

This is a scanned version of the text of the original Soil Survey report of Walla Walla County, Washington issued February 1964. Original tables and maps were deleted. There may be references in the text that refer to a table that is not in this document.

Updated tables were generated from the NRCS National Soil Information System (NASIS). The soil map data has been digitized and may include some updated information. These are available from <http://soildatamart.nrcs.usda.gov>.

Please contact the State Soil Scientist, Natural Resources Conservation Service (formerly Soil Conservation Service) for additional information.

# SOIL SURVEY OF WALLA WALLA COUNTY, WASHINGTON

BY EVEARD T. HARRISON, NORMAN C. DONALDSON, FRED R. McCREARY, AND ARNOLD O. NESS, SOIL CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, AND STEFEN KRASHEVSKI, WASHINGTON AGRICULTURAL EXPERIMENT STATION

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE WASHINGTON AGRICULTURAL EXPERIMENT STATION

WALLA WALLA COUNTY is in the southeastern part of Washington (fig. 1). It has an area of 814,080 acres, or 1,272 square miles. According to the 1960 U.S. Census, the county has a population of 42,195, most of which is concentrated in the Touchet and the Walla Walla Valleys. Walla Walla, the county seat and main

sistently above the national average. Although wheat is the main crop, the county is the Nation's second largest producer of green peas for canning and freezing.

The food-processing industry was started during the late thirties and has become an important part of the county's economy. Plants were first established for processing peas, but they now process other vegetables, including locally grown asparagus, spinach, carrots, sweet corn, and lima beans. The plants also process fruit and vegetables that are trucked from adjacent counties.

The valley soils are very productive. They could be more productive, however, if additional water were available for irrigation. The water now available for irrigation is obtained from deep wells and streams. Many dairymen and stockmen have found irrigated pastures profitable and are expanding their acreage of improved pasture. Alfalfa is an important irrigated crop. They hay is fed to livestock in the county and some is shipped elsewhere. Sugar beets and small grains are other important irrigated crops. Growers obtain good beet yields from some of the saline-alkali soils.

Commercial gardeners produce onions and lettuce and ship them in carload lots to markets outside the county. They use large quantities of barnyard manure and commercial fertilizer.

With a better knowledge of the soils and with help that is available from the county agricultural agent, the State experiment station, and the soil conservation districts, farmers can improve soil productivity and obtain higher yields of crops. A better knowledge of soils should help authorities administer the zoning acts now in force throughout the county. This cooperative survey of the Walla Walla County soils provides a basis for determining the best use for land in the county.

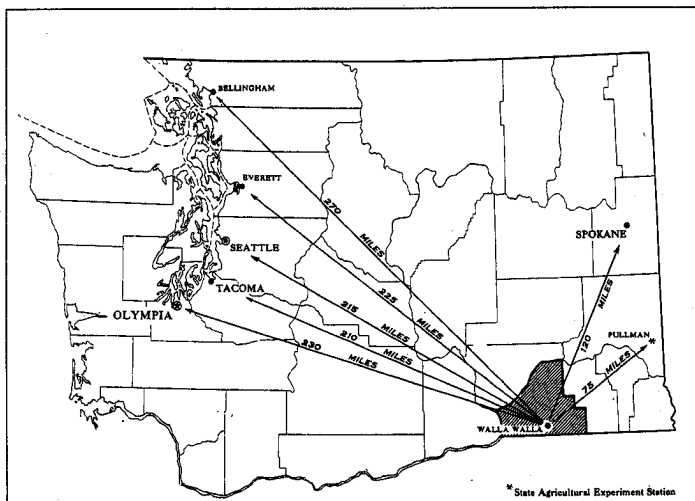


Figure 1.-Location of Walla Walla County in Washington.

shopping center, has a population of 24,536. Other centers of population are College Place, 4,031; Waitsburg, 1,010; and Prescott, 269.

Nearly all of Walla Walla County was once a waving sea of bluebunch wheatgrass (*Agropyron spicatum* and *A. inerme*). The early settlers passed over this treeless wilderness of grass and settled along the wooded stream bottoms and on the timbered foothills of the Blue Mountains. Agriculture started at the Waiilatpu Mission on the banks of the Walla Walla River, 6 miles west of the city of Walla Walla. Here, a pioneer, Dr. Marcus Whitman, had about 30 acres under cultivation at the time of the Mission Massacre in 1847.

From this beginning, cultivation has spread to 547,927 acres in 1959. This once-shunned grassland is now the Nation's fifth largest wheat-producing county. Many varieties and types of wheat have been tried, but the soft white winter varieties give highest yields. A record countywide average yield of more than 40 bushels per acre was obtained in 1956. Yields of wheat per acre are con-

## General Nature of the County

### Physiographic Features

Walla Walla County is in two physiographic divisions: (a) The Walla Walla section, and (b), the Blue Mountain section (5). The Walla Walla section is situated on the upper eastern edge of the central Columbia Basin. It consists of rolling, treeless upland, deeply mantled by fine, windborne deposits of silt that overlie the previously eroded and incised Columbia River basalt. Thick lake and

stream-terrace deposits occur in the valley. The Blue Mountain section consists of the extreme northern extension of the Blue Mountains of Oregon and the long, tilted plateau that extends northward into Columbia County. This section is a tilted, folded, and faulted uplift of the Columbia River basalt. Topography is largely the result of erosion and stream cutting in the basalt. Flat-topped ridges, steep-walled canyons, and mountain slopes characterize this section of the county.

Other important physiographic features are the Walla Walla Valley, Millcreek Fan, Gardena Terrace, Eureka Flats, and the Wallula Gap.

The Walla Walla Valley includes the area occupied by deposits of the Walla Walla River and Mill Creek.

Mill Creek Fan is a deposit of silt and gravel at the mouth of Mill Creek Canyon. It is approximately 2 miles wide and 5 miles long. The lower edge has an elevation of about 900 feet above sea level. The mouth of the canyon has an elevation of about 1,200 feet. The city of Walla Walla is located on this fan.

The Gardena Terrace is the remnant of lake-laid deposits consisting of fine sand and silt. These deposits

are called Touchet beds (4). The largest area of this formation is south of Pine Creek and the Walla Walla River, a mile or more south of Touchet.

The Eureka Flats, in the northwestern part of the county, are an abandoned glacial out-wash channel. The old glacial channel extends from near Pleasant View southwest for a distance of 36 miles to within 6 miles of the Columbia River. It is about 2 miles wide at the upper end and 6 to 8 miles wide below Eureka.

In the southwestern corner of the county, the Columbia River flows through a narrow, steep-walled canyon called Wallula Gap. This canyon was formed by the river as it maintained its channel throughout the Horse Heaven uplift.

The lowest point in Walla Walla County is in the southwestern corner, where the Columbia River leaves the county. This place is 300 feet above sea level. McNary Dam, about 20 miles downstream, raises the water in the river to a normal pool level of 340 feet. This is the spillway elevation of the dam. From the normal pool level to the top of Lewis Peak, on the eastern edge of the county, there is an increase of 4,540 feet in elevation. The increase is gradual

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for the first 40 miles, but about half the gain takes place in the last 5 or 6 miles. Walla Walla has an elevation of 949 feet.

## Drainage

The drainage pattern is controlled mainly by the surface of the underlying basalt. Channels have been modified but little by the mantle of loess. Stream gradients are determined by the tilt of the basalt; they are high, generally more than 50 feet per mile. Most streams are cutting their beds to grade across exposures of basalt bedrock. During high water, all streams carry excessive loads of silt.

