactorily after the first of May.

Temporary or permanent pastures seeded to legumes and grasses are excellent for checking erosion and building up and maintaining high soil fertility. Pasture mixtures recommended by the State College of Washington Extension Service include low sod-forming grasses and upright-growing grasses, with clovers to thicken the stand and add feeding value. The best forage species for soils of the stream bottoms and upland depressions include alta fescue, Italian and English ryegrasses, orchard grass, Kentucky bluegrass, and common white, red, and alsike clovers. For soils of the uplands and terraces the following species are recommended: Alta fescue, English and Italian ryegrasses, tall meadow oatgrass, orchard grass, Kentucky blue grass, and common white, red, alsike, and subterranean clovers. On low wet areas that cannot be satisfactorily drained, reed canarygrass provides excellent grazing. Ten pounds an acre is recommended for planting. A mixture of meadow foxtail and big trefoil (*Lotus uligninosus*) also has proved satisfactory on wet lands.

Small grains are used as nurse crops for hay and pasture mixtures, and the rate of seeding is usually reduced one-half on the better drained soils of the uplands and terraces. On soils of the stream bottoms and upland depressions the quantity of grain sown is about two-thirds that of a normal seeding.

Pastures are improved by a fall or winter dressing of 6 to 8 loads of manure and 400 pounds of superphosphate an acre. Under heavy grazing it may be necessary to add a nitrogen fertilizer or even a complete fertilizer. Usually satisfactory under heavy grazing is 100 pounds of sulfate of ammonia, or its equivalent, applied early in spring and again in April and May.

Truck crops are most often grown under intensive farming methods and heavily fertilized, but practices vary somewhat. Root crops and tubers respond best to complete fertilizer; but when they are grown under the less intensive cropping methods used in general farming, 6 to 8 tons of barnyard manure and 200 to 300 pounds of superphosphate an acre are usually satisfactory, provided the crops are grown as part of a regular rotation (*9*). Under more intensive truck farming, root crops and tubers may require, in addition to the manure, 100 to 125 pounds of sulfate of ammonia, 300 to 400 pounds of superphosphate, and 80 to 120 pounds of muriate of potash an acre, or the equivalents. On peat or muck the same crops may require 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 equivalents in other commercial fertilizer.

Under heavy cropping, garden peas and beans do well when 150 pounds of sulfate of ammonia, 625 pounds of superphosphate, and 200 pounds of muriate of potash, or the equivalents in other fertilizer, are applied (*9*). Cabbage, lettuce, celery, and such leafy vegetables produce well with 12 to 15 tons of barnyard manure and 600 to 800 pounds of superphosphate an acre. 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 results. If manure is not used on either the mineral or peaty soils, 300 to 350 pounds of sulfate of ammonia, 600 to 750 pounds of superphosphate, and 75 to 100 pounds of muriate of potash an acre should be used if cropping is heavy; this is equivalent to about 1,000 pounds of 6–10–4 fertilizer an acre.

Strawberries respond well to a dressing of 6 to 8 tons of well-rotted barnyard manure and 400 to 600 pounds of superphosphate an acre (*9*). This application is made following harvest or in fall. If manure is not used, 150 to 300 pounds of sulfate of ammonia, 250 to 500 pounds of superphosphate, and 60 to 120 pounds of muriate of potash an acre should be applied after harvest or in fall. An equivalent quantity of 6–8–6 fertilizer is satisfactory. Some farmers find 250 to 300 pounds an acre of 3–10–10 sufficient for good yields.

Raspberries and blackberries give satisfactory yields with 8 to 12 tons of well-rotted barnyard manure and 400 to 600 pounds of superphosphate an acre. If manure is not used, 100 to 175 pounds of sulfate of ammonia, 450 to 750 pounds of superphosphate, and 100 to 150 pounds of potash an acre, or the equivalents, should be applied (*9*).

Orchards are usually planted to vetch and rye or other cover crops that may be plowed under as green manure. Some orchards are benefited by nitrogen and occasionally by other commercial fertilizer. For nitrogen deficiency, an application of 2½ to 5 pounds of sulfate of ammonia a tree is usually satisfactory (*6*).

For convenience, use and management of the soils of the county are discussed by three groups: (1) Light-colored soils of uplands and terraces; (2) soils of stream valleys and upland depressions; and (3) organic soils.

LIGHT-COLORED SOILS OF UPLANDS AND TERRACES

Light-colored soils of uplands and terraces developed under coniferous cover are characteristically deficient in both organic matter and nitrogen. The organic residues they do possess are largely raw and fibrous and yield but little active organic matter or available nitrogen for farm crops. Phosphate applications have demonstrated that the soils also do not contain enough phosphorus in a satisfactorily available form for best plant growth, especially for legumes. Application of potash and lime seems beneficial in places, but further study is necessary before definite conclusions can be drawn. If sulfur is found deficient for legumes, this would be supplied by gypsum in superphosphate applications. It seems highly probable that more acid upland soils, as the Barneston and Heisler, under the heavy rainfall in the eastern part of the area surveyed will benefit by applications of lime to neutralize acidity.

The benefits resulting from application of various fertilizers on upland and terrace soils in this and other counties of western Washington have been demonstrated by experiments (*11*).

Forage crops on light-colored upland and terrace soils such as those in this county gave the greatest single response to nitrogen alone, but some additional increases in yield resulted when nitrogen was supplemented with applications of phosphorus or of both phosphorus and potash. Good response was obtained from fertilizers on the upland and terrace soils of medium natural productivity. The average yield of forage crops on glacially derived upland soils was 2.3 tons an acre on check plots and 3.9 tons the acre where complete fertilizer was applied.

On the more gravelly excessively drained soils, as the gravelly Kickerville soils of the uplands and the sandier Lynden soils of the terraces, there was not enough benefit from the various applications to justify their use. The increase in yield was not enough to pay for fertilizer, expense of application, and other incidental costs. The lack of profitable response may be due to a moisture deficiency and to a lack of the mineral and organic colloids, which act as a reservoir for plant nutrients. Nonetheless, a test made on a Lynden sandy loam soil showed that the yield of grass hay increased from 0.97 tons to 2.32 tons an acre when nitrogen fertilizer alone was used.

Because the soils of the uplands and terraces are deficient in nitrogen and organic matter, these plant nutrients must be present in satisfactory form and proportion before the soils can be farmed successfully. The cheapest and most satisfactory way of supplying them is by using legumes in crop rotations (*13*) and by growing supplemental green-manure crops and applying barnyard manure. Commercial fertilizer high in nitrogen can be applied, but it may be too expensive for any except special high-producing crops.

SOILS OF THE STREAM VALLEYS AND UPLAND DEPRESSIONS

Soils of the stream valley and upland depressions, as demonstrated by fertilizer experiments (*11*), are medium to high in inherent fertility, but they are becoming deficient in phosphorus and nitrogen under continuous cropping. For these soils, better use and management will vary somewhat, but use of crop rotations and fertilizer will be generally similar to that for the upland and terrace soils.

The results of fertilizer tests indicate the fertilizing elements these stream valley and upland depression soils need. On the stream bottoms the average yield of forage crops on check plots was 2.6 tons an acre. Addition of nitrogen fertilizer alone increased the average yield to 3.8 tons; and where nitrogen, phosphorus, and potash were added, the yield was 4.32 tons. Pasture increased an average of 32 percent when these soils were treated with 125 pounds of ammonium sulfate, 300 pounds of superphosphate, 100 pounds of sulfate of potash, and 500 pounds of lime an acre. Similar treatment for hay gave an increase of 29 percent. Favorable increases in yield were also obtained with treatment of superphosphate alone; with superphosphate and sulfate of potash; and with superphosphate, sulfate of potash, and lime.

Analyses of pasture clippings indicated that increased yields were not the only benefits obtained by applying complete fertilizer. Feeding value improved because the content of protein and minerals, notably phosphorus and calcium, increased. Nitrogen alone brought increased yields, but mineral content was low. Analyses also indicated that 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 and therefore should be fertilized heavily. The change in mineral content of hay and pasture following application of complete fertilizer would also confirm the observation of dairymen that peat soils are unfavorable pasture for milk cows. Peat soils are low in minerals.

In this county a test plot of upland depression soil (Bellingham silty clay loam) produced 3.08 tons of oat hay an acre without fertilizer and 5.18 tons when fertilized with nitrogen. On this plot no additional increase in yield resulted when phosphate and potash were applied in combination with the nitrogen, though the feed probably was of better quality. In adjacent Skagit County, nitrogen and phosphate increased one pasture cutting from 0.8 to 2.56 tons an acre.

Custer silt loam, in the depressions of the sandy glacial terraces of this county, produced 3.33 tons an acre of pasture clippings untreated and 8.4 tons when nitrogen and phosphate were applied. Another plot yielded 1.97 tons of pasture clippings untreated and 5.67 tons when treated.

A plot of stream-bottom soil (Puget silt loam) yielded 1.5 tons of hay an acre from two cuttings without treatment, whereas with nitrogen and phosphate fertilizer, the yield was 5.06 tons. The increase was lower from any of the other combinations of fertilizers used.

Yields of sugar beets on Puget silt loam increased from 10.45 tons to 25.26 tons an acre in one plot and from 18.40 to 25.75 tons in another when a complete fertilizer consisting of nitrogen, phosphate, potash, and lime was applied to both. Of the other treatments on these plots, phosphate used alone was the most important in increasing yields.

The yield of an experimental plot of barley on Puget silt loam rose from 25 to 55 bushels an acre with nitrogen alone. Yields were high with other combinations in which nitrogen was one of the constituents, but they were not higher than with nitrogen alone.

On Puget silt loam and other associated soils of the stream bottoms there were consistent increases in potato yields after applications of phosphate and potash. This confirms the experience of farmers that tubers and root crops benefit from applications of both phosphate and potash fertilizers.

ORGANIC SOILS

On peats and mucks—organic soils—the fertilizer trials (*11*) gave widely divergent results in this and in the adjacent counties. Phosphate and potash produced significant increases in yields, but in many places one would be more limiting to plant growth than the other.

On an experimental plot of peat soil in this county, three pasture cuttings produced 3.10 tons an acre untreated but 5.39 tons when treated with complete fertilizer including lime. In another test plot about a ton less pasture cuttings was obtained where phosphorus and potash were applied than where phosphorus, potash, nitrogen, and lime were added. In another plot, the yield was almost a ton less with potash, phosphorus, and lime than it was where these three and nitrogen were used.

On still another field the yield of two pasture cuttings increased from 2.35 tons an acre to 3.34 tons when treated with phosphate and potash. Here, nitrogen and lime gave no additional increase. On a peat bog, one cutting of hay yielded 2.24 tons on the check plot and 3.38 tons each on a phosphate-and-potash plot and on one receiving complete fertilizer, including lime. A cutting of hay on another field yielded 3.02 tons an acre without treatment; 4.37 tons with addition of lime and complete fertilizer; 4.16 tons with phosphate and potash; and 3.39 tons with lime, phosphate, and potash.

In adjacent Skagit County, lime increased the yield of oats grown on peat soil from 84 to 129 bushels an acre; and where both lime and phosphate were added, the increase was from 84 to 126 bushels. The yield from applications of other combinations and of complete fertilizer including lime was somewhat less.

In Snohomish County an application of phosphate, potash, and lime increased oat production on peat from 44 to 94 bushels an acre. In another peat field in that county the yield of oats increased from 22 to 92 bushels an acre with addition of nitrogen and phosphate, and to 89 bushels with nitrogen, phosphate, and potash.

