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Soil Survey

Astoria Area Oregon

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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Plant Industry, Soils, and Agricultural Engineering
In cooperation with the
OREGON AGRICULTURAL EXPERIMENT STATION

HOW TO USE THE SOIL SURVEY REPORT

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

Readers interested in the area as a whole include those concerned with general land use planning—the placement and development of highways, power lines, urban sites, industries, community cooperatives, resettlement projects, and areas for forest and wildlife management and for recreation. The following sections are intended for such users: (1) General Nature of the Area, in which location and extent, physiography, relief, and drainage, climate, organization and population, industries, transportation and markets, and cultural development and improvement are discussed; (2) Agriculture, in which a brief history and the present status of the agriculture are described; (3) Management and Productivity, in which are presented recommendations for management and productivity of the soils and their grouping according to relative physical suitability for agricultural use; (4) Water Control on the Land, in which problems pertaining to drainage and control of runoff are treated; and (5) Land Use in Clatsop County, in which the county is divided into sections to allow a more intimate consideration of the land use problems.

Readers interested chiefly in specific areas—as some particular locality, farm, or field—include farmers, agricultural technicians interested in planning operations in communities or on individual farms, and real-estate agents, land appraisers, prospective purchasers and tenants, and farm loan agencies. These readers should (1) locate on the map the tract with which concerned; (2) identify the soils on the tract by locating in the legend on the margin of the map the symbols and colors that represent them; and (3) locate in the table of contents in the section on Soils the page where each type is described in detail and information given as to its suitability for use and its relations to crops and agriculture. They will also find useful specific information relating to the oils in the sections on Management and Productivity, Water Control on the Land, and Land Use in Clatsop County.

Students and teachers of soil science and allied subjects—including crop production, forestry, animal husbandry, economics, rural sociology, geography, and geology—will find their special interest in the section on Morphology and Genesis of Soils. They will also find useful information in the section on Soils, in which are presented the general scheme of classification of the soils of the area and a detailed discussion of each type. For those not already familiar with the classification and mapping of soils, these subjects are discussed under Soil Survey Methods and Definitions. Teachers of other subjects will find the sections on General Nature of the Area, Agriculture, Management and Productivity, and the first part of the section on Soils of particular value in determining the relations between their special subjects and the soils of the area.

This publication on the soil survey of the Astoria area, Oregon, is a cooperative contribution from the—

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SOIL SURVEY OF THE ASTORIA AREA, OREGON

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

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

[2] The series names in parentheses are those formerly used for these soils now recognized as new series.

THE discovery of the Columbia River by Capt. Robert Gray in May 1792, near the present site of Astoria, marked the beginning of the early history on the Pacific coast. In November 1805, Lewis and Clark, traveling overland blazed what later became the Oregon Trail, concluded their westward expedition, built Fort Clatsop, and established winter quarters. The construction of a small sawmill in 1851 and a salmon cannery in 1866 marked the beginnings of industry on a commercial scale. The principal industries are lumbering, salmon fishing and packing, dairying, and general farming. To provide a basis for the best uses of the land a cooperative soil survey was begun in 1938 by the United States Department of Agriculture and the Oregon Agricultural Experiment Station. The report here presented may be summarized briefly as follows.

SUMMARY

The Astoria area, with a total area of 230 square miles in Clatsop County, includes the main bodies of developed agricultural lands adjacent to the Pacific coast on the west, the Columbia River on the north, and the Nehalem River in the eastern part of the county. About 90 percent of the area mapped is used for forestry and 10 percent for agricultural purposes. The forest lands are divided into two broad groups, those dominated by Douglas-fir, in the eastern half of the county, and those by western hemlock and Sitka spruce, in the western half.

Elevations within the area range from sea level along the Pacific Ocean to 3,266 feet. Drainage occurs in two general directions, one to the southwest through the Nehalem River, the other to the northwest through the Lewis and Clark and the Youngs Rivers. Streams draining approximately two-thirds of the county are tributary to the Columbia River, and the others flow into the Nehalem River or directly into the Pacific Ocean.

In the western and northwestern parts of the area the climate is characterized by high annual rainfall, a long, cool growing season, and mild winters. The valley of the Nehalem River has a shorter growing season, with warmer summers and colder winters. The conditions along the coast are especially favorable for the maximum production of hay and pasture crops. In summer the hill lands and benchlands have a tendency to suffer from drought, especially in July and August, when the rainfall is only about 1 inch each month. Because of the long dry period, June 15 to September 15, irrigation is becoming more popular.

In 1844 the provisional government created Clatsop County out of the northern and western parts of the original Quality district. The population of the county was 24,697 in 1940, of which 11,406 were classed as rural. The principal industries are lumbering, salmon fishing and packing, dairying, general farming, and manufacturing of fertilizers. Large lumber mills are located at Astoria, Warrenton, Wauna, Westport, and Bradwood.

The Spokane, Portland & Seattle Railway serves the northern and eastern parts of the county. Motorbusses operate daily between Portland and Astoria and between Astoria and points in California. Good roads connect all parts of the county. United States Highway No. 30, formerly the Old Oregon Trail, parallels the Columbia River in the northern part of the county and terminates at Astoria. The scenic United States Highway No. 101, known as the Roosevelt Highway, parallels the Pacific Ocean and follows it closely in a number of places. Daily ferry service across the Columbia River at Astoria links the Oregon coast highway system with that of the State of Washington. The Port of Astoria offers rail and water shippers complete service and the use of modern cargo-handling facilities. The shippers and industrial companies using the Port of Astoria have the choice of service of more than 50 steamship lines operating between the Columbia River and world ports. Most of the tonnage handled consists of grain, flour, lumber, and fish.

Telephones are in general use, and electricity is available in most parts of the area. In recent years many dikes have been rebuilt under the Federal flood control program. Considerable improvement by draining and clearing diked lands has been made. The use of lime and phosphate fertilizers has shown a marked increase in the past 10 years.

The soils of the area fall into six groups—soils of the uplands or hills, soils of the terraces, soils of the flood plains, soils from wind-blown sands, organic soils, and miscellaneous land types.

The soils of the uplands or hills are derived from the weathering of sandstone and shale in place. Of these, Astoria loam and silt loam have been mapped. The soils of the terraces are derived from old weathered unconsolidated alluvial deposits. They are classified in the Knappa, Klaskanine, Cinebar, Grande Ronde, and Hebo series. The soils of the flood plains are derived from recent alluvial material on bottom lands and include the Nehalem, Brenner, Sauvie, and Clatsop series. The Clatsop soils are typical tidelands with much organic matter in the surface soil.

The soils derived from wind-laid materials have been formed from sand drifted in from the ocean. They are of the Gearhart series, the best stabilized of the well-drained soils of the group, the Westport series, which is very young, and the Warrenton soils, which show some development and are poorly drained. If farmed, the Westport soil would soon become shifting sand dunes, since it has a shallow surface soil and little vegetation.

The organic soils are divided into two groups. The peat soils mapped along the coast are the Spalding peat and Brallier peat. They contain a very high percentage of organic matter and are derived largely from the decomposition of sphagnum moss, sedges, and some woody spruce material. The Spalding peat has a light-brown to straw color and is the rawer, or the less decomposed, of the two. The

Brallier peat in the northern part of the county is a brown fine fibrous peat moderately decomposed. It consists mainly of sphagnum moss with some mineral material and is less acid than the peat found along the coast.

The agriculture of the area consists chiefly of dairying, poultry raising, seed production, and market gardening. The value of dairy products comprises the largest proportion of the agricultural income.

An outstanding advantage of coast agriculture is succulent pasture, which can be liberally supplemented during the winter or when pasture is not available with green feed, root crops, and silage. The pasture provides an economical feed and the longer the period of grazing the greater the returns obtainable. The moist, mild, cool climate and the long growing seasons are usually favorable for the growth of abundant rich pastures. One of the urgent needs of the area is the improvement of pasture: This can be done by growing longer lived grasses and legumes, the application of 2 tons of ground limestone every 5 years to prolong the life of legumes, and the practice of crop rotation. Pasture occupies 43 percent of the cultivated area of the county.

About 40 percent of the cultivated area is used for hay crops. Grass seed production is becoming increasingly important and now occupies about 1,426 acres. Poultry ranks second in gross farm income. Commercial vegetable production has increased in recent years. Beach and resort properties at Seaside and Gearhart represent one of the major recreational areas of the State and afford seasonal markets for farm products.

Because of the heavy rainfall and the low position and heavy character of most of the better soils, drainage is a major problem on most farms. Only a few of the principal cultivated crops will yield well on poorly drained soils. Pastures and some vegetables respond well to irrigation during summer when the rainfall is low.

The soil materials of the area have been formed principally from the weathering of sandstone and shale in a climate that is uniformly wet, therefore, the soils are similar mineralogically. These soils may not fit well into any of the recognized great soil groups, but they have some characteristics of both the podzolic and lateritic soils.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

The Astoria area, covering a total area of 230 square miles or 147,200 acres, is in Clatsop County, Oreg. (fig. 1). Located in the extreme northwestern corner of the State, this county is bounded on the north by the Columbia River, on the east by Columbia County, on the south by Tillamook County, and on the west by the Pacific Ocean. Astoria, the county seat, near the mouth of the Columbia River, is 75 miles northwest of Portland. For economic reasons the survey was limited to the better developed lands bordering the Pacific Ocean, the Columbia River, valleys adjacent to Lewis and Clark, Youngs, and Nehalem Rivers and their tributaries. The area comprises the major agricultural parts of the county.

The principal areas covered by this survey include the sandy hills and tidelands along the coast, the agricultural lands in the northern

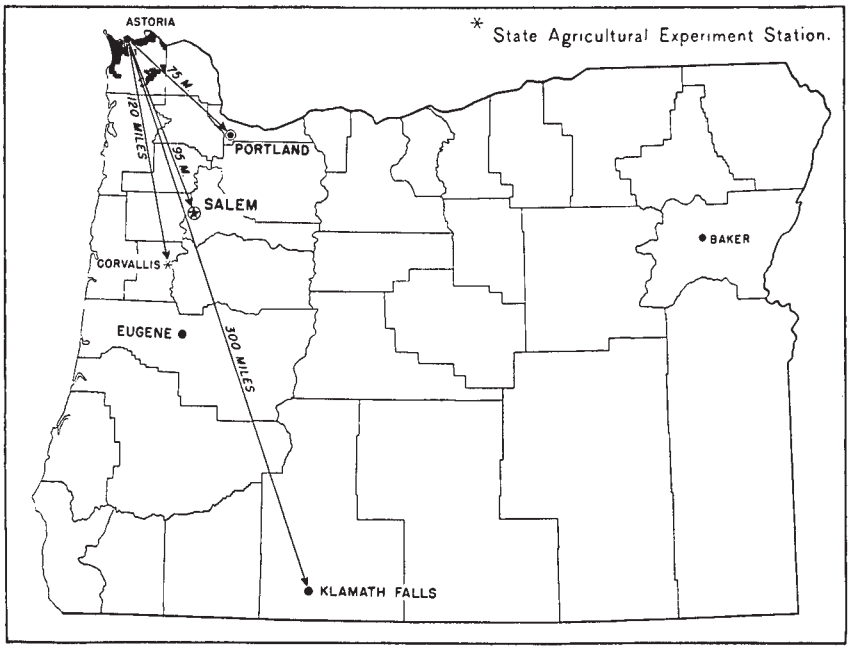


FIGURE 1.—Location of Astoria area in Oregon.

part of the county along the Columbia River from Astoria eastward to the Columbia County line, and the soils in the southwestern part of the county along the Nehalem River, beginning at the county line and extending westward along the river to beyond Jewell and Elsie.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

The topography of the county is varied. The principal agricultural soils occur at approximately sea level bordering the Lewis and Clark, Youngs, and Columbia Rivers. Dikes are necessary in farming these soils. The area north of Seaside consists of a series of recent sand dunes, reaching an elevation of 80 feet but averaging 40 to 60 feet. There are also ridges of old sand dunes of the same elevation that have become stabilized east of the recent sand dunes and extending to the foothills. Above the tidelands bordering Youngs and Lewis and Clark Rivers are narrow benches of old valley-filling material 100 to 200 feet high. These terraces have an undulating topography.

Just above the terraces are narrow fringes of developed agricultural land, with comparatively shallow soils over bedrock, commonly called hill soils, which have, for the most part, rolling topography. At present only two of the many islands belonging to Clatsop County—Karlson and Tenasillahe Islands—have been diked and farmed. Immediately above the bottom-land soils south of Svensen and Knappa are benches of old valley-filling soils of smooth topography with elevations of 100 to 200 feet. Immediately south of these terraces is a narrow fringe of residual soils which has been or could be developed, although the land rises sharply, often becoming very rough and broken.

Beach and sand-dune areas, averaging about half a mile wide, border the ocean from the mouth of the Columbia River to Seaside. The oldest and best established sand dunes begin immediately west of the coast highway at Warrenton and extend south to Seaside, with an average width of about 1 mile. The area extending east from the highway to the foothills consists of a series of ridges and depressions. The ridges are old sand dunes that have accumulated a thick covering of organic matter from the grass vegetation. Trees up to 3 feet in diameter, however, occur on these stabilized soils. Between the ridges, lakes and streams have developed as a result of the impounding of the surface drainage by sand dunes. Consequently many areas of organic or peat soils have been formed through the growth of vegetation in these wet areas.

The valley of the Nehalem River, in the eastern part of the county, is an important agricultural district. The low narrow terraces and bottom lands have an undulating topography, whereas the hill soils immediately behind the narrow fringe of tillable land are usually too steep or rough for agricultural purposes.

The Coast Range extends in a northerly direction through the county and turns northeast near the Columbia River. Saddle Mountain, the highest point in the south-central part of the county, has an elevation of 3,300 feet. A number of points in the Coast Range have elevations of 2,000 to 2,500 feet. The greater part of the county has low mountainous or hilly relief. These lands are primarily adapted to forestry.

The Nehalem River furnishes the principal drainage on the east side of the Coast Range and empties into Nehalem Bay near Nehalem. Northwest of the divide the Youngs and Lewis and Clark Rivers empty into the Columbia River near Astoria, and the Necanicum River in the southwestern part of the county flows into the Pacific Ocean at Seaside.

CLIMATE

Clatsop County has a mild, temperate, and equable climate, although greater extremes in temperatures are noted on the east side of the Coast Range. The western part has a very equable climate because of marine influence. The prevailing winds in summer are from the northwest, with warm southerly winds prevailing in winter. In this belt there is little freezing weather. On rare occasions snow falls but seldom remains on the ground more than a few hours. The mean annual temperature is about 51° F. with a mean winter temperature of about 42°.

The Coast Range has a great influence on climate and rainfall on the western slope. In general, rainfall increases rapidly with altitude on the west slope, decreasing from the summit eastward. The areas most openly exposed to the sea have the least rainfall, while those a short distance from the beach have heavy rainfall. In the northern part of the county, the rainfall decreases eastward up the Columbia River toward the Willamette Valley. The climate of this area is similar to that of the coast region.

The mean annual rainfall at Astoria is 76.57 inches and at Jewell, 69.32. The valley of the Nehalem River in the eastern part of the county has a total yearly rainfall slightly less than that along the coast. It differs mainly in having a lower summer rainfall, higher

summer temperatures, and much lower winter temperatures. The highest temperature recorded at Jewell was 102° F. and at Astoria 97°; the coldest temperature recorded at Jewell was —4° and at Astoria 10°.

Most of the rainfall occurs during fall and winter, the wet season beginning in October and extending through April. There is moderate rainfall during summer in the western part of the county. The distribution of rainfall along the coast is favorable for growing grass and forage crops. Severe rainstorms are exceptional, but winter rains may continue without interruption for several days. Fog and cloudiness are common during winter; hailstorms and thunderstorms are infrequent.

The snowfall differs considerably in various parts of the county. At Astoria the average annual snowfall is 4.2 inches and seldom remains on the ground more than a few hours. At Jewell it averages 13.6 inches, and the snow remains on the ground a little longer because winter temperatures are usually colder. In the mountains the snow is somewhat heavier and remains on the slopes longer.

The length of the frost-free growing season averages 272 days (March 8 to December 5) at Astoria and 166 days (May 8 to October 21) at Jewell. The latest killing frost ever recorded in the vicinity of Astoria was May 30 and the earliest October 19. The latest killing frost ever recorded near Jewell was June 17 and the earliest September 23. The normal monthly, seasonal, and annual temperature and precipitation at Astoria and Jewell, compiled from records of the United States Weather Bureau, are given in table 1.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Astoria and Jewell, Clatsop County, Oreg.*[1]

ASTORIA

[Elevation, 50 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	42.5	62	10	12.28	6.55	36.07	0.7
January	40.5	60	10	12.09	6.75	18.45	1.8
February	42.7	68	15	9.43	7.13	8.89	1.2
Winter	41.9	68	10	33.80	20.43	63.41	3.7
March	45.7	77	24	8.04	2.56	13.81	.4
April	49.4	83	31	5.00	4.59	2.90	(2)
May	53.6	89	30	3.66	1.36	8.10	0
Spring	49.6	89	24	16.70	8.51	24.81	.4
June	57.7	97	40	2.86	2.04	2.74	0
July	61.0	95	37	1.11	1.29	.50	0
August	61.6	95	42	1.19	1.83	1.05	0
Summer	60.2	97	37	5.16	5.16	4.29	0
September	59.0	91	37	3.33	6.22	6.19	0
October	54.1	81	15	6.27	6.43	7.85	0
November	47.3	76	19	11.31	2.63	7.48	.1
Fall	53.5	91	15	20.91	15.28	21.52	.1
Year	51.3	[3] 97	[4] 10	76.57	[5] 49.38	[6] 114.03	4.2

[1] From U. S. Weather Bureau records.
[2] Trace.
[3] In June 1903.
[4] In January 1888 and December 1919.
[5] In 1884.
[6] In 1933.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Astoria and Jewell, Clatsop County, Oreg.*[1]—Continued

JEWELL

[Elevation, 491 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	38.4	65	2	12.22	6.62	9.02	3.3
January	37.6	57	−4	10.44	3.82	15.53	5.7
February	40.7	65	8	8.96	11.02	11.87	1.7
Winter	38.9	65	−4	31.62	21.46	36.42	10.7
March	45.0	82	24	7.69	4.89	10.72	2.2
April	48.3	90	26	4.60	3.57	5.71	.7
May	53.3	95	29	3.22	5.83	2.90	0
Spring	48.9	95	24	15.51	14.29	19.33	2.9
June	58.2	99	33	1.66	1.68	2.82	0
July	62.4	102	36	.47	0	.28	0
August	62.7	99	38	1.18	0	1.25	0
Summer	61.1	102	33	3.31	1.68	4.35	0
September	58.9	97	25	3.38	1.32	4.35	0
October	52.5	87	38	6.02	4.14	7.98	0
November	44.0	70	21	9.48	6.35	19.62	(2)
Fall	51.8	97	21	18.88	11.81	31.95	(2)
Year	50.2	102	−4	69.32	[7] 49.24	[8] 92.05	13.6

[1] From U. S. Weather Bureau records. [2] Trace. [7] In 1930. [8] In 1921.

ORGANIZATION AND POPULATION

Early history [3] on the Pacific coast was begun when Capt. Robert Gray discovered the Columbia River, May 11, 1792. In November 1805, Lewis and Clark, traveling overland and blazing what is now known as the Oregon Trail, concluded their westward expedition at Fort Clatsop. It was not until 1810, however, that an attempt at settlement of the Oregon country was made by Capt. Mason Winship. Permanent settlement of this region began when Capt. Jonathan Horn, representing the Astor interests, anchored his ship *Tonquin*, on March 22, 1811, off the same shore where Captain Gray had set foot 19 years before. Much of the early activity and development in this area is due to John Jacob Astor and his Pacific Fur Co., which was established at Astoria in 1811.

Astoria was of little importance as a fur-trading station and port for vessels until 1843, when further development began. In 1844 the provisional government created Clatsop County out of the northern and western parts of the original Quality district. A census taken in 1846 placed the population of the county at 95. The Methodist Mission established by Frost in 1840 was the first church established in the Clatsop County area. The Clatsop Plains Pioneer Presbyterian Church was established in 1846, and a church building was constructed in 1850. In 1847, the first United States post office west of the Rocky Mountains was opened at Astoria.

[3] FITZGERALD, K. HISTORY OF CLATSOP COUNTY. Oreg. Univ. Commonwealth Rev. [May] : 486–505. 1938.

In 1850, the Federal census placed the population of Astoria at 252. The salmon-packing industry was begun on a commercial scale in 1866. At this time the importance of the Chinook salmon of the Columbia River was discovered. So successful did the salmon industry prove to be that dozens of canneries were soon built along the Columbia River and its tributaries. The construction of a small sawmill in 1851 and a cannery in 1866 marked the beginning of the city's industries. By 1875, marine shipping, the third great industrial activity, had become important and Astoria was considered an outstanding seaport.

The population of Clatsop County increased rapidly, especially during the seventies (498 in 1860 and 7,222 in 1880). This rapid increase had a marked effect on agricultural development, which began in the county with the settlement of Clatsop Plains. The population of the county was 24,697 in 1940, of which 11,406 were classed as rural. Astoria, the county seat and the largest city, had a population of 10,389; Seaside, the second largest city, 2,902. Other towns are Warrenton, Gearhart, Jewell, Hammond, Olney, Westport, and Elsie. In 1940 the population was 82.2 percent native-born white and 16.7 percent foreign-born white. Of the foreign-born population, the Finns are the most numerous, Swedes and Norwegians ranking next in order.

The first horses were brought to the area in 1841, and soon a herd of cattle was driven from the Willamette Valley through the Tillamook region to the Clatsop Plains. This area was especially attractive to the early settlers, as it was not only open and free from trees but had a dense covering of grass that supplied abundant feed for both dairy and beef cattle and permitted plowing and the growing of crops without first clearing the land of trees; elsewhere clearings were few. The fertile bottom lands, which have since been diked, were subject to overflow by the tides, and the rest of the area was covered by heavy virgin timber.

INDUSTRIES

The principal industries are lumbering, salmon fishing and packing, dairying, general farming, and manufacturing of fertilizers. Large lumber mills are at Astoria, Warrenton, Wauna, Westport, and Bradwood. A flour mill at the Port of Astoria terminal has a daily capacity of 450 barrels. The big grain elevator at that terminal, which is used by the flouring mill, has a 1,250,000-barrel capacity and is one of the largest in the United States.

Astoria is the commercial center of the Columbia River salmon fishery, one of the four leading revenue-producing industries of Oregon. This industry has two separate phases—the catching, represented by the independent fishermen, and the canning and processing, represented by the canneries and reduction plants.

The fish-packing industry has been established in Astoria for more than 70 years, the principal source of income being derived from salmon. The annual pack has become more or less stable, but the future of the industry depends a great deal on what effect the Bonneville Dam will have on the annual salmon run. The industry received a great stimulus, however, when there appeared off the Oregon coast two varieties of fish not previously caught in commercial quantities in these waters.

First, large schools of pilchards appeared off the Washington and Oregon coast from the Olympic Peninsula to Coos Bay. The main value of this fish is for reduction purposes, the byproducts being mainly fish oil and meal and commercial fertilizer. Oregon operators were not at first prepared to include this new process in their canneries and, as a result, the reduction plants were floating canneries sent up from California waters, but recently two or three shore units have been constructed for permanent operation at Astoria and Warrenton.

In 1936 the first catches of albacore tuna were reported off the Oregon coast and totaled 41,000 pounds, but the next year the catch increased to 1,721,759 pounds. A large part of this was shipped in refrigerator cars to California markets, and a great deal more to the Seattle and Portland fresh-fish markets. The shipping costs and loss through culling were not satisfactory to the local operators, and, although most of the 1937 catch was shipped out of the State, some experimental packing was done. Fish packing should have little difficulty in maintaining its position as the leading industry of Astoria and of Clatsop County.

The second ranking industry in Astoria, though far behind the fishery industry in importance, is commerce. Large cargoes are shipped from this locality by ocean transportation, by rail, by motortrucks, and by river boats. The year 1939 showed the second largest tonnage shipped in the 30-year history of the Port of Astoria, 462,648. The previous high was in 1924, when 484,051 tons were dispatched to all parts of the world.

Bulb production, one of the more recent industries, has developed since 1925. According to sample census of 1933, taken by the Oregon State Agricultural Extension Service, narcissus bulbs were produced on 30 acres. There were also 1½ acres of iris, bulbous iris, and lilies. The climate, with plenty of moisture and no extreme temperatures, is suited to raising narcissus bulbs, which grow sturdy, healthy, and disease-free. Only commercial-forcing varieties should be grown. Bulbs are marketed through Portland brokers for Eastern shipment.

TRANSPORTATION AND MARKETS

The Spokane, Portland & Seattle Railway follows the northern boundary of the county, paralleling the Columbia River from Portland to Astoria, then south along the coast to Seaside. Motorbusses operate daily between Portland and Astoria over United States Highway No. 30, and between Astoria and California on United States Highway No. 101, commonly known as the Roosevelt Highway. Daily bus service also is available from Astoria to Jewell, Elsie, and Portland. United States Highway No. 30 (the Columbia River Highway, formerly the Old Oregon Trail) terminates at Astoria. Federal Highway No. 101 parallels the Pacific Ocean and has often been designated by visitors one of the most picturesque roads in the United States. Well-improved roads connect all parts of the county. Daily ferry service across the Columbia River at Astoria links the Oregon coast highway system with that of Washington.

Astoria is located 10 miles from the ocean on a vast bay that forms the mouth of the Columbia River. The Port of Astoria offers rail and water shippers complete service and the use of modern cargo-handling facilities. Since the port has 6,370 linear feet of docking

space and 30 to 50 feet of water, vessels berth and leave without assistance of tugs. The shippers and industrial companies using the port have the choice of service of more than 50 steamship lines operating between the Columbia River and world ports. More than 500 vessels call at the port terminals annually. Most of the tonnage handled consists of grain, flour, lumber, and fish. With a landlocked harbor protected by nature from storms, its channel to the sea maintains a depth of 45 feet for a width of 1,200 feet and more than 40 feet for a width of 600 feet. As a result, this large fresh-water harbor has one of the best and safest entrances of any bar harbor known to shipping. The inner harbor has an anchorage base of about 12 square miles, with a depth of 24 to 70 feet at mean low tide. The water, fresh and free from ice at all seasons of the year, is not affected by river freshets.

CULTURAL DEVELOPMENT AND IMPROVEMENT

Telephones are in general use, and many homes have electric service. The county has two publicly financed libraries—at Seaside and at Astoria. Smaller community libraries are in Westport, Warrenton, and Hammond, each one serving only the people within its own limits. A beautiful monolith standing atop Coxcomb Hill commemorates the three epochal events connected with the discovery, exploration, and settlement of the Northwest.

AGRICULTURE

The early agriculture of the area consisted mainly of dairying and stock raising. Potatoes were grown on a large scale in the early days, with a limited acreage of wheat, oats, barley, and vegetables.

The present agriculture consists chiefly of dairying, poultry raising, seed production, and market gardening. This development has resulted from the demands of the Portland market, which is the chief sales outlet, and also from the growth of local markets at the Seaside and Gearhart beach resorts. The recent income from field crops, due to the increased acreage of bentgrass and turf crops, has increased appreciably. There has been a sharp decrease in the size of farms. The present average size of the 661 farms is 78.3 acres. The smaller farms require more intensive cultivation and larger yields per acre to maintain a family.

At present, the agricultural development is chiefly on the bottoms and benchlands, with the least development on the hills. In most cases, there are only narrow strips of developed land in the hills bordering the benchlands, because these soils are low in natural fertility and run down sooner. Often they are costly to clear and have a rough topography. Highly developed agricultural areas occur along the Lewis and Clark, the Youngs, and the Nehalem Rivers. For the most part the bottom lands are narrow—½ to 2 miles wide.

Dairying is the most important of the livestock industries. The agricultural income of Clatsop County depends chiefly on dairying and indirectly on farm crops. The delta soils along the Columbia, the Lewis and Clark, and the Youngs Rivers are especially adapted to the growth of abundant pasture and hay for dairy cattle. The county has established a reputation for high quality dairy products.

Practically all the milk and cream is marketed in Portland for the ice-cream trade, and the surplus butter is shipped to large cities in California.

CROPS

By 1940 the acreage of all field crops had increased more than 50 percent over that of 1910, and the acreage of hay increased about 70 percent during this period, but there was a substantial reduction in the acreage of oats, from 612 acres to 413. The total value of all crops harvested in Clatsop County in 1939 according to the 1940 census was $312,269. Dairying ranked first as a source of income, the value of whole milk, cream, and butter sold being $332,921. Poultry and poultry products were second with a value of $199,819. Acreages of the principal crops are given in table 2.