The Walla Walla River and its largest tributary, the Touchet River, originate outside the county. Mill Creek and its tributaries, Blue Creek, Coppei Creek, and Yellowhawk Creek are the smaller, perennial streams. Dry Creek, Pine Creek, Cottonwood Creek, and Russell Creek have water in some part or parts of their channel all the year. All other drainageways flow for a week or more when the snow melts. At that time of year they are usu-

ally filled to the top of the bank and carry large loads of silt and gravel.

A narrow strip in the northwestern and western parts of the county drains directly into the Snake and Columbia Rivers. The rest of the county is drained by the Walla Walla River and its tributaries.

## Climate

The climate of Walla Walla County is predominantly dry, but some of the characteristics of both continental and marine types are evident. The Selkirk and Rocky Mountains effectively protect the large inland basin of eastern Washington from the more severe winter storms that move southward from Canada. In the west, the Cascade Mountains are an effective barrier to moist air moving eastward from the Pacific Ocean. Air from each of these sources, however, reaches Walla Walla County.

Temperature and precipitation data in and around Walla Walla County are shown in table 1. The maximum

This section was prepared by **EARL L. PHILLIPS**, State climatologist, U. S. Weather Bureau, Seattle, Wash.

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and minimum measurements for stated climatic features in Walla Walla County are shown in table 2.

The summers are dry and rather hot, and the winters are comparatively mild for this latitude. There is an occasional sharp fall or rise in temperature caused by an outbreak of cold air from Canada or by a chinook wind that blows from a westerly direction. In winter, warm, moist air crossing the Cascades mixes with the colder air accumulated in the basin and produces considerable cloudiness, some fog, and an occasional freezing drizzle.

In winter there are from 18 to 24 cloudy days and only 3 to 5 clear days each month. In summer, there are from 20 to 25 clear days and less than 5 cloudy days each month. Possible sunshine ranges from 20 to 30 percent in the winter to 65 percent in the spring, and to 85 percent in midsummer.

The average afternoon temperature in summer is near 90 degrees F., but a day in which the temperature is 100 degrees or slightly higher occurs occasionally. Nighttime temperature is in the 60's. Maximum temperatures higher than 90 degrees occur on 35 to 40 days each summer. In winter, afternoon temperatures are in the 30's and lower

40's. Minimum temperatures range from 15 to 25 degrees, and a few nights are near zero.

Precipitation increases during the fall, reaches a peak in midwinter, and then gradually decreases through June. There is a very sharp drop in July. Precipitation increases as the elevation increases in an easterly direction across the county. Near the confluence of the Snake and Columbia Rivers, the annual precipitation is about 8 inches. It increases to between 11 and 13 inches in the northeastern part of the county, to 14 to 18 inches in the central and extreme eastern parts, and to 25 or 40 inches or more along the slope of the Blue Mountains.

Snowfall and the depth of snow also vary according to changes in elevation. In the lower elevations of the county, snow usually accumulates to a depth of 3 to 8 inches during an average winter, and to a depth of 12 or 15 inches in winters of heavier snowfall. Warm chinook wind or a rain sometimes melts the accumulated snow very rapidly.

A large amount of water is lost through evaporation in the summer months. The average evaporation, measured from a standard 4-foot pan, at Walla Walla is as follows

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April, 4.6 ; May, 6.4 ; June, 7.6 ; July, 10.3 ; August, 9.0 ; September, 5.3; and October, 2.6 inches.

The average relative humidity in winter ranges from about 80 percent at 4 a.m. to 75 percent at 4 p.m., and in summer the average humidity ranges from 72 percent at 4 a.m. to 26 to 30 percent at 4 p.m.

The occurrence of freezing and below-freezing temperature, by dates and probability, are shown in table 3.

## **Vegetation**

More than 90 percent of Walla Walla County was originally grassland. Wooded stream bottoms and timbered north slopes and tops of mountain ridges made up the rest. Early settlers reported an abundance of game birds and animals and other forms of wildlife in the county. Streams were clear throughout the year and were well stocked with fish. The large streams were subject to occasional overflow in spring, but the deposit of silt was seldom large. The native vegetation was closely related to soil, rainfall, and elevation.

Seven different vegetative associations are recognized in the county. Five are grassland and two are forests.

### ***Grassland***

The original vegetation was of the bunchgrass type, which consisted mainly of wheatgrass and fescue on the deep, medium-textured soils, and needle-and-thread, Indian ricegrass, and sand dropseed on the sandy areas. Giant wildrye, alkali cordgrass, and alkali bluegrass were dominant on the saline-alkali soils. Excessive grazing on uplands during the early years of settlement caused a reduction of bunchgrasses and an increase of brush and annual weeds. Saltgrass and saltbrush have become dominant on saline-alkali bottom-land soils.

Temperature and precipitation are influenced by the wide range in elevation within short distances. These factors, as well as the soil, control the growth of vegetation. Several of the more important species of plants grow in a wide range of conditions, but other plants thrive only within well-defined limits.

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Needle-and-thread, Indian ricegrass, and bluebunch wheatgrass are the most important forage species of the sandy terraces along the Snake and Columbia Rivers. Sandberg bluegrass is a very important understory, or ground-cover plant. Herbaceous plants such as arrowleaf balsamroot, yarrow, lupine, and wild buckwheat are also important plants on the sandy terraces.

In the 8 to 12-inch rainfall belt, bluebunch wheatgrass, Sandberg bluegrass, and dryland sedge or woolgrass are the most important grass plants. Arrowleaf balsamroot, yarrow, lupine, and milkvetch are the next most important group of plants in this rainfall belt.

In the 12- to 16-inch rainfall belt, beardless wheatgrass, Idaho fescue, and Sandberg bluegrass are the most important plants. Arrowleaf balsamroot, yarrow, lupine, and milkvetch are also important plants.

In the 16- to 19-inch rainfall belt, bluebunch wheatgrass, Idaho fescue, prairie junegrass, and big bluegrass are the most important forage plants. Sandberg bluegrass, arrowleaf balsamroot, yarrow, lupine, and rose are also important plants.

In the 19- to 23-inch rainfall belt, bluebunch wheatgrass, Idaho fescue, prairie junegrass, and big bluegrass are the most important forage plants. Arrowleaf balsamroot, yarrow, sticky geranium, rose, and snowberry are the important forbs and shrubs. In the mountain grasslands, Idaho fescue, and elk sedge are the most important forage plants. Also abundant are pinegrass, arrowleaf balsamroot, arnica, yarrow, and lupine.

### **Forests**

Somewhat less than 10 percent of the county is forested. Marketable species of trees are located in an area 8 miles wide and about 12 miles long along the eastern edge of the county, usually referred to as the Blue Mountains. The U.S. Forest Service and the city of Walla Walla own about 3,000 acres within the Mill Creek Watershed, which is managed as a watershed for the city of Walla Walla.

The timbered areas in the county are on slopes that face northwest, north, northeast, east, and southeast. The more gently sloping ridgetops and high plateaus above an elevation of 3,000 feet are also forested. Marketable species are ponderosa pine, Douglas-fir, white fir, and western larch. Other trees that occur in limited amounts, or are of low

value, are lodgepole pine, spruce, aspen, and cottonwood.

Soil and moisture determine the distribution of trees and their rate of growth. Exposure and elevation are closely related to these factors. Supplies of moisture are most favorable at high elevations and on slopes that face the north, northeast, and east.

Ponderosa pine is the main tree on the lower ridges and in the dryer canyons where the soils are 4 feet or more in thickness. In these areas, the stands are quite open, and the understory consists of grass and shrubs. Western larch, Douglas-fir, and white fir occur high on the slopes and in upper parts of canyons in such dense stands that the understory is suppressed. In these areas, Ponderosa pine makes up only a small percentage of the stand. White fir is the dominant tree in the moister sites.