In Skagit County an untreated plot on peat soil yielded 10.39 tons of potatoes, but it yielded 14.08 tons when treated with phosphate, potash, and lime.

PRODUCTIVITY

The principal natural factors influencing productivity are climate, drainage, relief or lay of the land, and the soil itself. To these natural influences must be added the effects of management, including the use of amendments. Crop yields over a period of years are the best measure of soil productivity, and whenever available, records of yield experience are used in determining long-time average yields.

A low yield for a particular crop may be due to unfavorable relief, drainage, climate, or some other detrimental local condition rather than to lack of soil fertility. For example, the physical characteristics of the soils, especially in relation to moisture storage, are very important in this area. Erodibility is also important, especially in that it involves the depth of surface soil and content of stone and gravel.

The soils of the county are grouped in land classes according to their suitability for agriculture and assigned general productivity grades. Soils with productivity grades 1 through 7 range progressively from excellent to very poor as cropland; soils in grades 8, 9, and 10 are best suited to forestry or are useful only for that purpose. The grade numbers indicate the general productivity of the soils under prevailing improved farming practices. Improved management practices are discussed generally in the section Soil Use and Management and explained for specific soils in the section Soil Series, Types, and Phases.

In table 6 the yields to be expected on soils of this county over a period of years under common management practices are estimated for the more important crops and pastures, the suitability for forest is given in descriptive terms, and a productivity grade is assigned each soil. In these estimates, common management does not include supplemental irrigation. Where stream-bottom and upland-depression soils are subject to flooding and have poor natural drainage, yields are estimated for drained[6] and protected conditions. If undrained or unprotected, such lands have little value other than for timber or pasture.

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[6] Drained areas are not shown on the soil map.

TABLE 6.—*Estimated acre yields of crops on soils of Whatcom County, Wash., under common management practices, suitability of soils to forestry, and productivity grade.*

[Common management practices do not include supplemental irrigation. Under good management that includes skilled operation, growing selected varieties, use of properly balanced fertilizer, and possibly supplemental irrigation, yields may be as much as 100 percent greater.]

Soil	Corn silage	Oats	Wheat	Barley	Oat hay [1]	Mixed hay	Alfalfa hay	Pasture [2]	Potatoes	Canning peas	Strawberries	Raspberries	Blackberries	Forestry	Productivity grade [3]
	Tons	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*		
Barneston silt loam:															
Gently undulating	(4)	45	20	25	2.0	2.3	3.0	3.0	150	(4)	1.5	1.5	(4)	Excellent	5
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	do	8
Rolling	(4)	45	20	25	2.0	2.3	3.0	3.0	150	(4)	1.5	1.5	(4)	do	[6] 5
Barneston stony silt loam, rolling	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	do	8
Barnhardt gravelly sandy loam:															
Gently undulating	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Good	[6] 6
Rolling	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Excellent	[6] 6
Steep	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Good	9
Barnhardt gravelly silt loam:															
Rolling	(4)	45	20	25	2.0	2.0	(4)	2.8	160	(4)	1.5	1.5	(4)	Excellent	[6] 4
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	do	8
Bellingham silty clay loam	10.0	80	(4)	35	2.8	3.0	(4)	4.0	250	1.5	(4)	(4)	3.8	Fair	[7] 1½
Bow-Bellingham silty clay loams	9.0	70	(4)	30	2.5	3.0	(4)	4.0	220	(4)	(4)	(4)	3.7	do	[7] 2
Bow silt loam:															
Gravelly substratum, undulating	8.5	70	30	40	2.8	3.3	3.5	3.5	190	1.3	2.0	2.0	(4)	do	2
Undulating	8.5	70	30	40	2.8	3.3	3.5	3.5	190	1.3	2.0	2.0	(4)	do	2
Bow silty clay loam:															
Rolling	8.0	70	30	35	2.8	3.5	3.5	3.6	180	1.0	2.0	2.2	(4)	do	2
Undulating	8.0	70	30	35	2.8	3.5	3.5	3.6	180	1.0	2.0	2.2	(4)	do	2
Cagey gravelly loam, undulating	7.5	55	20	30	2.4	2.5	3.0	3.5	210	1.0	2.0	2.8	3.0	Excellent	2
Cagey-Norma complex	7.0	55	20	30	2.4	2.5	(4)	3.0	200	(4)	2.0	2.8	3.0	Good	[7] 2
Cagey sandy loam, undulating	7.5	55	20	30	2.4	2.5	3.0	3.5	200	1.0	2.0	2.5	3.0	do	2
Cagey silt loam:															
Sloping	8.0	60	20	35	2.5	2.8	3.5	3.8	250	1.4	2.0	3.0	3.5	Excellent	2
Undulating	8.0	60	20	35	2.5	2.8	3.5	4.0	230	1.4	2.0	3.0	3.5	do	2
Carbondale muck	10.0	90	(4)	45	3.0	3.5	(4)	5.0	300	1.8	(4)	(4)	5.0	Poor	[7] 1
Shallow	10.0	85	(4)	40	3.0	3.5	(4)	5.0	300	1.8	(4)	(4)	5.0	do	[7] 1
Cathcart loam:															
Hilly	7.0	60	20	30	2.5	2.8	3.2	3.5	150	1.0	2.0	2.6	(4)	Good	8
Rolling	8.0	70	25	35	2.5	3.0	3.5	4.0	200	1.2	2.5	3.0	3.5	do	[6] 2
Clipper silty clay loam	8.5	80	25	40	2.8	3.2	4.0	4.0	200	1.3	2.0	2.8	3.3	Fair	[7] 1½
Coastal beach	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	Usually barren	10
Custer sandy loam	8.0	60	20	30	2.3	2.6	(4)	3.5	200	1.0	2.5	(4)	3.0	Fair	[7] 2
Custer silt loam	8.5	70	20	35	2.5	2.8	(4)	4.0	220	1.4	2.5	(4)	3.3	Good	2
Edmonds silt loam	9.0	80	(4)	35	3.0	3.2	(4)	4.5	230	1.2	2.5	(4)	3.8	do	[7] 1½
Edmonds-Tromp silt loams	9.0	80	(4)	35	3.0	3.2	(4)	4.5	230	1.2	2.5	(4)	3.8	Fair	[7] 1½
Everson silt loam	10.0	85	(4)	35	3.0	3.3	(4)	4.5	200	1.2	(4)	(4)	3.3	do	[7] 1½
Fresh-water marsh	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)	Poor	10

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Giles loam:															
Gently undulating	8.0	60	30	35	2.6	2.8	3.0	3.5	225	1.2	3.0	3.5	3.8	Excellent	2
Moderately steep	7.0	50	25	30	2.5	2.7	2.8	3.0	200	1.0	2.8	3.0	[4]	do	8
Rolling	8.0	60	30	35	2.6	2.8	3.0	3.5	225	1.2	3.0	3.5	3.5	do	2
Giles silt loam:															
Gently undulating	8.5	70	30	40	2.8	3.0	3.2	4.0	250	1.3	3.5	4.0	4.2	do	2
Gravelly subsoil, gently undulating	8.0	70	30	40	2.8	3.0	3.2	4.0	250	1.2	3.5	3.5	4.0	do	2
Moderately steep	7.0	65	25	35	2.5	2.8	3.0	3.5	210	1.0	3.0	3.0	[4]	do	8
Giles-Tromp complex	7.5	65	28	30	2.8	3.0	3.0	4.0	225	1.0	3.0	3.0	4.0	Good	2
Greenwood peat	[10]	[10]	[10]	[10]	[10]	[10]	[10]	[10]	[10]	[10]	[10]	[10]	[10]	Poor	10
Hale-Norma complex	8.0	60	25	35	2.7	2.8	[4]	3.5	[4]	[4]	2.0	2.8	3.5	Fair	[7]2
Hale silt loam:															
Gently sloping	8.0	60	25	35	2.7	2.8	3.3	3.5	220	1.3	2.0	3.0	3.5	Good	2
Moderately steep	[4]	50	20	30	2.5	2.5	3.0	3.2	[4]	[4]	2.0	2.8	3.2	do	8
Heisler shaly loam:															
Hilly	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	do	8
Rolling	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	do	[6]7
Hemmi silt loam	8.5	70	30	40	3.0	3.4	[4]	4.0	230	1.2	2.5	3.0	3.5	Poor	2
Hovde silty clay loam	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	Good	7
Indianola fine sandy loam, rolling	7.0	60	20	30	2.5	2.5	3.0	3.0	180	[4]	2.0	3.2	[4]	do	3
Indianola loamy fine sand, rolling	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	do	7
Indianola silt loam, undulating	7.5	70	30	40	2.8	3.0	3.3	3.5	200	[4]	2.5	3.5	[4]	Excellent	[6]3
Kickerville silt loam:															
Hilly	[4]	55	22	28	2.2	2.5	3.0	3.5	[4]	[4]	2.0	2.3	[4]	Good	8
Rolling	6.5	60	25	30	2.2	2.5	3.0	3.5	180	[4]	2.0	2.3	[4]	do	[6]3
Steep	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	do	9
Undulating	6.5	60	30	40	2.2	2.5	3.0	3.5	200	[4]	2.0	2.5	[4]	do	3
Kline gravelly loam	6.0	50	20	25	2.5	2.0	[4]	3.0	180	[4]	2.0	2.3	[4]	do	[6]4
Kline loam	6.0	55	25	30	2.8	2.5	[4]	3.0	190	[4]	2.0	2.3	[4]	do	[6]3
Labounty-McKenna complex	8.0	70	[4]	40	2.7	3.0	[4]	4.0	200	[4]	[4]	[4]	3.0	Fair	[7]2
Labounty silt loam:															
Moderately steep	[4]	60	25	35	2.7	2.9	[4]	4.0	[4]	[4]	2.0	[4]	[4]	do	8
Sloping	8.0	70	30	40	2.7	3.0	[4]	4.0	[4]	1.0	2.0	[4]	[4]	do	2
Undulating	8.0	70	30	40	2.7	3.0	[4]	4.0	200	1.1	2.0	[4]	3.0	do	2
Lummi silty clay loam	8.5	80	[4]	40	3.0	3.0	[4]	4.0	[4]	[4]	[4]	[4]	[4]	Poor	[7]2
Lynden gravelly sandy loam:															
Rolling	[4]	45	12	20	2.4	2.5	2.7	3.0	150	[4]	[4]	2.0	[4]	Fair	[6]6
Undulating	5.0	45	12	20	2.4	2.5	2.8	3.0	150	[4]	2.0	2.0	[4]	do	[6]6
Lynden sandy loam:															
Moderately steep	[4]	45	12	20	2.2	2.3	2.8	2.8	[4]	[4]	1.8	1.8	[4]	do	8
Rolling	[4]	45	12	20	2.2	2.4	2.8	2.8	[4]	[4]	1.8	1.8	[4]	Poor	[6]6
Undulating	5.5	50	12	20	2.4	2.5	3.0	3.0	150	[4]	2.0	2.0	[4]	Fair	[6]4
McKenna silty clay loam	7.5	70	20	35	3.0	3.2	[4]	4.0	200	1.0	[4]	[4]	3.2	do	[7]1½
Made land	[9]	[9]	[9]	[9]	[9]	[9]	[9]	[9]	[9]	[9]	[9]	[9]	[9]	Poor	10
Mukilteo peat	[4]	70	[4]	30	2.5	2.8	[4]	4.0	[4]	[4]	[4]	[4]	2.7	do	[7]2
Shallow	[4]	65	[4]	30	2.5	2.8	[4]	4.0	[4]	[4]	[4]	[4]	2.6	do	[7]2
Neptune gravelly sandy loam	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	--------	Good	7
Nooksack fine sandy loam	11.0	85	25	40	3.5	3.5	3.7	5.0	300	2.0	3.0	5.0	5.0	do	[7]1
Nooksack silt loam	12.0	90	30	45	3.5	3.5	3.8	5.5	300	2.0	3.0	5.0	5.0	do	[7]1
High bottom	11.0	85	30	40	3.5	3.5	3.8	5.0	280	1.8	3.0	5.0	5.0	Excellent	1

See footnotes at end of table.