TABLE 2.—*Acreages of principal crops and numbers of bearing fruit trees in Clatsop County, Oreg., in stated years*

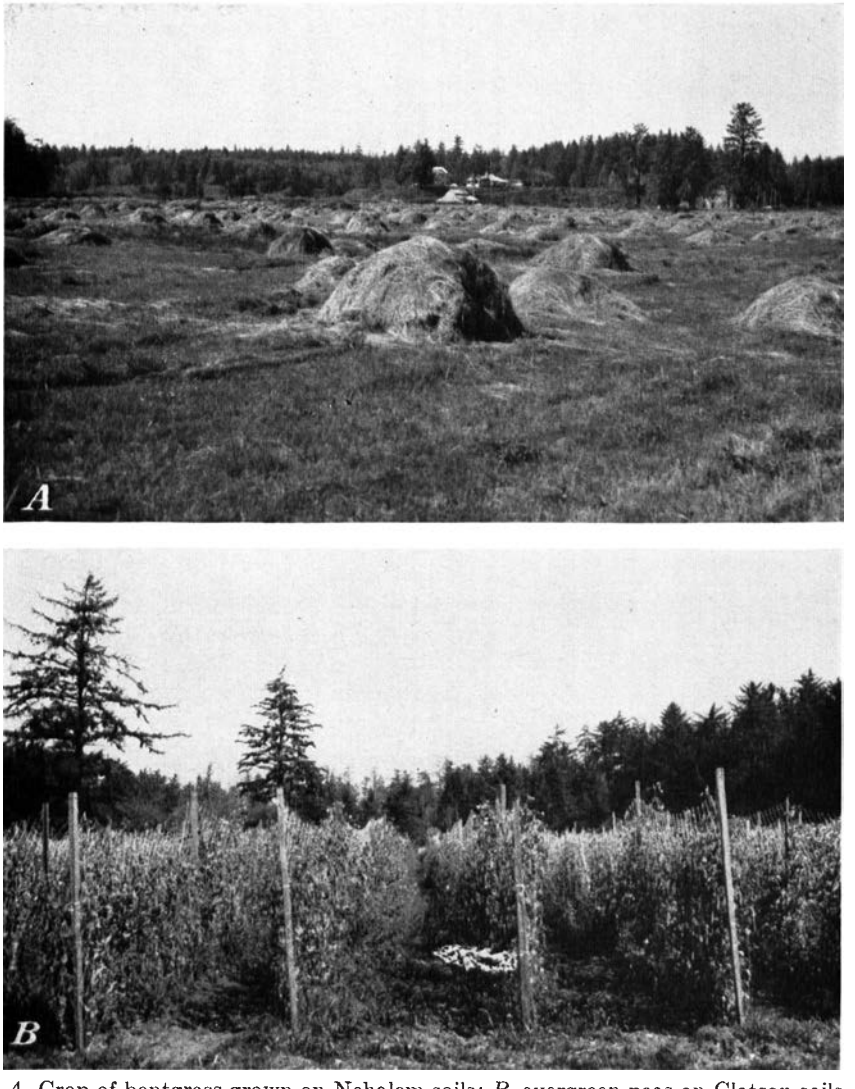
Crop	1909	1919	1929	1939
	Acres	*Acres*	*Acres*	*Acres*
Oats threshed	612	534	415	413
Hay	3,838	4,635	6,028	6,598
Timothy and clover, alone or mixed	1,949	2,234	772	898
Clover alone, all kinds	306	199	192	[1] 43
Annual legumes	----	150	82	193
Small grain hay	563	708	1,296	1,063
Other tame hay	887	861	3,111	3,383
Wild hay	133	423	575	1,018
Potatoes	273	410	252	81
Root crops for forage	----	180	212	38
Truck crops, except peas	----	46	98	35
Garden peas	----	3	33	84
Strawberries	15	17	29	10
	Number	*Number*	*Number*	*Number*
Apples ..... trees	13,388	13,650	10,111	6,780
Pears ..... do	743	555	840	767
Plums and prunes ..... do	2,749	1,671	1,800	1,306
Cherries ..... do	559	476	543	501

[1] Sweetclover only.

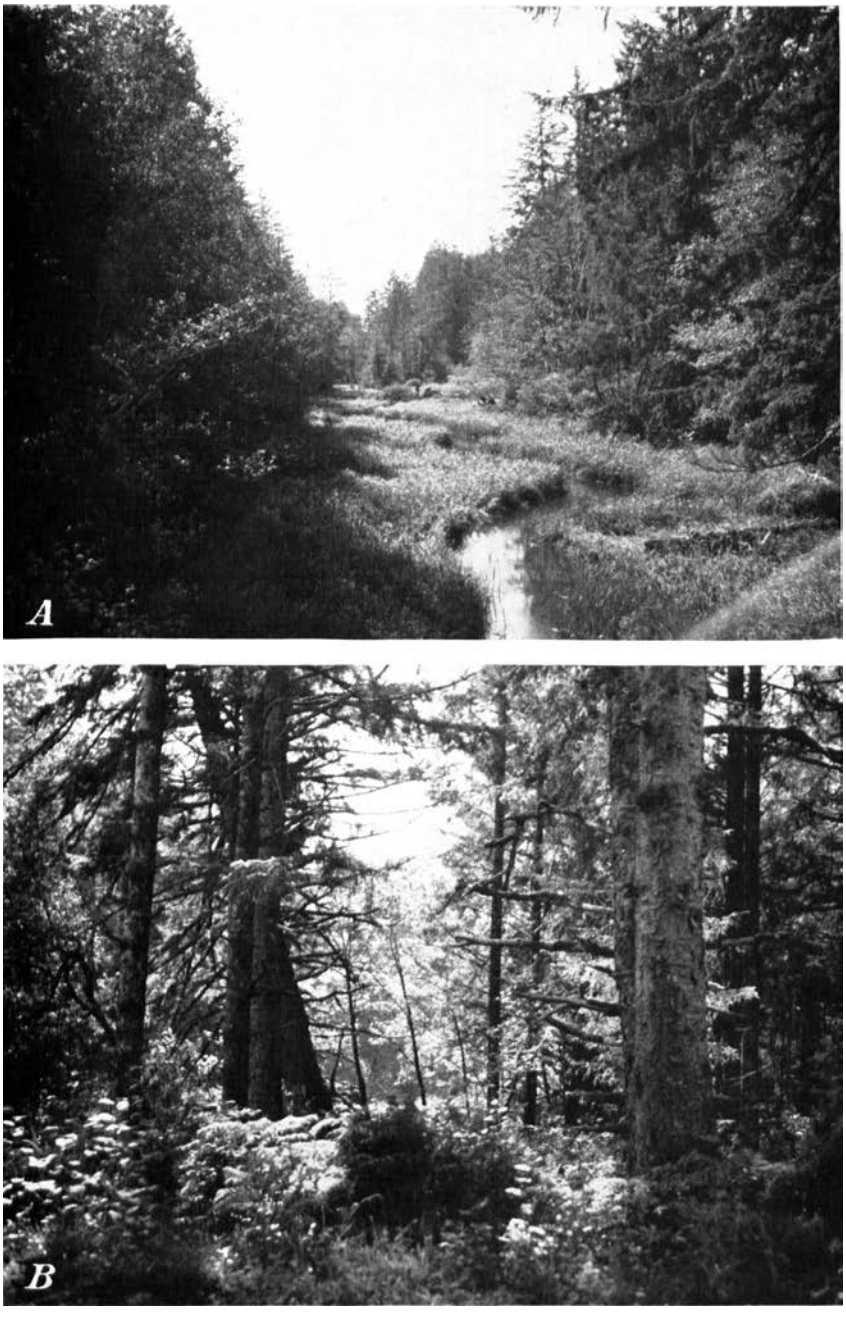
Hay crops of all kinds, both annual and perennial, occupied 6,028 acres in 1929 and 6,598 acres in 1939. Red and alsike clovers are the most important legumes for hay on the coast. The crop is usually easy to start on newly cleared land. On old hill land it is difficult to reestablish a stand, probably because of insufficient lime in the soil for proper maintenance and inoculation. Stands of clover deteriorate rather rapidly without lime or manure or lime and manure. Alfalfa at present is of small importance in coast agriculture. In 1920 there were 13 acres cut for hay, in 1930, 3 acres, and 1940, none. This crop is not so well suited to general coast conditions as peas, vetch, and clover.

Soil and climatic conditions are especially favorable for root crops. Since a cool, moist climate is best for root crops, very satisfactory yields are obtained in this area. These crops expanded rapidly from 180 acres in 1919 to 212 acres in 1929 but decreased to 38 in 1940.

Oats, the principal grain harvested, is grown chiefly in the valley of the Nehalem River. Very few other small grains are grown for threshing, and the acreage is decreasing because of the high cost of production and the cheapness with which grain can be shipped from central markets. In 1909 oats were planted on 612 acres but decreased



A, Crop of bentgrass grown on Nehalem soils; *B*, evergreen peas on Clatsop soils.



Between parallel ridges of the sandy Westport and Gearhart soils of the coastal region are (*A*) one of the long narrow ponded depressions and (*B*) heavy growth of spruce, tussock grass, ferns, and brush occupying low, wet margins of ponded swampy area.

to 413 in 1939. The Gray Winter variety is recommended for fall seeding because of larger yields. Support oats, a new variety of the Gray Winter type, is of good quality and is excellent for planting with vetch and with Austrian Winter field peas as a hay crop.

Bentgrass seed production is becoming a leading enterprise in the county (pl. 1, *A*). In 1941 the estimates of production were 2,500 acres harvested, 450,000 pounds of clean seed produced, valued at $193,000.[4] This grass is very good for lawns, golf courses, and football fields and is now included in mixtures on cut-over land.

Several other seed crops are grown but on a less extensive scale. Some promising crops are Chewings fescue, perennial ryegrass, orchard grass, and special strains of other grasses and legumes as lotus.

Statistics indicate a tendency toward smaller farms in Clatsop County and a substantially larger number of farmers. This condition, coupled with the necessity for crops that fit into a rotation plan, necessitates the growing of some specialized crop capable of large returns per acre. Among such crops are some not produced in surplus in the United States. They include a number of vegetable crops for seed. One of the most promising is the popular variety of garden beet known as Detroit Dark Red. Others are carrot, turnip, spinach, and cabbage seeds.

The most important truck crop is garden peas (pl. 1, *B*). In 1940, 84 acres were planted, which include the acreage for fresh market and cannery purposes. Other truck crops of importance are green beans, sweet corn, carrots, cauliflower, beets, and cabbage, which have a ready market at the local cannery and for the fresh trade. At present the limiting factor connected with the production of these crops is the demand. Persons interested in growing these crops should have a contract before the crop is planted. The growing of field peas for canning and freezing should be done on the larger farms; the smaller farms are better adapted to green beans, corn, carrots, beets, and cauliflower.

Orchard fruits are grown mainly for home use and local and occasional roadside markets. Apples are the main crop, and most of the acreage is in old orchards. The main varieties grown are Yellow Transparent, Gravenstein, Northern Spy, Spitzenburg, and Jonathan. Next in importance are the Italian prune and the Green Gage plum. The main varieties of pears are Bartlett and Bosc. Cherries were grown on 9 acres, the main varieties being Royal Anne and Lambert.

Small fruits, although grown on very small acreages, are well adapted to the soil and climatic conditions. According to the 1930 census there were 5 acres of blackberries, 9 of loganberries, 29 of strawberries, and 4 of raspberries. The 1940 census shows a reduction in these crops. The principal varieties of small fruits are: Raspberries, the Cuthbert, although the Lloyd George also is grown; blackberries, the Plum Farmer, with the Cumberland rating second. Strawberries are grown for home use, and in a limited way, commercially. The Narcissa is a good producer for fresh fruit purposes; the Marshall is the leading one on the upland soils for frozen-pack purposes; and the Ettersburg 121 is used locally for canning. The everbearing

[4] THOMAS, M. D., BREITHAUPT, L. R., and NIELSEN, N. I. OREGON'S FORAGE SEED CROPS. 1941–1942, ALFALFA, CLOVER, GRASS, PEA, AND VETCH SEEDS. Oreg. Agr. Col. Ext. Bul. 613, 24 pp. 1943.

varieties offer possibilities for summer-resort trade, the Rockhill being the first variety, with the Mastadon second. The yields of Rockhill are heavy, and the flavor is fine. The leading variety of currants is the Perfection, and of gooseberries are the Poorman and Oregon Champion.

Cranberry production in Oregon is limited to two areas, one in Clatsop County and the other in Coos County. The demand for cranberries has varied considerably during the past 10 years. According to reports of the United States Bureau of Agricultural Economics, the following carload shipments went from Clatsop County: In 1931, 20 carloads; in 1934, 12 carloads; and in 1935, 5 carloads. Estimates for 1938 [5] showed that 50 acres were being grown with an estimated yield of 5,600 boxes. Soil and climatic conditions are favorable for this crop. Average yields by good growers have been about 60 barrels an acre. Although conditions are favorable, expansion should be gradual, since it is a highly specialized industry and should be conducted only by those who are experienced in the business.

FERTILIZERS

The use of lime on an extensive scale began in 1930 when 221 tons were used. Since then the quantities used have varied from year to year with 357 tons in 1940, valued at $2,266. During 1939, 224 tons of lime was distributed to 86 farmers throughout the county through the county agent's office. Of this 100 tons was ground limerock from the State plant at Salem and 124 tons was oystershells from Nahcotta, Wash. The limerock is usually finer and more uniform than the oystershells.

As the soils were formed, they were subjected to leaching by the heavy rainfall that removed the lime; as a result, the soils of the county are acid. Practical experience of farmers supported by experimental results at the Astor Agricultural Experiment Station indicates the need of lime for successful production of many farm crops. Legumes, including clovers and vetch particularly, have been helped by lime. Increased yields of other crops, as peas and most vegetables, usually follow the use of lime. Ground limestone is best applied after plowing at the rate of 2 tons an acre once in 4 or 5 years and should be disked or harrowed in before seeding to legumes.

Phosphate fertilizers are needed by most crops in the county, and their use has increased steadily. In the past, superphosphate has been used most extensively, but in recent years more of the other phosphate fertilizers, treble superphosphate and ammonium phosphate, have been coming into use. Market price largely determines the form used. In 1939, 177 tons of commercial fertilizer was purchased for $6,463.

PERMANENT PASTURE

Grass, the principal crop of the coastal area of Oregon, is favored with climatic and soil conditions in Clatsop County that provide a grazing season of maximum length. Grass plantings have increased in recent years. This crop is one of the most important both in acreage and cash returns and is used primarily as a pasture crop and

[5] THOMAS, M. D., BREITHAUPT, L. R., and NIELSEN, N. I. PRODUCTION AND INCOME STATISTICS FOR SPECIALTY FARM PRODUCTS—OREGON 1938. Oreg. Agr. Col. Ext. Cir. 334, 26 pp. illus. 1939.

secondarily for hay. According to the 1930 census there were 4,910 acres of plowable pasture and 31,504 acres of woodland pasture. In 1940 there were 7,369 acres of plowable pasture and 20,896 acres of woodland pasture. It is estimated that 87 percent of pasture in the coast area is used by dairy cows and 7 percent additional by young dairy stock.

A study made by the Oregon State Agricultural Extension Service for the years 1926 to 1930 indicates that the average cash farm income was $1,089,000, with 23 percent coming from the sale of all crop products and 76.6 percent from all animal products. This indicates that pasture should be stressed from the standpoint of feed for dairy cows, with special consideration given to palatability, yield, and adaptability.

LIVESTOCK AND FARM PRODUCTS

Dairying is important in Clatsop County and produces a greater total income than any other branch of agriculture. It is most commonly practiced in connection with general farming along the Columbia River and on the tidelands in the western and northwestern parts of the county. The county is fortunate in having exceptionally favorable markets for dairy products in Portland, Astoria, Seaside, and other towns. Most of the milk produced in the area is marketed as whole milk. Butter and ice cream are the chief manufactured products of the industry and are known for their high quality.

The moist, mild, but cool, climate and long growing season are unusually favorable for the growth of abundant rich pastures and can be liberally supplemented during winter with green feed, root crops, and silage. Pasture provides economical feed and the longer the period of pasturing the greater the returns.

The cost of feed represents 60 percent of the total cost of producing dairy products, and the success of the dairy industry depends to a large extent on the kind, quantity, and quality of feed as well as on the most efficient method of producing it. Concentrates used in feeding the dairy herds are purchased, for the most part, from Portland. Some feed mixing is done locally, with ingredients from Portland or at times directly from producing areas. Occasionally hay for dairy purposes, principally alfalfa, is purchased from the producing areas of eastern Oregon and eastern Washington. Under normal conditions, dairy herds of less than 20 cows do not constitute an economic unit.

The 1940 census reported 7,264 cattle on farms on April 1 of that year, of which 4,346 were cows and heifers more than 2 years old kept for milk production. Of the cows in the county 85 percent are of the Guernsey breed, 12 percent Jersey, and about 3 percent Holstein-Friesian. A long-time program of permanent agriculture in Clatsop County, considering particularly the soil fertility problem, will place dairying in a major position. Agencies working closely with the agricultural program of the county should encourage the natural, healthy growth of the dairy industry based upon the improvement of pastures and the production of home-grown feed.[6]

The poultry industry has passed the developing stage and is now well stabilized. According to the census the value of chickens over 4 months old in 1940 was $38,816. White Leghorns are the predomi-

[6] Report of the Clatsop County Agricultural Conference by County Agent A. Zundel in 1936.

nant breed. Eggs are marketed cooperatively for shipment to eastern markets; approximately one carload of high quality eggs is shipped each week throughout the year. All poultry feeds except green crops are imported. Portland, a central grain market, gives this area some advantage over more remote areas. Turkeys are grown only in limited numbers, and there are no large commercial flocks. Turkey production may be increased for local needs; artificially brooded poults offer best possibilities.

Sheep are pastured on logged-off lands; some are kept on a year-round basis, while others are brought in only for summer grazing. The long wool breeds, Romney, Lincoln, and Cotswold, are adapted to this area. As these breeds are acquired, more year-round operations will be established. Portland is a good wool market and the central lamb market for the area, but lambs also are sold in other coast markets including San Francisco, Los Angeles, and Seattle. February and early March lambs can be marketed from July 1 to August 10.

Beef cattle are grazed in connection with sheep operations on the cut-over lands. Cows and heifers when brought from other areas adapt themselves more quickly to coast conditions than do steers. All classes do best when brought in early in spring. The beef cattle kept are on a year-round basis. Portland is the chief market, with a limited number slaughtered locally. At present the herds kept in connection with other farm enterprises vary in size from 10 to 12—not enough to require the full time of the operator.

Commercial hog raising is limited to the operation of garbage feeding in the vicinity of towns and camps. Farm wastes are utilized by feeding hogs for home use.

Horses for farm work have decreased with the increased use of tractors, although there is some demand for horses for short seasonal work, especially in grass-seed harvest. In general, horses are used on the smaller farms. Few are now being raised, and the present stock is comparatively old. The predominating breed is Percheron.

Values of agricultural products, by classes, are given in table 3.

TABLE 3.—*Value of agricultural products, by classes, in Clatsop County, Oreg., in 1939*

Crop	Value	Livestock and products	Value
Cereals	$7,138	Cattle, swine, and sheep sold and slaughtered	$102,749
Other grains and seeds	85,018	Dairy products sold	332,921
Hay and forage	138,069	Wool shorn	1,515
Potatoes and sweetpotatoes	7,092	Poultry and eggs produced	199,819
Vegetables for sale and households' use (excluding potatoes and sweetpotatoes)	35,821	Honey produced	802
Fruits and nuts	27,712	Total	637,806
Horticultural specialties sold	11,419		
Forest products sold	14,694	Total agricultural products	964,769
Total	326,963		

TYPES OF FARMS

In 1880, 7 percent of the county, or 37,469 acres, was classed as farm land. The 146 farms at that time had an average size of 256 acres, of which 27 percent was improved. By 1910, there were 369 farms with 54,221 acres; the average size of the farm was 146.9 acres. There was a total of 12,731 acres of improved land, or an average of

34.5 acres for each farm. All field crops totaled 4,851 acres. Hay was the principal crop with 3,844 acres; oats ranked next with 612 acres. Hogs numbered 1,451, sheep 1,493, and milk cows 3,325.

In 1940, there were 51,754 acres in 661 farms, an average of 78.3 acres each. Of this, 8,986 acres were used for crops.

FARM INVESTMENT AND EXPENDITURE

Need for permanent farm labor in the county is limited; however, the larger dairy farms keep hired labor the entire year. Hired help ranges from one to three men in addition to the owner or operator. In 1940, 164 persons were hired as laborers on farms, at a total cost of $102,346.

There is a definite demand for seasonal farm labor for pea harvest from about July 1 to August 10, and a limited demand for labor on vegetable crops from July 15 to September 1. Bentgrass harvest, beginning about August 1 and extending to September 20, and cranberry harvest in September and early in October demand considerable labor. For the most part this labor is supplied locally, with occasional help from outside. Farm labor on a monthly basis with board averages $30 to $50 a month. Pea and bentgrass harvest crews receive 50 cents an hour. Vegetable and cranberry harvest is done by piecework.

Part-time farming is scattered quite generally through the county. Operators of these small farms obtain employment, more or less seasonal, with the logging and fishing industries, in sawmills, and in flour mills.

Only a few farms are rented, especially larger farms. Even the few smaller farms that are rented have a small tenant turn-over. For the county as a whole the farms are owner-operated.

Tractors of many kinds have come into general use in the last few years. They range from the large Diesel crawler type used for land clearing and farm work on the large farms to the small rubber-tired type used on smaller farms and for light work and special jobs on the larger farms. A total of 133 tractors, 185 motortrucks, and 466 automobiles were on Clatsop County farms in 1940.

The value of farm property in Clatsop County for 1930 and 1940 is given in table 4.

TABLE 4.—*Value of farm property in 1930 and 1940 in Clatsop County, Oreg.*

Item	1930	1940
Land and buildings	$5,430,285	$3,875,373
Implements and machinery	345,775	392,478
Domestic animals, poultry, and bees	775,229	396,639
All farm property	6,551,289	4,664,490

SOIL SURVEY METHODS AND DEFINITIONS

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

The soils and the underlying formation are examined systematically in many locations. Test pits are dug, borings made, and highway or

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railroad cuts and other exposures studied. Each exposes a series of distinct soil layers, or horizons, termed collectively the soil profile. Each horizon, as well as the underlying parent material, is studied in detail, and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The chemical reaction of the soil and its content of lime and salts are determined by simple tests.[7] Other features taken into consideration are the drainage, both internal and external, the relief, or lay of the land, and the interrelations of soil and vegetation.

The soils are classified according to their characteristics, both internal and external, with special emphasis upon the features that influence the adaptation of the land to the production of crop plants, grasses, and trees. On the basis of these characteristics the soils are grouped into classification units, the principal three of which are (1) series, (2) type, and (3) phase. Some areas that have no true soil—as Alluvial soils, undifferentiated, Riverwash, and Dune sand—are termed (4) miscellaneous land types.

The series is a group of soils having horizons similar in their important characteristics and arrangement in the profile, and having similar parent material. Thus, the series comprises soils having essentially the same color, structure, natural drainage, and other important internal characteristics and the same range in relief. The texture of the soil may vary within a series. The series are given geographic names taken from localities near which they were first identified. Astoria, Hebo, Nehalem, Clatsop, and Sauvie are names of important soil series in Clatsop County.

Within a soil series are one or more types, defined according to the texture of the upper part of the soil. Thus, the class name of this texture—sand, loamy sand, sandy loam, silt loam, clay loam, silty clay loam, or clay—is added to the series designation to give a complete name to the soil type. Except for the texture of the surface soil, these types have approximately the same internal and external characteristics. Astoria loam and Astoria silt loam are soil types within the Astoria series.

A soil phase is a subdivision of the type based on variations that generally are external and of special practical significance. For example within the normal range of relief of a soil type some areas may be adapted to the use of machinery and the growth of cultivated crops and others may not. Differences in relief, stoniness, and degree of accelerated erosion may be shown as phases. The more sloping parts of the soil type may be segregated on the map as a sloping or a hilly phase. Similarly, some soils having differences in accelerated erosion may be mapped as eroded phases.

Some soil types possess a narrow range of phase characteristics and, hence, are not divided into phases. Such soil types could be thought of as consisting of only one phase. Most of the types in the Astoria area are of this nature. Brenner silty clay loam is an example. Where a soil type consists of more than one phase, one of them is generally of more common occurrence than the others. Such a phase is considered to be the normal phase of the type and bears no phase

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

designation. The Hebo silty clay loam type, for example, is divided into two phases: (1) Hebo silty clay loam (the normal or gravel-free subsoil phase) and (2) Hebo silty clay loam, gravelly subsoil phase.

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

SOILS

The soils of Clatsop County have developed under the influence of an abundant moisture supply under marine temperature conditions. Although the total yearly rainfall is high in the coast area, the summers are warm and dry. As it has been found profitable to irrigate in the Willamette Valley during the past few years, this practice has spread to the coast counties where it has given equally good results. The western part is heavily timbered with spruce and the eastern part with Douglas-fir. This is especially true on the uplands. The soils have been formed under typical humid conditions and, with the exception of the Sauvie and the Nehalem series, are distinctly acid.

The soils of the area fall naturally into six groups as follows: (1) Soils of the uplands, commonly known as hill soils; (2) soils of the terraces or benchlands, derived from old valley-filling materials; (3) soils of the flood plains, derived from recent stream alluvium on bottom lands; (4) soils from wind-blown sands; (5) organic soils; and (6) miscellaneous land types.

SOILS OF THE UPLANDS OR HILLS

The surface soil of the uplands is dark brown and moderately well supplied with organic matter and contains iron concretions or shot pellets. The subsoil is light-brown to yellowish-brown moderately compact clay loam, highly mottled, with gray, orange, and rusty brown in the lower part. Such soils are classified in the Astoria (Melbourne)[8] series.

ASTORIA (MELBOURNE) SERIES

The soils of the Astoria series were formerly included in the Melbourne soils. They occur on the uplands or hills developed on sandstone and shale. Except in the smooth lower lying foothills most of the relief is rolling to hilly. The surface soil is rarely more than 3 feet thick, frequently not more than 2, but the parent material is permeable to depths of 10 to 25 feet. The parent material differs from that of the Melbourne soils in the Willamette Valley in that it is softer and has a larger proportion of soft shale that usually has weathered to greater depths. Because of greater rainfall and warmer winter temperatures the soils are more completely leached and as a result are not so fertile for general farm crops and need more fertilizer and lime. The weathering of the soft shale and sandstone has not only produced deeper soils, but it has resulted in hills of more rounded topography. Astoria soils make up the hill lands almost to the exclusion of all other types. Astoria loam and silt loam and Astoria soils, undifferentiated, have been mapped.

[8] See footnote 2, p. 1.

SOILS OF THE TERRACES

The soils developed from old valley-filling materials occur on the terraces and flats of the valley floors in positions higher than the recent valley soils and lower than the soils of the hills. They range in development from moderately young to semimature. Because of differences in topography and drainage they have the appearance of varying in age. Many of the gravel deposits shown by narrow fringes or shoulders along the terraced slopes of present drainage channels are considerably less extensive than they were in former times. The age of these materials is intermediate between that of the Klaskanine (Salem) gravel of the Willamette Valley and the ancient gravel of the Salkum soils in the State of Washington. The soils are derived from mixed materials of mixed origin brought in by streams from the adjacent hills. The following series are included in this group: Knappa (Willamette), Klaskanine (Salem), Cinebar. Hebo, and Grande Ronde.

KNAPPA (WILLAMETTE) SERIES

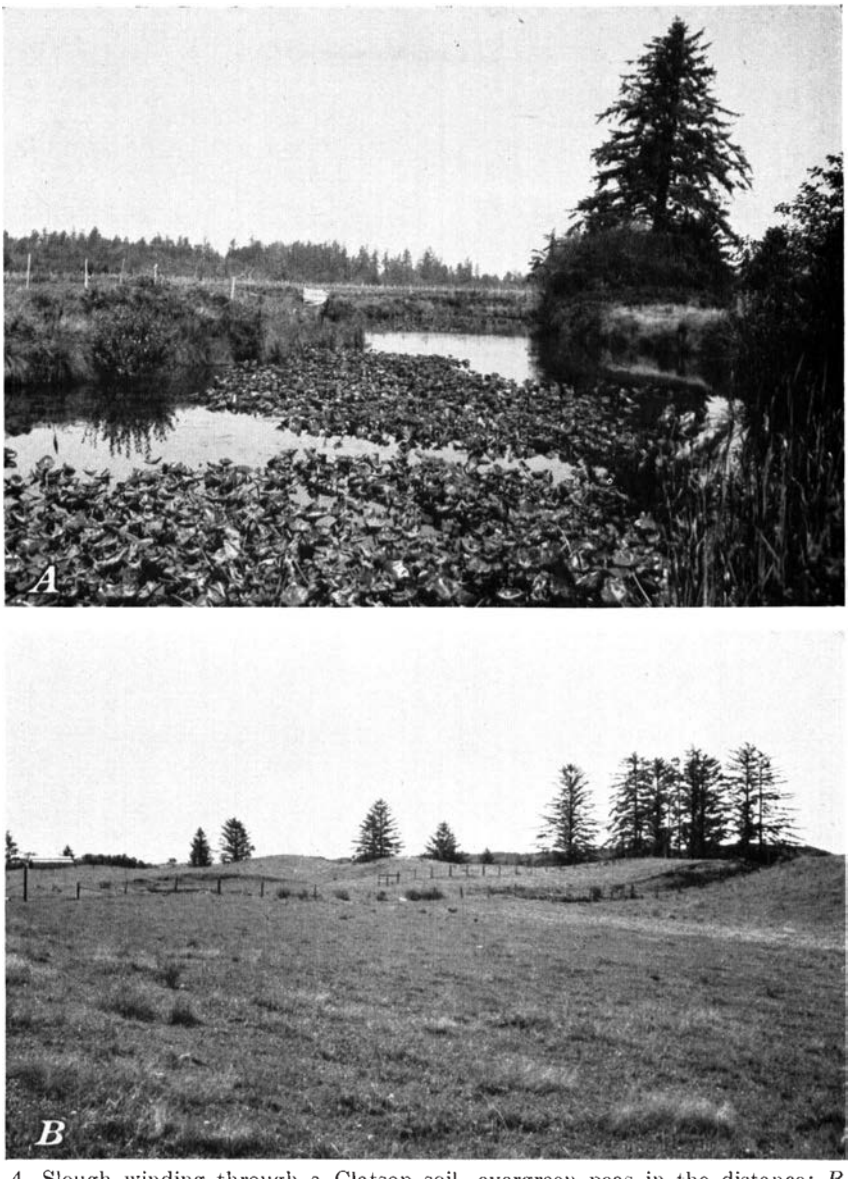
The Knappa soil, formerly included in the Willamette series, occupies well-drained sites on fairly smooth terraces. The rich-brown friable surface soil overlies lighter brown or yellowish-brown slightly compact mottle-free subsoil, which grades below a depth of about 30 inches into a little lighter yellowish-brown and more friable material. Typically, there are no pieces of gravel present, but as mapped in Clatsop County small areas containing water-worn gravel, which are more representative of the Klaskanine series, are included. Knappa loam is the only type mapped.