Present forests are mostly second growth and have an average age between 60 and 80 years. The demand for saw logs is good. In the past several years, lumbermen have taken renewed interest in the Blue Mountain area.

### **Wildlife**

Wildlife in the county consists of elk, deer, coyotes, bears, cougars, quail, partridges, ring-necked pheasants, geese, ducks, and grouse. Mule deer, elk, and blue grouse are on the forested uplands occupied by the Helmer and Couse soils and on the associated rocky soils of the Blue Mountains.

The winter range of deer and elk is in the open, foothill grassland and the forested slopes occupied by the Couse, Palouse, and Gwin soils. Whitetail deer roam the rocky slopes near wheatfields on the Walla Walla, Athena and Ritzville soils and the steep rocky soils along the Snake River Canyon. Bears and cougars are in the timbered areas of the county; coyotes are in the whole county and congregate wherever food is available.

Pheasants, partridges, and quail are on the Ritzville, Walla Walla, and Athena soils and on the associated Alluvial land in the middle and eastern parts of the county, where food and cover are available.

Reservoirs and streams are the habitats for ducks and geese, large flocks of which are on the Columbia and Snake Rivers during the spring and fall. Trout are in the ponds, reservoirs, and perennial streams. Hunting and fishing is well regulated by State and Federal laws.

## ***How Soils Are Named, Mapped, and Classified***

Soil scientists made this survey to learn what kinds of soils are in Walla Walla County, where they are located, and how they can be used.

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug or bored many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down to the rock material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to uniform procedures. To use this report efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Yakima, and Palouse for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in natural characteristics.

Many soil series contain soils that are alike except for texture of their surface layer. According to this difference in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Yakima cobbly loam and Yakima silt loam are two soil types in the Yakima series. The difference in texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into soil phases. The name of a soil phase indicates a feature that affects management. For example, Palouse silt loam, 0 to 8 percent slopes, is one of several phases of Palouse silt loam, a soil type that ranges from nearly level to steep.

After a fairly detailed guide for classifying and naming the soils had been worked out, the soil scientists drew soil boundaries on aerial photographs. They used photos for their base map because these show woodlands, buildings, field borders, trees, and similar detail that greatly help in drawing boundaries accurately. The soil map in the back of this report was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some

other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientist has a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map. Therefore, he shows this mixture of soils as one mapping unit and calls it a soil complex. Ordinarily, a soil complex is named for the major soil series in it, for example, Hezel-Quincy complex, eroded. Also, in most mapping, there are areas to be shown that are so rocky, so shallow, or so frequently worked by wind and water that they cannot be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Badland, Duneland, or Rockland, and are called land types rather than soils.

Only part of the soil survey was done when the soil scientist had named and described the soil series and mapping units and had shown the location of the mapping units on the soil map. The mass of detailed information he had recorded then needed to be presented in different ways for different groups of users, among them farmers, managers of woodland and rangeland, and engineers.

To do this efficiently, he had to consult with persons in other fields of work and jointly prepare with them groupings that would be of practical value to different users. Such groupings are the capability classes, subclasses, and units, designed primarily for those interested in the growing of short-lived crops and tame pasture; range sites, for those using large tracts of native grass; and the classifications used by engineers who build highways or structures to conserve soil and water.

### ***General Soil Areas***

After study of the soils in a locality and the way they are arranged, it is possible to make a general map that shows the main patterns of soils. Such a map is the colored general soil map in the back of this report. These general soil areas, or patterns of soils, are also called soil associations.

The soils within, any one association are likely to differ greatly from each other in some properties; for example, slope, depth, stoniness or natural drainage. Thus, the general map does not show the kind of soil at any particular place, but a pattern that has in it several kinds of different soils.

Each soil association is named for the major soil series. in it, but, as already noted, soils of other series may also be present. The major soil series of one soil association may also be present in other associations, but in a pattern different enough to require a boundary.

The general map showing patterns of soil is useful to people who want a general idea of the soils, who want to compare different parts of a county, or who want to know the possible location of good-sized areas suitable for a certain kind of farming or other land use.

### ***Soils of Bottom Lands and Low Terraces***

Five of the soil associations are on nearly level to gently sloping stream bottoms and low terraces. They occupy

a small acreage. Most of the irrigated farms are on the soils of these associations.

**1. Snow-Patit Creek association: Well-drained, deep soils; precipitation, 16 to 24 inches**

This association consists of the Snow and Patit Creek soils and a small area of Riverwash. It occurs in the upper valleys of major streams where the precipitation ranges from 16 to 24 inches per year. The Snow and Patit Creek soils were developed in alluvium that washed from the uplands. The Snow soils are deep, well drained, and medium textured; the Patit Creek soils are moderately shallow to deep, well drained, and medium textured, and are underlain by cobbles and loose gravel. Except for the shallower cobbly Patit Creek soils, the soils of this association are suited to a winter wheat-summer fallow or to a wheat-green peas system of cropping.

**2. Yakima-Hermiston-Ahtanum association: Mixed soils on alluvial fans, stream bottoms, and small outwash plains; precipitation, 12 to 16 inches**

This soil association consists mainly of the Yakima, Hermiston, and Ahtanum soils. Small areas of the Catherine, Pedigo, Onyx, and Touchet soils are also included. The association occupies alluvial fans, stream bottoms, and small outwash plains in the Mill Creek drainage system and in the lower valleys of Cottonwood, Reser, and Russell Creeks. The annual precipitation is 12 to 16 inches.

The Yakima soils are shallow and medium textured, and they overlie gravel or cobbles of basalt. In places they are gravelly or cobbly. The Hermiston soils are deep and medium textured and have a weakly calcareous upper subsoil. Ahtanum soils are medium textured, saline, and moderately to strongly alkaline. They have an alkalicemented hardpan.

The Catherine soils are imperfectly drained. The Pedigo soils are imperfectly drained and moderately to strongly alkaline. The Onyx and Touchet soils were formed in more recent alluvium than the other soils in this association. The Touchet soils have a seasonally high water table.

Winter wheat yields well on the Hermiston soils without irrigation. Crops of all kinds require irrigation when grown on the Yakima and Ahtanum soils. Water for irrigation is obtained from small streams and wells. The supply is limited.

**3. Onyx-Hermiston-Pedigo association: Deep, mostly well-drained soils; precipitation, 12 to 16 inches**

This association consists of the Onyx, Hermiston, and Pedigo soils. It occurs along Dry Creek above Sudbury and along the Touchet River above the Shaw bridge. The soils were formed in deep alluvium that washed from the uplands. The annual rainfall is 12 to 16 inches. This association is at lower elevations than the Snow-Patit Creek association.

The Onyx and Hermiston soils are well drained; the Pedigo soils are imperfectly drained. In many places the surface of the Pedigo and Hermiston soils has been covered by recent deposits.

These are all deep soils. Cropping systems used on them are like those used on adjacent soils of the uplands. Because of the lack of available water, only small areas are irrigated.

**4. Esquatzel association: Deep, well-drained soils; precipitation, 8 to 12 inches**

This association consists mainly of the Esquatzel soils and small inclusions of the Onyx, Pedigo, and Umapine soils. The association is on the wide bottoms of the lower Walla Walla and the Touchet Rivers. Rainfall is 8 to 12 inches per year.

The Esquatzel soils are deep, medium textured, and well drained. They were formed in alluvium that washed from the uplands. They are more calcareous and alkaline than the lower lying Onyx soils. In this association the Onyx soils are in small areas near the streams, and the Umapine soils are remnants of the low terraces. The Pedigo soils are darker colored and more alkaline and saline than the Esquatzel soils. In many places they have a high water table.