TABLE 6.—*Estimated acre yields of crops on soils of Whatcom County, Wash., under common management practices, suitability of soils to forestry, and productivity grade*—Continued

Soil	Corn silage	Oats	Wheat	Barley	Oat hay [1]	Mixed hay	Alfalfa hay	Pasture [2]	Potatoes	Canning peas	Strawberries	Raspberries	Blackberries	Forestry	Productivity grade [3]
	Tons	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*		
Norma-Cagey complex	8.0	70	(4)	30	3.0	3.0	(4)	4.0	(4)	1.2	(4)	(4)	3.0	Excellent	[7] 2
Norma-Hale complex	8.0	70	(4)	30	3.0	3.0	(4)	4.0	(4)	1.2	(4)	(4)	3.5	do	[7] 2
Norma silty clay loam	8.5	70	(4)	30	3.3	3.5	(4)	4.5	(4)	1.2	(4)	(4)	3.0	Fair	[7] 1½
Pilchuck fine sandy loam	9.0	70	20	30	3.3	3.5	(4)	4.0	180	1.1	2.0	3.0	3.0	Good	4
Pilchuck gravelly loamy sand	(4)	(4)	(4)	(4)	(4)	1.2	(4)	1.5	(4)	(4)	(4)	(4)	(4)	do	[6] 7
Puget silt loam	10.0	80	35	40	3.8	3.6	(4)	4.5	250	1.8	(4)	(4)	5.0	Fair	[7] 2
Puget silty clay loam	10.0	80	30	40	3.8	3.8	(4)	4.5	240	1.7	(4)	(4)	5.0	Good	[7] 2
Puyallup fine sandy loam	11.0	80	25	40	3.8	3.8	(4)	4.5	250	1.5	2.5	3.7	3.8	do	[7] 1
Puyallup loamy fine sand	9.0	70	22	30	3.3	3.0	(4)	4.0	200	1.0	2.0	3.0	3.2	do	2
Puyallup silt loam	12.0	95	40	45	4.5	4.2	(4)	5.0	250	1.6	3.0	4.0	4.0	do	[7] 1
Puyallup very fine sandy loam	11.5	85	35	40	4.0	4.0	(4)	4.5	250	1.5	2.5	3.7	3.7	do	1
Rifle peat	11.0	90	(4)	40	3.0	3.0	(4)	4.5	220	1.6	(4)	(4)	5.0	Fair	[7] 1
Shallow	11.0	85	(4)	40	3.0	3.0	(4)	4.5	210	1.6	(4)	(4)	5.0	do	[7] 1½
Rifle peat-Bellingham complex	10.0	80	(4)	35	2.8	2.8	(4)	4.0	210	1.5	(4)	(4)	5.0	do	[7] 2
Riverwash	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	Poor	10
Rough mountainous land	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	Good	10
Rough stony land	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	do	10
Salal silt loam	7.5	80	25	35	3.0	3.3	3.8	4.0	190	1.1	2.0	2.3	2.5	Fair	2
Saxon silt loam:															
Moderately steep	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)	Excellent	9
Rolling	7.5	80	30	40	2.8	3.3	3.5	4.0	200	1.3	2.0	3.0	4.0	do	2
Schnorbush loam:															
Hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	do	8
Rolling	(4)	50	20	30	2.2	2.5	(4)	3.0	(4)	(4)	2.0	2.3	2.5	do	[6] 3
Schnorbush-Norma complex	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	Good	7
Semiahmoo muck	(4)	70	(4)	30	2.5	2.8	(4)	4.5	160	(4)	(4)	(4)	3.0	Poor	[7] 1½
Shallow	(4)	70	(4)	30	2.5	3.0	(4)	4.5	160	(4)	(4)	(4)	3.0	do	[7] 1½
Skagit silty clay loam	8.5	80	25	40	2.8	3.2	4.0	4.0	200	2.0	2.0	2.0	2.3	Good	[7] 1½
Smith Creek gravelly loam:															
Gently sloping	(4)	50	20	25	2.0	2.3	2.5	2.5	150	(4)	1.5	(4)	(4)	do	[6] 4
Steep	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	do	9
Snohomish silty clay loam	10.0	90	30	40	3.5	3.5	(4)	5.0	240	1.8	(4)	(4)	4.5	Fair	[7] 2
Squalicum and Alderwood silt loams:															
Hilly	(4)	40	15	20	1.8	2.0	3.0	3.0	(4)	(4)	2.0	2.3	(4)	Good	8
Rolling	(4)	40	15	20	1.8	2.0	3.0	3.0	(4)	(4)	2.0	2.3	(4)	do	[6] 3
Squalicum and Alderwood stony silt loams, hilly	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	do	8
Squalicum silt loam:															
Hilly	(4)	45	15	25	1.8	2.0	3.0	3.0	120	(4)	2.0	2.3	(4)	do	8
Rolling	(4)	50	18	28	2.0	2.3	3.5	3.0	125	(4)	2.0	2.3	(4)	do	[6] 2
Steep	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	do	9

Squalicum stony silt loam:															
Hilly	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	do	9
Rolling	[4]	45	15	25	1.8	2.0	3.3	3.0	[4]	[4]	2.0	2.3	[4]	do	8
Sumas fine sandy loam	9.5	75	[4]	35	3.0	3.0	[4]	4.0	250	1.5	[4]	2.5	4.5	Fair	[7] 1½
Sumas silt loam	10.0	80	[4]	40	3.5	3.6	[4]	4.5	250	1.8	[4]	[4]	5.0	do	[7] 1½
Sumas silty clay loam	10.0	80	[4]	40	3.5	3.6	[4]	4.5	250	1.8	[4]	[4]	4.5	do	[7] 2
Tidal marsh	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	[5]	Poor	10
Tromp-Custer silt loams	8.0	70	25	35	3.2	3.0	[4]	4.0	240	1.1	2.0	3.0	4.0	Fair	[7] 2
Tromp-Edmonds silt loams	8.5	75	25	40	3.2	3.3	[4]	4.0	250	1.2	2.0	3.0	4.0	do	[7] 2
Tromp silt loam	8.0	65	25	40	3.5	3.4	[4]	4.0	250	1.2	2.5	3.0	3.5	do	2
Tromp silty clay loam	8.0	65	25	40	3.3	3.4	[4]	4.0	220	1.2	2.3	2.8	3.2	do	2
Tromp-Woodlyn silt loams	8.0	65	[4]	35	3.0	3.2	[4]	4.0	230	1.1	2.2	2.5	3.0	do	[7] 2
Whatcom-McKenna complex	7.0	60	20	35	2.5	2.8	3.5	3.6	[4]	[4]	[4]	[4]	[4]	do	[7] 3
Whatcom silt loam:															
Hilly	[4]	50	20	30	2.3	2.5	3.5	3.5	[4]	[4]	[4]	[4]	[4]	Good	8
Hummocky	7.0	55	25	35	2.5	2.6	4.0	3.8	200	1.2	2.0	2.3	2.5	do	[6] 4
Steep	[4]	[4]	[4]	[4]	[4]	2.2	3.5	3.5	[4]	[4]	[4]	[4]	[4]	do	9
Undulating	7.0	55	25	35	2.5	2.6	4.0	4.0	200	1.2	2.0	2.3	2.5	do	[6] 2
Wickersham shaly loam	6.0	50	20	25	2.0	2.0	[4]	3.0	[4]	[4]	1.8	2.0	[4]	do	[6] 3
Woodlyn silt loam	8.5	75	[4]	35	3.0	3.5	[4]	4.5	200	1.2	2.0	2.3	2.5	Fair	[7] 1½

[1] Usually a mixture of oats and an annual legume.
[2] Air-dry weight; equivalent to hay.
[3] Grade 1 soils are excellent cropland; grade 1½, very good cropland; grade 2, good cropland; grade 3, fairly good cropland; grade 4, fair cropland; grades 5 and 6, poor cropland; grade 7, very poor cropland; grades 8 and 9, land dominantly best suited to forestry, and grade 10, land best suited to forestry.
[4] Not well suited to the crop specified.
[5] Not in general agricultural use.
[6] Productivity is rated for the better areas and varies because of topography, drainage, texture, content of gravel and stone, or other characteristics.
[7] Productivity is rated for drained areas.
[8] Not in agricultural use.
[9] Not adapted to agricultural use.
[10] Not adapted to general farm crops; suitable for cranberries and blueberries if properly handled.

Higher yields than those given in table 6 could be expected under management practices better than the ordinary (or common) management assumed in making the estimates. Better management practices on the light-colored soils of the uplands and terraces include principally the adequate use of superphosphate and manure and the growing of legumes in suitable crop rotations. On the darker soils and peaty soils of the stream valleys and upland depressions, better management practices are varied, but they include rotation and fertilization for general farm crops and heavy applications of manure and complete fertilizer for truck crops.

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

ENVIRONMENT AND CHARACTERISTICS OF THE SOILS

The environment and characteristics of the soils of Whatcom County are extremely varied because the glacial deposits are of complex origin and composition, rock formations are diverse, relief is uneven, drainage varies widely, climate is varied, and native vegetation differs from place to place.

The counuty borders on Georgia Strait and Puget Sound, and a large part of the area surveyed lies within the Puget Sound Basin (*2*). The rest of the area, to the east, lies on the westward slope of the Cascade Mountains, the crests of which mark the eastern boundary of the county. Outlying mountain spurs and foothills occur within the basin and rise rapidly eastward to the crest of the range. The pronounced and varied relief has a marked influence on climate, vegetation, and soils.

The climate along the coast is maritime, but in the higher interior it is of a significantly modified continental type. Winds from the Pacific Ocean bring the characteristics of an oceanic climate to the lower basin and strongly modify climate in the mountainous area. The mean annual precipitation ranges from about 31 inches along the coast to more than 100 inches at the higher elevations. The summers are dry; about 70 percent of the precipitation occurs between the first of October and the last of March. The relative humidity averages about 80 percent much of the year but may drop to nearly 50 percent on dry afternoons in summer.

Snow is common in the lower basin region but remains only a short time. At higher elevations, however, snow accumulates and stays on the ground several months. The ground probably is frozen for extended periods at the higher elevations, but in the lower basin region it is only occasionally frozen deeper than the surface crust.

Because relief is extremely uneven, the mean annual temperature varies, the range being from about 50° F. near the coast to 48° or less in the low flats of the basin region and in the higher mountain areas. Near the coast the average January temperature is about 36° and the average July temperature is about 61°. The higher mountains have an average January temperature of about 34° or less, and the July temperature is about 64° or higher.

The native vegetation under which the soils developed was dominantly coniferous, with a ground cover of ferns and mosses and deciduous trees and shrubs in more open areas. Deciduous trees and brush were more in evidence in the stream valleys and depressions. Marshy flats supported sedges, reeds, and other water-loving vegetation, including mosses. The vegetative cover has been significantly modified on logged lands; deciduous trees have increased and in many places are dominant.