KLASKANINE (SALEM) SERIES

The Klaskanine soil, formerly included in the Salem series, resembles that of the Knappa in position, surface characteristics, and condition of drainage but has a lighter texture and a more pervious subsoil containing a large quantity of loose water-worn gravel. The gravel, mostly sandstone and quartzite, shows little weathering. The Klaskanine soil differs from the old established Salem soils in that it is not so productive for comparable textures and it requires different management for best results. The only type mapped is Klaskanine silt loam.

CINEBAR SERIES

Intimately associated with the Knappa and Klaskanine soils on old eroded terraces is the Cinebar series. This soil has a brown to dark-brown surface soil and brown to light-brown to yellowish-brown moderately compact heavier textured mottled subsoil containing a quantity of partly weathered water-worn gravel. Although the gravel is considerably more weathered than that in the Klaskanine soil, it is less decomposed than that of the Salkum series as mapped in the State of Washington. Gravel is embedded in similar-colored mottled clay loam or clay, however, which has about the same effect on underdrainage. The subsoil ranges from 2 to 8 feet in thickness and is underlain by sandstone or shale. Usually these benchlands are narrow fringes or shoulders of areas that formerly were much more extensive. Cinebar silt loam is the only type mapped in the area.



A, Slough winding through a Clatsop soil, evergreen peas in the distance; *B*, rounded or undulating parallel dunelike ridges of Gearhart soils developed on old wind-blown sandy areas along the coast; low intervening areas occupied by lakes, ponds, and swampy basins.

A, Tussock grass in pasture on overwash phase of peat near Lewis and Clark River; *B*, dense growth of alder, willow, spruce, and other trees and shrubs on Brallier peat.

GRANDE RONDE SERIES

Grande Ronde silty clay loam, the only type mapped, usually lies as gently sloping, poorly drained benchlands adjacent to the hills. It also is found in level poorly drained areas in association with the Cinebar soil. The soil is characterized by a brown, dark-brown, or pale grayish-brown surface soil with a dull grayish-brown heavy subsoil, mottled with yellow, orange, and gray. As mapped in Clatsop County nontypical areas are included in which weathered gravel is found in the deep subsoil embedded in gray compact silty clay loam that is highly mottled with yellow and rusty streaks.

HEBO SERIES

Resembling the Grande Ronde soil in position and poor condition of drainage are the soils of the Hebo series. They differ primarily in having a darker color—a very dark-brown or black surface soil with a gray heavy compact subsoil profusely mottled with yellow and orange. The normal and gravelly subsoil phases of Hebo silty clay loam are mapped in the area.

SOILS OF THE FLOOD PLAINS

Contrasted in position with the uplands and terraces are the soils of the flood plains along the streams. This group includes some of the most important soils in the area. Composed of alluvial materials washed from the hills, they are usually regarded as new soils as contrasted with the older soils of the uplands and terraces that have been acted upon for long periods by the forces of soil development. They display all conditions of drainage—from very well-drained to perpetually waterlogged soils (pl. 2). These soils are classified in the Nehalem, Brenner (Wapato), Sauvie, and Clatsop series.

NEHALEM SERIES

The best drained soils of the lowlands are included in the Nehalem series. The surface soil is brown or grayish brown when dry but becomes decidedly yellowish brown when moist. The subsoil is yellowish brown with orange and gray mottling in the lower part. The soils occupy first bottoms along rivers and smaller streams. Some areas are subject to overflow. These soils are derived from material that has been washed from hills that are predominantly of sedimentary rock. Nehalem loam, Nehalem silt loam, and Nehalem (Chehalis) silty clay loam are mapped in the area.

BRENNER (WAPATO) SERIES

The Brenner series includes a soil with a dark-brown or dark grayish-brown surface soil, mottled with rusty brown and underlain with a dark grayish-brown highly mottled moderately compact heavier textured subsoil. This soil occurs on alluvial deposits along streams and is subject to overflow. Both surface and internal drainage are poor.

The Brenner soil differs from the old established and widely mapped Wapato soils in that it is more acid, more highly mottled, less fertile, and is not adapted to so wide a range of farm crops. Brenner silty clay loam is mapped in the area.

SAUVIE SERIES

The most extensive of the soils of the flood plains are those of the Sauvie series. The surface soil consists of brownish-gray or gray highly mottled or iron-stained types with a relatively large content of organic matter. The stratified subsoil often has several layers that are somewhat similar in character. It is, however, grayer in color, is less mottled, and contains less organic matter than the surface soil. This layer ranges from fine sandy loam to silt loam and is always mellow and friable. The underlying material is mellow and friable, becoming very sandy in the deeper parts. These soils occur along the Columbia River and consist of recent alluvial sediments derived from a wide variety of rocks and brought in from great distances. They occupy first bottoms subject to overflow. Dikes are necessary before they can be farmed. The surface is undulating with low mounds, ridges, and shallow basins.

The soils of the Sauvie series are similar to those of the Clatsop series in surface characteristics. Both have a distinctly gray to brownish-gray color, and both are normally wet until drained. Clatsop soils, however, have a higher content of decomposed organic matter, as well as more raw fibrous roots. The Clatsop subsoil is much heavier textured, generally a silty clay loam or blue clay. Another important difference is that Sauvie silty clay loam is only slightly acid or almost neutral, whereas Clatsop silty clay loam as a rule is strongly acid. Sauvie silt loam and silty clay loam are the only types mapped in the area.

CLATSOP SERIES

The soils of the Clatsop series occupy a considerable acreage of coastland that is affected by tides. They are of marine origin. Most of them until drained are underlain by heavy and compact perpetually waterlogged mud-flat material. The topography usually is flat, except near the banks of sloughs where the land is higher (pl. 3, *A*), due to deposits of sediment when the channels overflow. Often the lower lying areas between sloughs are more peaty in character in both surface and subsoil than is typical. Drainage is poor because of the high water table and the heavy-textured subsoil. When diked and drained they are adapted to a wide range of crops.

The surface soil is yellowish brown, brownish gray or gray, mottled or speckled with orange or rusty brown and contains much organic matter. The upper subsoil is similar to the surface soil in all respects, except that it contains less organic matter. The lower subsoil is gray to bluish-gray silty clay or clay. These soils, however, have variable profiles and in places contain more peaty material than is typical. These deposits, nearly always waterlogged until reclaimed, are typical of tidelands or mud flats. This series resembles that of the Sauvie in that both have gray mottled surface soils, but the surface layer has a higher content of organic matter and the subsoil a layer of heavy silty clay loam that slows up underdrainage. The Sauvie subsoil, on the other hand, although composed of stratified layers, is lighter in texture, varying from a fine sandy loam in the upper part to more sandy material below. Clatsop silt loam and silty clay loam are the only types mapped in the area.

SOILS FROM WIND-BLOWN SANDS

The sandy soils of the Astoria area represent sand dune material in various stages of development. Dune sand is the newest of the wind-blown soils. In the native state it is almost bare of vegetation and is still in the process of being moved by winds.

Four soil groups in the area are derived from wind-blown materials. Of these, dune sand, which lies nearest the ocean, is the least developed. Dune sand consists of wind-drifted sands occurring in dunes, ridges, or hummocks. It is usually without vegetation and is still undergoing active wind erosion and redistribution by winds. It is considered one of the miscellaneous nonarable land types rather than a soil type.

The Gearhart soil is the oldest and best stabilized of the well-drained sandy deposits. It is fairly well tied down by vegetation and has become somewhat iron-stained. The Westport soil is newer. It has only a thin mat of organic matter and has but little firmness in the subsoil. All three of these groups of soil have dunelike topography, and all are excessively drained. The Warrenton series is composed of material blown from one of the above-named soils and redeposited in the narrow depressions between the dunes. It is a wet soil, usually iron-stained.

GEARHART SERIES

The Gearhart soil is on the oldest or best stabilized of the sand dunes (pl. 3, *B*). The Gearhart and Westport soils have the appearance of grasslands, although the Westport is still very young. Both have typical dune topography. The Gearhart has a dark grayish-brown to black surface soil high in black, sooty, finely divided organic matter that is very black when moist. Below the surface soil, which is loose but firmer than the rest of the profile, the rusty chocolate-brown material is still looser and contains less organic matter. The lower subsoil gradually loses the brown color of organic or iron staining until at 36 inches the loose fine sand is about the same color as beach sand. Only Gearhart fine sandy loam is mapped in the area.

WESTPORT SERIES

The Westport series represents the first stage in the stabilization of sand dunes. The soil is derived from wind-laid sands blown inland from the dunes nearest the ocean and covered by a thin mantle of vegetative growth. The surface soil consists of a 5- to 8-inch veneer of dark grayish-brown sandy material with a sufficient matting of roots and organic matter to hold the loose soil together. Immediately below, the sandy material contains very little organic matter and is very loose and porous. The entire profile, however, is faintly colored with humus or rusty-iron stains. Westport fine sand is the only type mapped in the area.

WARRENTON SERIES

The Warrenton soil closely resembles that of the Gearhart series in both surface soil and subsoil characteristics but differs in having iron-stained mottlings in the lower part and in occupying poorly drained depressions between the ridges of Gearhart soil. Warrenton loamy fine sand is mapped in the area.

ORGANIC SOILS

Associated with the soils from wind-blown sands and with the poorly drained soils of the flood plains are wet areas of highly organic soils that consist largely of partly decomposed plant remains known as peats (pl. 4, *A*).

The main areas of organic soils are located in the northwestern part of the county. The coast is bordered by drifting sand that has been thrown up by the waves and carried inland by winds. The irregular ridges and dunes of sand, in general, have their greatest dimension approximately parallel to the coast and in many places they enclose areas of peat.

Some of the deposits are sphagnum bogs, others are marshes, and the margins or shallow parts of a few are well covered with timber. This indicates that the rate of peat formation depends on the depth of the depressions and the character of the vegetation, including the order of succession of the various species which, dominating from time to time, presumably have marked stages toward a condition of ecologic stability. The character of the peat depends very largely on the kind of organic matter and the stage of decomposition. The organic soils of the area have been separated into types on the basis of differences in the character of parent material, stages of decomposition, or degrees of profile development. The material composing peat consists mainly of organic matter.

Two types—Brallier peat and Spalding peat—that closely resemble each other have been mapped. In the coastal section additional shades of differences may be recognized in the kinds of parent material, the coarseness of the organic fibers, and in the different stages of decomposition. Usually these differences, all indistinct and relatively unimportant, do not lend themselves readily to mapping.

All the peats in the area represent fairly deep deposits of felty or fibrous organic matter. The partly decomposed material may reach depths of 9 to 10 feet, but much of it is considerably shallower.

MISCELLANEOUS LAND TYPES

The miscellaneous land types include Coastal beach, Alluvial soils, undifferentiated, Dune sand, Marsh, and Riverwash.

DESCRIPTIONS OF SOIL UNITS

Thirteen soil series represented by 20 soil types and phases, together with 5 miscellaneous land types and 2 organic soils, are recognized and mapped in the Astoria area. In the following pages the soil types, phases, land types, and organic soils, are described in detail and their agricultural relations discussed. Their location and distribution are shown on the accompanying map, and their acreage and proportionate extent are given in table 5.

Alluvial soils, undifferentiated.—This unimportant group of soils, confined entirely to the northern part of the county, begins about 2 miles east of Svensen Island and extends along the Columbia River beyond Brownsmead. For the most part, these soils occupy inaccessible areas of bottom lands unprotected from tides. Inspection of isolated areas reveals that, in all probability, a considerable part of these soils is of the Sauvie series, since so many apparently similar areas diked and farmed appear to be rather uniformly of these soils.

A, Heavy growth of tussock grass, sedges, and juncus; *B*, evergreen peas, both on Brallier peat.

A, Diked tideland (Clatsop silty clay loam) near Astoria; *B*, typical cut-over land.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in the Astoria area, Oregon*

Soil type	Acres	Percent	Soil type	Acres	Percent
Alluvial soils, undifferentiated	1,344	0.9	Klaskanine silt loam	576	0.4
Astoria loam	7,872	5.3	Knappa loam	832	.6
Astoria silt loam	3,776	2.6	Marsh	448	.3
Astoria soils, undifferentiated	79,104	53.7	Nehalem loam	2,432	1.7
Brallier peat	1,984	1.3	Nehalem silt loam	2,752	1.9
Brenner silty clay loam	2,240	1.5	Nehalem silty clay loam	1,536	1.0
Cinebar silt loam	6,016	4.1	Riverwash	576	.4
Clatsop silt loam	384	.3	Sauvie silt loam	128	.1
Clatsop silty clay loam	9,920	6.7	Sauvie silty clay loam	10,624	7.2
Coastal beach	1,280	.9	Spalding peat	640	.4
Dune sand	2,944	2.0	Warrenton loamy fine sand	704	.5
Gearhart fine sandy loam	2,624	1.8	Westport fine sand	2,688	1.8
Grande Ronde silty clay loam	2,304	1.6			
Hebo silty clay loam	1,152	.8	Total	147,200	100.0
Gravelly subsoil phase	320	.2			

Many of these unmapped, undiked islands within the county are of similar nature to those that are mapped. Only slight investigation could be given them because of their inaccessibility. Their present or prospective value does not justify the expense of mapping them in detail as soil types.

Astoria loam.—Although one of the most extensive types mapped in the area, only a small part is under cultivation. It occurs in all parts of the uplands, always bordering the upper margins of the old valley-filling soils. Generally, both external and internal drainage are good. Some areas along the foothills affected by seepage, however, have good surface drainage with restricted internal drainage. Native vegetation along the coast is principally spruce, hemlock, and alder; in the valley of the Nehalem River there is also Douglas-fir.

In the virgin state this type consists of a surface layer about 2 inches thick of dark-brown loose friable loam high in roots and organic matter. When moist the color is almost black. This is underlain, to an average depth of 14 inches, by brown to slightly yellowish-brown mellow fine granular loam to light silt loam containing a quantity of soft shotlike pellets, which, when crushed, become a yellowish brown. The 20-inch upper subsoil is yellowish-brown, firm to moderately compact, medium to coarse granular clay loam. The lower subsoil, to a depth of 30 to 36 inches, is a yellowish-brown fine cloddy moderately compact clay loam mottled with orange and rusty brown. Occasionally on the lower foot slopes the soil is deeper, slightly heavier, and more compact. In place it is underlain at various depths with layers of gray silty clay loam or gray stiff clay stained with yellow and rusty brown. The underlying parent material of shale or sandstone ranges from 2 to 6 feet beneath the surface. On smooth-lying foothills adjacent to benchlands, the depth of the soil averages 4 to 5 feet, but where the hills are rolling to steep the depth is 1 to 3 feet.

About 5 percent of the soil is in cultivation. The principal crops are oat and vetch hay, clover and grass hay, grass for pasture, root crops, small fruits, and strawberries. Acre yields of oat and vetch hay range from 2 to 3½ tons, clover and grass ¾ to 1½ tons, and strawberries 1,200 pounds. One acre of pasture supplies about 90 days grazing for 1 animal unit.

As mapped in this county the soil is only moderately fertile. When first cleared it produces fairly good crops for a short period but there is a gradual falling off in production.

The original active organic matter soon disappears under cultivation, and it becomes necessary to add this constituent and to build up and maintain the supply of nitrogen if fair yields are to be obtained. Crop residues, green manures, and barnyard manures are valuable sources of organic matter and should be added frequently.

In order to make best use of these important sources and to realize the maximum benefits, systematic crop rotations should be followed. These rotations should include more extensive use of legumes and green-manure crops. The State agricultural experiment station recommends growing legumes for 2 to 4 years on hill lands followed by a cultivated row crop. Crop rotations are shorter on hill lands, because clovers are harder to maintain under the prevailing conditions of low fertility and high lime requirement. Both pasture and meadow can be maintained for a longer period if phosphate top dressing is used. This is especially true where clovers are desired.

Early in spring of the first year of the rotation superphosphate is used at the rate of 400 pounds an acre on row crops or 250 pounds on clover and grass seedings followed by top dressings at intervals throughout the growing season. As this is distinctly an acid soil, an application of 1 or 2 tons of lime is necessary to obtain good stands of clover or vetch hay.

The moisture-holding capacity of this soil is only fair, and moisture often becomes the limiting factor in crop growth. Irrigation would greatly increase yields, but due to the uneven topography and the lack of available water few installations are likely to be made. With the best management and practices only fair yields may be expected on this soil.

Astoria silt loam.—This soil differs from Astoria loam in having more silt and less shotlike pellets, which gives it a smoother feel. The soil occupies large bodies 1½ to 3 miles east and southeast of Olney. Other large areas occur along the highway from Jewell to Birkenfeld, 1 to 1½ miles east of Elsie, and half a mile southeast of Seaside. The relief is undulating to gently rolling. Although the surface drainage is always good, there are a few areas, especially on the lower foothills, that occasionally receive seepage and need drainage for best crop production.

Although this is a moderately extensive soil, only 5 to 8 percent of the area is under cultivation. In the area mapped the logged-off land has grown up into second-growth coniferous trees. Other areas have mountain-ash, alder, Oregon maple, and other shrubs.

In virgin areas, the 2-inch surface soil is dark-brown granular loam or light silt loam containing many fine roots and a good supply of organic matter. Immediately below, to a depth of 10 to 15 inches, the soil is brown fine-granular moderately mellow clay loam containing a few soft iron concretions. This material in turn grades into a brown clay loam or silty clay loam, slightly more compact than above. At an average depth of about 25 inches the subsoil is yellowish-brown silty clay loam of granular and angular structure and moderately compact. This layer is mottled with gray and rusty stains and is rarely penetrated by roots. Between depths of 38 and 70 inches the layer is definitely parent material of sandstone origin,

although it is moderately loose and highly weathered. This layer also is very highly mottled with gray, orange, and rusty stains.

The crops grown and the best methods of soil improvement are similar to those of Astoria loam.

Included with the type are a few low-lying foothill areas in which the surface color is somewhat lighter than typical, closely resembling that of Carlton silt loam. The surface soil is brownish-gray or grayish-brown silt loam somewhat more compact than the typical soil. The subsoil is yellowish-brown, mottled, heavier textured material similar in all respects to the subsoil of the silt loam. Most of these areas occur in the lower foothills extending from Jewell eastward along the Nehalem River to the county line. Crop adaptations and methods of handling are similar to those on Astoria loam.

Astoria soils, undifferentiated.—Forested cut-over and burned-over areas of undifferentiated soils of hilly to rough topography comprise this type. Although recognized in this county as consisting mainly of Astoria soils, especially in the vicinity of the agricultural lands, the State and Federal highways traversing the rough mountainous lands pass through small areas of basaltic rock that is quarried for road purposes. Several different soils, therefore, are present in these areas, but their occurrence is extremely limited.

This undifferentiated unit, as mapped, has smoother topography than that of most of the rough mountainous land mapped in other areas. Most of it is densely covered with brush. Under present economic and agricultural conditions it is not considered expedient to attempt the classification and detailed mapping of the soils in these areas because of inaccessibility and unjustifiable expense.

In some of the cut-over and more open districts, small areas are cultivated. Grazing is profitable on land that is sufficiently open and clear of underbrush; but little use is made of the pasture afforded, compared to that possible if care were taken to remove the debris left by lumbering operations and if the areas were seeded to grass.

Brallier peat.—This organic soil is rather extensive along the coast and in the alluvial bottoms of the lower Columbia River. Prominent areas are found in the vicinity of Hammond, Brownsmead, immediately northwest of Cullaby Lake, and a short distance east of Gearhart and Seaside. In the vicinity of Hammond there is somewhat more mineral soil in the profile than is typical, and in places it merges imperceptibly into soils of the Clatsop series. Along the Columbia River the type occurs in association with Sauvie soils into which it merges with no distinct line of demarcation.

This type occupies level poorly drained flats in places little above sea level. In its native state it is covered with spruce, willow (pl. 4, *B*), crabapple, wild cranberries, and brush (pl. 5, *A*). Until recently, when the county inaugurated a program of clearing and ditching an area in the vicinity of Hammond, only very small patches were under cultivation.

Generally ranging from 2 to 5 feet in depth, with a large proportion between 2 and 3 feet, this organic soil occupies level poorly drained flats in places little above sea level. The 2- or 3-inch surface layer consists of dark-brown to black undecomposed organic matter, high in sphagnum moss and fibrous roots with only a small quantity of decomposed organic material and very little mineral soil. The

material on the surface is very raw, but below it is more weathered and occurs in small dense clusters that are hard but friable when dry. It appears to be largely of sedge roots, many of which are about one-sixteenth inch in diameter.

Beneath the surface layer, to a depth of 17 inches, the peat consists of brown to dark-brown moderately decomposed fine felty fibrous organic matter high in sphagnum moss with a somewhat browner color than the material above. There is also less broadleaf vegetation and coarse roots. When dry, there is a slight staining of the organic material with gray mineral soil and the clusters of organic matter, although somewhat firm, are more friable than the material above. Rubbed between the fingers, it has a smooth velvetlike feel. The surfaces of freshly broken aggregates have a shiny appearance, due to the presence of thin films of colloidal material. There are some woody particles and sedges but only a small proportion of mineral soil.

Beneath the subsoil, to a depth of about 26 inches, the soil is similar to that above, except that darker brown or black color is more persistent either when dry or wet. The material has a higher content of moss and fine fibrous material with less raw roots and in general is somewhat more thoroughly decomposed. Some woody material is present, but there is very little sedge. When crushed between the fingers it feels like a light silt loam. In places, just below this layer, there is a 1- or 2-inch layer of silt loam or light clay loam that rests abruptly on gray iron- or organic-stained sand. The sand often has a greenish or iron tinge for several feet but gradually merges into dune sand.

The areas occurring immediately northwest of Cullaby Lake, three-fourths mile east of Gearhart, and about half a mile east of Seaside represent the most thoroughly decomposed peat in the county. The areas are less extensive than the typical peat.

In the virgin condition the surface layer, ½ to 1½ inches thick, consists of undecomposed litter—mainly of sphagnum moss, sedge, and woody material that is mainly of spruce origin. Beneath this layer to a depth of 12 to 14 inches, the material is very dark-brown to black organic matter in a rather well-advanced stage of decomposition, with a tendency to become very hard when dry. From the appearance of the soil and the presence of charred woody material, there is evidence that the soil in a number of areas has been influenced by fire. With the exception of the woody material the visible undecomposed vegetation is mainly fine fibrous roots. Much of the original vegetation is decomposed beyond recognition. The moist material when squeezed between the fingers has a colloidal siltlike feel. Underlying this layer to a depth of about 26 inches, the soil when moist is slightly lighter in color than the surface soil, although it becomes very dark when dry. The material is only partly decomposed and is quite high in sedge and woody remains. On drying, the firm clusters break apart readily with pressure.

Beneath a depth of 48 inches, the soil continues to become lighter colored, varying from a straw brown to brown. It is very high in coarse material and consists mainly of undecomposed willow, bark, cones, and some sedge. When moist there appears to be little highly decomposed material, but when dry its presence is more evident. At this depth there is much less mineral soil or colloidal material than is found above. The moist organic matter becomes much darker after

exposure to the sun. The underlying substratum, to a depth of about 60 inches, contains an appreciable quantity of fine and very fine sand. It is moderately high in coarse material, as willows, cones, bark, and other unidentified coarse residue. The material is very friable owing to the high sand content, yet there is enough highly decomposed peaty material to cause it to form into clusters of soil particles. Gray sand usually occurs between 5 and 9 feet in depth. Most of this phase is still covered with brush.

At present there is some question as to the best crops adapted to this soil type. The most important need is drainage in order to lower the water table to permit aeration and further decomposition of the raw organic material. In summer control of drainage is important in order to raise the water table to provide subirrigation. This can be accomplished by blocking the ditches draining the area. One of the first steps for the improvement of the land after it is drained is the growing of some annual crop for about 3 years. This entails plowing the land each year, thus assisting the decomposition and release of plant food. Another method of reclaiming this land is to seed it to grass for pasture, to canary grass for hay, or to Astoria bentgrass for seed until better drainage is effected. After this, blueberries or cranberries may be planted, and, if lime and phosphates are applied, other intensively cultivated crops can be grown. Within 3 to 5 years after the peat is first cultivated the land should be ready for growing vegetables (pl. 5, *B*) on a small scale in connection with general farming or the raising of livestock. Before extensive plantings of vegetables are attempted, however, it is desirable to have more information relative to the crops that are best adapted to it.

A somewhat browner variation of Brallier peat is found along the Columbia River in the vicinity of Brownsmead. This soil, with a content of 25 to 60 percent of organic matter that is fairly well decomposed, appears to be somewhat less acid than that nearer the coast. It is of very limited extent.

The surface soil to a depth of 12 inches consists of rich-brown moderately decomposed peat containing a small quantity of mineral soil. It is composed of fine fibrous material in which some of the plant remains are still visible. Below, to a depth of 26 inches, the color is about the same, the content of mineral soil is less, and the fibrous peat is a little coarser than near the surface.

The surface layer is underlain to a depth of 30 to 36 inches by dark-brown fine fibrous material containing a considerable quantity of coarse vegetation, as fern roots. Underneath, to a depth of 48 inches, the peat consists of fine fibrous vegetation, some partial remains of fern roots, and a small quantity of colloidal material. With increasing depth, more mineral soil is present.

The subsoil to a depth of 60 to 70 inches is very similar to the Sauvie subsoils, although there is a fair quantity of organic matter present. The areas of this variation are usually small and have a flat topography. They occur in the low depressions between sloughs, their depth decreasing near the sloughs. As the sloughs are approached, the soil gradually changes to a peaty silt loam and finally to Sauvie silty clay loam, which occurs as strips 300 or 400 feet wide.

This soil is usually farmed in connection with adjoining areas and is considered a productive soil. Acre yields of clover and grass are 2 to 3½ tons; oat and vetch hay, 2½ to 5 tons. Rotation pastures support

1½ animal units an acre for about 7 months. Other crops grown successfully are roots, peas, sweet corn, and vegetables. One of the principal needs is drainage to aerate the peat and assist organisms in the decomposition of the raw material. Drainage is accomplished by use of tide boxes, which in the dry season may be opened to permit subirrigation.

Phosphate and potash fertilizers are needed on this soil. Potash applied at the rate of 150 pounds an acre is especially desirable for vegetables and root crops. Phosphate is used at the rate of about 400 pounds an acre on root crops and vegetables and 200 to 250 pounds on pastures and meadows.

Brenner silty clay loam.—With exception of the marine soils, this is the most extensive of the recent alluvial soil types. It is mapped in most parts of the area along small streams and low drainage courses where seepage and runoff from the upper slopes have maintained a moist or wet condition conducive to the growth of water-loving plants. Large areas occur between Elsie and Tideport along the Nehalem River, and a number of others are found along the Necanicum River south of Seaside. Poor aeration has caused mottling and the accumulation of partly decayed plant remains. The surface is generally smooth or flat and consequently unfavorable for surface runoff; for the most part, this type is poorly drained and one of the first steps in its improvement is drainage by tile.

In cultivated fields the 10- to 14-inch surface soil is dark grayish-brown to brown granular silty clay loam faintly mottled with rusty brown. The upper subsoil is grayer, heavier textured, more compact dark grayish-brown silty clay loam mottled with yellow and rusty stains. At depths of 22 to 30 inches, the subsoil is moderately compact highly mottled or rust-stained heavy silty clay loam that gradually changes at 35 to 65 inches to mottled brownish-gray or gray heavy silty clay loam. The lower subsoil is distinctly gray when dry and becomes dark bluish gray when moist. Variations occur due to differences in drainage. Likewise, some areas associated with Clatsop silty clay loam have a more distinct yellow mottling and more of the yellowish-brown color of the Clatsop series, although they do not have the typical tideland subsoil. Some of the areas south of Knappa and Svensen are of this character.

About 30 percent of the type is in cultivation. Most of the rest is uncleared and covered with alder, hemlock, and brush. A considerable acreage has been cut-over and, where cleared of brush, supplies good pasture between the stumps.

The principal crops are oats and vetch that yield 2½ to 4½ tons an acre; clover, and clover and grass hay that yield 1¼ to 2¼ tons. A large percentage of the area is in pasture.

Although drainage is the first step in the improvement of this soil, the application of lime, superphosphate, and barnyard manure results in improved yields.