Except for small saline-alkali areas, the soils in this association are suited to the winter wheat-summer fallow cropping system that is used on the soils of the adjacent uplands. Small areas in the association are irrigated, and in these areas, alfalfa, sugar beets, sweet corn, and small grains are grown. The irrigated acreage would be larger if more water were available.

**5. Umapine-Stanfield association: Saline or alkaline soils; precipitation, 8 to 12 inches**

This soil association consists mainly of the Umapine and Stanfield soils. Areas of the Onyx and Touchet soils on the flood plain of the Walla Walla River are included. The association is in the Walla Walla Valley. The annual precipitation ranges from 8 to 12 inches.

The Umapine and Stanfield soils are moderately well drained and medium in texture. They are saline-alkali soils. The Stanfield soils have a hardpan at a depth of 1.5 to 4 feet. The Touchet soils are subject to a seasonally high water table.

The Umapine and Stanfield soils are not suitable for crops unless supplemental moisture can be supplied through irrigation and the harmful salts are leached away. Irrigation for 1 year and not more than 2 years generally reduces the concentration of salts low enough to allow alfalfa and sugar beets to be grown on Umapine soil. A hardpan in the Stanfield soils limits their use to the growing of shallow-rooted hay and pasture crops. If irrigation is discontinued, harmful salts will again concentrate in the soil.

## Soils of Loessal Uplands

The soils that have formed from loess occupy nearly two-thirds of the county. They are grouped into three associations, which are closely related to the rainfall pattern of the county.

**6. Athena-Palouse association: Dark-colored, well-drained soils; precipitation, 16 to 24 inches**

This association occupies a narrow belt along the eastern edge of the loessal upland. Although the annual rainfall generally ranges from 16 to 19 inches, extremes of as much as 24 inches have been measured.

The Athena and Palouse are the principal soils in this association. The Athena soils are in the lower and drier parts of the area, where the rainfall is 16 to 19 inches per year. The Palouse soils are in the higher and wetter





**Figure 2.-Looking east up Dry Creek toward the Blue Mountains. Bottom land is Hermiston soils; upland is Walla Walla and Athena soils.**

parts. The Athena and Palouse soils are dark colored, medium textured and well drained. A zone of lime has accumulated in the lower subsoil of the Athena soils.

There is enough moisture to allow the growing of a crop each year. Green peas for canning and freezing are grown in alternate years with winter wheat. The production of green peas in the county is concentrated in this soil association.

**7. Walla Walla association: Well-drained, mostly deep soils; precipitation, 12 to 16 inches**

This soil association is in an area 6 to 10 miles wide that extends from the town of Walla Walla in a northeasterly direction to the Columbia County line. Precipitation ranges from 12 to 16 inches per year. The Walla Walla soils are dominant. Also included are Spofford soils and a small area of alluvial soils that make up 1 percent or less of the total acreage.

The Walla Walla soils are mostly deep well drained, and medium textured. A small area of these soils near the city of Walla Walla has compact, lake-laid sediment in the substratum at a depth of 1.5 to 4 feet. The Spofford soils have a thin, medium-textured surface layer over a dense, columnar subsoil that restricts the movement of water and the growth of roots.

The winter wheat-summer fallow cropping system is commonly used on the soils of this association. Green peas are grown and the soil is cropped every year along the eastern edge of the association were the Walla Walla soils blend with the Athena soils (fig. 2).

**8. Ritzville association: Well-drained soils that have lime at a depth of 30 to 36 inches; precipitation, 8 to 12 inches**

This is the largest soil association in the county. It occupies approximately the western half of the loessal

uplands. The soils have developed under 8 to 12 inches of precipitation per year.

Ritzville soils, the most extensive soils in the county, are dominant in the area. They are well drained and medium textured and in most places have lime at a depth of 30 to 36 inches.

Included in this association are small areas of Ritzville soils that contain enough volcanic ash to have a gray or almost white color. These areas have lenses of nearly pure pumice in the subsoil. They are highly susceptible to wind erosion and often develop into blowouts. Also included in this association are small areas of Farrell soils, formed in wind-worked loess and lake sediment Ellisforde soils, formed in loess and stratified lake-laid material; and Esquatzel soils along streams.

The soils of this association are used mainly for winter wheat in a cropping system that includes summer fallow. The choice of crops is narrow.

**Soils of Loessal and Basaltic Uplands**

**9. Couse-Palouse association: Dark, well drained to moderately well drained soils with clay in subsoil**

This association consists mainly of Couse and Palouse soils. It occupies the transitional areas between the loessal uplands and the mountains and between the grassland and forests (fig. 3). Small areas of steep Basalt rock land are included.

The Palouse soils in this association are well drained, dark colored, and shallow to moderately deep. They have formed in loess under aspen and a few shrubs. The Couse soils are moderately well drained and medium textured. They have formed in loess over a strongly weathered layer of silty clay loam that is nearly impervious to roots and water. The Couse soils support an open stand of coniferous trees and an understory of grasses, forbs, and shrubs.

Some areas of the Couse soils have been cleared and were planted to wheat and peas. Good yields were obtained for a few years, but severe erosion caused yields



**Figure 3.-High ridges in background are occupied by the Couse soils. The cultivated fields in foreground are the moderately deep Palouse soils.**

to decline. As a result, many fields were abandoned. The moderately deep Palouse soils produce good yields of wheat if erosion is controlled and fertility is maintained.

### Soils of Loessal and Lake-Laid Terraces

The two associations in this group receive enough moisture for winter wheat. The dry parts can produce other crops if water for irrigation is available.

**10. Ellisforde-Ritzville association: Well-drained to somewhat excessively drained, loessal soils; precipitation, 9 to 12 inches**

This association consists mainly of Ellisforde and Ritzville soils. It occupies the strongly rolling to hilly uplands north of the Walla Walla Valley, on both sides of the Touchet River. The annual precipitation is 9 to 12 inches. In this area loess was deposited over the stratified silt and sand of the Touchet formation, in depths ranging from 1.5 to 10 feet.

The Ritzville soils are on north-facing slopes and ridge tops where the loess is more than 5 feet thick. The Ellis: soils formed on south-facing slopes where the loess is 6 to 36 inches thick. The Ellisforde soils are more alkaline than the Ritzville soils and have calcareous layers closer to the surface. Large areas of the Ellisforde soils were mapped on "islands" in the Walla Walla Valley. Small areas of the Sagemoor and Esquatzel soils and of rock land are also included in this association.

The soils in this association are used mainly for winter wheat under a cropping system that includes summer fallow.

**11. Sagemoor-Ellisforde association: Well-drained to excessively drained soils over stratified lake deposits; precipitation, 6 to 12 inches**

This association occurs mainly on the old lake terraces in the lower part of the Walla Walla Valley. In this area stratified silt and sand are the dominant soil-forming materials. Although the annual rainfall ranges from 6 to 12 inches, it is generally 6 to 8 inches. As a result, the soils are light colored and low in organic matter.

The Sagemoor and Ellisforde are the principal soils in the association. The Ellisforde soils have formed on north-facing slopes where the loess is thickest. The Sagemoor soils are on ridgetops and south-facing slopes where the calcareous and strongly alkaline materials from the Touchet formation have influenced soil formation. The Ellisforde and Sagemoor soils are moderately alkaline; accumulations of lime may be as near as 12 inches to the surface in the Sagemoor soils. Also included in the association are small scattered areas of saline-alkali soils, Basalt rock land, and Farrell soils.