In most of western Washington the dominant soil-forming processes on the well-drained sites are greatly influenced by temperature, especially that in winter. Soils in areas where the average winter temperature is less than about 32° or 33° F. are detectably different from those in areas having winter temperatures of 35° to 40°. The well-drained soils developed near the coast under the milder maritime climate have characteristics similar in some respects to lateritic soils, especially in regard to structure and water-stable aggregates; whereas those inland are influenced by a continental climate and have characteristics of the Podzols.

In the eastern part of this county well-developed distinct Podzols have a distinguishable thin (½ to 2 inches) gray A_2 layer beneath a 2- or 3-inch organic layer. The ortstein layer is very weak or absent, except in unusually favorable sites. Some iron or manganese concretions are noticeable in the layer beneath the gray leached one.

In the western part of the county the soils have characteristics very similar to the Brown Podzolic soils (*10*) of New England. The outstanding difference is their content of iron concretions, or shot. Except for the shot, the Gloucester soils in New England and the Barneston soils of this county are very similar in the upper part of the profile. Probably the two are near enough alike to be included within the same great soil group—the Brown Podzolic. More careful examination and chemical analysis may show, however, that soils of these two widely separated areas should not be in the same great soil group, and therefore the Brown Podzolic soil group is only suggested for the soils in this area.

In the western part of this county the soils appear to be in a zone transitional between the Brown Podzolic and the fairly distinct lateritic soils of western Clallam, Jefferson, and Grays Harbor Counties. The lateritic soils of those counties have tentatively been called "brown lateritic" soils, and corresponding ones in the western part of this county have tentatively been called "brown lateriticlike" because they have some characteristics of both the Brown Podzolic and the "brown lateritic" soils.

Parent materials largely determine some of the outstanding characteristics of the soil series, and apparently they have not been greatly modified by soil-forming forces. The parent materials of the nonagricultural undifferentiated mountain areas differ from the deep glacial deposits of variable texture and heterogeneous lithological composition from which many of the agricultural soils have formed. The silty texture of many of surface soils in the agricultural area suggests that considerable wind-borne loess was laid down during or following the glacial period. The deepest loesslike deposits are adjacent to marine deltas, which would be the most prolific source of such materials. The texture of the parent materials and the manner in which they were laid determine to a considerable extent the physical characteristics of the soils—their porosity, permeability, drainage, and water-holding capacity.

The glacial materials were deposited by at least two continental glaciers, the Admiralty and the Vashon, the latter probably of Wisconsin age (*1*). Between these glaciations occurred a period of uplift during which the glacial deposits were deeply eroded; and following the uplift and erosion, the land was lowered. Though the drift deposits indicate that the oscillating Vashon glacier readvanced many times, the accumulated ground moraine and glacial outwash are thinly laid over the deeply eroded relief features of the interglacial period. Because these outwash and moraine accumulations are thin, the major glacial land features and valley drainage pattern conform largely to the interglacial relief, which in the more mountainous sections may have become well established in preglacial time.

In places bordering the basin region, Vashon glacial deposits and, to a small extent, alpine glacial deposits, thinly covered glacially scoured Eocene (coal bearing), Mesozoic, and Paleozoic (*2*) sedimentary strata. In places these sedimentary strata influence a few of the soils. Much of the western half of the mountainous part of the area surveyed—that part where the soils are undifferentiated—is underlain by yellowish-gray shale and sandstone of the Eocene epoch. Along the national forest boundary in the eastern part of this mountainous area the soils are underlain by dark bluish-gray hard argillites and schists of Mesozoic and Paleozoic age. There are, however, exceptions to this. On Sumas, Black, and Twin Sisters Mountains (in the unsurveyed area) there are inextensive areas of soils high in bases that are derived from basic volcanic rocks (*2*).

The heavy clay till of the low drift-filled basin appears youthful and differs from the older more sandy drift occurring in the whole Puget Sound Basin south of the extensive Cascade Mountain spur at Bellingham and elsewhere in the county. The youthfulness of this clay till and the presence of intact recent marine shells suggest that a later glacier advanced or that the late Vashon glacier readvanced into marine deposits. Geologists (*1*) ascribe this clay till to the late Vashon, and they suggest that the extensive outwash plains indicate that the glacier stood for a long time in this basin. Marine strata and beach ridges on the outwash plain also show that marine waters invaded closely behind the retreating ice or moved back and forth with an oscillating glacier.

The older sandy glacial deposits south of Bellingham and elsewhere in the county occur on higher ground than the clayey compact but uncemented more youthful till; in contrast, they are compacted and partly silica-cemented. Possibly the sandy glacial deposits have this indurated character because they are older and because they were submerged for a long time in both marine and glacial lake waters. Another possible reason for the induration is that they were buried under stagnant ice during crustal movements occurring in the Pleistocene glacial period.

Characteristically, the higher older glacial deposits are bluish gray and contain varying quantities of rounded rock fragments resembling stream cobbles and pebbles. In most places boulders are not massed but abundantly scattered throughout the deposits, especially in the clayey till. These rock materials are derived largely from granite, quartzite, shale, and argillite, and lesser quantities of gneiss, schist, basalt, and andesite.

The compact clayey or indurated nature of these older till deposits has retarded internal drainage and normal soil development over large areas that have relief favorable to normal development. Gravel and sand mantle the till deposits to varying depths in some areas. On the morainic relief where these gravel or sand deposits are deep and internal water movement is relatively free, soils normal to the region have developed, but hydromorphic or intrazonal soils have formed where the gravel or sand deposits are thin, especially on the smooth or depressional areas.

In the lower basin region, where most of the agricultural soils occur, relief and drainage features were established during the late glacial period. About half of this region consists of alluvial flats and low smooth glaciofluvial and postglacial or marine terraces. In this area the Nooksack River has a low gradient and does not promote effective drainage of either the recent alluvium or of the older alluvial and glacial deposits laid down on a floor of clay till or clayey marine strata. The rest of the lower basin consists of a low rolling somewhat mantled clay ground moraine marked with prominent frontal and recessional moraines of stronger relief. On this morainic part, channels have not developed enough to establish good surface drainage. Because of unfavorable conditions in both parts, the lower basin has a pattern of poor, imperfect, and moderate drainage that transcends in complexity the involved physical make-up of the soil materials. As a result a very intricate and highly diversified soil pattern has formed.

Examination of the better drained more normally developed soils indicates that the podzolization process has not been sufficiently strong or has not operated long enough to modify the parent material significantly. The soils have formed under a dominantly coniferous vegetation, characteristically have a moderate content of organic matter, and are brown and acid. The forest litter is comparatively high in bases, decomposes slowly, and mixes but little with the soil material. This partly decomposed or humified organic mat is thin over the mineral soil, though it is thicker at higher elevations where there is more rainfall and cooler temperature. Considering the heavy dense forest cover, the organic mat seems surprisingly thin.

The acid organic matter probably tends to become neutralized during the protracted dry season in summer. The reaction of the mat is strongly acid at the lower elevations, though rarely more acid than pH 5. Toward higher elevations acidity of the mat increases. Observations in the mountain region indicate that a pH value below 5 is common, though one less than pH 4 seldom occurs.

In soils of the lower basin region leaching apparently ceases during the dry summers, and there is, instead, a reverse or upward movement of moisture. The rising moisture may carry bases up with it, and these precipitate and tend to neutralize the more effective deep leaching. Wheeting (*12*) attributes the occurrence of iron shot pellets in the soils of the lower basin to this dry period, during which strong precipitation and dehydration of iron and aluminum compounds take place at such focal points as sand grains, gravel, or other nuclei. At higher elevations, where the more acid Podzol soils occur under a cooler temperature and higher rainfall, these shot pellets decrease in number or disappear. The high shot content suggests that the Brown Podzolic soils are not continuously leached nor sufficiently acid to promote uniform movement and precipitation of sesquioxides or organic colloids in a definite zone; instead an imperfect B horizon of scattered shot pellets forms. The pellets cannot be attributed to imperfect drainage, inasmuch as they occur also in the droughty excessively drained soils. Their occurrence is to a certain extent correlated with moisture, however, because the pellets are appreciably more densely massed in soils of slow or restricted drainage.

The silica-sesquioxide ratio of Bonner silt loam, a shot soil (*12*) of Bonner County, Idaho (*7*), has a development rather similar to that of the Brown Podzolic soils in Whatcom County. Under the organic mat of Bonner silt loam is a very thin incipient A_2 layer underlain by two horizons in which the shot pellets are concentrated. The segregation of silica and sesquioxides is suggested by analyses made of the whole soil but more strongly indicated by those made of the colloid. This trend of development is probably more strongly impressed in the shot soils of the glaciated Puget Sound region than in the Bonner soils.

CLASSIFICATION OF THE SOILS BY HIGHER CATEGORIES[6a]

A number of the important soil groups are well represented by one or more soil series in this county. In the following pages they are discussed according to the three soil orders: (1) Zonal—including the Brown Podzolic, Podzol, and Prairie soils; (2) intrazonal—including Wiesenboden, "wiesenbodenlike," Ground-Water Podzol, "ground-water podzolic," Planosol, Bog, Half Bog, and Rendzina soils; and (3) azonal—including the well to moderately well drained and poorly drained Alluvial soils.

Study of many of the soil groups has not been sufficient to indicate definitely that the members belong distinctly to one great soil group and not another. Some of the soils now listed under one group may be changed at some later time to another, or a new soil group name may be given to them. In this report classification of the soils into great groups is tentative and subject to change. Many of the soil groups

[6a] In general, classification follows scheme presented in 1938 Yearbook of Agriculture (*10*).

exist in complex patterns, and there are transitional soils that have some characteristics of those in two or more groups. The Barneston soils, for example, have some characteristics of both the Brown Podzolic soils and the Podzols. In such instances the soil series is placed in the group it most nearly fits, and in its description, reference is made to the other soil group it resembles.

ZONAL SOILS

Soils of the zonal order are those that reflect in their development chiefly the influence of climate and vegetation. In this county, three great soil groups of the zonal order are represented—Brown Podzolic, Podzol, and Prairie soils.

BROWN PODZOLIC SOILS

Considered as belonging to the Brown Podzolic group are those soils occurring in the part of the Puget Sound Basin below an altitude of about 1,000 feet and having a probable rainfall of 31 to 60 inches, an average annual winter temperature of about 34° to 36° F., and an average annual summer temperature of about 61° to 63°. In this area summers are relatively dry, and fall and winter are wet. The Kickerville, Cathcart, Giles, Indianola, Saxon, Schnorbush, Smith Creek, Squalicum, Whatcom, Barneston, and Lynden are soils of this county in the Brown Podzolic group. The Lynden and Barneston differ from the others in some profile characteristics, the Barneston tending toward the profile of the Podzols and the Lynden toward that of "ground-water podzolic soils."