Cinebar silt loam.—This is one of the most extensive soils of the terraces or benches. This type differs from the Grande Ronde silty clay loam in having better drainage, a richer brown surface with less mottling, and a lighter textured less compact subsoil. As mapped in this area, it is considered to be intermediate in development between the maturely developed Salkum soils of the State of Washington and

the immature or slightly developed Salem soil of the Willamette Valley. The gravel in the Salkum soils is so completely weathered that it may be easily cut through with a shovel or knife and is densely packed in heavy-textured, highly mottled material. The gravel in the Salem is hard and firm and shows no signs of weathering. It is loosely arranged in sandy or medium-textured material. In the Cinebar soils, however, only the surfaces of the pieces of gravel and cobbles have become softened, and the interstitial material is medium to heavy textured and only moderately compact.

Although this soil type is mapped in most parts of the county, the largest areas occur 2 miles east of Gearhart, 1½ miles southeast of Olney, 1 mile south of Knappa, and ½ mile south and 1½ miles southeast of Svensen. Other areas occur along the Necanicum River south of Seaside and bordering the Klaskanine River southeast of Olney. There are a few areas southwest of Tideport.

The surface is comparatively smooth to gently undulating. This soil often occupies high terraces at the base of hills, and in places it is difficult to determine where the Cinebar soil ends and the Astoria soil begins. The chief difference between the Cinebar and the Astoria is the topographic position and the origin or parent material. The Astoria soils are developed from the weathering of underlying sandstone and shale and are therefore residual, whereas the Cinebar is derived from the weathering of old transported gravelly alluvium.

The surface soil is a brown to dark-brown friable, smooth-textured silt loam, extending to a depth of 12 to 15 inches. It has a moderate quantity of organic matter and a crumb structure and contains numerous fine roots. The moderately compact upper subsoil is yellowish-brown faintly mottled granular silt loam that is usually a little heavier than the surface soil. This layer extends to approximately 22 inches where it changes to a brown or yellowish-brown clay loam with subangular aggregates and granular structure. Some mottling may occur in this layer, and the material is always moderately compact. Underneath to a depth of about 55 inches, the color and texture are about the same, but there is more mottling with gray and orange stains. Beneath this, to a depth of 78 inches, the subsoil is light brownish-yellow silty clay loam, highly mottled with orange and gray. This layer may or may not contain gravel. Although gravel underlies most of this soil type, the pieces generally are deep, rarely occurring within less than 4 feet of the surface. Deep cuts along the highways show gravel 8 to 10 feet below the surface. Over much of the area, however, they are somewhat less than this.

Between 20 and 30 percent of the area is cultivated; the rest is in spruce, hemlock, and underbrush. With the exception of Knappa loam, which has a more mellow subsoil, Cinebar silt loam is the most productive of the soils of the terraces or benches. The two soils lie adjacent to each other in the vicinity of Svensen. Of the many areas mapped, only small patches have been cleared. For a very large part of the area both surface and subsoil drainage are fairly good. Areas occur, however, where this soil receives seepage from adjoining hill lands. Soils of this nature are mapped southwest of Chadwell School.

Oat and vetch hay yield 2 to 4½ tons and clover and grass hay, 1¼ to 1¾ tons an acre. Permanent pastures support 1 animal unit an acre for about 4 months, and rotation pastures 1 animal unit for

about 5 months. This soil type is considered to have fair to medium natural fertility, but yields can be increased by rotating crops, applying lime and superphosphate, and practicing good soil management. The principal use is pasture. Harvested crops include oat and vetch hay, clover and grass hay, berries, and root crops.

Early in spring 150 to 200 pounds of superphosphate is applied before seeding pastures or meadows, and 400 pounds is broadcast or drilled on root crops, vegetables, and strawberries. Applications of 2 tons of lime once in 4 years before seeding has been found necessary in growing red clover, vetch, and peas. Root crops and vegetables respond to 20 tons of barnyard manure applied to plowed land before final seeding preparation. Fall or early spring top dressings of 10 to 15 tons an acre on pastures and hay lands produce good results. Where barnyard manure is not available, a spring dressing of 100 to 200 pounds of ammonium sulfate or sodium nitrate is recommended as a top dressing on grass for hay or pasture.

Irrigation in normal years can be used with good results from June 15 to September 15. Pastures especially and some vegetables give good response to irrigation.

As mapped this soil includes small areas of Klaskanine silt loam, which occur in small bodies along Humbug Creek northwest of Elsie. A few areas have been included south of Chadwell School in which the soil is darker colored than typical and not so well drained. The soil in these areas is usually considered to be somewhat better than the Grande Ronde soil.

Clatsop silty clay loam.—Were this soil, which occupies tide flats and first bottoms, not protected by dikes, a very large part would be covered by high tides. As a result of the frequent changes in the river channels and sloughs and the deposition of various kinds of materials, a complexity of soils may occur within short distances. The numerous depressions, small ridges, stream channels, and sloughs give a varied relief. The deposition of fine material along the slough channels has built up the banks 2 to 3 feet higher than the intervening depressions. Although the soil on all these different elevations appears on the accompanying map as one soil type, the lower areas generally contain more organic matter and are usually more poorly drained with a higher water table than on the ridges. The soil also in the higher areas is more mellow. In these positions the soils present a varied profile—both in organic-matter content and in depth—due largely to the different kinds of material deposited over the organic layers and the varying lengths of the periods of temporary stabilization, during which organic layers could be formed. Because of the high water table and heavy subsoil drainage is restricted. Outlets for drains are regulated by tide gates, which open at low tide and close during high tide.

This type is the most extensive bottom-land soil in Clatsop County. The largest area lies north and east of Warrenton in one continuous strip on both sides of the Lewis and Clark River and continues southward to 1 mile beyond Neteli Grange or to where the bottom lands become slightly higher and merge into soils of the Nehalem series. Another large body lies adjacent to Youngs Bay south of Astoria and on both sides of the Youngs River to 1½ miles beyond the fork of the Klaskanine River, still another smaller area lies along the Walluski

River from Youngs River eastward and southward for about 4 miles. The principal need of this soil is drainage.

The native vegetation is mainly spruce, which attains growths up to 5 feet in diameter, some crabapple, vine maple, and smaller shrubs.

The surface soil consists of 10 to 14 inches of gray to brownish-gray silty clay loam, highly mottled with dark rusty-brown iron and organic stains. The texture varies from a light clay loam to silty clay loam, and in the virgin state appears a little lighter after it has been cultivated, because the surface soil has a high content of well-decayed organic matter and fine fibrous roots. Although the soil has the appearance of being rather dense, amorphous, or compact, it is moderately friable. After years of farming, however, the mellow friable condition is considerably reduced. With increased depth the texture becomes slightly heavier but other characteristics remain practically the same. In places the subsoil is stratified and varies both in organic content and in depth. Often below 20 inches there are layers 1 to 4 inches thick of thoroughly decomposed organic matter or muck. Usually there is a sharp line of demarcation between the organic matter and the layer above or below. As a rule, the layers of organic matter do not occur below 40 inches or below the beginning of the heavy silty clay.

Heavy bluish-gray silty clay or clay, representing underlying tideflats material, is encountered at depths of 30 to 40 inches. Above the blue clay the soil is speckled with dark rusty-brown organic and iron stains and there is a large content of decomposed organic matter and fine roots. The clay layer has little decomposed organic matter and fine roots. Fresh surface breaks appear glossy and shiny due to colloidal coatings, and iron stains occur in cracks and crevices along the lines of cleavage. Iron also occurs in thin sheets in root cavities but does not develop so thick a film as in the layer above the heavy clay. The lower part of the heavy blue clay is stiff and impervious, with practically no organic matter. The slight mottling that occurs in this layer gradually disappears with depth. The presence of the stiff blue clay forms the chief difference between the Clatsop soils and the mellow friable fine sandy loam to silt loam subsoil of the Sauvie series.

Although strongly acid the soil is highly productive and suited to a wide range of crops. About 80 percent of it is in pasture or in cultivated crops. The principal crops are bentgrass seed, pasture grasses, oat and vetch hay, clover and grass hay, grass for silage, cannery peas, vegetables, and root crops.

Where the soil is well farmed, crop yields are good. Bentgrass seed yields 100 to 300 pounds an acre. Rotation pastures support 1½ animal units an acre for 10 months, and permanent pasture 1 animal unit an acre for 10 months. Oat and vetch hay yields 3 to 5 tons an acre, clover and grass hay 2 to 3½ tons, rutabagas and stock turnips 40 to 60 tons, and peas 1 to 2 tons, with an average of 1½. Although this soil type is productive, good farm practices are necessary for satisfactory results. These practices should include a good rotation, together with the incorporation of barnyard or green manures and an application of phosphates and lime, especially where legumes are to be grown.

The soil, especially well adapted to the production of bentgrass, is one of the best soils in the county for permanent or rotation pas-

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tures. Pastures and some vegetables respond well to irrigation, which can be used to advantage in normal years from about June 15 to September 15. In fact, this applies to all soils except those lower bottom lands that are subirrigated. On tideland pastures, irrigation has increased the carrying capacity two to three times. Inasmuch as these soils are strongly acid, an application of 2 tons of lime every 4 to 5 years about 1 month before seeding is desirable, especially on clover, vetch, vegetables, and peas. Applications of superphosphate at the rate of 400 pounds an acre before planting time is beneficial for root crops and vegetables. An early spring top dressing of 200 to 250 pounds substantially increases the yields of clover, grass, and grass seed. Applications of 20 tons to the acre of barnyard manure early in fall or spring are recommended for root crops and vegetables, and lesser quantities, 10 to 15 tons, have given satisfactory results on other crops.

Included with Clatsop silty clay loam is a small area along the Columbia River between Hammond and Warrenton that is underlain at 14 to 30 inches by gray river-laid fine sand. This area is unimportant, as only a small acreage is being farmed.

Clatsop silt loam.—Since this type usually occurs in small areas at elevations slightly lower than adjoining soils, it is generally poorly drained. This soil differs from Clatsop silty clay loam in being more silty and in having a higher content of organic matter in the surface soil. The subsoil is similar to that type. The most important bodies lie along the Walluski and Youngs Rivers; other areas are found at the mouth of the Lewis and Clark River and northwest of Warrenton. This soil type is farmed in conjunction with adjoining soils, most frequently Clatsop silty clay loam. Crops grown and methods of soil management are similar on both types.

A yellowish-colored variation is included, which is of small extent and confined primarily to small areas in the northwestern part of the area. As a rule, it lies in slightly lower positions than the associated Nehalem soils and little above tideland. Like Clatsop silty clay loam, the subsoil consists of tidal mud-flat material. The soil, to a depth of about 20 inches, is yellowish-brown silty clay loam mottled with yellow and gray. When moist the soil has a pronounced yellow color and, because of its high content of fibrous roots and decomposed organic matter, is quite mellow and friable. The upper subsoil is similar to that above except that it is heavier textured, more bluish gray, and more highly mottled with orange-colored organic or iron-rust stains. This layer may contain peat or muck and is similar to Clatsop silty clay loam subsoil. The deep subsoil is mainly the bluish-gray silty clay that commonly characterizes the tidelands. The variation differs from Brenner silty clay loam in having a deeper and better drained surface soil and poorly drained mud-flat or tideland material underneath. The relief is comparatively level, except where sloughs give it an undulating topography. Artificial drainage is necessary to obtain satisfactory yields.

Originally, the variation was heavily timbered with spruce, hemlock, and alder, but a number of areas are now covered with blackberries and wiregrass. Between 30 and 40 percent of the area is cultivated. Although it is not extensive, it is one of the desirable soils of the recent alluvial group. Its adaptation, crop yields, and

methods of improvement are similar to those on Clatsop silty clay loam.

Coastal beach.—This is a loose light-gray sand a little, if any, above high tide. The material generally is very fine and, in places, is packed hard by the waves. It occupies a very narrow strip bordering the ocean. It has been formed by the combined action of waves, shore currents, and wind. Many areas are too small to indicate on the soil map and have been represented by the shore line or included with adjoining soils. This class of material has no agricultural value.

Dune sand.—This land consists of wind-drifted deposits of medium and fine sand that occur in dunes usually too large to be economically leveled for farming. The sand is light brown or grayish brown, is loose and porous, and usually shows little change to a depth of 6 feet or more. The dunes range from 10 to 40 feet high with a maximum elevation of about 80 feet. They are either bare of vegetation, or the growth is insufficient to protect the soil from blowing. Consequently, under the influence of the strong ocean winds, the dunes are creeping eastward burying fences, buildings, and whatever else may be in their path. In places along the coast they have invaded forests and have caused more or less damage to timber.

The areas vary from a fourth to a half mile in width and extend along the coast for several miles. Although they are of no value for agriculture, they serve admirably as recreational grounds. Many of the dunes near Warrenton have been effectively stabilized by establishing a vegetative cover.

Gearhart fine sandy loam.—Although the soil is loose, the high content of black, sooty, finely divided organic matter and fine roots makes it fairly firm; the aggregates, however, crush easily into a loose mass.

This soil is confined to the northwestern corner of the county, where it parallels the coast highway in almost one continuous body from Warrenton to Seaside. It erodes easily because of its sandy texture, looseness, and rolling topography, especially where the organic-matter content is reduced.

The surface soil consists of very dark-brown to black fine sandy loam or loamy fine sand, the fine sandy loam predominating. Often this layer is grayish black, the gray color being due to the high content of quartz in the sand. At depths varying from 8 to 11 inches there usually is a definite change to dark chocolate-brown fine sandy loam containing fewer roots and slightly less compaction. The upper subsoil, from 11 to 17 inches, is rich-brown loamy fine sand with sufficient cementing material to form small lumps that crush easily. This is underlain by light-brown loose fine sand that becomes lighter colored and somewhat iron-stained in the lower part. The deep subsoil, below 45 inches, is not so brown as the layers above but browner than the gray fine sand immediately below. Like the Westport soil, this soil has the appearance of having developed under grass, although the Westport is still very young. Both have typical sand dune topography and both, because of their looseness, are excessively drained.

This is the most important of the soils from wind-laid material. Although it has the appearance of being grassland, owing to its high content of organic matter, spruce trees up to 3 feet in diameter are

scattered over the area. The type has little agricultural importance; less than 5 percent is being cultivated and the greater part is in permanent pasture. The crops grown consist of oats, oat and vetch hay, and a limited quantity of grass hay. Where this soil is in permanent pasture, native grasses, mainly fescues, seashore bluegrass (*Poa macrantha* Vasey), and hop and white clovers predominate. The pastures are grazed most extensively in fall and early spring, but they are used also in a limited manner in winter. Native pastures require about 10 acres to support 1 animal unit for 5 months, whereas rotation pastures require slightly more than 4 acres for each animal unit for a period of 5 months.

Even though this soil has a good appearance, native fertility is low and yields fall off rapidly after a few years of farming. The soil, therefore, must be heavily fertilized to obtain fair yields. Where manure is not available, nitrate fertilizers at the rate of 150 to 200 pounds an acre should be applied annually; where barnyard manure is available, applications of 15 to 20 tons should be applied in spring or early in fall. Every effort should be made to increase the organic-matter content of this soil by returning all crop residues or the growing of green-manure or cover crops. Owing to the high content of loose sand the soil dries out rapidly and is droughty. Where topography is favorable, irrigation would increase yields considerably.

Grande Ronde silty clay loam.—This type occupies terraces and alluvial slopes and is derived mainly from water-laid deposits having their source in the sandstone or shale in the adjacent hills. It often occurs in an intermediate position between the lower alluvial soils of the Klaskanine series and the residual Astoria soils of the hills. The topography is gently sloping to slightly undulating. Surface drainage is usually good, but internal drainage is always restricted and in many cases poor. On level spots drainage is especially bad, for here the moisture accumulates from adjacent areas and may keep the soil wet until late in spring.

To a depth of 8 or 10 inches the brown or dark-brown granular silty clay loam surface soil with a very slight gray cast is faintly mottled with orange, yellow, and gray stains. When clods are mashed between the fingers, the material takes on a yellowish cast. The subsoil, to a depth of 28 to 30 inches, is a grayish-brown to yellowish-brown compact silty clay loam or silty clay, mottled with orange, rusty brown, and gray, containing some fine roots, and is underlain by brownish-yellow friable silty clay loam or clay mottled with rusty gray with much the same appearance as the Astoria subsoils. Gravel and cobbles, 2 to 6 inches in diameter, are occasionally found in this layer at varying depths. In places this horizon is underlain by a gray or bluish-gray stiff clay mottled with rusty orange and yellow. A precipitated iron layer is found in places above the gravel. This soil usually becomes lighter in texture and more friable with increasing depth. Slight variations occur within the soil where it approaches the richer brown, better drained soil of the Klaskanine series on the one hand and the foot slope soils of the Astoria series on the other.

From 10 to 20 percent is under cultivation, and the rest is covered with alder, hemlock, spruce, and brush. A small acreage is partly cleared and used for pasture. Areas used for rotated pastures support 1 animal unit an acre for about 4 months, whereas the area in per-

manent pasture supports 1 animal unit for about 2 months. Clover and grass hay yields ¾ to 1½ tons an acre and oat and vetch hay 1 to 2¾ tons.

One of the principal needs of this soil is drainage. Where areas occur at the base of hills, the drainage can be improved by installing cut-off drains to intercept and carry away the water before it has an opportunity to spread out over the lower areas. As only fair yields are obtained under favorable conditions, the average is low. Frequently the soil is wet until late in spring, and during protracted dry seasons it is seriously affected by drought.

Cropping practices and management of this soil are similar to those on Hebo silty clay loam. Slightly better yields, however, should be expected.

Hebo silty clay loam.—Poor drainage of this soil of the benchlands is caused by its low-lying positions on the benches and its dense, heavy clay in the subsoil. The principal areas occur 2½ miles northwest and 2½ miles southeast of Olney and ½ to 2 miles south of Chadwell School. Native vegetation consists of spruce, hemlock, and alder. After logging, alder, willow, and small brush predominate.

The surface soil is a very dark-brown or gun-metal-black granular silty clay loam, matted with very fine roots and exceptionally high in organic matter. It grades rather abruptly at a depth of 6 inches into gray or dark-gray stiff clay highly mottled with bright orange and yellow. This layer is very compact, sticky, and tough and extends to depths of 36 to 42 inches, becoming bluish gray in the lower part. The 42- to 66-inch subsoil is mainly light-gray stiff clay distinctly mottled at irregular intervals.

Between 10 to 20 percent of the soil is under cultivation. The greater part of the cultivated area is in permanent pasture for which it is best suited. At present this is a relatively unimportant soil agriculturally. Although most of the cleared area is used for pasture, there is some hay harvested. Yields of oat and vetch hay range from 1 to 2½ tons and clover and grass hay ¾ to 1½ tons an acre. Permanent pasture supports 1 animal unit an acre for about 3 months, and, where crop rotation is used, an acre of pasture supports 1 animal unit for about 4 months. On most farms the soil is tilled in connection with adjoining soils and is similarly managed. For permanent improvement, drainage is required. In order to obtain fair yields of other crops, it is necessary to lime at the rate of about 2 tons an acre once in every 4 or 5 years. Superphosphate should be applied at the rate of 200 to 250 pounds an acre on pastures, on oat and vetch hay, and on mixtures of grasses and clovers. Where barnyard manure is available, 10 to 15 tons should be used for pasture and hay crops.

Although this soil typically has a nearly black surface soil and a gray, yellow, and brown highly mottled heavy clay subsoil, the type as mapped includes areas of dark-brown clay loam or silty clay loam that are poorly drained and frequently waterlogged. It is closely associated with Cinebar silt loam, which is moderately well drained, and with Grande Ronde silty clay loam, which is poorly drained. Inasmuch as a great deal of this soil is heavily timbered or in dense brush, it is not always possible to make detailed separations.

Hebo silty clay loam, gravelly subsoil phase.—Associated with the normal phase, this phase has several areas with water-worn gravel em-

bedded in very heavy, compact clay at about 30 inches in depth. These areas are usually very flat and poorly drained. The largest areas are ¼ and 1½ miles southeast of Chadwell School; others are located immediately west of Elsie. Only a small acreage, which is used mainly for grazing and hay, is in cultivation. This phase is of small extent and unimportant agriculturally. Management and practices are similar to those on the normal phase of the type.

Klaskanine silt loam.—The type occurs principally on the well-drained short, steep terrace slopes that separate the Knappa or Cinebar soils from lower lying soils derived from recent alluvium. The terraces are only remnants of former plains. They stand 20 to 40 feet above the first bottoms.

This inextensive type consists of brown or rich-brown granular silt loam 8 to 12 inches thick in places, containing a few unweathered water-rounded pieces of gravel. The subsoil is lighter brown or yellowish-brown fairly loose gravelly loam. The gravel and cobble, ranging from 3 to 4 inches in diameter, consist chiefly of acid igneous rocks and show practically no indication of weathering. Usually, the gravel deposits continue many feet in depth.

The soil is somewhat earlier in warming up than the Knappa or Cinebar but is probably slightly less productive. Steep topography renders some of the short slopes unsuited to cultivation. The soil differs from that of the Knappa in having loose unweathered gravel in the subsoil. It is, therefore, more open and pervious; and because of the better drainage which this affords, the color is a little more yellow, with the appearance of having better oxidation. It is more inclined to cling to terrace slopes rather than on broad expanses of level land and is much less developed with lighter textured less compact subsoil and substrata than the soil of the Cinebar series.

Knappa loam.—Closely associated with Cinebar silt loam immediately south and southeast of Knappa and south of Svensen are several large areas of this type that are well drained. The surface soil consists of a 12- to 14-inch layer of brown to dark-brown mellow loam with a high content of fine fibrous roots. The layer below, to a depth of 18 inches, is brown to reddish-brown mellow silt loam, with many iron concretions. This layer is underlain by brown to yellowish-brown silt loam, becoming slightly more compact, yet remaining quite friable to a depth of 50 inches, where it grades into yellowish-brown slightly compact clay loam faintly mottled with gray. From 65 to 72 inches gray mottled silty clay loam containing old highly weathered gravel sometimes occurs. These areas are not typical but are more nearly representative of the Cinebar soil, and had they been of larger extent they would have been so mapped.

This type, although of limited extent, is one of the important agricultural soils of the area. As mapped it is somewhat similar to the Cinebar soil in that it is underlain by gravel. The surface soil is more mellow and granular, however, and the deep subsoil is somewhat less compact and not so pronounced a yellowish brown. Gravel rarely occurs above 40 inches but is frequently found below 5 feet.

Probably 80 percent of this type is in cultivation. Oat and vetch hay yields 2¼ to 5 tons an acre and clover and grass hay 1½ to 2¼ tons. An acre of permanent pasture supports 1 animal unit for about

5 months and slightly more where the pastures are in a crop rotation. Small fruits are grown to some extent. A number of poultry farms are located in this general area.

Where crop rotations are practiced the one most commonly followed runs about 6 years. Sod is followed by oat and vetch or oat hay for 1 year, which helps to break down the sod in preparation for the row crop which follows. This may be potatoes or root crops for 1 or more years or cane fruits or strawberries for 2 or 3 years, after which the land is again seeded to pasture or meadow for a period of 4 or 5 years. This soil is adapted to a wide range of crops, because it is moderately productive and well drained. Cropping practices, fertilizers, and other needs are similar to those described for Cinebar silt loam.

Marsh.—Caused in many cases by the filling in of the outlets of lakes, this wet semiflooded land type is confined principally to low, wet locations on the landward side of the sand dunes. Practically all are fresh-water marshes that occur in long narrow areas between sand dunes. Because of their wet condition, inaccessibility, and small extent, they have little agricultural value.

Nehalem loam.—Areas of this type occupy the first bottoms of the larger streams, usually in slightly lower positions than Nehalem silt loam. The largest acreage lies along the Nehalem River between Elsie and Tideport. Other large areas occur north of Jewell on Beneke Creek, on Fishhawk Creek, and southwest of Knappa. The relief is almost level to slightly undulating, owing to the presence of old abandoned stream channels. Some of the lower areas are subject to overflow, but, except when actually flooded, both the surface soil and subsoil are well drained. Lying only a few feet above the normal level of streams the greater part occupies a favorable position for irrigation.

The soil is a brown to light grayish-brown loam when dry but becomes distinctly yellowish brown when moist. The surface soil is grayish-brown mellow friable loam with a fair supply of organic matter to a depth of 18 to 26 inches, where it grades very gradually into somewhat paler yellowish-brown loam faintly mottled with gray. The texture is somewhat lighter than the surface soil owing to a higher content of sand. At a depth of 30 to 36 inches the subsoil gradually grades into material of similar color, except that it is more distinctly mottled with iron or orange stains. The texture of the subsoil varies from fine sandy loam to silt loam, with the lighter textures predominating. The mottling is not caused by poor drainage but is an inheritance from the color of the parent material.

About 60 percent of the soil is cultivated; this is one of the most important agricultural soils of Clatsop County, although it is not so extensive as some of the other bottom-land soils. It is considered one of the most desirable, as it is both productive and adaptable to a wide range of crops. The principal crops are clover and grass hay, pasture, oats, oat and vetch hay, peas, and vegetables.

Where the soil is well farmed, crop yields are good. Returns generally are slightly less, however, than on Nehalem silt loam unless the land is irrigated. A good rotation that includes a legume, together with the incorporation of barnyard manure or green manures and

applications of phosphate, is necessary if maximum yields are to be expected. The crops grown, yields obtained, and methods of management are similar to those on the silt loam.

Nehalem silt loam.—This type closely resembles Nehalem silty clay loam in position, condition of drainage, productivity, and agricultural value. It differs in having a yellower colored surface and a slight gray mottling in the subsoil. The mottling is not caused by restricted drainage as this soil is well drained. Like the silty clay loam, it is one of the productive soils in the county and is rather widely distributed. A large body occurs at the south edge of Seaside. Other areas are along the Nehalem River between Elsie and Tideport, in the vicinity of Jewell and Melville, and southeast of Olney. The surface relief ranges from almost level to slightly undulating. Drainage is excellent.

The 18- to 24-inch surface soil is a brown to yellowish-brown mellow silt loam becoming brownish gray when dry. The 30- to 35-inch subsoil is yellowish-brown granular silty clay loam in which gray mottlings are conspicuous when dry but show only faintly when wet. The mottling apparently is due to faint gray coatings of the soil aggregates. The lower subsoil is yellowish brown and slightly heavier in texture. Mottling may or may not occur at this depth.

A fairly large proportion of this soil is under cultivation, mainly to clover, oats and vetch, potatoes, peas, root crops, and vegetables. Most crops give good to excellent yields. Oat and vetch hay yields 2½ to 5 tons an acre, clover and grass hay 1¼ to 2¾ tons, and silage 5 to 15 tons. Rotation pastures support 1½ animal units an acre for 8 months, and permanent pasture supports 1 animal unit for about 6 months. Yields of 1 ton of shelled peas an acre have been reported.

The soil responds favorably to irrigation. When these lands are irrigated, 2 to 3 times as much grass is produced as when they are farmed under natural rainfall. Although it is one of the least acid soils of the area, such crops as clover, vetch, peas, and vegetables are improved by applying 1 to 2 tons of lime every 4 or 5 years previous to seeding. Phosphate fertilizers are especially needed on most crops. Grass, grass seed, clover, vetch, and peas are improved by the addition of 200 to 250 pounds of superphosphate before seeding. Vegetables and root crops require 200 to 400 pounds of superphosphate which may be either broadcast or drilled previous to planting. Cultivated crops respond to the application of 15 to 20 tons of barnyard manure, which should be applied after plowing but before final preparation of the seedbed. For meadows and pastures 10 to 15 tons of barnyard manure are recommended, but liquid manure, applied at the rate of 2,500 to 5,000 gallons an acre, is preferable. Where barnyard manure is not available, grass and grass seed crops are improved by applying 100 to 150 pounds of sodium nitrate or ammonium sulfate as a top dressing in spring.

Nehalem silty clay loam.—This soil, formerly included in the Chehalis series, differs from Chehalis in that it is slightly more acid, more yellow, and less fertile. It occupies most of the valley of the Nehalem River between Jewell and the Columbia County line. It is found in first bottoms along the river, and much of it is flooded during periods of abnormally high water. The surface is smooth to slightly undulating. Except when actually flooded, the drainage in most areas is adequate, but where it adjoins the heavy soil of the Brenner series, drainage is inadequate, although such areas are not typical.

The surface soil is brown to yellowish-brown moderately friable silty clay loam to a depth of about 18 inches. The subsoil, to a depth of 40 inches, is yellowish-brown silty clay loam slightly heavier textured and a little more compact. The underlying material is pale yellowish-brown silty clay loam with occasional light-gray mottlings. As mapped, it includes a number of areas in which the surface soil texture is not so heavy as a silty clay loam. These areas are located principally east of Jewell and the soil is recognized as being somewhat easier to work.

This is one of the most productive and desirable of the river bottom soils. It is mellow and easily tilled, and, because of its high state of fertility, excellent drainage, and water-holding capacity, it is well adapted to a fairly wide range of crops.

About 70 percent of the type is under cultivation, and the rest is in second-growth fir and underbrush. The principal crops are oats, oat and vetch hay, clover and grass hay, grass for pasture, root crops, vegetables, and small fruits. Yields of oats vary from 30 to 70 bushels an acre, with an average of 50; clover hay 2 to 3 tons; oat and vetch hay 3½ to 5 tons, with an average of 4 tons under good farming practices; and silage 4 to 12 tons, with an average of 7 tons. Small fruits and strawberries are produced mainly for home use.

Supplemental irrigation can be used to advantage in normal years from about June 15 to September 15. It is especially helpful to pastures and some vegetables. Irrigated Ladino clover pastures offer a source of cheap high-quality feed, with a carrying capacity of two to four cows an acre for 6 or 7 months of the year. This soil, although naturally productive, is responsive to good treatment. The nitrogen content is only moderate, and crop rotations that include legumes are essential to maintain organic matter and fertility.