The Ellisforde soils produce fair yields of winter wheat. The Sagemoor soils are not suitable for cultivation unless irrigated. If water for irrigation is available the entire growing season, good crops of alfalfa, small grains, and sugar beets can be grown.

### Soils of Mountains

**12. Klicker-Gwin-Helmer association: Well-drained to somewhat excessively drained, steep soils formed mainly from loess and weathered basalt**

This association consists of soils of the Blue Mountains in the southeastern part of the county. The Klicker and Gwin soils have formed mainly in weathered basalt on



Figure 4.-Landscape of the Klicker-Gwin-Helmer soil association in the headwaters of Mill Creek in the Blue Mountains.

steep slopes, and they are characteristically rocky and shallow to moderately deep (fig. 4). The dark grayish-brown Gwin soils occur on the steep south- and southwest-facing slopes under a cover of grass. The Klicker soils occupy the steep, rocky, north-, northeast-, and east-facing slopes and have an open cover of trees, shrubs, and grasses. They generally contain more loess and are about a foot deeper than the Gwin soils.

The Helmer soils were developed from a mixture of loess and pumice and in the lower part of the profile from some basalt material. They are about 5 feet deep over the unbroken basalt. Water erosion is very rapid once the surface layer of duff is removed or destroyed. These soils are best used for range and woodland. The rocky south-facing slopes and open ridges provide most of the grazing. Timber grows on the deeper soils of the coves, on north-facing slopes, and where moisture is adequate.

### Soils of Sandy Terraces and Outwash Plains

These soils are droughty most of the time. Winter wheat can be grown in some places if precipitation is normal or above normal.

**13. Adkins association: Well-drained to somewhat excessively drained soils formed in wind-deposited silt and sand**

This association occurs along the upper margins of sandy terraces that join the loessal uplands. The Adkins soils are dominant, but small areas of the Quincy, Ritzville, and Taunton soils are included.

The Adkins soils formed in deep, moderately coarse textured material consisting mainly of sand and coarse silt deposited by the wind. They occupy an undulating to gently sloping terrace, the upper edge of which joins the Ritzville soils, and the lower edge, the Quincy soils. Precipitation ranges from 8 to 10 inches. The vegetation is bunchgrasses.

If management is good and precipitation is normal, the soils of this association will produce fairly good yields of winter wheat when grown in a cropping system that includes summer fallow. Crop failure and wind erosion can be reduced through management of stubble. Yields are not satisfactory if precipitation is less than normal.

**14. Adkins-Quincy-Ritzville association: Well-drained to excessively drained soils formed in wind-deposited sand and silt; mainly with lime in the subsoil**

This soil association is near and west of the Touchet River. Precipitation is 8 to 10 inches per year. Early in the century, this area was severely eroded by wind following a range fire. Large quantities of fine sand were blown from the terrace over the Adkins and Ritzville soils and deposited in long narrow dunes. These dunes have their long axis in a southwest-northeast direction.

The Quincy soils formed in the dunes, which are now partly stabilized by grasses. Adkins and Ritzville soils are in narrow valleys between dunes.

The soils in this association are subject to severe wind erosion if the grass is removed. Because of the erosion hazard and the low rainfall, the growing of wheat is hazardous.

**15. Quincy association: Excessively drained and somewhat excessively drained soils formed in wind-worked deposits of sand**

This association is between the Walla Walla and Snake Rivers in the western part of the county. It consists of wind-worked soils (fig. 5). Precipitation ranges from 6 to 8 inches per year. One-third of this falls as small showers in the season from March through September and quickly evaporates.

The Quincy soils are the most extensive in the association. They are sandy and were formed in old lake deposits and valley fill. The soil surface has a hummocky or dune relief; large areas have little or no vegetation. Two moderately deep (20 to 60 inches) phases of the Quincy soils were recognized in this survey. In one, the substratum consists of coarse basaltic sand, and in the other, it consists of cobbles and coarse gravel.

Both of these moderately deep phases of the Quincy soils are in the Burbank Irrigation District. When the soil moisture exceeds field capacity, the excess water rapidly drains away, except where lenses of lime cemented gravel are in the substratum. When soil moisture does not exceed field capacity, little or no movement of water occurs, either into or out of the substratum.



**Figure 5: Adkins soils in foreground; Quincy soils in background on gently sloping Columbia River terrace.**

The Hezel soils consist of 15 to 30 inches of loamy fine sand over the stratified fine sand and silt of the Touchet formation. The surface layer of the Hezel soils resembles that of the Quincy soils; the substratum, that of the Sagemoor soils.

All the soils in the Quincy association are too droughty for crops, unless they are irrigated. Water for irrigation is available for about 5,000 acres out of a total of 6,000 acres. The production of usable range forage is limited by the low water-supplying capacity of the soils. Most of the range is in poor or fair condition. Areas without adequate cover blow readily.

## **Soils of Terraces and Riverbanks**

**16. Magallon-Starbuck-Rock land association: Soils and rock land formed from material derived from basalt**

This association is in and adjacent to the canyon of the Snake River in the north and northwestern parts of the county and near Wallula Gap in the southwestern part of the county. The Magallon, Starbuck, and Ellisforde soils and Basalt rock land and Basalt rock outcrop are in this association.

The Magallon soils have formed in the outwash of swift glacial streams that was deposited on the basaltic terraces and against the walls of Snake River Canyon. The parent materials are silt; coarse, sharp basaltic sand; and rounded basaltic and granitic gravel. Each of these was deposited in well-defined strata, or all three were deposited as a mixture in a single layer. In places the Magallon soils are shallow over basalt.

The Starbuck soils are shallow and rocky. They formed in a mixture of loess and fragments of basalt that overlies basalt bedrock. The basalt fragments are largely unweathered, and there is little textural change in the profile. Slopes of the Starbuck soils are as much as 60 percent. Small areas of the Ellisforde soils are on the lower terraces. Basalt rock land and Basalt rock outcrop are both too rocky for tillage. Outcrops in areas of Basalt rock land occupy 25 to 90 percent of the surface. Basalt rock outcrop has outcrops on more than 90 percent of its surface.

Only the larger areas of the deep Magallon soils are suitable for cultivation. They are used for winter wheat that is grown in a cropping system with summer fallow. The shallow, rocky Magallon soils, the Starbuck soils, and Basalt rock land are used for the grazing of livestock.

## **Descriptions of the Soils**

The soils of Walla Walla County are described in this section. Their approximate acreage and proportionate extent are shown in table 4, and their location and distribution are given in the detailed map in the back of the report. All the soils mapped in Walla Walla County, their map symbol, the capability unit and the range site in which they have been placed, and the pages on which descriptions of the soil, the capability unit, and the range site occur, are given in the guide to mapping units at the end of this report. The absence of a range site designation means that the soil should be managed for use other than range.

In the original manuscript, there was a table in this space.  
All tables have been updated and are available as a separate document.

In this section the soil series are first described, and then all the mapping units that belong to that series. The series are described in alphabetical sequence.

An important part of each series description is the soil profile, a record of what the soil scientist saw and learned when he dug into the ground. It is to be assumed that all soils of one series have essentially the same kind of profile. The differences, if any, are explained in the description of the soil or are indicated in the soil name. To illustrate, a profile is described for the Adkins series, and the reader is to conclude that all soils in the Adkins series have essentially this kind of profile.

The name of each soil is followed by a set of symbols in parentheses. These symbols identify the mapping unit on the detailed soil map. At the end of the description for each soil, the capability unit and range site for that soil are shown. The capability units are described in the section "Use and Management of the Soils." The range sites are described in the section "Range Management."