Brown Podzolic soils have several well-defined characteristics when developed from open permeable materials on smooth relief under good external and internal drainage. Following is the kind of profile typical in a large part of western Washington where precipitation and temperature range within the limits just defined:

1. Dark grayish-brown [7] (10YR 3/2) [8] or very dark-brown (10YR 2/2) friable, loose, very strongly acid organic layer 2 to 3 inches thick.
2. Brown (10YR 5/3) coarse granular or fine nuciform, medium-textured, very permeable layer of water-stable aggregates abruptly replaces layer above; about 10 inches thick; shows a very noticeable color change between dry and moist clods; does not expand or contract greatly at extremes of moisture; readily penetrated by water and air; dark brown (7.5YR 3/2) or dark reddish brown (5YR 3/2) when moist; many iron shot pellets ranging from the size of small peas to sand grains are scattered throughout but are more concentrated in the upper part; pH, about 5.5.
3. Pale-brown (10YR 6/3) faintly granular fairly permeable layer 20 to 26 inches thick and similar in texture and acidity to the one immediately above.
4. Light yellowish-brown (10YR 6/4) or light gray (10YR 7/2) parent material very slightly less acid than layers above except in places where it is dense, compact, or semi-indurated; in such places water penetration is prevented and the pH may be 6.0 or above; some areas are calcareous.

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[7] Soil color names used are provisional names proposed by the 1946 committee on soil color. Unless otherwise stated, color is of dry soil.

[8] Symbols express Munsell color notations.

There is little or no evidence of a zone of clay accumulation in the profile but the layer immediately below the organic mat is apparently the zone of iron enrichment.

The line marking the upper limits of the Brown Podzolic and the lower limits of the more strongly podzolic, or Podzol, soils of the mountains is arbitrary and ill-defined because of the extremely irregular relief and the associated variation in effective moisture. Even on isolated high moraines within the lower basin region the Podzol character of the higher lying soils is impressed, and this shows also in places on the well-drained sites. Because of the climatic belts, even the Brown Podzolic soils within the lower basin region differ somewhat in the western and eastern parts. Furthermore, the variable local microrelief and restricting underlying strata have profound influence on the degree of drainage and soil development.

The Kickerville soils, extensive and typical of the Brown Podzolic soils of northwestern Washington, are well drained and have developed from a gravelly mantle 8 to 12 feet or more thick overlying tight clay till similar to that of the Whatcom soils. This till retards free downward percolation of moisture and creates a saturated condition, which in turn promotes rusty-iron discoloration and some slight localized cementation of the materials just above. The upper part of the profile is well drained and has received full impression of the soil-forming processes that have taken place in western Washington. A very youthful expression of the podzolization process is evident, whereas the laterization process is not nearly so evident as in the Hoquiam and the Hoko series of western Washington.

Profile of Kickerville silt loam soil collected in a virgin area in the western part of this county:

1½ to 0 inches, dark grayish-brown (10YR 3/2) loose organic mat; pH, 5.

0 to 10 inches, brown (10YR 5/3) fine granular or nuciform permeable silt loam; brown (7.5YR 4/4) or dark reddish brown (5YR 3/4) and friable when moist; granules and aggregates stable in water and very slightly plastic; layer contains many firm to hard shot pellets ranging from the size of sand grains to small peas; pH, 5.4.

10 to 20 inches, pale-brown (10YR 6/3) slightly compact gravelly loam; brown (7.5YR 4/4) and friable when moist; pH, 5.

20 to 30 inches, very pale-brown (10YR 7/3) gravelly loam; grayish brown (10YR 5/2) and friable when moist; pH, 5.5.

30 inches to 12 feet, very pale-brown (10YR 7/3) loose sand and gravel; pH, 5.5.

12 feet +, gray (10YR 6/1) dense semicompact calcareous stony clay till; olive gray (5YR 4/2) and slightly plastic when wet.

The other zonal soils of the Brown Podzolic group have profiles very similar to the Kickerville, though each series differs from the others in some morphological characteristics that can be detected in examination and mapping in the field. Some of these differences are mentioned in the following paragraphs.

The Cathcart series includes shallow soils developed over bedrock of sandstone and shale. They formed from glacially scarred consolidated sandstone, and though they typically contain little or no glacial gravel, a considerable area having a thin glacial mantle is included in mapping because separation of the complexly associated areas was too difficult. Cathcart soils occur on low elongated glacially scarred ridges bordering the lower basin area.

Soils of the Giles series have developed on terraces from younger glacial or postglacial outwash that has been covered with a thin loesslike mantle. Although somewhat youthful, the soils have a fairly well developed solum approaching that typical of the more mature members of the Brown Podzolic group. They are associated with the Lynden in the smoother more nearly level places where finer silty or clayey sediments overlie sandier strata. Shot pellets are more plentiful than in the Lynden soils, and the lower part of the heavier layers may be marked by faint iron staining. As in the Lynden, shallow ground water may form some rusty-iron stains in the sandier layers.

The Indianola soils are derived from a sandy mantle over clay till and in morphological characteristics, differ but little from the Kickerville soils, which are derived from glacial drift. Indianola soils occur in kamelike deposits and eskers. There is a scattering of gravel in places and boulders occur infrequently.

The Saxon soils, bright yellowish brown throughout, are underlain by and deeply developed from stratified or laminated marine-delta and lacustrine deposits. They are somewhat immature or less perfectly developed zonal soils, partly because their materials were laid down at a later period and also because their lower subsoil is slowly permeable.

The Schnorbush soils have developed from sandstone till in which huge angular rubblelike boulders are embedded. Their strongly rolling morainic or knobby relief conforms to the sandstone till, and kettle holes are common. Talus rubble and local glaciation may have contributed considerably to the stony unassorted character of the till. The soil materials are more highly decomposed and plastic than the Cathcart, and internal moisture movement is slower. Clay lenses also retard moisture movement somewhat, and consequently, the soils are more drab and iron-stained than the Cathcart.

Soils of the Smith Creek series are inextensive and have open porous gravelly subsoil. They are developed on low-lying, smooth, nearly level gravelly postglacial stream terraces and have profiles very similar to the Kickerville, though they are looser, more gravelly, and very droughty. In many respects Smith Creek soils are very similar to the Everett soils occurring in a number of counties of western Washington.

Soils of the Squalicum series occur on high moraines in the foothill and mountain tracts where only thin areas of very compact or softly cemented older Vashon drift remain. They have developed on gravel-like till somewhat similar to that underlying the Whatcom soils. The till of these soils has a gravelly light sandy clay texture; that of the Whatcom is gravelly silty clay. Squalicum soils are very closely associated with the Alderwood; and in fact, Alderwood soils of this county are mapped only in association with them. Alderwood soils have a till of gravelly loam texture. Apparently a thin loesslike mantle lies upon the Squalicum soils and upon the Whatcom and Alderwood as well.

As indicated in table 7, there are significant chemical differences among Squalicum, Alderwood, and Whatcom soils. Mechanical analyses of Squalicum, Alderwood, and Whatcom silt loams are included with those of McKenna and Bellingham silty clay loams in table 8.

TABLE 7.—*Base exchange data on three soil types of Whatcom County, Wash.*

Soil type and sample No.	Depth	Clay	Hydrogen (me. per 100 g.)[1]	Calcium (me. per 100 g.)[1]	Magnesium (me. per 100 g.)[1]	Base saturation	pH
	Inches	*Percent*				*Percent*	
Whatcom silt loam:							
5525260	1½– 0	----------	74. 7	25. 0	3. 9	27. 9	----------
5525261	0 –10	3. 8	16. 9	2. 4	. 8	15. 9	5. 7
5525263	20 –28	10. 4	4. 8	2. 9	2. 2	51. 5	6. 0
5525265	36 –50	30. 8	3. 8	10. 6	9. 4	84. 0	7. 1
Alderwood silt loam:							
5525267	2 – 0	----------	44. 0	19. 3	4. 7	35. 3	----------
5525268	0 – 8	7. 5	11. 6	4. 0	. 6	28. 4	5. 9
5525270	18 –24	7. 3	9. 1	. 9	. 3	11. 6	5. 5
5525272	30 –36	10. 9	6. 9	2. 5	. 8	32. 4	5. 4
Squalicum silt loam:							
5525278	2 – 0	----------	27. 2	15. 7	4. 8	43. 0	----------
5525279	0 –12	12. 9	13. 4	1. 6	. 7	14. 6	5. 4
5525280	12 –24	12. 8	17. 1	1. 8	. 5	11. 9	5. 6
5525282	30 –40	23. 3	7. 5	3. 8	5. 1	54. 3	5. 6

[1] Milliequivalents per 100 grams oven-dry soil.

TABLE 8.—*Mechanical analyses of several soil types in Whatcom County, Wash.*

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Organic matter [1]	pH
McKenna silty clay loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
552502	0 – 6	0	0. 1	0. 2	3. 2	6. 7	50. 6	39. 2	14. 8	5. 3
552503	6 –12	. 1	. 2	. 3	4. 1	7. 1	45. 7	42. 5	6. 3	5. 3
552504	12 –30	. 3	1. 0	2. 0	18. 5	21. 8	35. 6	20. 8	. 1	6. 2
552505	30 –72+	0	. 3	. 5	4. 2	11. 2	47. 3	36. 5	0	6. 6
Bellingham silty clay loam:										
552548	0 – 9	0	. 1	. 5	8. 1	9. 7	51. 6	30. 0	8. 7	5. 0
552549	9 –18	. 3	. 5	1. 2	6. 8	5. 1	52. 9	33. 2	3. 1	5. 5
552550	18 –40	. 1	. 3	1. 1	6. 8	8. 8	50. 5	32. 4	. 1	6. 6
552551	40 –72+	. 1	. 3	. 8	4. 5	7. 2	53. 2	33. 9	0	6. 7
Whatcom silt loam:										
5525261	0 –10	. 2	. 4	. 6	2. 0	7. 6	85. 4	3. 8	3. 9	5. 7
5525262	10 –20	0	. 2	. 3	1. 2	10. 8	85. 1	2. 4	2. 1	5. 9
5525263	20 –28	2. 0	3. 6	4. 6	12. 5	18. 1	48. 8	10. 4	. 3	6. 0
5525264	28 –36	1. 0	2. 6	3. 4	9. 1	10. 7	50. 2	23. 0	. 1	5. 7
5525265	36 –50	1. 0	2. 1	3. 4	7. 5	9. 4	46. 7	30. 8	. 1	7. 1
5525266	50 –80+	1. 2	2. 3	2. 7	7. 5	9. 7	45. 9	30. 7	0	7. 1
Alderwood silt loam:										
5525268	0 –8	4. 0	7. 6	6. 8	10. 4	12. 4	51. 3	7. 5	4. 1	5. 9
5525269	8 –18	2. 0	6. 1	7. 2	17. 3	20. 3	41. 2	5. 9	2. 7	5. 6
5525270	18 –24	2. 7	5. 7	6. 0	15. 1	26. 8	36. 4	7. 3	. 8	5. 5
5525271	24 –30	. 5	1. 6	2. 5	8. 8	34. 1	41. 0	11. 5	. 5	5. 0
5525272	30 –36	3. 5	6. 7	7. 1	21. 4	15. 1	35. 3	10. 9	. 1	5. 4
5525273	36 –80+	2. 2	4. 3	5. 3	14. 8	21. 1	39. 5	12. 8	0	5. 3
Squalicum silt loam:										
5525279	0 –12	2. 4	3. 2	2. 3	4. 6	8. 4	66. 2	12. 9	3. 8	5. 4
5525280	12 –24	. 8	4. 5	3. 3	4. 7	8. 1	65. 8	12. 8	3. 3	5. 6
5525281	24 –30	9. 5	10. 6	6. 9	14. 0	12. 1	35. 8	11. 1	. 7	5. 4
5525282	30 –40	3. 2	4. 8	3. 8	7. 4	8. 6	48. 9	23. 3	. 4	5. 6
5525283	40 –80+	5. 1	6. 8	5. 4	11. 8	10. 3	39. 8	20. 8	0	6. 5

[1] Content as determined by treatment with hydrogen peroxide (H_2O_2). Organic material removed from samples by use of H_2O_2 before percentages of various separates were determined.