Riverwash.—This is a miscellaneous mixture of sand, gravel, and cobblestones, usually poorly assorted and occupying stream channels and narrow strips immediately adjacent to larger streams. In most instances the areas are only a few feet above the normal flow of the rivers. It is inextensive. The largest area is found within the southern part of the city of Seaside. Narrow strips occur along the Necanicum River beginning about 1½ miles south of Seaside and extending southward almost continuously for about 6 miles. This land type is of no agricultural value, as it rarely supports vegetation and is flooded for a considerable period annually.

Sauvie silt loam.—Areas of this soil are on low nearly flat bottom lands adjacent to slightly higher ridges along sloughs. They represent a gradation between Sauvie silty clay loam and peat and are found only in the Brownsmead district. The 8- to 12-inch surface soil consists of light brownish-gray granular silt loam highly mottled with iron stains and contains a moderately high content of peaty organic matter that becomes dark rusty brown when wet. Below, to a depth of 18 or 20 inches, there is an increasing quantity of mineral soil and a decreasing supply of organic matter. Between depths of 18 and 36 inches the subsoil is similar to that of Sauvie silty clay loam, except that it contains more organic matter of sedgelike character. The deep subsoil is quite variable. In places it is a gray mottled clay loam or silty clay loam of moderate organic content. Elsewhere it is more sandy and of lower organic-matter content. Crops grown and

methods of soil improvement are similar to those of Sauvie silty clay loam.

Sauvie silty clay loam.—This soil is the second most extensive soil mapped in the area and one of the most important and productive. It is confined to the Columbia River bottoms in the northern part of the county. The largest areas begin in the vicinity of Svensen and continue eastward up the river to the county line. The most important areas are found on Tenasillahe and Karlson Islands and in the vicinity of Brownsmead.

As a result of frequent changes in the river channel and new depositions from year to year, a mixture of soil materials may occur that differ considerably within short distances. Numerous depressions, low ridges, stream channels, and sloughs cause a varied surface relief. In the small depressions small ponds form, and there are lakes of varying sizes. Because of the high water table, drainage is restricted. All the agricultural lands, however, that are farmed have been diked.

Where the water table is high, drainage is needed. Drainage is possible, however, only where outlets are sufficient to carry the water away. A number of tide gates have been installed recently in connection with the dike-rebuilding program and very satisfactory results have been obtained.

Cultivated fields are characterized by a 20-to 26-inch surface soil of light-gray clay loam or silty clay loam with pronounced iron mottling. When moist the soil has a light grayish-brown color with rust staining that gives a distinct brownish cast. In most places it contains a high content of organic matter and a considerable quantity of fine sand and silt, which has the effect of making it more mellow and more friable than the silty clay loam of the Clatsop series of the tidelands. Many roots and many fine channels left by decayed roots are present. In many instances the channels have become lined with a soft iron deposit. In places the coating attains a thickness of as much as 2 millimeters.

Beneath the surface layer and continuing to a depth of about 34 to 38 inches, the subsoil has characteristics similar to those of the layer above but with less organic matter and less mottling or brown iron stains. When dry the color is gray and when moist dark dull gray. Iron-coated channels occur, but they are smaller than those found above. Although the texture of this layer is practically the same as that above, the material is slightly more compact and contains fewer roots. The underlying material, to a depth of about 52 inches, is decidedly light-colored when dry with only faint mottling, but when moist a faint bluish-gray color is discernible. Very little organic matter or roots are present. Except for a somewhat higher content of fine sand the material continues with little change to a depth of several feet. The entire profile is mellow and friable. The depth at which the different layers occur varies as does the content of very fine sand.

As mapped the soil includes some variations. Agriculturally, they differ little from the typical soil and, being of small extent, have been included. For example, an area in the vicinity of Westport has a subsoil considerably heavier than typical. In the Brownsmead district a number of small areas occur with a higher content of peat in the surface soil. These usually occupy depressions where organic

matter has had a better opportunity to accumulate. Several other small areas occur that contain a moderately high content of peaty material in the subsoil.

This is the most productive soil in Clatsop County. Owing to its high state of fertility, excellent facilities for drainage, and high water-holding capacity it is well adapted to a wide range of crops. Parts of it are subirrigated. The soil is well suited to dairying, one of the principal industries of the county. Because of the excellent pastures and high yields of root crops and hay, the soil lends itself admirably to low-cost production.

The principal crops are clover, oats and vetch, grass seed, root crops, and vegetables. Acre yields of oats and vetch range from 4 to 6 tons and clover and grass, 2 to 4 tons. An acre of permanent pasture supports 1¼ animal units for about 10 months and 1 acre of rotation pasture 1⅔ animal units for about an equal length of time.

Crops can be grown more successfully on this type than on Clatsop silty clay loam of the tidelands because of the lower acidity. On land that has been cultivated for considerable time, however, 1 to 2 tons of lime should be applied every 4 or 5 years for satisfactory yields. Root crops and vegetables respond readily to the application of 400 pounds of superphosphate an acre before seeding. An application of 200 to 250 pounds either before seeding or as a top dressing is recommended for grass, grass seed, or the clovers. For root crops and vegetables an early spring application of 20 tons of barnyard manure is recommended. For hay or pasture crops 10 to 15 tons of manure may be used.

In places the soil is more sandy than typical; it is underlain by gray river-laid fine sand at a depth of about 22 inches. Only one body, containing perhaps 300 acres, is mapped. This area is located three-fourths mile north of Brownsmead adjacent to the Columbia River. Because of the sandy subsoil some difficulty has been encountered in maintaining a dike along the river past this area.

Spalding peat.—Consisting almost entirely of sphagnum moss, with some woody material, mainly spruce, this peat is somewhat less extensive, more raw, and less decomposed than Brallier peat. Some sedge and other vegetation are present. All layers appear raw and straw-colored when moist, but the material becomes darker brown or nearly black when dry. The more soil or colloidal material present, the darker the color becomes. Laboratory tests indicate that Spalding peat is the most strongly acid soil mapped in the county.

The surface 2 inches consists largely of sphagnum moss that is highly decomposed, and when dry the material forms clusterlike granules between the fine fibrous roots. When wet it has a dark-brown to black color and remains almost as black when dry. These granulelike clusters when moist mash into a smooth, silty, velvety material that contains very little mineral soil, colloidal material, or roots larger than those of moss. The organic matter, to a depth of 12 inches, is moderately raw and has a lighter brown color than the surface layer. It is composed almost entirely of sphagnum moss with some other fine roots, which when dry form into a somewhat firm mass. Beneath, to a depth of 24 to 30 inches, the material is much the same, except that it is less decomposed and has more sedge

and some woody material up to one-fourth inch in diameter. The upper part of this layer, which has a color slightly darker than straw when moist, becomes darker with depth. It is quite raw with only a small quantity of fine material with some woody fragments. Below, to depths of 40 to 50 inches, the peat is straw-colored when moist, but a somewhat darker brown when dry. It contains much highly decomposed material, yet has a high quantity of raw sedge and coarse vegetation. Below 50 inches and continuing to gray sand, the material is raw, straw-colored organic matter, chiefly sphagnum moss, with some woody remains but usually very little sedge. Clean gray sand occurs at 5 to 10 feet.

The native vegetation consists mainly of spruce, crabapple, willow, sphagnum moss, sedge, pale laurel, wild cranberry, and spirea. About 10 percent of the area is cultivated. With the exception of about 50 to 60 acres of developed cranberry bogs only a few small tracts of this type of peat have been cleared, drained, and prepared for crops. These small tracts are used mainly for pasture and some vegetables. Opportunity exists for increasing cranberry production on this soil, but since it is costly to prepare the land for this crop, one should be sufficiently financed and have some experience before taking up the enterprise. Prices received for western cranberries are usually higher than the average for the United States. The more successful growers of the county report average yields of about 60 barrels an acre, which is higher than the average for the country as a whole. The problems in developing Spalding peat are similar to those discussed for Brallier peat.

Warrenton loamy fine sand.—Although this soil occupies narrow valleys of streams and pot-holelike depressions, it is not alluvial in origin; rather, it consists of sandy material blown in from adjoining higher lying areas of dune sand or Gearhart fine sandy loam. In places the drifting sands have clogged the streams along which it lies, causing a high water table to form in the areas above. The water table varies with the season of the year and with the varying effectiveness, from time to time, of the sandy dams that form across the streams. Generally, these interfere to a more or less degree with free drainage into nearby lakes. It is not uncommon to find the water table at 30 to 50 inches beneath the surface.

The largest areas of this inextensive type are found 1 to 1½ miles south and immediately south of Warrenton. Other areas occur as narrow strips 2 or 3 miles long immediately east of Gearhart. This soil differs from Gearhart fine sandy loam in occupying narrow valleys or basinlike positions instead of undulating dunes, in being more poorly drained, and in having more iron staining in the subsoil. It is low in productivity and requires careful handling to prevent blowing.

Although this type is similar to Gearhart fine sandy loam, it is rated as a better soil, due to its more favorable topography. Having moisture at shallow depths to draw upon, the soil is less droughty and as a result responds better to irrigation. The bodies south and southwest of Warrenton lie immediately above tideland flats or peat land. Where this occurs, the soil near the peaty areas may contain a higher percentage of organic matter than typical and near the tidelands it may assume the characteristics of the Clatsop soils.

The surface soil consists of about 8 inches of dark grayish-brown to black loamy fine sand or light fine sandy loam high in fine fibrous roots and finely divided organic matter, which leaves a dark sooty stain when crushed between the fingers. Immediately below is a 3-inch layer of rich chocolate-brown or rusty-brown loose fine sand containing a much smaller quantity of roots and other organic matter. The material grades downward into a 4-inch layer of light rusty-brown, iron-mottled loose fine sandy loam, the mottling increasing in the lower part. Generally there is a slight quantity of iron at this depth which in places is enough to fill small root channels and to give the soil a certain degree of firmness. The iron particles are easily crushed and when reduced leave a red or rusty stain. The 16- to 40-inch subsoil is gray to brownish-gray loose fine sand distinctly marked with irregular wavy rust-colored lines and contains almost no organic matter. Much iron mottling is present and small soft pebblelike iron concretions about one-eighth inch in diameter occur in the upper part. With increasing depth the color becomes a more pronounced gray with only enough rusty brown to distinguish it from the dune sand material that underlies it. In this part of the profile mottling and evidences of iron have practically disappeared.

In the native state the vegetation consists of willows, skunk cabbage, and rushes. Native wiregrass soon dominates cleared areas unless the land is cultivated.

About 50 percent of this soil is in cultivation. The principal crops are flower bulbs, truck crops, small fruits, and strawberries. Clover, vetch, and oats for hay are grown on only a small part of the land and in small patches. Yields, with the exception of bulbs, range from low to fair. Strawberries yield 1,200 pounds and hay crops ½ to 2 tons an acre. About 6 acres of permanent pasture are required to carry 1 animal unit for 6 months.

The type is easily worked and is especially adapted to the production of early maturing crops. It must be heavily fertilized and irrigated, however, for satisfactory production. The improvement and management of this soil is similar to that of the Gearhart fine sandy loam with the exception that artificial drainage is necessary in some areas with high water table.

Westport fine sand.—Adjoining the coastal sand dunes on the landward side, this type represents a very youthful stage in soil development. It is intermediate in character between unstabilized dune sand on the one hand and the more completely stabilized Gearhart fine sandy loam on the other. Although its stabilization is still incomplete, the greater part of it is covered by a thin toupeelike mat of grass and forest litter. Toward the coast the type merges gradually into dune sand and on the landward side the line of demarcation is indistinct between this soil and Gearhart fine sandy loam. The topography is undulating or rolling, the higher parts reaching elevations of 40 to 60 feet.

The 3- to 8-inch surface soil is brownish-gray to black semicoherent fine sand, and in the upper 2 or 3 inches it is loosely bound together by a mass of fine roots—except for this the organic-matter content is low. The upper subsoil, to a depth of about 12 inches, consists of slightly rust-stained loose fine sand containing only a few grass roots and very little decomposed organic matter. Below a depth of about

12 inches the material is light brownish-gray loose fine sand with practically no organic matter. To all appearances it is identical with dune sand. Small areas occur in which the soil has more organic matter and is somewhat darker than typical. The soil in these areas is considered to be somewhat better than the typical soil.

In the past large areas have been seriously overgrazed. Because of the damage done, grazing now is restricted in certain districts in order to prevent further blowing. There is a thin covering of native grass, but tansy and other weeds predominate on many of the areas. When farmed the organic matter disappears rapidly, leaving very few roots to hold the soil together. Wind erosion follows cultivation; sand dunes form and, shifting from place to place, bury and destroy cropland of better quality. The soil has little agricultural value and should be left in permanent cover. If used for pasture it should be grazed lightly, for the vegetation is easily destroyed, inviting wind erosion.

SOIL MANAGEMENT AND PRODUCTIVITY

The soils of Clatsop County should not be plowed and left bare over winter. A cover crop may be sown in fall on cultivated land and turned under the following spring, after which the seedbed can be worked down for planting vegetables, bulbs, or other annual crops. Fall plowing of sod is preferred and may either be disked or left rough during the winter. Early in spring, it should be thoroughly disked, harrowed, and dragged until a fine firm seedbed is obtained. Where fall plowing is practiced, it is usual to seed such spring crops as peas or other vegetables, spring-planted pasture or meadow, or annual hay crops as oats and vetch. Rotation pastures and meadows are best seeded in fall. The seeding usually follows an annual crop that has been grown 1 or more years since the sod was broken. After the annual crop is harvested, the soil is reworked to a fine firm seedbed on which the pasture or meadow mixture is sown. As a rule, shallow planting of the seed is desirable.

Weed control is needed for quackgrass and Canada thistle, both of which are found in small patches in all sections of the county. Morning-glory and creeping velvetgrass are found in a few places, while two patches of gorse and one patch of bulbous oatgrass have been found. Buttercup is a weed of pastures and meadows; its control is difficult. These weeds are all serious and should not be allowed to increase. They spread and crowd out other vegetation or weaken the growth of more desirable plants. At the present stage there is possibility of control. Chemical treatment with chlorates is suggested but is not so satisfactory for the land as control by tillage. Clipping of pastures controls weeds and other objectionable plants. One of the best methods of controlling quackgrass is by clean cultivation during the driest period of the year. Avoid spreading with implements while cultivating. Heavy stands of blackberries can be handled most economically with a bulldozer.

As the soils were formed, they were subjected to leaching by the heavy rainfall, which removed their lime; as a result they are generally acid. Practical experience of farmers, supported by experimental results at the John Jacob Astor Agricultural Branch Experiment Station, indicates the need of lime for successful production of many farm

crops. Legumes, including clovers and vetch particularly, have been helped by lime. Increased yields of other crops and most vegetables usually follow use of lime. Ground limestone is best applied after plowing at the rate of 2 tons an acre once in 4 or 5 years and should be disked or harrowed in before seeding to legumes.

Under coastal climatic conditions, exposure of manure to heavy rains results in the loss of much of the fertilizer elements. The use of liquid-manure tanks, which are coming into use, is the most desirable method known to store manure and preserve its value. The tank should be of sufficient size to allow for emptying only twice a year. It will vary in size from 150 to 200 cubic feet for each cow. Where a tank is used, the solids need no shelter, provided they are well stacked and the drainage from the stack is directed into the tank.

More benefit can be had from the solid manure if applied rather lightly (10 to 15 tons to the acre) on the cropland and applied more frequently. Liquid manure is especially suited to use on pastures and meadows and is used at rates of 2,500 to 5,000 gallons to the acre. On trials with liquid manure on grass and clover in comparison with various commercial fertilizers, liquid manure and 150 pounds of superphosphate an acre were equal to any commercial fertilizer or combination of fertilizers tried. A good practice is to add 50 to 75 pounds of superphosphate to each ton of manure, or the phosphate can be spread on the stable floor.

Evidence of the effects of different soil treatments in maintaining soil fertility is found in the analytical data from certain plats of the State branch experiment station at Astoria. Inasmuch as Astoria loam is developed under an annual rainfall of approximately 76 inches, the untreated soil is distinctly acid. The application of manure and lime has tended to decrease the acidity of the plats. The treatments apparently have increased the phosphate-supplying power and, by aiding the growth of clover grown in rotation with grain and root crops, have generally increased the content of nitrogen and organic matter. Both lime and manure have resulted in an increased base exchange capacity, and the calcium has markedly increased the exchange calcium of the soil. No correction for calcium carbonate on base exchange content was made. As may be noted in table 6, sulfur has not improved this acid soil and has apparently decreased its base exchange capacity.

TABLE 6.—*Value of various treatments for maintaining soil fertility plots at the John Jacob Astor Branch Experiment Station*[1]

Plots	Treatment	pH	Available phosphorus	Total N	Organic matter	Base exchange content	Exchangeable		
							Ca	Mg	K
			Lb.	*Percent*	*Percent*	*Milli-equivalent 100 gm.*			
1, 11, 21	Untreated	4.80	43	0.329	7.19	8.35	4.92	2.90	0.53
2, 12, 22	Manure	4.98	65	.352	8.69	9.47	5.92	3.05	.50
3	Lime	5.91	40	.393	8.89	17.75	14.80	2.75	.20
4	Manure and lime	5.72	70	.378	6.96	14.00	10.65	2.95	.40
6	Manure, lime, and phosphate plats	5.73	75	.378	6.74	13.60	9.80	3.20	.60
19	Sulfur	5.05	40	.292	8.03	6.93	4.00	2.60	.33

[1] POWERS, W. L. PRESERVATION OF SOILS AGAINST DEGENERATION. Soil Sci. 37: 333-341. 1934.

Liming should precede application of soluble phosphates. Solid and liquid manure should be conserved and used before investing heavily in commercial fertilizers. Phosphate with manure will help reinforce, balance, and conserve the soil, and the phosphate so used will remain more readily in available form. Lime and phosphate will aid in successful growth of soil-building legumes, and nitrogen can be economically obtained from the abundant supply in the atmosphere. Suggestions for fertilization and recommendations for management of soils of the Astoria area are given in table 7.

TABLE 7.—*Recommendations for the management of the soils of Astoria area, Oregon*

Soil series	Water control required [1]	Lime [2] and fertilizer requirements [3]	Crops adapted [4]	Rate per acre, time, and method of applying fertilizer
SOILS OF THE UPLANDS OR HILLS				
Astoria		Lime	Clover (red, especially), vetch, and peas.	2 tons once in 4 or 5 years 30 days before seeding; raked or harrowed in.
		Phosphate	Pasture, grass seed, vetch, hay mixtures, especially when clover is in mixture.	200 to 250 pounds each year before seeding early in spring.
			Root crops, vegetables, and berries.	400 pounds broadcast or drilled; as top dressing.
		Nitrate [5]	Grass for hay and pasture, legumes on soil cultivated previously, and grass seed.	100 to 150 pounds in spring as top dressing; broadcast.
		Manure	Root crops and vegetables.	20 tons on plowed land before working down for seeding.
			Pasture and hay crops.	10 to 15 tons as top dressing early in fall or spring.
SOILS OF THE TERRACES				
Knappa, Klaskanine, Cinebar		Lime	Clover (red, especially) and vetch.	2 tons once in 4 or 5 years 30 days before seeding; disked or harrowed in.
		Phosphate	Pasture, grass seed, vetch, hay mixtures, especially when clover is in mixture.	200 to 250 pounds each year before seeding early in spring.
			Root crops, vegetables, and berries.	400 pounds broadcast or drilled; as top dressing.
		Nitrate [5]	Grass for hay and pasture, legumes on soil cultivated previously, and grass seed.	100 to 150 pounds in spring; top dressing or broadcast.
		Manure	Root crops and vegetables.	20 tons on plowed land before working down for seeding.
			Pasture and hay crops.	10 to 15 tons as top dressing early in fall or spring.
Grande Ronde, Hebo	Drainage	Lime	Clover, vetch, and vegetables.	2 tons once in 4 or 5 years 30 days before seeding; disked or harrowed in.
		Phosphate	Pasture, vetch, and hay mixtures of grass and clover.	200 to 250 pounds each year before seeding early in spring.
			Vegetables and berries.	300 to 400 pounds broadcast or drilled; as top dressing.
			Strawberries.	100 to 150 pounds in fall or spring as side dressing.
		Nitrate [5]	Vegetables.	100 to 250 pounds before seeding.
			Grass seed.	100 pounds in spring as top dressing.
		Manure	Vegetables.	20 tons on plowed land before working down for seeding.
			Pasture and hay crops.	10 to 15 tons as top dressing early in fall or spring.

See footnotes at end of table.

TABLE 7.—*Recommendations for the management of the soils of Astoria area, Oregon*—Continued

SOILS OF THE FLOOD PLAINS

Soil series	Water control required [1]	Lime [2] and fertilizer requirements [3]	Crops adapted [4]	Rate per acre, time, and method of applying fertilizer
Nehalem		Lime	Clover, vetch, peas, and vegetables.	1 to 2 tons once in 4 or 5 years before seeding; broadcast or spreader.
		Phosphate	Grass, grass seed, clover, vetch and peas, and vetch and oats.	200 to 250 pounds before seeding or as top dressing.
			Vegetables and root crops.	200 to 400 pounds broadcast or drilled in.
		Nitrate [5]	Grass and grass seed	100 to 150 pounds in spring as top dressing.
			Vegetables	200 to 300 pounds before planting.
		Manure	Cultivated crops	15 to 20 tons after plowing and before working down.
			Meadow and pasture	10 to 15 tons or 2,500 to 5,000 gallons as top dressing; liquid preferable.
Sauvie Brenner	Drainage	Lime	Clover, vetch, and vegetables on land cultivated a number of years.	1 to 2 tons once in 4 or 5 years 30 days before seeding; broadcast or spreader.
		Phosphate	Root crops and vegetables.	400 pounds before seeding, in row.
			Grass, grass seed, and clovers.	200 to 250 pounds before seeding and as top dressing.
		Nitrate [5]	Vegetables	150 to 200 pounds before planting or as an early side dressing.
			Grass	100 to 150 pounds as top dressing.
		Manure	Root crops and vegetables.	20 tons early in fall or spring.
			Other crops	10 to 15 tons early in fall or spring.
Clatsop	Drainage	Lime	Clover, vetch, grass, vegetables, peas, and other crops.	2 tons once in 4 or 5 years 30 days before seeding.
		Phosphate	Root crops and vegetables.	400 pounds before planting in row.
			Clover, grass, grass seed, and other crops.	200 to 250 pounds early in spring as top dressing.
		Nitrate [5]	Vegetables	150 to 200 pounds in rows or as side dressing.
			Grass and grass seed	100 to 150 pounds early in spring as top dressing.
		Manure	Root crops and vegetables.	20 tons early in spring.
			Other crops	10 to 15 tons early in fall or spring.

SOILS FROM WIND-BLOWN SANDS

Westport		Nitrate	To be left in permanent pasture.	150 to 200 pounds early in spring.
Gearhart Warrenton		Phosphate	Bulbs	300 to 400 pounds early in fall.
		Nitrate	Vegetables	150 to 200 pounds early in spring.
		Potash [6]	Other crops	150 pounds early in spring.
		Manure Crop residues Green manures Cover crops	All crops	15 to 20 tons in spring or early fall.
	Irrigation		Vegetables, grass, and clover (Ladino, especially).	5 gallons per minute continuous flow, June 15 to September 15, water applied by sprinkler.

ORGANIC SOILS

Brallier peat [7] Spalding peat [7]	Drainage	Lime after drainage.	Vegetables, clover, grass, and vetch.	2 tons once in 4 or 5 years.
		Phosphorus	Vegetables and root crops.	400 pounds in row.
			Clover, vetch, and grass	200 to 250 pounds in spring as top dressing.
		Potash	Vegetables and root crops.	150 pounds before planting in spring.

[1] Irrigation is profitable from June 15 to Sept. 15 in normal years on all soils, except in subirrigated areas and where distance to water supply is not excessive. Crops in order of their response to irrigation are as follows: Pasture, vegetables, strawberries, and hay and silage crops; grass-seed crops respond least.

[2] Lime applied every 4 or 5 years 30 days or more before seeding to pasture; lighter additional annual applications for vegetable production.

[3] Phosphates are applied annually, and rates refer to superphosphate; other phosphate carriers are applied in proportion to the percentage of phosphate present. Where phosphorus is added to manure, 40 to 50 pounds per ton of manure is recommended.

[4] Clovers include red, white, and alsike; vetch is mostly common vetch; peas refer to garden peas for fresh market, canning, or freezing purposes.

[5] Nitrates are used where manure is lacking. [6] Potash for vegetables and bulbs.

[7] Crop adaptations questionable, not enough experience to warrant statement.

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Every effort should be made to improve the quality of pastures by the use of legumes and grasses of high quality and long life. Dairying is the most important agricultural industry in the county, and grass is the principal crop. The coastal area is favored with conditions that provide a maximum pasture season; still there is need of improved pastures. Under present conditions the Extension Service recommends that pastures be renewed every 5 years. Longer lived grasses should be seeded in order to establish productive pastures of longer duration. The application of 2 tons of lime every 5 years will materially assist in prolonging the life of the legumes in pastures. The production of home-grown feed should be encouraged to reduce the cost of dairying.

Both experience and experiments have shown that fall seeding of grasses and legumes is more successful than spring seeding. When mixtures of grasses and clovers are used, early fall seeding is desirable; otherwise clover especially may not become well enough established to stand the winter. Bentgrass is usually seeded on land that has been in crops other than sod for at least 2 years. It is especially important that a firm seedbed be prepared for bentgrass, because the seed is so small that there is danger of covering too deep. This applies also to Ladino clover and other very small-seeded crops.

The following is the recommendation of the Oregon Extension Service at Astoria for grass mixtures for the different lands and different conditions:

Pasture mixture:[1]	*Pounds per acre*
For use on tidelands:	
Common ryegrass	4
Perennial ryegrass	4
Meadow fescue	3
Meadow foxtail	2
Ladino clover	2
Alsike clover	2
For use on cut-over lands:	
Astoria bentgrass	1
Perennial ryegrass	3
Common ryegrass	3
Timothy	2
Orchard grass	3
Chewings fescue	3
Native white clover	3

Pasture mixture—Continued	*Pounds per acre*
For use on uplands:	
Perennial ryegrass	3
Common ryegrass	4
Orchard grass	4
Chewings fescue	2
Hop clover	1
Native white clover	1
For use where irrigated:	
Perennial ryegrass	6
Meadow fescue	2
Orchard grass	4
Ladino clover or lotus	3
White clover	2

[1] Western or Italian ryegrass may be included in these pasture mixtures, but if included some additional seed should be added each year, as Italian ryegrass is an annual.

To obtain good results the pasture area is fenced into three fields. The milking herd first uses one of the fields until the best of the field is utilized; then they are moved to a second field and later to the third. Each time the cows are moved to a new field, the young and dry cattle are put into the field just left by the milking herd. This procedure can continue throughout the grazing season. The number of times the milking cows will be moved during the season will depend upon the soil, moisture conditions, and number of cows pastured. To obtain maximum benefits this system should not start until the pasture has made considerable growth. Cows should be moved to a new field before any shortage of pasture is indicated in the field in use. With this system more production an acre can be obtained than if all the cattle are turned into the entire pasture. If the dry cows leave a field

unevenly grazed, it is advisable to clip the pasture; this keeps the pasture fresh and growing at all times. Harrowing occasionally to scatter droppings is desirable.

Table 8 indicates the relative carrying capacity of rotation pastures on certain soils of the area.

TABLE 8.—*Rotation pastures on certain soils in Clatsop County, Oreg.*

Soil	Animal units per year per acre	Months used (inclusive)	Time used	Animal units per pasture season per acre	Comparative values (cow-acre-days) [1]
			Days		*Index*
Sauvie silty clay loam	1-1.5	Feb.-Nov.	300	1.8	540
Clatsop silty clay loam	1-1.25	Feb.-Nov.	300	1.5	450
Nehalem silty clay loam	1.00	Mar.-Nov.	270	1.4	360
Nehalem loam	.75	Mar.-Oct.	240	1.12	270
Nehalem silt loam	.75	Mar.-Oct.	240	1.5	270
Brallier peat	.75	Apr.-Oct.	180	1.5	270
Brenner silty clay loam	.50	Apr.-Sept.	180	1.0	180
Spalding peat	.50	May-Oct.	150	1.2	180
Knappa loam	.42	Mar.-July 15	135	1.1	150
Cinebar silt loam	.42	Mar.-July 15	135	1.1	150
Astoria silt loam	.33	Mar.-June	120	1.0	120
Hebo silty clay loam	.33	Mar.-June	120	1.0	120
Grande Ronde silty clay loam	.33	Mar.-June	120	1.0	120
Astoria loam	.25	Apr.-June	90	1.0	90
Warrenton loamy fine sand	.17	Dec.-May	180	.33	60
Gearhart fine sandy loam	.10	Dec.-Apr.	150	.24	36

[1] Cow-acre-days, used to express the carrying capacity of pasture land, is the product of the number of animal units carried per acre multiplied by the number of days that animals can be grazed without injury to pasture; for example, a soil that supports 1 animal unit per acre for 360 days rates 360; a soil supporting 1 animal unit on 2 acres for 180 days rates 90; and a soil supporting 1 animal unit on 4 acres for 100 days rates 25.