The descriptions of the soil series and soils are more meaningful if some of the terminology used in describing their characteristics is explained, and if the significance of these characteristics are mentioned. The color of a soil can be described in words alone, or by symbols called Munsell color notations, or by both. In this section, words alone are used to describe color. The colors are for dry soil unless otherwise stated. In the section "Formation, Classification, and Morphology of the Soils," however, both words and notations are used, since the descriptions of soil profiles in that part are the technical, more detailed kind scientists need for study and classification of soils.

The terms for drainage have specific meaning. A well-drained soil, for example, commonly retains optimum amounts of moisture for plant growth after a rain or after irrigation water has been added. Roots can grow deep in such a soil. In contrast, a poorly drained soil is wet most of the time; the water table is at or near the surface a considerable part of the year. The large quantity of water in such a soil prohibits the growing of field crops. Only moisture-tolerant plants can grow on poorly drained soils.

The terms used to describe texture of soils indicate proportionate content of sand, silt, and clay. Soils with texture near either extreme, all sand or all clay, are the

most difficult to, manage; those near the midpoint in the texture range, the loam soils, are considered best for most kinds of agriculture.

The terms used for structure describe how the individual soil particles are arranged in larger grains, or aggregates, and indicate the amount of pore space between the grains. In describing structure, separate terms are normally used to indicate strength or grade, of the aggregate; size of the aggregate; and shape of the aggregate. For example, a soil horizon may have "weak, fine, blocky structure." Descriptions of structure help in identifying soils and aid in making inferences concerning their behavior under management.

### **Active Dune Land**

**Active dune land (Ac).**-This land type consists of low, rounded, or dune-shaped hills and long, narrow ridges of eolian sand that have little or no vegetation to protect them. Ridges of sand are as much as 25 feet high and a mile or more in length. Their long axis is southwest to northeast-the direction of the prevailing wind. Active dune land is associated with the Quincy and Adkins soils in the drier and sandier part of the county. One large dune area is on the north edge of Wallula and another is about 4 miles northwest of Eureka. The rest of the acreage of this land type, about one-third of the total, consists of small dunes scattered over the county.

Thickspike wheatgrass and sand-dune wildrye are the perennial grasses most likely to grow in areas of shifting sand. Russian-thistle occurs along the edges of bare areas, grows rapidly late in summer when sand movement is least, and matures late in fall. It protects cheatgrass and other winter annuals, which start growing with the approach of cool weather and fall rain. Winter annuals, generally considered to be troublesome weeds, help to stabilize dune areas. Shepherders, however, often burn them if they hinder the movement of sheep.

Active dune land is too unstable for cultivation. It supports too little vegetation to provide forage and prevent movement of sand. (Capability unit VIIIe-1.)

### **Adkins Series**

The Adkins series consists of deep, well-drained to somewhat excessively drained soils on undulating to steep uplands. The soils are coarse to moderately coarse

textured and have formed in wind-deposited silt and sand. They are in the western part of the county at an elevation of 700 to 1,000 feet above sea level and in positions where the silty uplands merge with the highest river terraces.

The Adkins soils have a thin, brown surface layer that gradually changes to a pale-brown subsurface layer of about the same texture. A zone of lime accumulation is present at a depth of 40 to 48 inches. A compact, calcareous layer of silt loam is in the substratum in some places at a depth of about 50 inches.

At higher elevations, the Adkins soils are adjacent to the more silty, darker colored Ritzville soils; at lower elevations, they merge with the coarser textured Quincy soils.

The main native plants are bluebunch wheatgrass, Sandberg bluegrass, and needle-and-thread grass. Cheatgrass is the main plant in abandoned and overgrazed areas. Adkins soils are used mainly for dryland wheat and grazing.

#### **Adkins fine sandy loam, 0 to 15 percent slopes**

(AdC).-This soil is in the vicinity of Slater, along the Northern Pacific Railroad. It occupies the highest terrace above the Snake and Columbia Rivers. This terrace gradually merges with the upland.

This soil is adjacent to Ritzville silt loam or Ritzville very fine sandy loam of the uplands. At the lower elevations, it merges with Adkins loamy fine sand.

Representative profile in an area that has not been cultivated:

0 to 5 inches, brown fine sandy loam, dark brown when moist; massive to very weak, medium, platy structure; soft when dry, very friable when moist, nonsticky when wet; many fibrous grass roots; contains most of the organic matter that is in the soil.

5 to 23 inches, similar to horizon above, but massive and contains fewer fibrous roots; mildly alkaline.

23 to 40 inches, pale-brown fine sandy loam, brown when moist; massive; soft when dry, very friable when moist; mildly alkaline.

40 to 52 inches +, pale-brown fine sandy loam, brown when moist; massive; soft when dry, very friable when moist; strongly alkaline and strongly calcareous.

This soil is deep and well drained and is moderately rapidly permeable above the substratum. This substratum in most places is more than 5 feet below the surface, and it consists of compact calcareous silt or irregularly stratified sand and gravel. The soil is moderately fertile. The water-supplying capacity is fair to good. Runoff is very slow to slow. The hazard of erosion is moderate to high.

Wind erosion may become serious on overgrazed rangeland or on unprotected cropland. The loss of soil can be adequately controlled by maintaining a good stand of native perennial grass on rangeland, by cultivating in wind strips, and by using stubble mulch on cropland. This soil is suitable for dryland wheat if wind erosion is controlled. (Capability unit IVe-1; Sandy Upland range site.)

#### **Adkins fine sandy loam, 0 to 15 percent slopes, eroded**

(AdC2).-This soil is like Adkins fine sandy loam, 0 to 15 percent slopes, except that most of the organic matter and silt-sized particles have been blown away by the wind. The texture varies from fine sandy loam to loamy sand in a short distance. This soil is moderate to low in fertility and low to fair in water-supplying capacity. The hazard of erosion is high.

In its present condition, this soil is not suitable for wheat. It should be seeded to sand-tolerant grasses and used as range. If not properly managed, eroded areas become larger as coarse sand is blown from them into nearby uneroded areas. This soil is inextensive and occurs in small areas many of which are too small to map. (Capability unit VIe-1; Sandy Upland range site.)

#### **Adkins fine sandy loam, 15 to 30 percent slopes**

(AdD).-This soil is similar to Adkins fine sandy loam, 0 to 15 percent slopes, but it is steeper and has the substratum nearer to the surface. The surface soil is generally thinnest on south-facing slopes and thickest on north-facing slopes. Many places have layers of compact, calcareous silt in the lower subsoil.

This soil is somewhat excessively drained. Runoff is slow to medium. Large machinery used in tillage tends to slip down the slope.

This soil is suitable for winter wheat if wind erosion is controlled. (Capability unit IVe-1; Sandy Upland range site.)

#### **Adkins fine sandy loam, 30 to 45 percent slopes**

(AdE).-This soil occupies steep, north-facing slopes or terrace faces where wind-drifted material has accumulated. It varies extremely in texture and depth. The substratum is silty and near the surface over most of the area.

The soil is moderate to low in fertility and fair in water-supplying capacity. It is too steep for cultivation. Natural drainage is somewhat excessive. Runoff is medium to rapid. (Capability unit VIe-1; Sandy Upland range site.)

#### **Adkins fine sandy loam, shallow, 8 to 30 percent slope, eroded (AeD2).**

-This soil consists of about 5 inches of brown fine sandy loam, underlain by 12 to 24 inches of pale-brown fine sandy loam or sandy loam. The substratum consists of basalt bedrock cemented gravel and sand, or loose gravel. In most places the soil is thick enough above the substratum to hold the normal annual rainfall. Consequently, the native plants have about the same growth on this soil as on the deeper Adkins soils. Many rock outcrops are included in this soil.