The Whatcom soils are developed from compact clay till of the late Vashon glaciation, and because their lower subsoil is slowly permeable, they have characteristics similar to imperfectly drained "wiesenbodenlike" soils. The upper part of the profile is typical of zonal soils, but the lower is less acid, less leached, and more mottled. Nonetheless, Whatcom soils are placed in the zonal order, as they have more characteristics in common with the zonal soils than with the intrazonal.

Following is a profile description of a Whatcom silt loam soil observed on the extensive rolling ground moraine near Pleasant Valley—a tract developed under a cover of mixed conifers (largely Douglas-fir and cedar) and a scattering of deciduous trees, brush, shrubs, and ferns:

1½ to 0 inches, dark grayish-brown (10YR 3/2) partly decomposed organic mat; pH, 4.5.
0 to 10 inches, brown (10YR 5/3) friable floury permeable silt loam containing a few round shotlike concretions of impure iron and probably some manganese; dark reddish brown (5YR 3/3) and friable when moist; pH, 5.7.
10 to 20 inches, pale-brown (10YR 6/3) very friable heavier silt loam containing a somewhat larger quantity of shot; brown (10YR 4/3) when moist; pH, 5.9.
20 to 28 inches, light brownish-gray (2.5Y 6/2) mottled gritty loam; somewhat vesicular and has yellowish iron-stained horizontal bands; dark yellowish brown when moist (10YR 4/4); pH, 6.0.
28 to 50 inches, light brownish-gray (2.5Y 6/2) dense silty clay loam; breaks into angular blocky fragments ¼ to ½ inch across and these have brown and gray colloidal coatings; fibrous roots are matted in the fracture planes; slightly acid in the upper part, neutral in the lower; yellowish brown (10YR 5/4) when wet.
50 inches +, gray (5Y 6/1) silty clay loam till but little modified though cut by fracture planes coated with dark brown; plastic and pale brown (10YR 6/3) when wet; neutral (pH, 7.1); in places contains marine shells.

Embedded gravel, stones, and boulders are common throughout the subsoil and substratum.

The Barneston are somewhat more podzolized than typical Brown Podzolic soils but have more characteristics in common with them than with the Podzols. Indicating more extensive podzolization in the Barneston soils is a faint A_2 horizon well developed in many places. Barneston soils occupy a zone transitional between the areas of high precipitation and cold winters and those of moderate precipitation and moderately cool winters. They have a morainic relief pronouncedly modified by fluvioglacial outwash and are derived from a loesslike mantle deposited on gravelly Vashon drift. The drift is largely granite and quartzite, but appreciable quantities of argillite and shale are included.

A Barneston silt loam soil representative of the series has the following profile on a high uncleared moraine near Bellingham where the cover is mixed conifers, scattering deciduous trees, and an understory of brush and shrubs:

1½ to 0 inches, dark-brown partly decomposed organic layer forms a distinct mat over the mineral soil; mat is acid and consists chiefly of loose needles; an adhering ashy film marks the point of contact between this and the layer below.

0 to 12 inches, light yellowish-brown (10YR 6/4) moderately loose faintly granular silt loam; contains considerable shot ranging from buckshot to pea size or larger; dark reddish brown (5YR 3/4) when moist; pH, 5.5.
12 to 18 inches, more yellowish-brown loam subsurface layer containing a scattering of gravel or shot; yellowish brown (10YR 5/4) when wet; pH, 6.0.
18 to 24 inches, light yellowish-brown (10YR 5/4) medium acid gravelly slightly plastic silt loam or loam.
24 to 50 inches, light-brown or yellowish-gray iron-stained and clay-coated assorted gravelly glacial drift; porous sands, gravel, and stones in drift are coated with a very thin film of clay; gravel shows some rusty-brown iron staining and silica coating on the under side.
50 inches +, light yellowish-brown or olive-tinted poorly assorted glacial drift; consists of slightly acid to neutral coarse porous salt-and-pepper-colored sands, gravel, and stones showing some clay coating, rusty-brown iron staining, and, occasionally, silica coating; sands, gravel, and stones attain a washed appearance with depth. Boulders are common throughout the underlying materials, which consist largely of quartzite, granite, and granodiorite but include argillite, andesite, basalt, diorite, gneiss, schist, sandstone, and shale.

The Lynden soils are developed on smooth terraces from stratified sandy postglacial outwash material. They have some characteristics of the "ground-water podzolic" soils and could be classified with the intrazonal rather than with the zonal soils. They occur where the water table may be at shallow depths. Some rusty-brown mottling and bands may show in the lower subsoil and substratum. Also, an ashy-gray film may occur under the organic mat in the sandier textured types of this series. The shot pellets are smaller and more highly dispersed than in the Giles soils.

PODZOLS

The soils in the eastern part of the area surveyed are imperfectly developed Podzols. Characteristically, they lie in a belt transitional between the less acid more granular Brown Podzolic soils to the west and the more strongly developed Podzols in the higher mountains to the east. Profile characteristics of these imperfectly developed Podzols are peculiar to the climate of the region in which they occur. Temperatures are prevailingly cool, summers are dry, and precipitation is greater than in the Brown Podzolic area to the west but not so great as in the mountains to the east, where considerable snow falls. Most of these Podzol soils are at altitudes of more than 1,000 feet. The mean annual precipitation varies from 60 to 100 inches or more, depending on location. The mean annual temperature is usually less than 48° F. The average January temperature is less than 33°, and the ground is frozen more often and deeper than it is at lower elevations.

The morphology of the imperfectly developed Podzols varies because of irregular relief and attendant differences in microclimate. The leached A_2 layer may be incipiently or imperfectly developed, or thick and very well developed, or any gradation between the extremes. The ortstein layer is lacking in nearly all well-drained sites.

The Podzols are well represented in the large areas of undifferentiated soils mapped as Rough mountainous land, but the Heisler and

Barnhardt are the only series belonging to the Podzols great soil group that have been more carefully observed in the county.

Heisler soils are better developed than the Barnhardt and have formed on glacial moraines derived from hard dark argillites and sericitic and graphitic schists. These materials show a direct relation to the scoured country rock and apparently were not transported from other areas but were accumulated locally by the lobes of the continental glaciers and, to some extent, by alpine glaciers. The podzolic character of Heisler soils, and the Barnhardt as well, is considered to be totally the result of environment, not of the origin of parent materials. The Barnhardt soils have some characteristics of Brown Podzolic soils.

Heisler shaly loam, rolling, is representative of the Podzols. Following is a profile of that soil as developed on a high moraine in the SE¼ sec. 36, T. 38 N., R. 5 E. under a thick forest cover of Douglas-fir, cedar, and hemlock and an undercover consisting almost entirely of ferns and mosses:

2 to 0 inches, very dark-brown partly decomposed humified granular strongly acid organic mat; where mat contacts the mineral soil there is a thin black greasy-feeling layer containing considerable mineral material.

0 to 1 inch, leached light brownish-gray or ashy-gray strongly acid A_2 horizon of shaly loam; irregular in outline and penetrates downward in tonguelike projections or along old animal burrows or root channels.

1 to 3 inches; brown strongly acid compact shaly loam; horizon is irregularly developed, and many tongues penetrate downward; material shows staining or rusty mottling from iron concentration but little or no cementation; infiltrations of dark organic material appear in some places.

3 to 15 inches, strong yellowish-brown strongly acid shaly loam; less compact than the horizon immediately above.

15 to 47 inches, light yellowish-brown or olive medium to strongly acid clay loam bedded with stones, boulders, and fragments of argillite and schist.

47 to 62 inches, light olive-yellow or bluish-gray slightly acid loam; looser than horizon above but bedded in a like manner; the materials—largely dark bluish-gray argillite and schist—are very angular, become more rubblelike with depth, and gradually merge with those below.

62 inches +, bluish-gray or steel-gray drift consisting principally of argillite and graphitic and sericitic schist.

Barnhardt soils occur at elevations higher than most areas of Kickerville and Alderwood soils but not so high as the Heisler. They have somewhat the same profile as the Heisler and have formed on gravelly glacial material underlain at 6 to 10 feet by cemented drift similar to that from which the Alderwood soils are developed. In most places Barnhardt soils have a thin ash-gray A_2 horizon beneath a strongly acid organic mat. The A_2 grades into a horizon that is brown (7.5YR 5/4) when dry and dark brown (10YR 3/3) when wet. The last-mentioned horizon gradually grades into the lighter colored and less acid horizon below.

PRAIRIE SOILS

The Prairie soils are represented in this county by only one type, Salal silt loam. This soil is not typical of the Prairie soils. It has some characteristics of the "wiesenbodenlike" soils and some of the Alluvial. As indicated by some mottling below a depth of 20 inches, it has been somewhat influenced by imperfect drainage.

The soil is developed on low terraces from fine-textured glacial outwash under vegetation of grasses and ferns. In color and texture the profile is very distinct. There is a 10- to 14-inch dark grayish-brown or very dark grayish-brown granular silt loam surface soil, light in weight and possessing many characteristics of soot. This gradually grades into a pale-brown friable faintly granular loam or fine sandy loam that continues to a depth of several feet before it gives way to stratified layers of sand.

INTRAZONAL SOILS

Intrazonal soils are those reflecting the dominating influence of some local factor, such as imperfect drainage, relief, age, or parent material, over the normal effect of climate or vegetation. In this county intrazonal soils occupy low-lying areas throughout the uplands and terraces and have developed mainly under conditions of excessive moisture. The zonal profile of the region is therefore feebly impressed, and the soils are hydromorphic.

Vegetation under which these soils developed differed from that on well-drained lighter colored soils. Instead of a coniferous forest with few deciduous trees and undergrowths of brush and shrubs, these darker or grayer soils had denser growths of deciduous trees, brush, grass, and water-tolerant vegetation. This heavier growth contributed larger quantities of organic residues of higher base content to the soil, and, as might be expected, the darker and more highly organic intrazonal members occur in thoroughly saturated depressions where a luxuriant vegetation grows. The organic residues do not oxidize as they do on well-drained soils; incorporation of large quantities of organic matter is therefore promoted; and as a result, the soils become very dark. Poor drainage gives them a gray color in the subsoil.

The intrazonal soils can be classified in several accepted or tentative great soil groups: (1) Wiesenboden, (2) "wiesenbodenlike," (3) Ground-Water Podzols, (4) "ground-water podzolic," (5) Planosols, (6) Bog, (7) Half Bog, and (8) Rendzinas.

WIESENBODEN SOILS

The Wiesenboden soils in this county have developed on glacial lake basins and marine terraces and occur in poorly drained flats, basins, and depressions where moisture accumulates. They are highly saturated in winter and spring, and commonly throughout summer. The soils are variously formed from glacial till, drift, and glacial and postglacial outwash. These materials are probably covered with a loesslike mantle similar to that from which the associated soils of better drainage have formed. Excessive moisture has prevented formation of zonal profile characteristics, and the soils have a hydromorphic character.

Wiesenboden soils are dark, and a surface horizon of organic accumulation is a distinct feature of their profiles. Their substrata range from clay till and gravelly drift to glacial or postglacial outwash, dominantly of sandy character. These materials are mostly dark grayish brown, gray, or bluish to steel gray and are highly stained or mottled with red, rusty brown, yellow, green, or blue. The various colors result from changes in moisture conditions, which promote successive reduction, oxidation, and hydration.