Instead of growing an annual hay crop year after year permanent seeding of grasses and legumes should be made from the standpoint of economy as well as soil fertility. The agricultural experiment station recommends the growing of annual hay crops, as oat hay or oat and vetch hay, only as a reseeding practice. It is recognized that oat, oat and vetch, and oat and pea hay silage will be produced in the county. Growing these crops on the same land year after year is not considered good practice. The production of these crops is recommended only where new land is put under cultivation and where old pastures and meadows are being worked for reseeding. Fall-planted Gray Winter oats and common vetch can be grown on the better lands. On upland soils of poor fertility the use of hairy vetch and oats is better. Seeding rates an acre should be about as follows: Oats, 60 to 70 pounds; hairy or common vetch, 20 to 40; fall-seeded oats alone, 80 to 100. The following rates of seeding are given for hay crops:

Hay crop:	*Pounds per acre*
On bottom lands where lime has been added:	
Common ryegrass	4
Perennial ryegrass	4
Meadow fescue	4
Timothy	1
Red clover	6
Alsike clover	3
White clover	1

Hay crop—Continued	*Pounds per acre*
On bottom lands where lime has not been added:	
Common ryegrass	4
Perennial ryegrass	4
Lotus	4
Alta fescue	4
Meadow foxtail	4
On limed uplands:	
Tall oatgrass	6
Orchard grass	4
Common ryegrass	4
Red clover	4

While fall seeding is preferable, early spring seeding of oats and Austrian Winter peas on tidelands generally brings fair yields. Spring-planted oats and vetch also do well. In some instances on uplands early spring-planted oats and peas produce satisfactorily. For late spring planting of hay, the use of 100 to 120 pounds an acre of Schoolman oats is advised.

Red clover is best suited to well-drained bottom land and other soils not too acid. Alsike is best on tidelands and acid hill soils. Clover usually is planted in the coast district, either alone or with a grain nurse crop, early in fall. Sometimes good stands are obtained with early spring planting.

For successful production of legumes, including clovers and vetches, on moist soils lime should be added every 4 or 5 years at the rate of 1½ to 2 tons an acre previous to seeding. Superphosphate applied early in spring on clover seedings the first year in hay have given excellent results.

Silage is desirable on the dairy farm to furnish a cheap source of succulents for summer or winter feeding. This reduces the quantity of hay required by 40 percent or more. Many crops may be successfully stored in the silo. Best silage crops for the area are pea vines, clover, and grass. In the past, oats and vetch were used most extensively for silage purposes, but recently grass has been replacing them, and when cut at the proper time makes a good silage.

The important factors in the production of good silage are maturity and packing. Crops harvested in early maturity have the highest feed value. Because of developments in the pea industry in Clatsop County and recent information on the value of rapidly growing young grass as silage for dairy feed, the use of silos should be encouraged among dairymen. Much interest has developed in making silages out of legume and grass crops, due largely to the fact that early in spring, weather conditions may prohibit the making of legume and grass crops into good hay. The use of molasses is suggested on silage from pea vines and immature grasses. Because of the high protein content of these products, the molasses assists in fermentation as well as increasing both the palatability and feed value. Molasses can be used also on inferior roughage to make it more palatable and more nutritive.

Crops best adapted to making silage are young grasses, oats and vetch, peas and oats, and vines from cannery peas. Oats and vetch are best sown in fall and peas and oats in spring. Silage crops are best seeded on newly broken sod. These annual crops give an opportunity for turning under sod before preparing a seedbed and reseeding to perennials. Since Clatsop County has a heavy rainfall, the more the land can be kept in perennial crops the better, inasmuch as annual crops permit the soils to leach and, in the case of sandy soils, to lose organic matter.

Clatsop County is not a grain-growing section; practically all the grain produced is confined to the valley of the Nehalem River. Grain growing is being discouraged, principally because of the high cost of production. Growing grain on small farms of 25 to 50 acres costs nearly twice as much as it does in eastern Oregon. Such farms should produce forage crops for hay or pasture, and cultivated crops for sale or home use rather than grain. At present the county imports both grain and hay, and some dairy farmers buy both. As hay is bulky,

it is expensive to bale and ship, and the price for baled hay is usually about three times the price of stacked hay in eastern Oregon. Grain is comparatively cheap to ship. The local price for grain is only slightly more than the price in Portland.

Present information indicates there is approximately 2,000 acres of cultivated land in the valley of the Nehalem River with about 800 acres used for grain. Oats occupy the largest acreage. The Gray Winter oat is at present considered the best variety. It offers a possibility in seed production, since it is a variety of good quality and has the advantage of not lodging easily.

Peas for freezing and canning should be recognized as an important crop. On the average this type of pea will yield 1 to 1½ tons of shelled peas an acre. Land preparation, fertilization, and insect disease control are the same as for the garden peas. The land should be well drained if peas are to yield their maximum. Phosphate fertilizer is required on most of the lands. The standard recommendation has been 400 pounds of superphosphate an acre, or its equivalent in phosphate content. If drills are available with fertilizer attachment, the rate of fertilizer used may be reduced somewhat and applying it in this way saves one operation. Nitrogen fertilizer is suggested on hill land, sandy land, and land that has been growing annual crops for some time. Lime is necessary on most of the soils.

There has been some question on seed treatment, and it is believed that on land that has not grown peas or vetch, inoculation is more important than the seed treatment. On the land that is well inoculated and where peas are being planted early, seed treatment or seed disinfection would be advisable. It is useless to use both treatments since the seed disinfection kills inoculation.

Much interest has been shown in this crop as feed, and where the grower has a permanent set-up with dairy cattle or other livestock, it is believed that the stave silo will be a satisfactory means of storing the crop. For a temporary operation, stack or trench silos are fairly satisfactory.

On some dairy farms there is a need for an annual crop that can be used in rotation for improvement of pastures and meadows. Dairymen might grow cannery peas or freezing peas for this purpose. It is necessary to have a well-prepared seedbed, and in some instances improved drainage, for the successful production of peas. By making this preparation for growing peas, the land will be in excellent condition for seeding back to meadow or pasture. To a large extent hay can be replaced with silage. If the cash returns will pay for labor and other expenses, peas appear worthwhile as a crop in such a rotation; they can be worked into a dairy program, both from the standpoint of utilizing the vines for feed and as a means of getting the land in good shape for better pastures and meadows.

From the dairying standpoint root crops, including mangels, turnips, and rutabagas, can undoubtedly be grown profitably on the more fertile uplands and especially on the lower lands that have been diked. The choice of root crops depends considerably upon individual preference. Mangels are being grown successfully on Sauvie soils, and large crops are harvested, but they are not grown in the area on other soil types. Mangels have done well in the Brownsmead section, with the Danish Sludstrup variety making the best yields. There are no diseases or insect enemies attacking this particular type of root. Turnips and

rutabagas produce large crops, but are occasionally attacked by aphids on the leaves and root maggots on the part of the plant beneath the surface. Late plantings (June 15 or later) as a rule control this insect satisfactorily. In sections where turnips do better than mangels, it is recommended that Pomeranian White Globe or Imperial Green Globe turnips be used for early fall feeding; Bortfeld turnips are recommended for late fall and early winter feeding and storage. Ground for root crops should be plowed shallow in fall and again deeply in spring. This should be followed by heavy manuring and an application of superphosphate at the rate of 400 pounds an acre. Roots, when planted on land subject to overflow or excessive winter moisture, should be harvested and stored for use. It is recommended that dairy farmers grow an acre of root crops for every six or seven cows.

The acreage in peas will not materially reduce the need for roots, since on most farms the acreage used for pea production will replace the feed acreage that is used for hay or pasture. Ensilage from pea vines should furnish early succulent feed, while the roots would supply that for winter.

The principal soils in the area are listed in table 9 in the approximate order of their general productivity for the more important crops, and estimated average acre yields are given for each soil.

TABLE 9.—*Estimated acre yields*[1] *of the more important crops on the principal soils in Astoria area, Oregon*

Soil types grouped by productivity	Hay			Oats	Roots	Clover and grass silage	Strawberries	Pasture	Bentgrass seed	Principal use when drained
	Clover	Oat and vetch	Oat							
	Tons	*Tons*	*Tons*	*Bu.*	*Tons*	*Tons*	*Lb.*	*Cow-acre-days*[2]	*Lb.*	
Excellent:										
Sauvie silty clay loam	3.50	5.00	------	60	60	9.0	-------	540	250	Feed and seed crops.
Clatsop silty clay loam	3.00	4.50	------	50	50	8.5	-------	450	200	Do.
Nehalem silty clay loam	2.50	4.00	------	50	40	8.0	2,000	360	150	General crops.
Nehalem loam	2.00	3.25	------	45	40	8.0	1,800	270	150	Do.
Nehalem silt loam	2.00	3.50	------	40	40	8.5	1,600	270	150	Do.
Good:										
Knappa loam	1.75	3.25	------	40	40	7.0	1,800	150	-----	Do.
Cinebar silt loam	1.50	2.50	------	15	40	6.0	-------	150	-----	Hay and pasture.
Klaskanine silt loam	1.75	3.00	------	35	40	7.0	1,500	150	-----	General crops.
Fair:										
Brenner silty clay loam	1.50	3.50	1.75	-----	40	6.0	1,500	180	100	Feed and seed crops.
Astoria loam	1.25	2.75	1.50	-----	30	5.0	1,200	90	-----	General crops.
Astoria silt loam	1.25	2.75	2.00	-----	30	5.0	1,200	120	-----	Do.
Brallier peat	2.00	3.00	2.00	-----	35	8.0	-------	270	100	Pasture.
Spalding peat	2.00	2.50	1.50	-----	35	6.0	-------	180	75	Do.
Poor:										
Warrenton loamy fine sand.	1.25	2.00	1.50	-----	30	5.0	1,200	60	-----	Pasture and truck.
Hebo silty clay loam	1.25	2.00	1.50	-----	15	5.0	-------	120	75	Pasture and hay.
Grande Ronde silty clay loam.	1.25	2.00	2.00	-----	20	5.0	1,100	120	100	Do.
Gearhart fine sandy loam	------	1.00	1.50	-----	20	3.0	1,000	36	-----	Pasture and truck.

[1] Where good farm practices as drainage, liming, and fertilization are used.
[2] See footnote 1, table 8, p. 51.

WATER CONTROL ON THE LAND

DRAINAGE

Owing to heavy rainfall in the area and to the low position and heavy character of most of the better soils of the county, drainage is a

major problem on most farms. The importance of drainage can hardly be overstressed, since few of the important cultivated crops will yield satisfactorily on poorly drained soils. Because of the fact that the area of tillable land is so small in proportion to the total acreage of the county, it is important that any permanent agricultural program provide for the full conservation and utilization of the small acreage available.

On the basis of drainage requirements, the agricultural soils may be divided into three classes, as follows: (1) Soils with good drainage—Knappa loam, Nehalem loam, silt loam, and silty clay loam, Astoria loam and silt loam, and Klaskanine and Cinebar silt loams; (2) soils with excessive drainage—Westport fine sand and Gearhart fine sandy loam; (3) soils with poor drainage—Warrenton loamy fine sand, Grande Ronde silty clay loam, Hebo, Brenner, Clatsop, and Sauvie silty clay loams, and Brallier and Spalding peats.

Drainage may be improved on diked tidelands by intercepting drains bordering the hills to cut off seepage from the higher areas and to carry it into natural drainage outlets, thus preventing the water from reaching the tidelands. Much improvement can be made by keeping drainage channels clear of annual growth and by the use of underdrains on the improved areas. Experience has demonstrated that the most successful underdrains on tidelands can be constructed with puncheons. While draining may be done by open ditches, puncheons are preferred because nearly all tidelands settle more or less after cultivation begins, in which event tile lines are put out of alinement. The principle of the puncheon is more or less an open ditch, about 2 feet wide and 3 to 4 feet deep, with a narrower ditch about the size of tile in the bottom. Split puncheons or slab wood is laid over the small ditch. This permits water to flow through the openings as it would in tile. The soil is thrown back, covering the slab wood or puncheon, as must be done when tile is covered.

In recent years, since new diking districts have been organized in order to avail themselves of the benefits of the Federal Flood Control Act of 1936, practically all the dikes in the various districts have been rebuilt (pl. 6, *A*). They range from a top width of 8 feet and a height of 10 feet along the Columbia River to a top width of 4 feet and a height of 7 feet along the interior streams. The dikes are built to protect lands against a 13.6-foot flood stage with a 1- to 4-foot freeboard. The average tide stage is 8 feet. The lower freeboard dikes in the interior rivers are sloped 3 to 1 on the inside, which, it is said, prevents scouring should a 40-year flood cycle overtop the dikes.

Construction of open interior drainage ditches is not practical. Large sloughs, however, which provide storage for a few days' heavy precipitation, are useful. It is now deemed more practical to construct closed drainage ditches either with puncheon, tile, or wood planks. Pumping is not required on any of the diked lands as the elevation is approximately 6 feet above the low water stage. Tide boxes, a foot square to large concrete structures having outlets of 200 square feet, automatically open and allow drainage when the tide falls below the land level. This is particularly economical on Clatsop County tide lands, for it eliminates the cost of pumping.

During the last few years the acreage in farms has steadily increased as a result of the decrease in cost of clearing by the use of bulldozers.

Rarely now does one see land being cleared by manpower or teams. The use of the bulldozer not only reduces the cost of clearing the land of trees and stumps, but it is a rapid and economical method of leveling and filling unnecessary ditches.

The various diking, drainage, and improvement districts (fig. 2), and the acreage protected in each district are as follows:

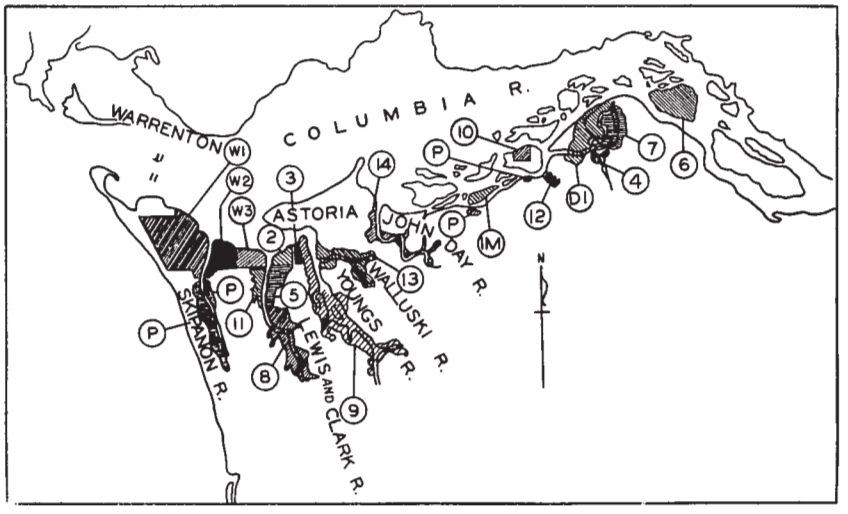


FIGURE 2.—Diking, drainage, and improvement districts of Clatsop County, Oreg.: W1, W2, and W3, Warrenton diking districts; D1, Clatsop County drainage district; 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14, diking districts; P, privately developed diking districts; and 1M, Svensen Island improvement district.

	Acres protected
Warrenton diking district:	
No. 1	1,915
No. 2	996
No. 3	945
Clatsop County drainage district No. 1	1,391
Clatsop County diking district:	
No. 2	248
No. 3	485
No. 4	90
No. 5	535
Tenasillahe Island diking district No. 6	1,709
Blind Slough diking district No. 7	928
Lewis and Clark River area diking district:	
No. 8	1,506
No. 11	
Youngs River area diking district No. 9	2,528
Karlson Island diking district No. 10	370
Knappa area diking district No. 12	69
Walluski River area diking district No. 13	610
John Day River area diking district No. 14	246
Svensen Island improvement district	326

IRRIGATION

As a result of low rainfall during summer the production of many crops, particularly pasture crops, is retarded because of the lack of moisture. Irrigation in normal years can be used from June 15 to

September 15, and pastures and some vegetables respond well to its use. This applies to all soils except those lower bottom lands that are subirrigated. On tideland pasture, irrigation increases carrying capacity two to three times.

Experience has shown that where the water can be applied economically, irrigation can be easily justified. Irrigated Ladino clover and grass pastures offer to the dairyman a possible source of cheap high-quality feed. The pastures may be expected to have a carrying capacity of 2 to 4 cows an acre for 6 or 7 months.

On some of the diked land in this area it is possible to irrigate through tide boxes, which will allow water to run over the land during high tide. Where this system is possible, the cost of irrigation water is very low. On other lands it may be necessary to pump the water. Each farm presents an individual problem.

Where it is possible to prepare the land properly, some type of flood irrigation will be the most economical. Where the land cannot be properly prepared, there are several methods of sprinkler irrigation that have proven practicable in the coast areas. There are many places along the smaller streams where water may be diverted by gravity and carried onto the land.

Before 1937 irrigation was limited; the acreage increased to 240 in 1938. The principal soils irrigated are Clatsop, Nehalem, and Sauvie soils and Brallier peat. The total area irrigated in 1940 was 460 acres.

Soils that respond well to supplemental irrigation are Knappa loam, Cinebar silt loam, Nehalem loam and silt loam, and Nehalem silty clay loam; when well drained, Sauvie and Clatsop silty clay loams; when well fertilized, Astoria loam and silt loam, although water supply is difficult to obtain. Soils that respond fairly well to supplemental irrigation are Brenner silty clay loam when well drained; Grande Ronde and Hebo silty clay loams when well drained and fertilized; and Warrenton loamy fine sand and Gearhart fine sandy loam when well fertilized.

LAND USE IN CLATSOP COUNTY[9]

Clatsop County is divided according to land-adaptability classification into (1) forestry (324,070 acres), (2) agricultural (51,087 acres), (3) grazing (125,270 acres), (4) recreational and resort (11,616 acres), (5) marsh (waste) (6,426 acres), and (6) urban and military reservations (8,072 acres).

AGRICULTURAL LANDS

The agricultural lands, primarily because of their soil characteristics, are divided into two classes—those adapted to general crops and those that are limited to special crops.

GENERAL CROPS

The agricultural lands adapted to general crops, mainly alluvial in origin, occur in the bottoms adjacent to streams or tide flats and comprise the greater part of the developed and potential agricultural soils of the county. The topography is generally level. Both the surface and subsoil are fine-textured and are usually free from gravel

[9] BAKER, V. W. AN AREA PLAN FOR LAND USE, CLATSOP COUNTY, OREGON. U. S. Bur. Agr. Econ. 57 pp., illus. 1940. [Processed.]

or hardpan. They have the high inherent fertility that is characteristic of recently formed bottom-land soils. When properly managed they may be maintained in a permanent high production of a wide variety of crops, depending somewhat on the present drainage, protection from overflow, and state of available fertility maintained by cropping and fertilizing processes. When adequately drained and protected from overflow, they are well adapted to the growth of legumes and grasses for hay and pasture and numerous other crops common to the area.

In general these lands will justify the cost of clearing, diking, and draining, where these improvements are necessary. Preliminary results of a survey by the United States Bureau of Agricultural Economics indicate the possibility of clearing land by modern methods at costs that range from $40 to $65 an acre, depending upon local conditions. The diking of most of the lands requiring this protection has been done or is now being done either privately or under the flood-control program of the War Department. Some of this land, however, will require additional drainage. Marsh lands and islands along the Columbia River have not been included in this classification unless tentative feasibility of their reclamation has been indicated by the War Department. It should be pointed out that there are great variations in the cost of diking, clearing, and draining, and each particular tract of land should be evaluated on its own merits.

LIMITED CROPS

The agricultural lands adapted to limited crops are less favorable for agricultural development than those for the general crops. In general they are located adjacent to bodies of high-quality agricultural land and include low hills and benches. The soils, which have been derived from the weathered parent bedrock, are comparatively low in mineral fertility and strongly acid. The low fertility and high acidity make them poorly adapted to the growth of legume crops. They require more fertilizer and more care in tilling than the agricultural lands that have general crop adaptability, if they are to be productive and if excessive erosion is to be prevented. These characteristics usually limit these soils to pasture use or to the growing of grain and vetch hays. Where located close to bottom lands the soil areas are valuable as building sites and supply supplemental pasture during the rainy season when the bottom lands may be extremely wet. In certain localities they serve as satisfactory locations for part-time farms or poultry farms. Such uses require only small acreages, and operators are willing to make larger investments an acre for fertilizers and soil-building programs than where larger tracts are involved.

Extensive clearing and development of the hill land and benchland for general farming is not justified under present economic conditions. It is probable that all of this land may not be needed for agriculture for many years, and where covered with forest growth, it may profitably be used for farm forestry as an additional farm enterprise. Where these lands are already cleared or where their location makes them a valuable supplement to bottom lands, their use or development for agricultural purposes may be desirable.

Peat lands are included in this class. They require special provision for draining and sanding for cranberries, to which crop certain of the

bogs are well adapted. Their use for other specialized crops, including truck crops and berries, requires special management.

GRAZING LANDS

Grazing lands involve the use of natural forest lands that are now chiefly cut-over or in process of being logged. The attempted use of such lands for grazing purposes involves a problem of economically establishing suitable forage species on lands naturally adapted to the growth of trees.

The best experience and judgment of local stockmen and agricultural and forest leaders familiar with the problem indicate that lands having potential range use are confined to the Nehalem River watershed in the southeastern part of the county. This conclusion is based on certain fundamental physical and climatic differences and to the fact that any grass stands that are established must be maintained in competition with the native woody species, which have a persistent tendency to reestablish themselves.

The close proximity of agricultural bottom lands adapted to producing winter feed and serving as bases for home-ranch operations have an important influence on the development and use of the forest lands for grazing purposes.

The grazing lands have been divided into four classes: (1) Those having great possibilities for grazing development for home-ranch use; (2) those having secondary possibilities for home-ranch use; (3) those having best possibilities for range without home-ranch facilities; and (4) those on which grazing should be deferred because of valuable immature forest.

The lands that have the greatest possibilities for grazing development for home-ranch use include those that have been recently logged or that now carry mature stands of timber that probably will be logged in the near future. They are further characterized by a moderate slope (25 percent or less) and usually have deep soils of fine texture. The recency of logging operations permits the clean burning of refuse which better prepares the land for the establishment of grass through the accumulation of ash and the consequent temporary increase in soil fertility and decrease in acidity (pl. 7, *A*). The areas are easily accessible to agricultural lands where winter feed can be raised, where public facilities are provided, and where conditions are favorable for establishing ranch headquarters.

The lands having secondary possibilities for home-ranch use are characterized for the most part by nonrestocking old cut-over and burned areas, poorly stocked stands of coniferous young growth (10 years of age), small areas of merchantable timber and recent cut-over lands with slopes greater than 25 percent, and soils that are prevailingly shallow. Because of the time that has elapsed since they were logged and burned and the general lack of sufficient debris for suitable reburning, these areas are less favorable for the development of grazing under present generally accepted seeding practices. The shallower soils and steeper slopes increase the difficulty of range maintenance and erosion control.

The lands having the best possibilities for range without home-ranch facilities lie in the more remote parts of the watershed and are characterized by a rather high proportion of rough lands and greater distances to winter-feed bases. No developed agricultural land is in

the territory included within this class, and sites suitable for growing winter feed are very limited. The bulk of the winter feed needed and much of the livestock therefore would have to be brought from the Willamette Valley or other agricultural areas. Because of these conditions these lands are less susceptible to range utilization than are lands in the other grazing classes. The great majority of the lands are nonrestocking old cut-over (pl. 6, *B*) or burned-over areas, and consequently the extent of their use and the degree of success in their development for grazing purposes depend upon the development of economical and satisfactory means of establishing and maintaining grass on land of this character.

The land where grazing is deferred because of valuable immature forest includes all second-growth and forest reproduction occurring within the general body of grazing lands, except the poorly stocked stands in the 10-year age group. These lands are physically similar to the first two classes, but the present timber stands are sufficiently valuable to warrant protection. The cost of preparing this land for grazing (slashing, burning, and seeding) would be excessive, and the waste of the forest cover would be uneconomical.

FOREST LANDS

The forestry industry is the most important factor in the economic life of Clatsop County and one upon which much of the industrial and municipal activity depends.

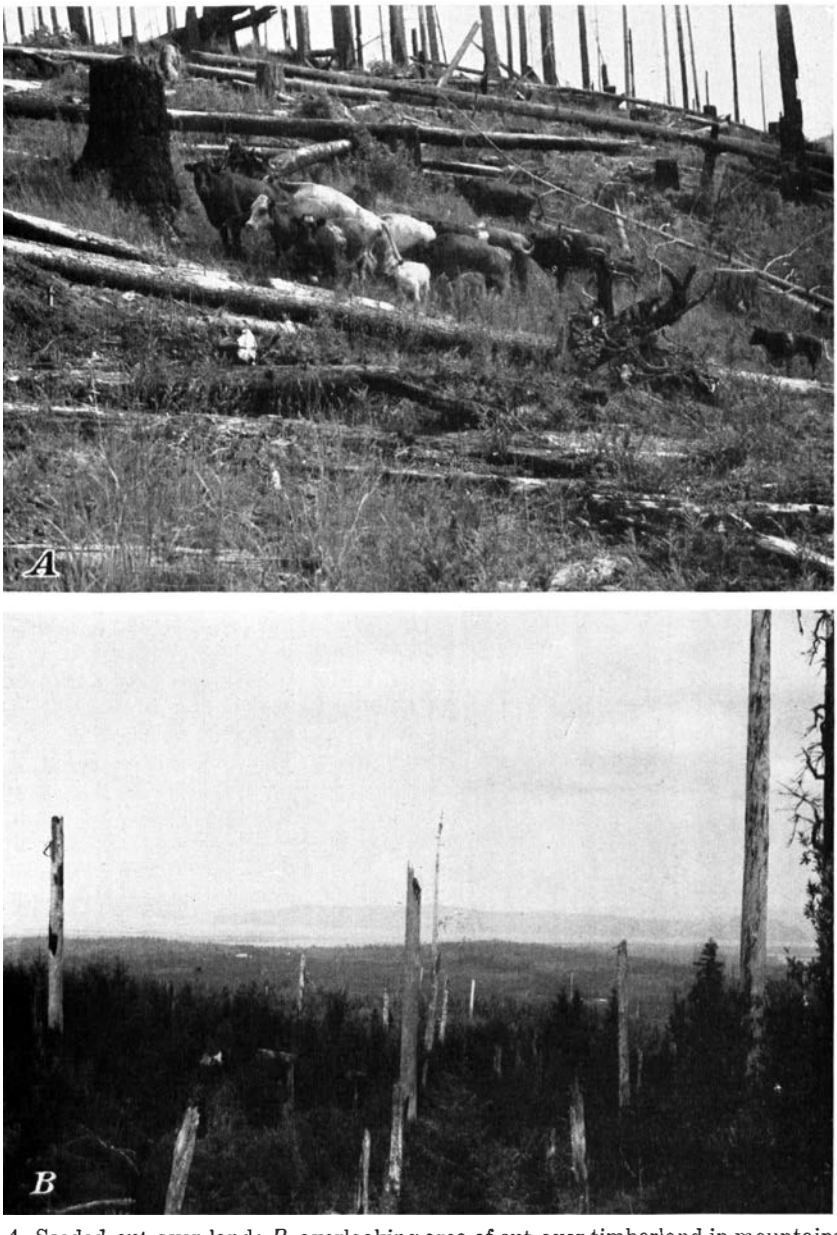
According to the 1940 census, 20,099 persons 14 years of age and over were gainfully employed in the county. Roughly 1.8 percent of these were employed in the forestry (except logging) and fishery industries, 3.3 percent directly employed in agriculture, and the rest in various trade and service industries. The 1940 census reported 366 persons in the county gainfully employed in forestry and fishery, exclusive of mills and other processing plants.

The forest lands are primarily adapted to this use because of the inaccessibility for other purposes and because of climatic and soil conditions that especially favor the growth of forest trees. Topography ranges from gently sloping to rough and mountainous, where forest cover is essential for a protective cover to conserve the soil and water resources. The soils are residual in character, usually strongly acid, relatively low in organic matter as compared to the soils of the lowlands, and, in places, shallow or stony.

Practically all of the upland in the western part of the county is included in this class because of topography, soil conditions, and the persistence of the spruce-hemlock type of growth. These lands are highly productive of forest, a large part of them being of forest-site qualities 1 and 2 (excellent and good.)[10]

Substantial acreages of merchantable saw-timber still remain in some parts of the county, which comprise the major part of the spruce-hemlock belt lying west of the summit of the Coast Range. These large acreages of merchantable timber are supplemented by sizable stands of young and second-growth timber. Only about 14 percent is clear-cut or burned-over. Proper management and protection of these timber resources would insure a permanent supply of forest products. In contrast is the depleted condition of the forest

[10] BUELL, E. D. FOREST STATISTICS FOR CLATSOP COUNTY, OREGON. Pacific Northwest Forest and Range Expt. Sta. 11 pp., illus. 1938. [Processed.]



A, Seeded cut-over land; *B*, overlooking area of cut-over timberland in mountains back of Svensen, Columbia River in distance.

A complex of shifting sand, vegetated hummocks, and low pockets followed the inland movement of sand by wind and surf from the original fore dune. Remnants of the fore dune remain; destruction was caused by overgrazing. Courtesy of Soil Conservation Service.

resources of the remaining areas lying principally in the Douglas-fir belt. Here, only 23 percent of the forest land is left with commercial stands of saw-timber size.

RECREATIONAL AND RESORT LANDS

The recreational and resort lands occur along the coastal beach and consist chiefly of sandy beaches and points of scenic beauty. Because of their location and accessibility they are valuable primarily for recreational and resort purposes.