This soil is well drained, and it is moderately rapidly permeable above the substratum. Natural fertility and the water-supplying capacity are low. Runoff is slow to medium. The hazard of wind erosion is high.

This soil is suitable for a limited amount of grazing. Native vegetation still grows over most of the area. (Capability unit VIIe-2; range site, Shallow Upland, 6 to 9 inches precipitation.)

#### **Adkins loamy fine sand, 0 to 15 percent slopes (AfC).**

-This soil is in a slightly lower position than the Adkins fine sandy loams, and it is just above the Quincy loamy fine sands. The native plant cover included needle-and-thread grass. Wind has reworked the surface soil and obliterated most of the dendritic drainage pattern. In addition, it has blown away most of the silt and clay.

Representative profile in a range area that has been overgrazed:

0 to 4 inches, pale-brown loamy fine sand, brown when moist; contains a mass of fibrous grass roots; single grained; loose when dry or moist, nonsticky when wet; neutral.

4 to 24 inches, similar to horizon above but has slightly lighter color and fewer grass roots.

24 to 46 inches, light brownish-gray sandy loam or fine sandy loam, dark grayish brown when moist; single grained; loose

when dry or moist, nonsticky when wet; moderately alkaline.  
46 to 55 inches, light-gray fine sandy loam or very fine sandy loam,  
grayish brown when moist; massive; calcareous and moderately to  
strongly alkaline.

This soil is somewhat excessively drained, and it is rapidly permeable. Roots penetrate deeply. Natural fertility and the water-supplying capacity are low. Runoff is slow to very slow. The hazard of wind erosion is high.

This soil is suitable for cropping only if it is irrigated. A large part of the annual plant growth or a cover of living vegetation must be kept on the surface to control wind erosion. (Capability unit VIIe-1; Sand range site.)

**Adkins loamy fine sand, 0 to 15 percent slopes, eroded (AfC2).**-This soil is similar to Adkins loamy fine sand, 0 to 15 percent slopes, except that the surface soil has been severely reworked by wind. As a result, the dark-colored surface layer and the fibrous roots that hold particles of soil together have been destroyed. Little living vegetation is on the surface. The hazard of further erosion is very high. Only a limited amount of grazing is advisable. Nearly all the annual growth of vegetation is needed to hold the soil in place. The soil is not extensive, and it occurs in small areas. (Capability unit VIIe-1; Sand range site.)

**Adkins loamy fine sand, 15 to 30 percent slopes (AfD).**-This soil occurs on the slopes of terraces. The material in the lower subsoil is variable because strata of an older landform are fairly close to the surface. These strata consist of coarse sand, compact silt, or sand and gravel. The hazard of wind erosion is very high, especially on slopes that face southwest. This soil is suitable for a limited amount of grazing. (Capability unit VIIe-1; Sand range site.)

**Adkins loamy fine sand, 15 to 30 percent slopes, eroded (AfD2).**-This soil is on slopes that receive the full force of the prevailing southwest winds that blow through Wallula Gap. It was originally the same as Adkins loamy fine sand, 15 to 30 percent slopes but when the protective plant cover was destroyed, wind blew off the surface soil and left the limy layer at or near the surface. Fertility and the water-supplying capacity are very low. The plant cover is hard to reestablish. (Capability unit VIIe-1; Sand range site.)

**Adkins loamy fine sand, 30 to 45 percent slopes (AfE).**-This soil is on short, steep slopes of canyons that have cut into the terraces. The surface layer is 18 inches or less of loamy sand and sandy loam over the compact, calcareous material. The soil is too droughty and too steep for cultivation. (Capability unit VIIe-1; Sand range site.)

**Adkins rocky sandy loam, moderately deep, 3 to 30 percent slopes, eroded (AgD2).**-This soil consists of 24 to 36 inches of dark-brown (moist) sandy loam over an irregular substratum of basalt. Rock outcrops occupy up to 25 percent of the area. The soil is too rocky for cultivation. (Capability unit VIIs-2; range site, Shallow Upland, 6 to 9 inches precipitation.)

**Adkins very rocky sandy loam, moderately deep, 0 to 30 percent slopes (AkD).**-This soil has a dark-brown (moist) sandy loam surface layer over 15 to 30 inches of lighter colored subsoil. Under the subsoil is a rough, ir-

regular substratum of basalt. Rock outcrops occupy 35 to 50 percent of the surface. They reduce the yield of forage and interfere with the movement of livestock. The hazard of wind erosion is high on overgrazed areas. (Capability unit VIIs-2; range site, Shallow Upland, 6 to 9 inches precipitation.)

## Ahtanum Series

The Ahtanum series consists of moderately well drained, medium-textured, saline-alkali soils that developed in a mixture of loess and pumice alluvium. The soils occupy low terraces or wide valley bottoms at an elevation of 800 to 1,200 feet above sea level.

The Ahtanum soils are characteristically grayish-brown, moderately to strongly alkaline silt loams. They have a weakly cemented to indurated hardpan that varies in thickness and hardness and that everywhere is strongly or very strongly alkaline.

Ahtanum sods occur with the nonsaline and much less alkaline Hermiston and Walla Walla soils, neither of which has a cemented hardpan. The Stanfield soils are lighter colored, and if not leached, are more saline than the Ahtanum soils.

The native vegetation in the strongly saline and alkaline areas probably was saltgrass and rabbitbrush. That in the deeper, better drained areas probably was giant wildrye and beardless wheatgrass.

All the Ahtanum soils are cultivated. When irrigated and managed properly, they produce good yields of alfalfa hay and sugar beets.

**Ahtanum silt loam, 0 to 3 percent slopes (AmA).**--This soil is the only member of the Ahtanum series mapped in the county. The largest area of the soil is immediately west and south of the Braden school.

Representative profile in an area 1 mile west of the Braden school:

0 and 7 inches, grayish-brown silt loam, very dark grayish-brown when moist; weak, fine, granular structure; soft when dry, very friable when moist; calcareous and moderately alkaline.

7 to 34 inches, light brownish-gray silt loam, dark grayish brown when moist; massive to weak, coarse, prismatic structure; soft to slightly hard when dry, very friable when moist; strongly alkaline and strongly calcareous.

34 to 40 inches, light-gray silt loam, dark grayish brown when moist; massive; strongly cemented to indurated hardpan; strongly alkaline and calcareous; very few roots.

40 to 72 inches, brown silt loam, dark brown when moist; moderate, fine granular structure; hard when dry, friable when moist; slightly plastic and slightly sticky when wet; moderately alkaline, very few roots.

Small light-colored areas that contain large amounts of pumice are included. These areas are very fine sandy loam in texture.

The root zone in this moderately well drained soil is moderately shallow to moderately deep. Its depth depends on distance of the very slowly permeable hardpan from the surface. Above the hardpan, the soil is moderately permeable. The water-supplying capacity is fair to good; natural fertility is moderate. Runoff is very slow, and the hazard of erosion is slight. Irrigation is necessary for the production of crops. (Capability unit VI s-1, dryland; capability unit II s-2, irrigated; Alkali Bottomland range site.)

## Alluvial Land

**Alluvial land (An).**-This miscellaneous land type consists of deposits of recent alluvium along the major streams. It differs from Riverwash in being sandy or silty instead of gravelly or cobbly. The profile may be layered or stratified, but soil horizons have not yet developed. Areas of Alluvial land are small and generally occur below the high water line. They are frequently flooded in the spring. (Capability unit VIIIw-1.)