The Wiesenboden group includes the McKenna and Norma soils of the morainic uplands, the Bellingham of the glacial lake basins and marine delta terraces, the Everson and Woodlyn soils developed from gravelly glacial outwash, and the Skagit soil from mica schist. The profiles of all the soils have a similar hydromorphic character but differ in point of origin and in kind of material from which they developed.

McKenna silty clay loam, underlain by gravelly clay till, is representative of these soils, and following is a profile of this type as observed in a depression in the SW¼SW¼ sec. 25, T. 38 N., R. 1 E. under a mixed forest cover (largely deciduous) and a thick undergrowth of brush, shrubs, ferns, and other vegetation thriving in wet places:

2 to 0 inches, very dark brownish-gray spongy decaying organic horizon, fibrous and woody at the surface but mull-like below; material is brownish black and medium acid.

0 to 6 inches, dark grayish-brown (10YR 5/1) granular silty clay loam rather high in organic matter; pH. 5.3.

6 to 12 inches, colloid-stained silty clay similar in color to horizon above; has irregular angular fractures; fine roots, cavities, and worm casts are numerous and a few gravelstones occur; pH, 5.3.

12 to 30 inches, light brownish-gray loam with rusty-brown or light yellowish-brown mottlings; contains rounded gravel and stones; pH, 6.2.

30 to 60 inches, light olive-brown colloid-coated angularly fractured silty clay loam containing embedded gravel and stones; brownish colloidal coating decreases with depth; usually 2 to 4 feet thick.

60 or 72 inches +, bluish-gray dense neutral clay till; fractures into angular blocks that are cut in places by tilted or oblique planes.

The Norma soils are formed from thin mantles of gravel or sand, probably modified by loesslike materials, that overlie heavy clay till similar to that under McKenna soils. This clay till usually occurs in the lower subsoil but in places may lie deeper. On the higher moraines and in the higher interior region the till may be softly cemented drift or open gravel. The hydromorphic character of Norma soils is much like that of the McKenna, even though the gravel and sand promote more rapid internal drainage.

Bellingham soils of this county are characteristically developed over terraced marine-delta deposits composed of thickly bedded clay in which there are fine seams of sand and silt. These clay materials resemble the clay till of the McKenna soils but contain no gravel. They probably are outwash materials from the clay-till moraines of the upland. Marine shells are common in the substratum. Morphologically, the profiles of Bellingham and McKenna soils are very similar.

The Everson soil is classified with the Wiesenbodens but has some characteristics of the "ground-water podzolic" soils as well. It has a gray gleylike layer above the stratified sandy lower subsoil or substratum. In most sites the iron-stained clay layer is very plastic and sticky. Drainage waters throughout areas of this soil appear to be iron-saturated, as they are reddish brown. Everson soil is in close association with the Hemmi, Custer, and similar soils.

The Woodlyn soil has developed from silty and clayey sediments deposited over gravelly glacial outwash. It is much like the Everson soil, inasmuch as both are about as typically "ground-water podzolic" soils as they are Wiesenbodens. The highly organic surface soil probably was mucky at one time but has become grayish brown and more highly mineralized through an extended period of continuous cultivation. Highly iron-charged ground waters circulating through the porous gravelly subsoil and substratum have promoted the development of iron-stained clays, the precipitation of some iron materials, and slight cementation in the granules.

The Skagit soil developed on alluvial fans and stream bottoms. It is classified as a Wiesenboden but has some characteristics of the poorly drained Alluvial soils as well. It has been much influenced by the parent material, a steel-gray mica schist. Skagit soil is highly saturated, but the water table is stable enough to permit a luxuriant growth of deciduous vegetation, including water-tolerant grasses and sedges. Because of this vegetation, abundant organic residues have been incorporated with the soil materials, and the surface soil is dark and highly organic as a result. The blue-gray subsoil has gley characteristics and much rusty-iron staining, which has resulted from alternate oxidation and reduction.

"WIESENBODENLIKE" SOILS

The "wiesenbodenlike" soils have some characteristics of the Wiesenbodens, and they owe these to imperfect or restricted drainage. They have darker surface soil and grayer subsoil than the zonal soils but are not so dark as the Wiesenbodens, nor do they have a pronounced gley layer.

"Wiesenbodenlike" soils have a darker yellowish-brown or more grayish-brown surface soil than the better drained counterparts because moisture is more abundant throughout the season. Greater moisture has promoted a more luxuriant growth of deciduous trees, brush, and shrubs. The heavy forest litter, higher in bases and more readily decomposed than residues from conifers, has been incorporated to some extent with the mineral soil, and has been largely responsible for the darker shade. Because of restricted drainage, more iron is precipitated in the subsoil. Highly yellowish, orange, or rusty-brown mottling or intense staining is common in this grayish subsoil. In some subsoil, an ortstein layer of softer cementation has resulted from precipitation of iron, and the reddish color of the surface soil may be significantly intensified. The ground water throughout the lower basin region is highly charged with iron.

The "wiesenbodenlike" soils include members of six series. The Labounty, Cagey, and Hale comprise one group, as they all occur on morainic uplands. Members of the second group—Clipper and Wickersham soils—all occur on gravelly or shaly alluvial fans.

The Labounty soils of the first group are characteristically associated with the better drained Whatcom soils and are underlain by similar clay tills. The Cagey soils have similar catenary [9] relations to and are associated with the Kickerville. The Hale soils are associated with the Indianola and have catenary relations with the Indianola similar to those between the Labounty and Whatcom and the Cagey and Kickerville.

Labounty silt loam, undulating—a soil typical of the group occurring on smoother places on the morainic upland—is described as it oc-

[9] A catena is a group of soils in one zonal region developed from similar parent material but differing in characteristics of the solum because of differences in relief or drainage.

curs in the NW¼NW¼ sec. 15, T. 38 N, R. 3 E. under a mixed cover of Douglas-fir, cedar, alder, birch, willow, maple, and a dense undercover of brush, shrubs, and ferns:

1½ to 0 inches, dark-brown medium acid organic mat; acidity is usually lower in logged areas.
0 to 10 inches, dark-brown or grayish-brown friable very fine granular silt loam; high in content of pinhead to pea-size shot; medium acid.
10 to 18 inches, brownish-gray very granular silty clay loam; contains a large quantity of shot; pH, 6.
18 to 36 inches, yellowish-gray, olive-gray, or pale-brown iron-stained or mottled clay loam; contains some gravel and has horizontal yellow and rusty bands over tight clay till; pH, 5.8.
36 to 48 inches, light brownish-gray clay fractured into angular somewhat blocky pieces ⅛ to ½ inch across; contains embedded gravel and stones; colloid-stained; matted roots along fracture planes.
48 inches +, yellowish-gray compact highly fractured clay till in which gravel, stones, and occasional boulders are embedded; becomes light brownish gray with a somewhat bluish shade when wet; dark-brown stains in larger fracture planes; fractures decrease with depth; pH for yellowish-gray clay is 6.5; lower subsoil and substrata materials are neutral or mildly alkaline.

The Cagey soils have developed from loesslike mantled gravelly drift over a clay till much like that under the Labounty soils and have very similar surface soil and other morphological characteristics promoted by restricted drainage. The clay till characteristically occurs only in the lower part of the profile, however, and is overlain by a gravelly mantle. In winter and spring this till causes a high saturation of the overlying material, and this has created a zone of rusty-brown discoloration in the gravelly capping. The iron is not segregated into cementing concentrations.

The Hale soils are the sandy counterpart of the Cagey. Because of the sandiness of their mantle, iron is more effectively precipitated than in the gravel of the Cagey, and soft cementation is common, though an ortstein layer is rare.

The Clipper and Wickersham soils are developed on alluvial fans. The Clipper soils have a dark-gray acid surface soil underlain by mottled gray and rusty-brown subsoil. The lower subsoil of the Clipper is semi-indurated. In some characteristics the Clipper soils resemble Prairie soils.

The Wickersham soil is developed from coarsely stratified old alluvium laid down largely on alluvial fans. The alluvium is derived chiefly from drift materials, as bluish-gray argillite, mica schist, and gray shale washed from the uplands. Wickersham soil receives considerable runoff from adjacent slopes and, in addition, has slightly imperfect drainage and dark parent material. These factors have influenced the soil so as to make the entire profile darker than that typical of zonal soils, but in most places it is fairly typical of the "wiesenbodenlike" group in which it has been placed.

GROUND-WATER PODZOLS

Typical Ground-Water Podzol profiles can be observed in a number of soil types in this county, but these generally occur in only a small area consisting of favorable sites. Exceptions to this are the Custer soils, which have a distinct and well developed Ground-Water Podzol profile in all virgin areas. Even where they are plowed, that profile is still distinct in some places. The Custer soils are poorly drained because they have a high water table. They developed on sandy glacial outwash and have a leached ash-gray or grayish-white sandy A_2 layer over an ortstein layer of bog-iron character.

Custer silt loam is characteristic of Ground-Water Podzols. Following is a profile of this soil observed in the NW¼NW¼ sec. 26, T. 40 N., R. 1 E. under a forest cover of mixed coniferous and deciduous trees, dominantly alder, and a dense undergrowth of brush, shrubs, and ferns:

3 to 0 inches, dark forest litter and acid organic mat several inches thick.
0 to 2 inches, grayish-brown or dark grayish-brown somewhat granular silt loam; medium acid.
2 to 8 inches, light-gray or grayish-white highly podzolized iron-stained strongly acid material.
8 to 15 inches, rust-colored strongly acid ironpan in which occur localized dark metalliclike zones; material is shotlike and there are fragmental or rounded accretionary stones embedded in rusty brownish-red sand.
15 to 23 inches, yellowish-brown or orange medium acid sand in which are a few iron accretions or localized rusty areas.
23 to 69 inches +, steel-gray pepper-and-salt colored thickly bedded sands of washed appearance; usually saturated with water; medium acid.

"GROUND-WATER PODZOLIC" SOILS

"Ground-water podzolic" soils include members of the Edmonds, Hemmi, and Tromp series. In characteristics these soils approach the Ground-Water Podzols, but their process of podzolization has not yet reached a stage advanced enough to make them true Ground-Water Podzols. All of them are somewhat wet, and this has had a strong influence in determining their profiles. The soils of this group are closely related to those of the Custer series.

In some characteristics the Edmonds soils resemble the Ground-Water Podzols. They have developed from terrace deposits similar to those of the Custer soils, but there is usually a difference in elevation and saturation between the two. Additionally, Edmonds soils generally have a more luxuriant vegetation, including grasses and sedges. Their surface soil also is darker, more highly organic and granular, and directly overlies the ortstein layer, inasmuch as a podzolized A_2 horizon has not developed. In some places the ortstein layer is less concentrated and fragmental pieces are highly dispersed through the sandy subsoil layers.

The Tromp soils are developed from loesslike strata and somewhat resemble the Hale but have no clay in their subsoil. Also, they characteristically have a somewhat brighter surface soil and a more yellowish or olive subsoil in which there usually are indurated zones of iron concentration where fragments or fragmental plates occur. The iron concentration is variable, and compact subsoils having softer silica and iron cementation are common, especially where soils of this series join with the Lynden. Tromp soils are usually associated with the Lynden.