Lands used for these purposes consist chiefly of the beach lands extending along the coast almost the full length of Clatsop County. Improvements consist of golf courses, cabins, and other structures designed to meet the needs of vacationists. The area plays host annually to thousands of summer tourists. With the completion of the new coast highway along Cannon Beach and the Wolf Creek Highway from Portland, this area is destined to become increasingly more important from a recreational and resort standpoint.

In certain places, however, along this natural playground the recreational values have been seriously impaired by improper use of the land. On the sand dunes north of Gearhart and west of the main highway, overgrazing and attempted cultivation have destroyed the cover and caused serious damage to beach-resort properties and adjacent agricultural lands by partly burying them under drifting sands. Until the shifting sands are again tied down by vegetation, they will continue to be a threatening menace to these properties.

RESOURCES

Present agricultural land resources of the county include 20,896 acres of woodland pasture. The total number of farms, as reported by the 1940 agricultural census, was 661. Present and potential resources included in agricultural land-adaptability classes total approximately 51,000 acres. As already pointed out, however, the way in which certain of these lands are to be used will determine the justification for their agricultural development under present economic conditions. The probable number of farms these agricultural resources will support under existing conditions is estimated at around 1,200. Other potential agricultural resources are represented by the possible development of more than 105,000 acres of cut-over forest land for grazing use which would give an added estimated maximum carrying capacity of 16,500 animal units. Apparently the potential resources, if successfully developed, will substantially increase the present agriculture of the county.

Persons who wish to establish farms in Clatsop County should consult the county agricultural agent.

Clatsop County is divided naturally into six geographic and economic sections that are treated individually to allow a more intimate consideration of the land use problems as they affect each local community. Some of the relations involved in the use of the land resources of each area are discussed in the following six groups.

YOUNGS BAY-ASTORIA AREA

The Youngs Bay-Astoria area embraces the territory around Youngs Bay and that drained by the Lewis and Clark and Youngs Rivers, covering about 130,000 acres. The agricultural land is for the most

part along the river bottoms tributary to Youngs Bay and on the adjacent low hills and benches bordering these bottoms. The bottom lands particularly, which are protected from tides by diking, are quite highly developed. Farming ranges from small part-time units and combination truck crop and dairy units to large specialized dairy farms. Dairying is the chief type of farming and is frequently combined with grass-seed production on some of the permanent pasture land. Part-time farming is concentrated largely in the vicinity of Warrenton and near Astoria between the mouths of the Lewis and Clark and Youngs Rivers. Truck gardening is becoming important on the lands around Warrenton.

The potential agricultural land in this area includes 11,551 acres classed as having general crop adaptability and 9,434 acres having limited crop adaptability. These two classes together represent an increase of about 68 percent over the land now in agricultural use. Most of the latter class is bench and low hill land bordering the river bottoms. Care should be exercised in the further development of land of this type. Ordinarily it will not justify clearing for general farming purposes, except where it is to be used in connection with adjacent bottom lands for pasture, hay, or for farmstead purposes. Annual cultivation or excessive pasturing should be avoided to prevent erosion.

Other areas included in this class are located in the lowlands west and north of Warrenton. They are characterized by peat soils that may be adapted to general crops after they have been drained and cultivated for a few years. These lands generally have high fertilizer and lime requirements. A high percentage of the bottom lands is already developed. Some draining and a limited quantity of clearing will be necessary to place the remaining undeveloped land in agricultural use.

Undoubtedly most of the agricultural land will continue to be used for dairying, the most important farm enterprise in the county. A summary of over 100 Agricultural Adjustment Administration farm records for the year 1938, covering over 50 percent of the farm land in this section, shows only about 6 percent of the farms without some dairy stock; the remaining farms report an average of 12 cows each. The minimum-sized economic dairy unit is believed to be about 15 cows. According to these records, farms that carry about this number of cows average around 40 acres of cropland. The acreage of noncrop pasture and other lands (usually forest) varies considerably.

KNAPPA-SVENSEN AREA

The Knappa-Svensen area, in addition to the Knappa and Svenson communities, includes the section around Brownsmead and Clifton, together with the forest land extending to the east and south. Agricultural land is found along the bottoms adjacent to the Columbia River and tributary streams and on the benchlands between Knappa and Svensen. Tenasillahe, Karlson, and Svensen Islands also contain agricultural land. The remaining islands in the Columbia River are mostly low marshy wastes that are usually covered by water during high tide. Approximately 7,000 acres are now in agricultural use. As is characteristic of most of the county, the predominant type of farming on the tide flats and stream bottoms is dairying. This

enterprise is combined in some instances with grass-seed and vegetable production.

Part-time farming is common on the benchlands between Knappa and Svensen. The poultry enterprise is the principal source of income from this district.

More than 13,800 acres of land in this area are potentially suited to agriculture. About 9,000 acres are bottom lands having general crop adaptability and the remaining 4,800 acres are of the benchland type. A considerable acreage of this latter type is in the cut-over stage or is supporting scattered stands of coniferous second-growth or lowland hardwoods (pl. 7, *B*). The area is adapted to such specialized types of agriculture as poultry production. A limited acreage of benchland bordering the bottoms will no doubt be used in conjunction with the bottoms as farmstead sites and for supplemental forage production.

WESTPORT AREA

This area of approximately 12,000 acres is located in the extreme northeast corner of the county extending southward. Within the district are the two communities of Wauna and Westport, which are almost entirely supported by mills and other forest industries. Farming is very limited and is confined to the bottom lands in the immediate vicinity of Westport. Most of the remaining land is too rough and steep to be used for other than forest purposes.

The agricultural land is very limited from the standpoint of both present use and potential development. The 1940 census reports only 14 farms. These vary in character from subsistence or part-time farms to small dairy units. Fifty percent of the operators worked an average of 195 days off their farms in 1934. The total potential agricultural land is about 350 acres, of which approximately half is now in farm use. These lands form a part of a much larger agricultural district across the Columbia County line.

ELSIE-JEWELL AREA

The Elsie-Jewell area comprises that part of the Nehalem River watershed lying in the southeastern part of the county and includes a total of about 170,000 acres. It is bounded on the north and west by the divide of the Coast Range and on the south and east by the county boundary. Most of the acreage is cut-over forest land with scattered remnants of mature Douglas-fir timber now in process of being logged. Relatively small tracts of immature forest growth are also found scattered among large tracts of nonrestocking old cut-over and burned-over land and more recently logged lands. Narrow strips of agricultural land border the Nehalem River and its tributaries.

About 50 percent of the bottom lands has been cleared for farming purposes. These lands are used almost entirely for dairying, although a limited acreage is in the commercial production of grass seed. The potential agricultural lands, which total about 9,000 acres, are all located along the Nehalem River or close to the mouth of tributary streams; about 7,000 acres are classed as having general crop adaptability and the remaining 2,000 acres as having limited crop adaptability. These latter areas consist mainly of foot slopes and low hills that lie adjacent to the agricultural bottoms, most of which are cut-over, although only very small parts of them have been cleared. Their

adaptability is limited primarily to pasture or hay crops. If they can be successfully established and maintained in forage grasses without incurring high clearing costs, it would appear that clearing for farm use would be justified where there is definite need for additional land to complete the farm unit.

The future use of the agricultural land is closely associated with the development of grazing on the cut-over lands. Successful utilization of the range land will be dependent upon the agricultural lands for a supply of winter feed. As the range land would be unadapted to large-scale grazing by dairy stock, a major shift would be required in the type of farming from dairy to beef production, should any considerable acreage of hill land be developed for pasturing.

Although information is meager on the probable carrying capacity of the grazing lands under proper development and management, estimates by members of the staff of the Oregon Agricultural Experiment Station and local stockmen range from 1 to 2 sections of land per 100 animal units for an 8- to 10-month grazing season. Winter-feed requirements have been conservatively placed at 1 ton for each animal unit. Based on an average production of 2½ tons of hay an acre, which is common on bottom lands in the valley of the Nehalem River, approximately 40 acres of cultivated land would be required for each 1 to 2 sections of grazing land to provide adequate winter feed.

NORTH NEHALEM AREA

The North Nehalem area situated in the southwestern part of the county is a natural part of the Nehalem Bay district of Tillamook County. The area includes the drainage of the North Fork of the Nehalem River south of Hamlet, which includes a total of 33,350 acres, most of which is forest land. The narrow strip of agricultural land found along the river in the lower part of the area emerges into a much larger agricultural district south of the county line. The natural trading center for the relatively few residents is also located in the small towns near Nehalem Bay.

Less than 200 acres of bottom land have been developed for farming purposes. Although there are two or three dairy farms, most of the places are little more than garden spots.

SEASIDE-NECANICUM AREA

The Seaside-Necanicum area lies along the west side of the county and includes all the coastal beach together with the Necanicum River watershed and the watershed in the upper part of the North Fork Nehalem River as far south as Hamlet and totals 102,150 acres. It is somewhat different from other sections of the county. Although timber interests are of great importance, the area along the coast is dominated by recreational and resort uses. The agricultural interests are closely associated with the resort development, as the latter furnishes local markets for most of the farm produce. Centers of urban development and recreational interests are Seaside and Gearhart.

The developed agricultural land is found chiefly on the bottoms near Seaside and along the highway north toward Astoria. It is used mostly in small farms for producing dairy and poultry products, truck, and other specialized crops.

About 6,000 acres of potential agricultural land is included in the

area; approximately 3,100 acres of this is classed as having limited crop adaptability. These latter lands are largely peat soils varying in degree of decomposition, depth, drainage, and soil development. Some are well adapted to cranberry and blueberry culture. This enterprise requires specific soil, drainage, and moisture-control conditions, and it is, therefore, essential that a careful and detailed investigation be made of each location before any development is undertaken. Some of the soils are sandy and are adapted to poultry raising. The soils in general are strongly acid, and their successful use for farming depends on the application of lime and fertilizers and the selection of crops adapted to the soils. The narrow strip of bottom land along the Necanicum River is relatively undeveloped, and it would require costly clearing operations in most instances to bring it into agricultural use.

CLATSOP PLAINS DUNE AREA [11]

The Clatsop Plains dune area borders the coast and extends southward from the mouth of the Columbia River for about 16 miles or nearly to the rocky promontory known as Tillamook Head. In 1935, sand blowing inland from the beach (pl. 8), together with sand from the back areas where the protective cover was destroyed, threatened to inundate the military preserves at Fort Stevens at the mouth of the Columbia River and Camp Clatsop farther south. Moreover, lakes adjacent to the coast, lying on wild fowl migratory routes and natural havens, were rapidly disappearing beneath the blanket of shifting sand.

Sitka spruce forests, fringing Clatsop Plains on the east, were succumbing as the sand moved slowly in upon them (pl. 9). Here and there a few bricks and scattered boards marked the location of former houses. Hundreds of acres of valuable pasture land were reduced to barren shifting sand, and several thousand additional acres of pasture and cropland were endangered.

In 1935 the Soil Conservation Service of the United States Department of Agriculture, cooperating with the Civilian Conservation Corps, undertook the task of stabilizing approximately 3,000 acres of shifting sand dunes and barrens with the objective of protecting several thousand acres of land to the eastward and property valued in excess of $5,000,000.

For the control work a number of native and introduced plants of demonstrated value as sand stabilizers were available. Among these were American dunegrass (*Elymus mollis* Trin.), seashore bluegrass (*Poa micrantha* Vasey), red fescue (*Festuca rubra* L.), beach pea (*Lathyrus japonicus* Willd.), silky pea (*L. littoralis* (Nutt.) Endl.), and preeminent among them, Holland grass or European beachgrass (*Ammophila arenaria* (L.) Link), and American beachgrass (*Ammophila breviligulata* Fern.) The value of European beachgrass had already been demonstrated in Europe and in this country.

By transplanting European beachgrass into hills and rows 18 inches apart it is possible to establish an initial planting that, in 2 years, will transform an unvegetated, shifting sand plain into a knee-high "sea of grass." The control work, actually, however, was a highly complex problem involving land use, vegetal succession, soil and climatic factors, normal geologic processes, physiographic forms, and drainage.

[11] Summarized from U. S. SOIL CONSERVATION SERVICE, CONTROLLING OREGON COASTAL DUNES: CLATSOP PLAINS DUNE AREA, WARRENTON, OREGON. 10 pp., illus. 1941. [Processed.]

The Clatsop Plains dune area may be divided, on the basis of physiographic characteristics and control problems involved, into two parts. The northern half, except for the back area, is a sand plain of very recent formation. The southern half is a mature topography that has been partly destroyed by scouring and inland movement of sand.

CONTROL PROBLEMS ON THE SOUTHERN HALF

Extending from the beach eastward to the foothills, with an average width of 1½ miles, the coastal flat may again be divided into three zones based on topography, vegetative cover, and degree of sand stability: (1) From the beach eastward, with an average width of half a mile to Lake Neacoxie and Neacoxie Creek, a complex of shifting sand, numerous vegetated hummocks, and low, undrained pockets; (2) east of Lake Neacoxie to the red alder-Sitka spruce forest a sodded expanse, characterized by a remarkable series of parallel, stabilized dune ridges and troughs—the ridges, with a maximum height of 30 feet, paralleling the coast in a great sweeping arc; and (3) between the sodded flat and the hills is a continuation of the dune ridge topography covered with forest.

Control work was concerned mainly with the first or western zone. The irregular topography presented a difficult control problem. Every eminence caused eddying effects of the wind, intensifying the tendency to scour, and making it difficult to establish a grass cover. Control work here involved removal of the vegetal cover on the small hummocks to allow them to scour down. Plantings of European beachgrass were followed, after a 2-year interval, by a seeding program in order to introduce nitrogen-building legumes and to thicken the vegetal cover. Seeds of native grasses and legumes were drilled into the European beachgrass plantings. Where the topography was very irregular, plantings of trees and shrubs were made to eliminate gaps and reestablish the topographic regularity.

The cause of the destruction of the old vegetative cover was largely due to grazing by livestock. It is known that sheep, horses, and beef cattle grazed this area since its settlement. Trailing repeatedly across the dunes, the stock cut through the protective cover and deep into the sand beneath. From these small beginnings gaps, scoured by the wind, widened and rapidly extended north and south. Millions of tons of sand blew eastward, even to the edge of Neacoxie Creek, pushed the creek out of its original course, and obliterated the drainage line that extended north and south parallel to Neacoxie Creek and between the fore dune and secondary dune. From the original fore dune, extending about 16 miles from Fort Stevens to Gearhart, approximately 40,000,000 cubic yards of sand blew inland.

The fore dune, immediately behind the storm tide line, normally is of great importance in stopping sand from the beach and keeping it from blowing farther inland. The fore dune vegetation, dominated by American dunegrass, is able to withstand a foot or more of annual sand deposition and will grow up through this deposit to catch the incoming sand during the winter season of storm and high southwesterly winds. Since the destruction of the original fore dune a new fore dune has built up naturally and attained in 50 years or less a height of 20 feet and a width of 300 feet. The development of this new fore dune has extended northward only as far as Sunset Beach.

CONTROL PROBLEMS ON THE NORTHERN HALF

From approximately Sunset Beach northward, the beach line has been moving rapidly oceanward. Since 1856 a low-lying sand plain has been formed by the deposition of sand, resulting from the effect of the south jetty at the mouth of the Columbia River. This sand flat attains a maximum width, near the jetty, of approximately half a mile. The oceanward movement of this beach line has been so rapid that vegetation has been unable to keep pace with it and the normal dune-building processes were outstripped.

In 1935, storm tides broke over this flat, extended inland to the edge of the old high dunes, and deposited quantities of driftwood. This great expanse of unvegetated sand was the source of small dunes that were moving inland, engulfing the old drainageways, covering timber, and theatening military lands and recreational areas.

To protect the flat from storm tides and as the initial step in control of this part of the project, two parallel lines of picket fence were driven 30 feet apart. These extended for 8 miles, parallel to the ocean beach at a point somewhat above the high tide line. In the fore part of the 1937–38 planting season the ocean side of the artificial fore dune was planted to European beachgrass in a strip 50 feet wide. Later in the season the eastern slope was similarly planted and the crest, between the two lines of picket fences, was planted to American dunegrass. The dune ridge is now approximately 8 feet above the original sand level, with a base 130 feet wide, and forms an effective barrier to the sea and to the sand moving inland from the beach.

The rest of the sand flat is being similarly treated. Heavy grass plantings cause sand deposition; unplanted gaps are free to scour. A series of north-south trending dune ridges, with intervening troughs, are in this way being initiated.

The control program on the northern half may thus be summarized: (1) Construction of an artificial fore dune by picket fences and by planting of sand-binding grasses. (2) Construction of secondary dunes parallel to the fore dune by picket fences and by planting sand-binding grasses. Development of intervening troughs by leaving wide unplanted gaps between the grass strips. (3) Seeding of sand-binding grasses and legumes into the European beachgrass plantings. (4) Planting of trees and shrubs in areas of irregular topography and in areas considered critical because of use.

Because of the ease with which the vegetal cover may be destroyed and the danger of shifting sands to valuable property, recreational lands and wildlife refuges are the only proper land use of the protected dune areas.

JOHN JACOB ASTOR BRANCH EXPERIMENT STATION [12]

The Oregon Agricultural Experiment Station has maintained the John Jacob Astor Branch Experiment Station in Clatsop County since 1914. It was established by an act of the 1913 Oregon Legislature, which provided that the initial land and buildings were to be furnished and owned by Clatsop County and operated by the State agricultural experiment station.

The branch station was set up to work on the problems of agriculture

[12] Contributed by H. B. Howell, superintendent of the John Jacob Astor Branch Experiment Station, Astoria, Oreg.

peculiar to the high rainfall area along the Oregon coast, which included all of the counties of Columbia, Clatsop, Tillamook, Lincoln, Coos, and Curry and the coastal sections of Lane and Douglas. Dairying was the principal agricultural industry at the time the station was established and it continues to provide the principal income, although other production has increased. Almost the entire coastal section is one of high rainfall, long growing seasons, and mild winters. Rainfall varies from 60 to over 100 inches annually. The growing season is generally over 200 days, and temperatures in the average winter do not fall much below the freezing point. These climatic conditions bring about problems regarding soil fertility and its relation to the various crops.

The branch station is located about 4 miles southeast of Astoria on the tidelands of the Walluski River. When established it consisted of a tract of 50 acres, of which 30 was diked tideland and 20 was secondary bench or upland. All the land was covered with heavy native growth that required clearing at heavy expense and consumed much time. The tidal lands required drainage after clearing and some leveling to fill sloughs and low places. In 1937, an additional adjoining tract of 50 acres was obtained, which consisted of 20 acres of diked tideland, 20 acres of upland, and 10 acres of creek bottom land.

Soil fertility experiments, conducted for the past 20 years on Astoria loam, have clearly shown the need for a soil fertility program of lime, manure, and phosphorus. The same requirements also exist in the diked tidelands. Experience at the branch station and that of farmers has clearly shown that after diking or clearing the native growth, the soils rapidly increase in soil acidity and need lime after 10 to 15 years of cropping. Soil acidity on these lands varies from pH 4.8 to 5.5. Application of 2 tons of ground limestone has proved profitable in every instance and resulted in crops of vetch, peas, or clover where they could not be grown before. An average return for all lime applications at the branch station has been over $2 for every dollar expended for lime.

The successful growth of legumes is dependent upon the application of phosphorus as well as lime. The returns per dollar expended on phosphate fertilizers has been higher than the returns on lime. In general, the soil fertility experiments have shown a return of $3 for every dollar expended for phosphates.

Crop experiments carried on at the branch station have developed standard practices in the culture of vetch and peas and have introduced rust-resistant varieties of oats. The introduction of Schoolman oats served to relieve farmers of serious losses from oat rust. Experiments on root crops have been conducted since the station work began and have demonstrated that high yields of such roots as turnips, mangels, and carrots can be obtained. The station pioneered the development of the Bortfield turnip, which has been grown extensively since 1930. A complete root-crop program has been developed for farmers of the coast section. Growing beets for livestock-feeding purposes has not been successful on the experiment station lands because of high acidity.

Experimental work on grasses and legumes has resulted in the testing of a large number of varieties and in the introduction of improved species, as Ladino clover, big trefoil (*Lotus uliginosus* Schkuhr), birds-

foot trefoil (*Lotus corniculatus* L.), and subterranean clover. Among the grasses introduced that proved of value in recent years have been meadow foxtail, alta fescue, creeping red fescue, and improved strains of orchard grass.

The preparation and feeding of silage made of grass and clover, oats and vetch, or oats and peas has been carried on since the experiment station was established. The preservation of forage in the form of grass silage has proved to be the best method of storing feed for winter use. Mature grass and legume mixtures preserved as silage maintain milk flow in dairy cattle in a very satisfactory manner. This type of silage has been fed as the exclusive roughage ration with satisfactory results. The use of grass silage offers the greatest possibility in improving locally produced feed supplies in the coastal area where hay is cured under extreme difficulty.

Experiments in the growing of garden peas for fresh market as well as canning and freezing have been carried on. These trials show that proper varieties, when carefully grown, are successful for the various markets. These trials also show a need for well-prepared seedbeds with applications of lime and phosphorus and the necessity of inoculation on soils where the crop has not been grown previously. Many other vegetables have been tried and information on varieties and cultural practices developed.

Tourists' visits to recreational areas along the coast have increased the markets for vegetables and small fruits. Variety trials of strawberries have shown Rockhill everbearing strawberry to be one of the best adapted for these market purposes. Lloyd George and Newburg have proved to be the best adapted raspberries.

To solve the problems associated with the multiple uses of cut-over lands in the coast section of Oregon, the Northrup Creek Grazing Experiment Station was established in 1936 under the supervision of the Jacob Astor Branch of the Oregon Agricultural Experiment Station, Astoria, in cooperation with the State Board of Forestry and the Soil Conservation Service. The project, containing 697 acres, is located 3 miles north of State Highway No. 202, which passes through Jewell and Birkenfeld about 4 miles west of the Columbia County line. This experiment station was established with the following objectives: (1) To determine the value of cut-over timberland for grazing purposes; (2) to test new and improved grasses and legumes as to length of life, palatability, and effect upon forest reproduction; (3) to determine the effect of grass planting upon the fire hazard as it affects timber reproduction; (4) to determine and establish best methods of livestock management on these lands in western Oregon; (5) to establish a possible use for this land between logging and reforestation and create taxable wealth to take the place of timber being marketed.

Livestock has been grazed on the area, and the indications are that returns from grazing will be large enough to attract considerable interest in this type of development. It is being demonstrated that grass mixtures properly made up will establish good ground cover and prevent erosion. The combination of the grass sod and grazing indicates that the growth of brush and weeds can be controlled. Returns from the animals on this experiment indicate a grazing capacity of 1 animal unit to 5 acres, or that this land will carry one cow and a calf

on 5 acres or one ewe and a lamb on 1 acre for a 7 or 8 months' pasture season.

The need for adapted legumes is becoming increasingly apparent as the grazing of these cut-over lands is carried on year after year. The fertility of the soils under heavy rain is apparently decreasing and trial plots with big trefoil and subterranean clover show increased yields. It is believed that both of these legumes offer a real possibility on these lands.

MORPHOLOGY AND GENESIS OF SOILS

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

The soil materials of the Astoria area have been formed principally from the weathering of sandstone and shale in a climate that is uniformly wet. As a result of these uniform conditions within the area the soils are similar mineralogically. Some of the principal differences in the soils are due to differences in position; that is, whether the soil materials still are in the hills overlying the rocks from which they have weathered or have been transported and spread out over the lower lying coastal plain. In the latter case, differences in soils occur because of difference in drainage, vegetation, and the length of time the materials have been in place.

The area lies in the extreme northwestern corner of Oregon bordered on the north by the Columbia River and on the west by the Pacific Ocean. The soils have developed, therefore, in a marine climate with mild temperatures and an abundant winter rainfall that has produced dense stands of coniferous forest growth. The average annual rainfall varies only slightly along the coast with 76.57 inches at Astoria and 77.91 inches at Seaside. The summer season, which extends from June to September, is dry with a total rainfall of only 5.16 inches at Astoria. July and August average a little more than 1 inch each. The winter season at Astoria, from November to March inclusive, receives an average rainfall of 53 inches, or about 70 percent of the year's supply. During each of the 3 months, November, December, and January, more than 11 inches of rain falls. Eastward from the coast, going up the west slopes of the Coast Range, the rainfall increases rapidly, reaching more than 100 inches a year near the crest.

The mean annual temperature along the coast varies from 50° to 52° F. The mean temperature for January varies from 37° to 44° and for August from 60° to 62°. Ascending the Columbia River east of Astoria the influence of the marine climate becomes less pronounced with the soils becoming more and more like those of the Willamette

Valley. The climate in the upper part of the valley of the Nehalem River is intermediate between that of the Willamette Valley and along the coast. Owing to the higher altitude there are greater snowfall, colder winters, and warmer summers than near the coast.

The heavy growth of Douglas-fir in the eastern part and spruce and hemlock over most of the rest of the area has left its mark on the soils in the high content of organic matter. The heavy rainfall has leached the soils of lime and other soluble constituents and left them acid. The light snowfall has left the ground bare throughout the year, but the moist atmosphere has prevented excessive evaporation. The soils, therefore, except for a few acres of salt marsh, are free of harmful accumulations of salts.

Topographically, the area is made up of low mountains or hills in the eastern and southern parts, river bottoms along the Columbia River and other major streams, and tide flats and sand dunes along the coast. Between the lowlands and the mountains are extensive areas of terrace and foothill soils with indentations of alluvial soils along the Youngs, Lewis and Clark, and Nehalem Rivers. The Coast Range in Clatsop County, being formed of soft sandstone and shale, has weathered into smooth, though sometimes steep, slopes without the angular outlines that so frequently characterize mountain slopes of harder rock materials. Most of the steeper slopes vary between 12 and 15 percent, and considerable areas have slopes of 8 to 12 percent.

The upland soils derived from rocks in place cover a large part of the county. They have been derived from the weathering of soft fine-grained sandstone and shale. The soils near the coast appear to represent a different age or are derived from a softer type of sedimentary rocks than those which give rise to the Astoria soils of the Willamette Valley. There the sandstone is mostly hard, dense rocks often resembling basalt. Although the hill soils along the coast have the salient characteristics of the Astoria series, the rocks from which they are formed are markedly softer sandstone with a larger proportion of soft gray shale. In places these rocks weather to depths of many feet. Not only do these soils weather deeper than those derived from resistant rocks, but as a result of the greater weathering they also occupy hills of more subdued topography. In addition, many small areas with a subsoil of dense gray clay occur as a result of the greater proportion of soft gray shale in the parent rock. Had such areas been of sufficient extent they would have been mapped in the Coates series.

Both the soft sandstone and shale are prevailingly gray with many yellow and red mottlings, especially on the surfaces of the cleavage planes. Variations occurring within short distances result in quite variable soil profiles. Weak evidence of podzolization can sometimes be found, but more frequently it is only faintly discernible. The place of these soils within the great soil groups is not clear as yet, and they may not fit well into any of the recognized great soil groups. They have some of the characteristics both of podzolic and lateritic soils. The weakness of podzolic development may be due to a combination of environmental factors, among which are (1) the hilly relief which in many places promotes erosion and interferes with normal profile development; (2) the relatively mild winters and cool summers that apparently are favorable for accumulation of organic

matter in the soils as well as a relatively thick forest litter on the surface; and (3) the heavy texture of the soil material.

Normally the profile consists of a medium-textured surface layer with a high content of organic matter and a heavier textured subsoil that grades into soft decomposing sandstone or shale. Usually, where topography is not too steep, the rocks have weathered to a depth of many feet; whereas in steep areas the mantle of the soil material is shallow, frequently only 2 or 3 feet thick. The profile of the Astoria soil (pl. 10) is still relatively immature. This is caused in part by the steep topography; the surface horizon washes away about as fast as it is formed. From this it can be gathered that the normal soil profile of a region develops only where the topography is sufficiently smooth to permit the soil material to remain undisturbed for a long period of time. This has not occurred in the hills.

Following is a detailed description of Astoria loam as observed at the John Jacob Astor Branch Experiment Station:

1. 0 to 3 inches, dark-brown mellow loam, containing a large quantity of forest duff and grass roots.
2. 3 to 12 inches, yellowish-brown mellow loam or silt loam, containing a quantity of soft shotlike pellets, most of which become yellowish brown when crushed.
3. 12 to 18 inches, light yellowish-brown moderately compact clay loam, breaking out of banks in coarse granular fragments; the shotlike granules easily crushed into yellowish-brown single grains.
4. 18 to 36 inches, light yellowish-brown fine blocky clay loam mottled with yellow, orange, and rusty brown; fragments easily crushed into a smooth silty yellowish-colored powder of single grains.
5. 36 to 54 inches, light yellowish-brown somewhat more compact silty clay loam mottled with gray and orange.
6. 54 to 72 inches, gray compact silty clay loam mottled with yellow.
7. 72 to 84 inches, light-gray massive clay grading into thick beds of gray thinly stratified shale and soft light-brown sandstone.

In places near the coast the deep substrata consist of thick beds of thinly stratified unconsolidated gray- and ocher-colored, greasy-feeling loam or silt loam, containing a high content of fine and very fine sand. These deep materials, which are open and pervious, appear to have resulted from the weathering of decomposed or unconsolidated deposits that seem to be about the same age as the adjacent areas of sandstone and shale. Although found in many places near the coast the individual areas are small and indistinct.

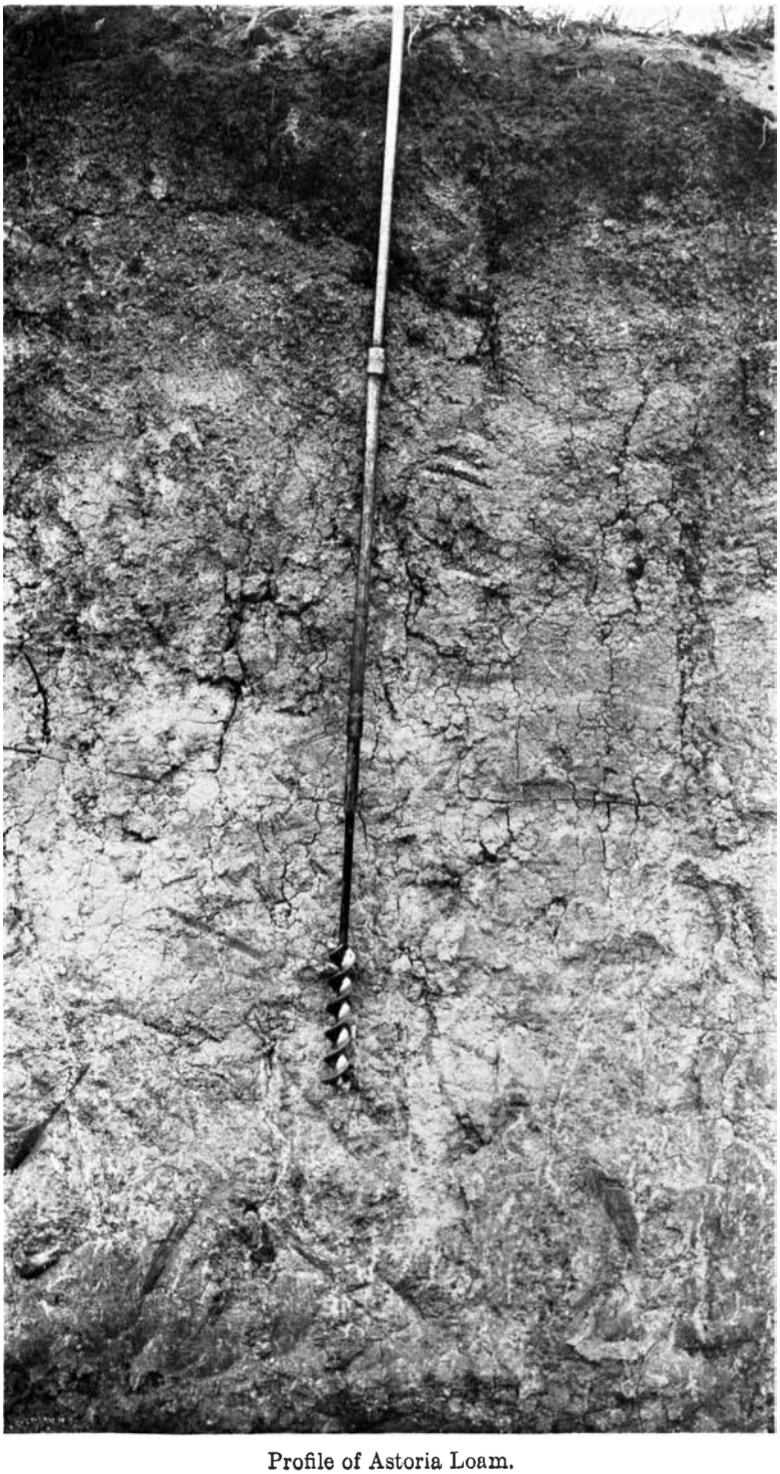
The chemical characteristics and absorption of moisture of Astoria loam are shown in table 10.

The Clatsop County coast is bordered in places by drifting sand which was thrown up by the waves and carried inland by winds. The irregular ridges and dunes of sand, in general, have their largest diameter approximately parallel to the coast and in many places enclose areas of peat. Some of the deposits are sphagnum bogs, others are marshes, and a few are well covered with timber.

In the vicinity of Seaside the profile features of unreclaimed sphagnum bogs are more or less similar to the Tillamook profile,[13] and scalped areas of peat, utilized for the commercial growth of cranberries,

[13] DACHNOWSKI-STOKES, A. P. PEAT LAND IN THE PACIFIC COAST STATES IN RELATION TO LAND AND WATER RESOURCES. U. S. Dept. Agr. Misc. Pub. 248, 68 pp., illus. 1936.

Sand drifting into the timber near Coffinbury Lake has killed the trees. Courtesy of Soil Conservation Service.



Profile of Astoria Loam.

TABLE 10.—*Chemical characteristics and absorption of moisture by various horizons of Astoria loam,*[1] *John Jacob Astor Branch Experiment Station*

Soil profile layers in forest area	Depth	pH	Base exchange capacity	Organic matter	Total nitrogen	Hydroscopic coefficient [2]
	Inches		*M. e.*[3] *1 gm.*	*Percent*	*Percent*	*Percent*
Litter	0–¼	4.4	0.487	88.10	0.989	33.31
F	¼–1	4.8	.641	80.50	1.119	13.10
H	1–1½	5.0	.641	31.80	.655	18.00
Humus soil, silt loam	1½–2½	5.1	.433	7.08	.293	12.00
A_2	2½–14	5.0	.389	3.13	.155	8.40
C	60–66	5.0	.506	1.30	.057	14.50

[1] POWERS, W. L. CHARACTERISTICS OF FOREST SOILS OF THE NORTHWESTERN UNITED STATES. Soil Sci. 34: 1–10, illus. 1932.
[2] Over 3.3-percent sulfuric acid indicating colloid content.
[3] m. e. = milliequivalents.

generally resemble the Coos profile. The marsh tracts illustrate, more commonly, features of the Hauser profile.

In places where trees invaded marshy tracts, the original stand consisted of rather large conifers and associated shrubs. Pines were prevalent over practically the whole tract at one time, and, to a less extent, hemlock, and still more rarely, cedar. In addition to these were thickets of willow, alder (*Alnus rubra* Bong.), and crabapple (*Malus fusca* Raf.). Thickets of *Spiraea douglasii* Hook. and other shrubs occupied most of the wetter places or formed the characteristic fringe along small streams. Common constituents in the undergrowth were elderberry (*Sambucus callicarpa* Greene), cascara, salmonberry (*Rubus spectabilis* Pursh), dogwood (*Cornus pubescens* Nutt.), vine maple (*Acer circinatum* Pursh), western skunk cabbage, and various ferns. Following is a detailed profile description of Brallier peat.

1. 0 to 6 inches, the surface material consists of undecomposed very dark-brown granular woody residue.
2. 6 to 18 inches, the material is moderately decomposed, contains coarse and lumpy woody fragments from roots and decaying timber, and has a somewhat larger content of reddish-brown material derived from a litter of needles, cones, twigs, and herbaceous components.
3. 18 to 60 inches, dark-brown moderately decomposed and partly fibrous sedge and reed peat, containing an appreciable quantity of granular residue at the upper level. The material below this is distinctly matted or felty fibered and yellowish brown. In the lower part of the layer there is a slight admixture of organic sediments, suggestive of material formed in standing water.
4. 60 inches +, the substratum, which occurs at variable depths, is sand containing in most places, black organic residue and roots. This material grades into dark-gray or gray sand that becomes less stained with depth.

The terraces or benches in Clatsop County comprise five soil series; two are well drained, one imperfectly drained, and two poorly drained.

The well-drained soils are classified in the Knappa and Klaskanine series. The Knappa soil has a rich-brown friable surface soil and somewhat lighter brown or yellowish-brown slightly compact upper subsoil. The deeper subsoil, below 30 inches, becomes slightly lighter colored yellowish brown and is more friable than above. Typically

the profile contains little or no mottling and is free of gravel. As mapped in this area, however, pieces of water-worn gravel are occasionally found in the deep subsoil, and near terrace slopes they may be within 3 or 4 feet of the surface. Such a gravelly soil is recognized as the Klaskanine type and would have been so mapped had it been of sufficient size. Typical Knappa soil differs from the Klaskanine in having a gravel-free, slightly more compact subsoil. Also the Knappa soil is less frequently found on terrace slopes but is almost invariably confined to smooth old valley floors.

Associated with the Knappa and Klaskanine soils and closely resembling them in surface characteristics is the well-drained Cinebar soil. This soil occurs on smooth or gently sloping terraces with good surface drainage but with somewhat impeded underdrainage because of heavy-textured moderately compact gravelly subsoils. This soil is the most maturely developed of this old valley-filling group. It has a brown to dark-brown surface soil and a light-brown to yellowish-brown heavy-textured compact upper subsoil containing a few partly weathered pebbles. The lower subsoil is brown or yellowish-brown heavy-textured material mottled with gray, orange, and rusty-brown, and contains a quantity of old partly weathered gravel. The gravel is considerably older than that in the Klaskanine soil yet much less weathered than that of the Salkum soils. It is, however, embedded in similar-colored clay loam or silty clay loam, which seems to have a similar effect on underdrainage. Next to the Knappa soil it is the most productive of the old valley-filling group.

Following is a detailed profile description of Cinebar silt loam:

1. 0 to 10 inches, brown to dark-brown granular silt loam, containing a small quantity of reddish-brown pellets. The granules are large, stable, and durable.
2. 10 to 22 inches, light-brown to yellowish-brown mellow but firm acid silty clay loam, the granules spherical and coated with colloids.
3. 22 to 48 inches, yellowish-brown moderately compact clay loam, mottled with yellow and gray.
4. 48 to 55 inches, yellowish-brown moderately compact clay loam mottled with yellow and gray and containing a quantity of partly decomposed gravel. The material becomes lighter colored with depth and the gravel is less decomposed but still iron-stained and strongly acid.

Unlike the thoroughly weathered gravel of the Salkum soils, which can be cut through with a shovel or knife, the gravel of the Cinebar soil has only a weathered coating on the outside. A more important difference, however, lies in the fact that the Cinebar is much more fertile than the Salkum soils, probably because they are younger and less strongly leached.

Poorly drained soils of the terraces are grouped in the Grande Ronde and Hebo series. The Grande Ronde soil is a medium- to heavy-textured soil from old valley-filling material on terraces, foothills, or fans. It is grayish-brown to dark-brown over yellowish-colored heavy subsoil mottled with rust brown and gray. Except for position and poorer conditions of drainage, the soil bears a close resemblance to the Astoria series, which it always adjoins and from which the parent material has been washed. Poor drainage has given it a tendency to have poor tilth.

The Hebo soils are dark-brown to black poorly drained old valley

soils with a gray heavy clay subsoil profusely mottled with yellow and orange. The dark-colored surface soil, highly charged with organic matter, has a thickness of about 10 inches. The upper subsoil, to a depth of about 18 inches, is yellow silty clay loam mottled with bright orange and gray, and overlies gray, stiff, heavy clay profusely mottled with bright orange yellow, the yellow and gray about equal. At a depth of about 30 inches bluish-gray heavy clay predominates, but around 4 feet bright orange-yellow clay is likely to reappear. As will be seen from the description above, poor drainage, with some waterlogging, is due not alone to a flat surface but also to the character of the soil profile.

The soils of the flood plains are of four kinds, namely, recently formed soils from materials laid down by streams; recently formed soils from materials laid down by streams, modified by marine deposits; recently formed soils from materials laid down by winds; and soils composed of organic matter. In most of these groups soils occur with different degrees of drainage.

In the first group, the well-drained soils comprise types of the Nehalem series. These soils have mellow or only slightly compact profiles that permit the rapid removal of excess water and promote free aeration. The Nehalem soils may be considered as a yellow counterpart of the Chehalis series of the Willamette Valley. Although considered to be well drained the subsoil is slightly mottled. The surface soil consists of about 20 inches of yellowish-brown mellow silt loam becoming yellowish gray when dry. The upper subsoil is yellowish-brown granular silt loam grading gradually heavier. The mottlings which are visible when dry are apparently caused by thin gray coatings on the soil aggregates. The lower subsoil, below 35 inches, is a solid yellow color when moist, although faint gray mottlings may be found in places below a depth of 45 inches. These soils occupy first bottoms of streams and represent reworked stream-laid Astoria soil materials derived from sandstone and shale.

In the group of recently formed soils from materials laid down by streams, the poorly drained types have been classified in the Sauvie, Brenner, and Clatsop series.

The Sauvie soils are good examples of soils developed under conditions of poor drainage. Continual saturation has caused a high degree of mottling with some iron staining, and the soils are distinctly acid. The organic matter, which is unusually abundant, is not well decomposed and may occur in any part of the profile. Owing to their origin and to the fact that, until they were diked, they were still being added to by every overflow, they have not yet formed any well-developed profile. The various layers are primarily the result of deposition rather than due to any change in soil development. The profile is always mellow and pervious with layers of sandy materials, a prominent characteristic. This is in contrast to the subsoil of the Clatsop series, which is dominated by clays that effectively restrict drainage. In the Sauvie series the surface soil is gray or brownish gray, high in raw organic matter, and strongly mottled. The subsoil consists of successive layers of various-textured materials ranging from micaceous fine sandy loam to silt loam. Although acid in reaction, it is somewhat less strongly acid than the Clatsop soils.

The Brenner soil has medium- to heavy-textured poorly drained surface soil and heavy-textured mottled subsoil. The surface soil is dark with a high content of organic matter. The heavy-textured subsoil is brown or dark brown, mottled with gray, drab yellow, or rusty brown. The series represents recent alluvial material, mostly from sedimentary rocks but also from basic igneous rocks, that has been washed in and deposited on the flood plains of streams and in local depressions. Aside from the accumulation of organic matter in the surface soil, little change has taken place in the soil profile since the material was deposited, the clay subsoil being the product of deposition rather than that of soil development.

Newness of the soil profiles is still more apparent as one approaches the coast. There the stream alluvium, well supplied with organic matter in various stages of decomposition, has been laid down over raw, waterlogged marine mud flats, which in many places is still affected by tides. On the ocean side they merge into tidal mud flats that are covered by tides twice a day. As the distance from the ocean increases, the depth of the developed layer increases to about 36 inches. Here a better drained horizon has formed on the surface, starting the transition from the Brenner to the Nehalem series.

Clatsop silty clay loam consists of gray to brownish-gray silty clay loam highly mottled or speckled with dark rust-brown stains and containing much well-decayed organic matter and less well-decomposed fibrous roots. At depths varying from 10 to 14 inches, the texture becomes a little heavier but the other characteristics remain about the same. The subsoil is often stratified with layers up to 4 inches thick of highly decomposed peat or muck. Usually, organic layers do not occur below 3½ feet. Here bluish-gray silty clay loam, representing the waterlogged underlying tide-flat material, is encountered. These deposits are heavy textured and somewhat impervious, in which respect they differ from the underlying materials of the Sauvie soils. The soils of both series, however, require diking before they can be used for cropping. The Clatsop soil also is more acid than the Sauvie soils.

Sand dunes border the coast, especially north of Seaside. Near the ocean they are masses of loose shifting sand reaching an elevation of 80 feet but usually ranging from 10 to 40 feet. Continually moving inland, they have been the cause of much expense for sand removal from around buildings and other structures. Inland from the first few lines of dunes the dunes are older and more stabilized. They still have the same dunelike topography, however, and about the same elevation. They are separated by narrow depressions that parallel the coast.

The dunes near the coast consist of typical dune sand. Going inland, stabilization of the sands has steadily increased, the dunes being covered by a vegetative mantle varying from a shallow veneer to a rather dense mat 5 or 6 inches thick. Immediately underneath, the subsoil is gray incoherent fine sand recently removed from dune sand. Such material is representative of the Westport series. The Westport soil, therefore, represents dune sand in the first stage of being tied down by vegetation. It is intermediate in character between the bare shifting dune sand nearer the coast and the darker colored more

firmly anchored Gearhart soil farther inland. The Gearhart soil represents the most mature and best stabilized deposits of dune sand. Apparently, stabilization has been going on for some time, as is evidenced by the very dark-brown or nearly black surface soil, which is highly charged with organic matter. Although the soil has the appearance of grasslands, owing to the dark color and high content of organic matter in the surface soil, spruce trees up to 3 feet in diameter are scattered over the areas. The surface soil is dark brown, dark ashy gray, or nearly black and contains a large quantity of finely divided sooty material. The surface is loose, although it is firmer than the rest of the profile. The subsoil is rusty brown or brown to about 3 feet thick, where the iron-staining disappears and the loose fine sand has the same color as the underlying parent dune sand. The soil still maintains a dune topography and is of low fertility. The following profile description of Gearhart fine sandy loam indicates a high concentration of organic matter in the surface 8 inches, beneath which it rapidly falls off.

1. 0 to 8 inches, dark grayish-black to black granular fine sandy loam, the gray color due to gray quartz sand. The dark color is imparted largely by a very high content of black sooty finely divided organic matter. This layer is loose but is firmer than the rest of the profile, due to the organic matter and numerous fine roots. The soil particles crush easily into a very loose mass.
2. 8 to 11 inches, dark chocolate-brown loose fine sandy loam with many fine roots. The material is loose but still holds its form when freshly dug. Organic matter distinctly colors the horizon.
3. 11 to 17 inches, brown single-grained loamy fine sand. Enough roots and cementing material are present to form small aggregates that are easily crushed.
4. 17 to 25 inches, brown to light-brown loose fine sand. The color gradually changes to a lighter brown due to slight staining of iron. This horizon is quite distinct from the horizon above or below.
5. 25 to 45 inches, brownish-gray loose fine sand with a slight tinge of iron stains.
6. 45 to 57 inches, brownish-gray loose fine sand parent material.
7. 57 to 109 inches, gray loose fine sand parent material.

Partial analyses of soil samples collected from the Astoria area, Oregon, are presented in table 11.

The moisture equivalent or upper limit of the normal useful moisture range for these soils is rather high. This appears to be related to the granular structure and good organic-matter content of these soils.

TABLE 11.—*Some physical and chemical characteristics*[1] *of the soils of the Astoria area, Clatsop County, Oreg.*

SOILS DERIVED FROM SANDSTONE AND SHALE

Soil type	Depth	Moisture equivalent	Organic matter[2]	Total nitrogen	pH
	Inches	*Percent*	*Percent*	*Percent*	
Astoria loam	0–8		9.48	0.45	
	8–20		6.00	.31	
	38–60		.46	.06	4.45
Astoria silt loam	0–8		3.77	.20	5.19
	8–14		2.22	.15	
	14–25		1.02	.09	4.79
	25–38			.06	4.61
	38–70			.04	4.53
	70–80			.04	4.31

See footnotes at end of table.

TABLE 11.—*Some physical and chemical characteristics* [1] *of the soils of the Astoria area, Clatsop County, Oreg.*—Continued

OLD VALLEY-FILLING SOILS

Soil type	Depth	Moisture equivalent	Organic matter [2]	Total nitrogen	pH
Cinebar silt loam	0–8	46.5	12.21	0.61	4.89
	8–15	41.1	7.39	.43	4.53
	15–22	32.9	2.75	.24	4.66
	22–48	27.5	----------	.11	4.43
	48–55	29.5	----------	.07	4.48
	55–78	31.7	----------	.05	4.44
Grande Ronde silty clay loam	0–8	42.3	3.83	.28	4.52
	8–28	41.7	.91	.08	4.50
	28–47	42.5	1.18	.05	4.53
	47–51	34.1	----------	.04	4.52
	51–61	54.0	----------	.03	4.57
Hebo silty clay loam	0–8	42.4	9.55	.63	4.67
	8–11	31.0	2.94	.22	4.67
	11–24	39.5	.94	.09	4.65
	24–30	36.6	----------	.07	4.55
	30–50	32.4	----------	.10	4.44
	50–60	39.4	----------	.05	4.34
	60–66	46.0	----------	.05	4.37

RECENT ALLUVIAL SOILS OF THE STREAM BOTTOMS

Soil type	Depth	Moisture equivalent	Organic matter [2]	Total nitrogen	pH
Nehalem silty clay loam	0–8	37.6	4.27	0.28	5.60
	8–18	32.3	1.90	.20	5.76
	18–40	33.5	1.47	.18	5.80
	40–58	32.9	----------	.12	5.73
Brenner silty clay loam	0–8	46.5	5.46	.40	4.46
	8–14	41.4	2.00	.23	4.32
	14–22	40.4	1.49	.17	4.44
	22–35	35.0	----------	.12	4.49
	35–68	33.0	----------	.07	4.50
Nehalem silt loam	0–8	51.8	4.85	.38	4.97
	8–18	49.8	3.98	.31	5.23
	18–30	48.0	2.34	.22	5.38
	30–47	47.8	----------	.17	5.41
	47–60	49.6	----------	.15	5.42
Nehalem loam	0–8	44.4	4.96	.41	4.65
	8–26	36.8	1.27	.16	4.65
	26–38	28.9	.56	.07	4.65
	38–64	----------	----------	.06	5.17
Sauvie silty clay loam	0–8	51.2	5.23	.34	5.46
	8–28	48.4	4.64	.27	5.19
	28–38	52.9	6.77	.28	5.36
	52–98	28.0	----------	.09	5.24
Sauvie silt loam	0–12	67.9	55.27	1.50	4.65
	12–24	71.0	62.07	1.47	4.66
	24–36	75.2	65.75	1.37	4.50
	36–48	60.2	68.35	1.53	4.89
	48–60	57.1	52.73	1.21	4.98
	60–72	59.1	31.84	.69	4.92

RECENT ALLUVIAL SOILS DERIVED FROM MARINE DEPOSITS

Soil type	Depth	Moisture equivalent	Organic matter [2]	Total nitrogen	pH
Clatsop silty clay loam	0–8	----------	6.85	0.43	--------
	8–11	----------	7.74	.36	--------
	11–20	60.4	9.35	.34	4.23
	20–24	63.2	----------	.55	4.16
	24–34	51.8	----------	.32	4.17
	34–44	42.6	----------	.14	4.45
	44–47	49.6	----------	.32	3.92
	47–61	41.6	----------	.14	4.70

See footnotes at end of table.

TABLE 11.—*Some physical and chemical characteristics* [1] *of the soils of the Astoria area, Clatsop County, Oreg.*—Continued

SOILS FROM WIND-LAID DEPOSITS

Soil type	Depth	Moisture equivalent	Organic matter [2]	Total nitrogen	pH
Westport fine sand	0- 8	10.5	4.67	0.19	5.38
	8-12	4.3	2.34	.03	5.30
	12-16	4.4	.36	.03	5.21
	16-54	4.2	----------	.01	5.53
Gearhart fine sandy loam	0- 8	18.4	8.30	.46	5.02
	8-11	7.6	1.91	.12	5.36
	11-17	4.2	.60	.06	5.77
	17-25	5.4	----------	.04	5.86
	25-45	4.7	----------	.02	5.99
	45-57	4.0	----------	.02	6.06
Warrenton loamy fine sand	0- 8	17.0	5.32	.33	5.00
	8-11	7.3	1.19	.09	5.00
	11-16	4.6	.46	.06	4.86
	16-40	4.1	----------	.03	5.05
	40-54	4.3	----------	.02	4.97
	54-58	4.4	----------	.02	5.07

ORGANIC SOILS

Brallier peat	0-12	----------	75.11	1.35	4.66
	12-24	----------	67.77	1.70	4.66
	24-36	----------	63.41	1.44	4.50
	36-54	----------	71.00	1.54	--------
Brallier peat	0 - ½	----------	88.29	1.72	5.29
	½- 1½	----------	74.81	1.72	4.90
	1½-12	----------	77.15	1.50	4.53
	12 -24	----------	97.85	1.19	4.03
	24 -36	----------	97.79	1.19	4.01
	36 -48	----------	99.91	1.38	4.07
	48 -60	----------	55.53	.92	4.51
	60-sand	----------	3.37	.06	4.66
Brallier peat	0 - ½	----------	83.43	1.48	4.61
	½- 2½	----------	92.22	2.32	4.42
	2½-17	----------	83.51	1.99	3.14
	17 -26	----------	87.12	2.31	4.13
	26 -42	----------	6.74	.12	4.44
Spalding peat	0- 2	----------	88.69	2.47	4.29
	2-12	----------	99.20	2.14	4.02
	12-24	----------	82.51	2.12	4.02
	24-36	----------	84.62	1.63	3.98
	36-48	----------	79.52	1.57	4.08
	48-78	----------	78.87	1.93	--------

[1] Determinations by Soils Department, Oregon Agricultural Experiment Station.
[2] Organic soils and Sauvie silt loam were done by direct ignition; all others by Rather method.

The organic matter supply below the surface layer is moderate in some acid hill and terrace soils that become very dry in summer. The ash content of Brallier peat is similar in certain layers to that of pure sphagnum moss. As shown elsewhere the base exchange capacity of the organic matter and of peaty soils is high, yet the degree of saturation in acid peat is low.

The total nitrogen content of normal surface soils for the area is very good or is generally above 0.2 percent. For the peaty soils the total nitrogen is near 1.5 percent or a good average value for acid peat. The nitrogen content of Spalding peat is relatively high. The recent stream-bottom soils, Nehalem and Sauvie, are less strongly acid and may not respond markedly to liming. Peat and the coastal sandy soils of the area in many cases are distinctly acid, having reaction values below pH 5.0, and should be benefited by an initial application of 2 tons an acre of ground limestone. Available potash is low in the sandy and peaty soils.

Mechanical analyses of Astoria silt loam and Nehalem silty clay loam in the Astoria area are given in table 12.

TABLE 12.—*Mechanical analyses of Astoria silt loam and Nehalem silty clay loam in the Astoria area, Oregon*

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
Nehalem silty clay loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
562350	0–8	0.1	0.1	0.1	0.4	0.9	63.9	34.5
562351	8–18	0	.1	1.6	15.1	15.9	37.5	29.8
562352	18–40	0	0	.8	10.2	17.7	37.8	33.5
562353	40–58	0	.2	.1	5.5	22.3	36.8	35.1
Astoria silt loam:								
562393	0–2	.3	.7	1.2	5.8	11.7	56.1	24.2
562394	2–14	.2	.8	1.4	5.6	11.9	63.1	17.0
562395	14–25	.1	.5	.9	5.0	11.1	56.1	26.3
562396	25–38	.1	.2	.5	6.8	24.0	33.7	34.7
562397	38–70	.3	.5	.8	5.0	11.7	59.8	21.9
562398	70–80	.1	.2	.2	1.0	6.6	65.8	26.1

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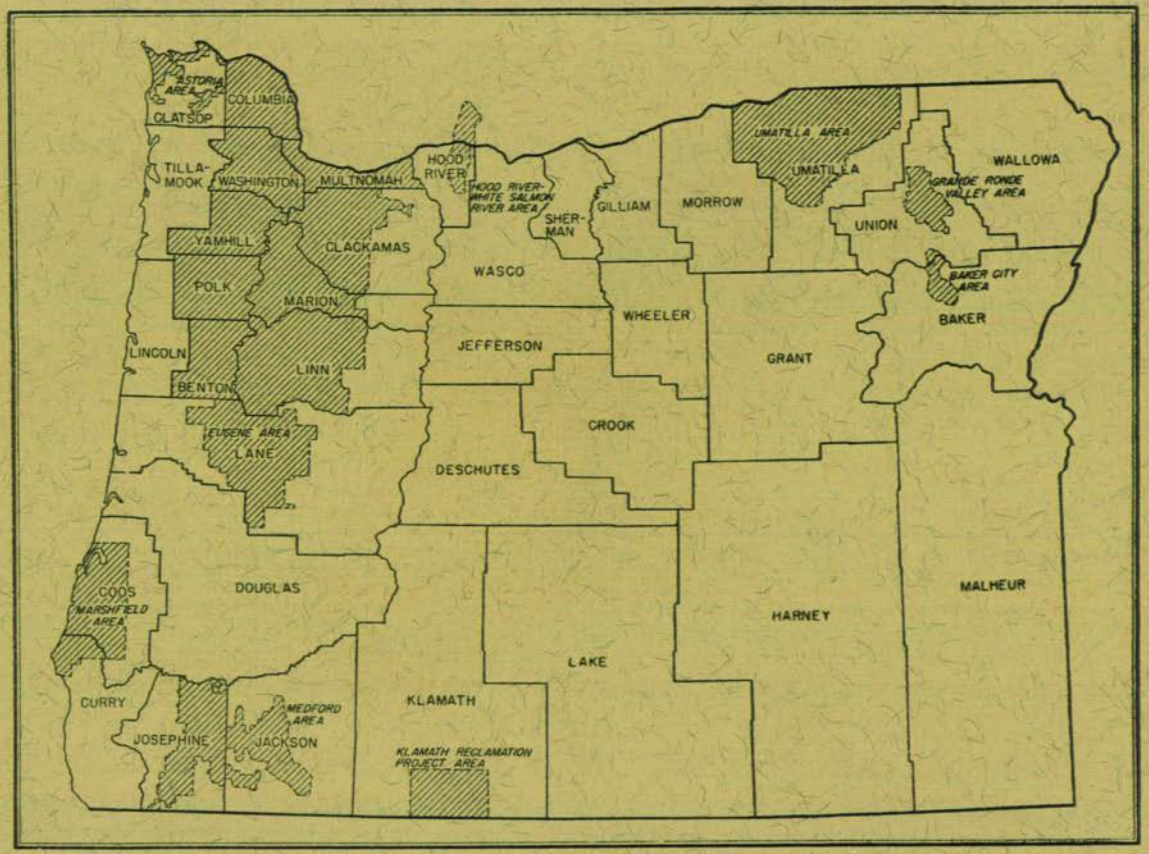

Areas surveyed in Oregon shown by shading.

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