The Hemmi soil occupies low imperfectly drained positions similar to those held by the Tromp soils and has some characteristics of "wiesenbodenlike" soils. Following is a profile description of Hemmi silt loam:

3 to 0 inches, dark-brown medium acid organic mat.
0 to 8 inches, moderate-brown friable fine granular loam containing shot; reddish brown or grayish brown when wet.
8 to 15 inches, yellowish-brown or pale-brown slightly mottled somewhat compact medium acid silt loam containing fine shot.
15 to 27 inches, rusty yellowish-brown or ocherous sticky plastic clay with bluish-gray inclusions; slightly acid.
27 to 37 inches, yellow, brown, and gray transitional layer of sand and clay.
37 inches +, pepper-and-salt colored or steel-gray sand containing rusty-iron bands.

PLANOSOLS

Soils of the Bow series are the only ones mapped in this county that might be classified with the Planosols, and these are less typical Planosols than the Bow soils in Skagit County, where they occupy more extensive areas. In Skagit County, Bow soils have a well-developed claypan subsoil and a gray leached layer ¼ to 1 inch thick above the claypan. In this county they have a thin acid organic mat over a grayish-brown granular friable layer 6 to 12 inches thick. The 6- to 12-inch layer grades into a strongly acid light grayish-brown flour-like one, which is abruptly underlain by compact thick-bedded massive clay layers at a depth of about 18 inches. The natural structural blocks of the clay layers are coated by a thin veneer of dark material. The structural units, or blocks, are very distinct, especially in the upper part. The clay material is grayish brown and plastic and grades into bluish-gray less dense clay or silty clay in which occur a few cobbles, boulders, and gravel. A few marine shells may occur throughout the lower strata.

BOG SOILS

The Bog soils include organic soils, as the peats and mucks. Five have been recognized and mapped in the county—Rifle peat, Greenwood peat, Mukilteo peat, Carbondale muck and Semiahmoo muck. These form an important group of soils, and all are derived from organic remains of plants in various stages of decomposition. The kind of plants and the stage of decomposition are important factors in identification and classification of the various types.

All of the peats and mucks of the county have the properties characteristic of organic soils developed in the northern region of the United States. They are formed in low basins or shallow depressions where standing water or seepy conditions result from a continuous high water table. Generally they have formed from remains of plants that grew in the following stages of ascending succession: Aquatic vegetation in open water, then sedges and reeds in open marsh, and finally brush, shrubs, trees, and water-tolerant swamp and forest vegetation. The vegetation of the last stage may be followed by sphagnum, hypnum, and other mosses after the bases become exhausted, as these mosses will grow under an acid condition other plants cannot tolerate.

Peat designates organic soils in which the partly decomposed fibrous and matted plant remains can be identified. In this area occur woody, sedge, and moss peats. The woody properties of the first named identifies it as Rifle peat; similarly, sedge peat in this area is classified Mukilteo peat. Moss peat comprises areas of highly acid well-preserved sphagnum peat moss and is called Greenwood peat. The moss is sold commercially, but Greenwood peat is not farmed as a soil.

Muck consists of well-decomposed finely divided organic remains usually mixed with more or less mineral soil material. The fibers of the organic materials are not recognizable, but the mucks are identified by the vegetative cover or by association with identified peats. Woody muck, classified as Carbondale muck, and sedge muck, called Semiahmoo muck, have been mapped in this area.

HALF BOG SOILS

The Half Bog soils include only Snohomish silty clay loam. This soil consists of dark mineral layers underlain by mucks and peats in various stages of decomposition.

RENDZINA SOILS

The Rendzina soils of this county include only one type, Neptune gravelly sandy loam, which consists of dark grayish-brown or nearly black calcareous surface soil underlain by washed sand and gravel of coastal beach origin. The upper part of the profile is littered in most places with fragments of clamshells and other marine accumulations. Apparently the dark surface soil has developed because of the liminess of the incorporated litter of shells. In this county the Neptune soil has some characteristics of well to moderately well drained Alluvial soils.

AZONAL SOILS

ALLUVIAL SOILS

The soils derived from recent alluvium occur on stream bottoms, fans, and deltas in varying proximity to active streams that have transported and deposited sediments during recurrent floods. Where conditions are relatively stable, much organic matter has accumulated, become mixed with the soils, and made them dark. Under unstable conditions and frequent overflows, the Alluvial soils are gray and iron-mottled because the high water table inhibits oxidation. Alluvial soils have a wide range of drainage and vary from gray to nearly black.

On the basis of drainage Alluvial soils can be classified as (1) well drained to moderately well drained and (2) poorly drained. The well-drained group includes soils of the Puyallup, Nooksack, Pilchuck, and Kline series.

The well-drained Puyallup soils developed from sandy alluvial sediments of varied and mixed origin. They occupy more elevated positions in the stream valleys and commonly occur as natural levees along streams. They have been subject to spring flooding and some attendant sedimentation. The flooding and sedimentation, together with fair to good drainage, have promoted the development of brownish-gray surface soil and slightly iron-mottled brownish-gray to gray subsoil.

The following profile description of Puyallup fine sandy loam is characteristic of the well-drained group:

0 to 12 inches, light brownish-gray somewhat olive-tinted friable fine sandy loam; becomes brownish gray when moist; slightly acid.
12 to 24 inches, light brownish-gray faintly iron-mottled slightly compacted loamy fine sand.
24 to 70 inches, brown loose fine sand containing dark- and light-colored grains, probably largely argillite, that impart a dark pepper-and-salt appearance; slightly acid or neutral.

The Nooksack soils are associated with the Puyallup in areas where a finer textured more yellowish or olive-colored alluvium has been deposited. The color inherent in the alluvium is retained in the soils. Owing to the finer textured silty and clayey sediments in their subsoil, Nooksack soils are not so gray as the Puyallup, but slightly more rusty-iron mottling occurs in their lower parts.

The Pilchuck soils are developed from loose sand and gravelly material, varied in origin, laid down as stratified gravelly alluvium along streams. The soils are subject to frequent overflow, and many areas have a high water table part of the year. If Pilchuck soils were not overflowed or did not have a high water table, they would be excessively drained. They are associated with soils formed from similar material, as the Puyallup, for example, but are more porous and coarser textured. In some characteristics they resemble soils in the Alluvial (poorly drained) group.

The Kline soils are derived from mixed gravelly alluvial fan material. They have brownish-gray surface soil and light grayish-brown gravelly subsoil underlain by olive-gray poorly assorted stratified sand and gravel.

The second group of Alluvial soils—the poorly drained—includes the Sumas, Puget, Lummi, and Hovde series. The Puget, Sumas, and Lummi soils occur in low places in the stream bottoms and deltas. Such places were, and in some areas still are, subject to flooding. Sediments probably were deposited on the soils every year, and their drainage fluctuates. Because of the small quantity of organic matter incorporated and the poor oxidation, these soils are gray and highly mottled. The Puget soils are from deep clayey sediments, usually thickly bedded.

The Sumas soils are associated with the Puget but differ in the character of the subsoil. The Sumas subsoil is highly stratified with coarse- and fine-textured sands, and these afford better drainage than the silty layers in the Puget. In consequence, Sumas soils are better drained than the Puget under natural conditions. Many areas of the Puget soils are now artificially drained, however, so drainage for the two is actually about the same.

The Lummi resemble the Puget soils, but they are younger, have a slightly more bluish cast, are bedded with sedge remains, and contain salt in their virgin state.

Profile description of Puget silty clay loam:

0 to 8 inches, pale-brown or light brownish-gray granular slightly acid or neutral silty clay loam with faint rusty-iron staining; becomes brown when wet.
8 to 22 inches, highly iron-stained silty clay loam or silty clay of a color similar to horizon above; has irregular angular fractures; slightly acid to neutral.

22 to 75 inches, light-gray or steel-gray very plastic stratified or laminated clay or silty clay that breaks to angular pieces; nearly neutral; rusty-iron mottling increases with depth.

The Hovde soil occurs in fresh-water marshes along the coast where luxuriant growths of reeds sedges, and coarse grasses flourish. It consists essentially of shallow, dark, root-bound surface soil over beach deposits of gravel or sand.

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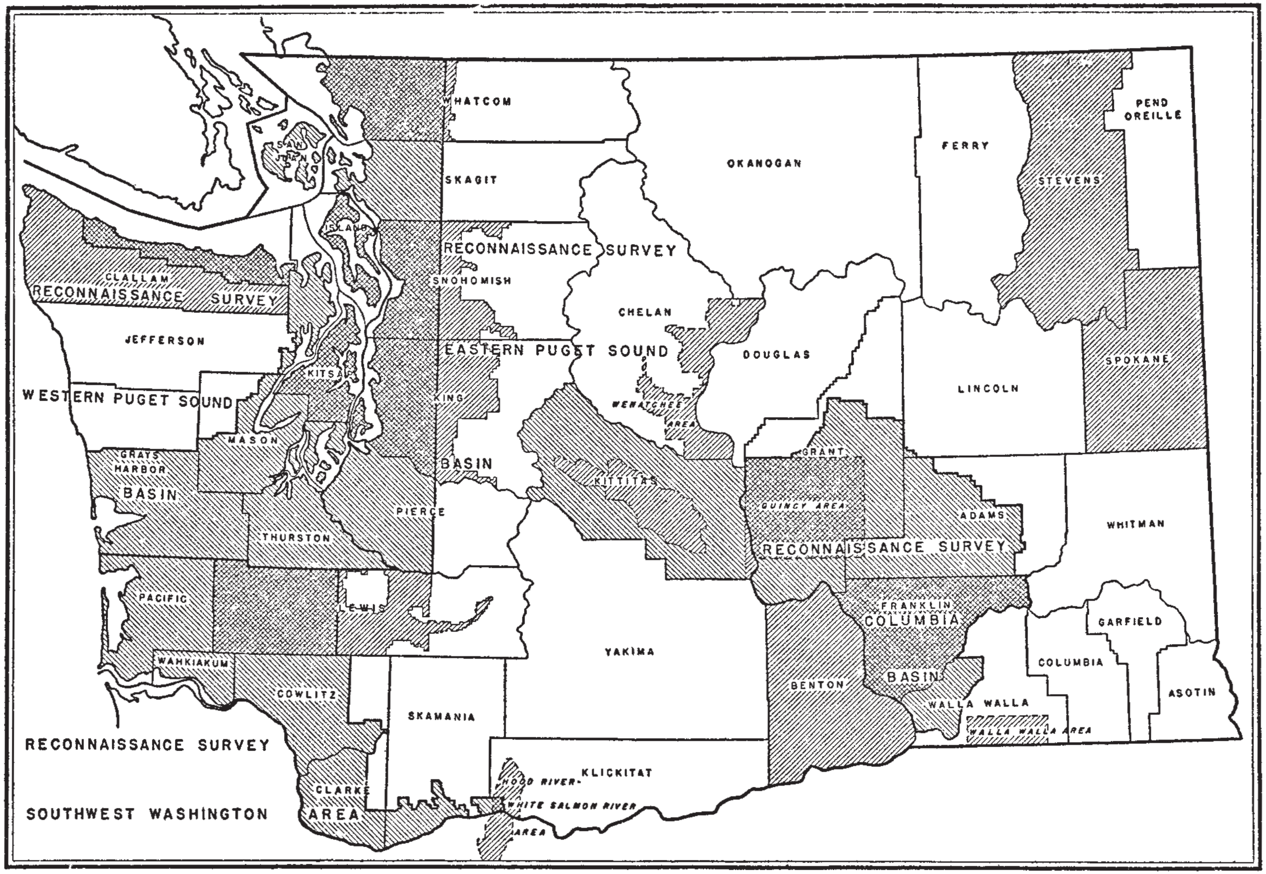

Areas surveyed in Washington shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching; cross hatching indicates areas covered in both ways.

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