## Athena Series

The Athena series consists of deep, well-drained soils that are noncalcareous to a depth of at least 4 feet. The soils occupy the gently sloping ridges and steep slopes on the lower foothills of the Blue Mountains, at an elevation of 1,300 to 2,200 feet above sea level. They have formed in fine, floury loess under thick stands of bunchgrasses where the precipitation is 16 to 19 inches per year.

The Athena soils characteristically, have a dark grayish-brown silt loam surface layer and a brown, heavier silt loam subsoil. The surface layer is thicker, darker colored, and higher in organic matter than that of the Walla Walla soils. It is thinner and lower in organic matter than that of the Palouse soils. Athena soils produce high yields of wheat and green peas.

**Athena silt loam, 8 to 30 percent slopes (AtD).**-This soil makes up nearly 80 percent of the acreage of Athena soils in Walla Walla County. It includes all areas except those on gently sloping ridgetops, those on steep south slopes, and those that are severely eroded.

Representative profile in an area along the Five Mile Road, approximately half way between Russell Creek and Mill Creek:

- 0 to 8 inches, dark-gray silt loam, very dark brown to black when moist; granular structure; slightly hard when dry, friable when moist, slightly sticky when wet; neutral.
- 8 to 16 inches, dark-gray silt loam, very dark brown when moist; coarse, blocky to weak, coarse, prismatic structure ; slightly hard when dry, friable when moist, slightly sticky when wet; slightly acid to neutral.
- 16 to 48 inches, brown silt loam, dark brown when moist; weak to moderate, coarse, prismatic structures; hard when dry, friable when moist, slightly sticky when wet; thin coatings of clay and dark-colored organic matter on the horizontal and vertical surfaces of prisms and in pores; neutral.
- 48 to 60 inches, brown silt loam, dark brown when moist; medium, subangular blocky structure; hard when dry, friable when moist; lime in veins; neutral.
- 60 to 72 inches, pale-brown silt loam, dark brown when moist; massive; slightly hard when dry, friable when moist; neutral.

Included with this soil are areas with slopes of more than 30 percent and eroded areas that were too small to be mapped separately. These included areas are frequently left in weeds, grass, or brush because farmers find it more convenient not to cultivate them.

This is a moderately permeable, well-drained soil that has a high water-supplying capacity. Roots penetrate deeply. Natural fertility is high. Runoff is slow to medium, and the hazard of erosion is moderate.

This soil can be cropped every year if practices are used to control erosion. Special practices are needed to maintain an adequate supply of organic matter in the soil. Tillage that produces a dust mulch or that packs the sur-

face soil should be avoided. (Capability unit IIIe-1; range site, Deep Upland, 16 to 24 inches precipitation.)

**Athena silt loam, 0 to 8 percent slopes (AtB).**-This soil is in small areas along with the similar but steeper Athena silt loam, 8 to 30 percent slopes. In most places it has been only slightly eroded; its surface layer is slightly thicker and darker colored than that of the steeper Athena soils. Runoff is slow, and the hazard of erosion is slight. Excellent yields of wheat and green peas may be produced with a minimum of soil loss when simple practices are applied to control erosion. When large farming implements are used, the small areas of this soil are generally farmed with the steep soils in the same fields. (Capability unit IIe-1; range site, Deep Upland, 16 to 24 inches precipitation.)

**Athena silt loam, 8 to 30 percent slopes, eroded (AtD2).**-This soil is similar to Athena silt loam, 8 to 30 percent slopes, except that most of the original surface soil has been lost through erosion. The plow layer is now a, mixture of the brown subsoil and the remaining original surface layer. Additional subsoil is brought to the surface each time the soil is plowed.

The plow layer slakes on wetting and becomes hard when dry. The soil is moderate to low in fertility, depending on the amount of subsoil in the plowed layer. Yields. Of wheat and peas are low but can be increased by growing soil-building crops for a long period. (Capability unit IVe-2; range site, Deep Upland, 16 to 24 inches precipitation.)

**Athena silt loam, 30 to 45 percent slopes (AtE).**-This soil is mainly on the north-facing slopes, where the surface layer is generally thicker and darker colored than on south-facing slopes. These characteristics are caused by the extra moisture from the large drifts of snow that form just below the breaks of the north-facing slopes and the resulting heavy growth of vegetation and rush that grows when these slopes are not cultivated.

Runoff is rapid, and the hazard of erosion is high. The runoff from melting snow often causes excessive rilling in cultivated fields. Drifts of snow often delay spring tillage and may cause some damage to winter wheat. This soil is too steep for peas; wheat should be grown only occasionally. The soil is best suited to hay and pasture. (Capability unit IVe-3; range site, Deep Upland, 16 to 24 inches precipitation.)

**Athena silt loam, 30 to 45 percent slopes, eroded (AtE2).**-This soil has a profile similar to that of Athena silt loam, 8 to 30 percent slopes, except that nearly all of the original surface layer has been lost through erosion. It occupies south-facing slopes. Runoff is rapid, and the hazard of further erosion is high. Several small areas of Athena silt loam on steeper slopes were mapped with this soil.

This soil is cultivated. The yields of wheat and pasture crops are low and will continue to be low for many years, even under improved management. Areas of this soil that are seeded to perennial grasses are suitable for grazing. (Capability unit IVe-2; range site, Deep Upland, 16 to 24 inches precipitation.)

## Badland

**Badland (Ba).**-This severely eroded and gullied land occurs mainly on remnants of old terraces in the canyons

of the Snake River and on the Touchet formation in the Walla Walla Valley. The land is so eroded that it is no longer suitable for crops or pasture. Practically all of it is barren and in many places it is both rocky and stony. (Capability unit VIIIs-1.)

## Basalt Rock Land

Basalt rock land consists of outcrops and exposures of basalt that cover from 25 to 90 percent of the surface. In most places, the outcrops do not extend far above the surface. The soil between outcrops is generally less than 10 inches thick.

In the Blue Mountains, Basalt rock land occupies steep canyon walls that have slopes of 30 to 70 percent. The soil between outcrops is thin and consists of loess and weathered basalt. Along the Snake River and in the southwestern part of the county the soil was deposited by wind and water and is mixed with weathered basalt.

The dominant plants are the native bunchgrasses, Sandberg bluegrass, bluebunch wheatgrass and annual weeds. These are mainly on south-facing slopes.

**Basalt rock land, steep (BcF).**-This land type consists of Basalt rock land that has slopes of 30 to 60 percent. The areas are suitable for a limited amount of grazing, but most of the annual growth of forage must be left ungrazed to control erosion. (Capability units VIIs-6 and VIIs-7; range sites, Rockland, 6 to 16 inches precipitation and Rockland, 16 to 24 inches precipitation.)

**Basalt rock land, very steep (BcG).**-This land type has slopes of 60 percent or more. It is almost impossible for livestock to graze these slopes. These areas are suitable only for watersheds and wildlife habitats. (Capability unit VIIIs-1.)

**Basalt rock land, undulating to hilly (BcD).**-This land type occupies the gently sloping ridgetops and hilly areas. The mantle of soil is generally thicker than on the steeper slopes of Basalt rock land. Slopes do not seriously limit grazing. (Capability units VIIs-6 and VIIs-7; range sites, Rockland, 6 to 16 inches precipitation and Rockland, 16 to 24 inches precipitation.)

**Basalt rock land-Walla Walla complex, 30 to 60 percent slopes (BdF).**-This mapping unit consists of Basalt rock land and Walla Walla soils that occur in such a complex pattern that it was impractical to map them separately. The complex is on steep, north-facing slopes where the precipitation is 12 to 16 inches per year.

Steep slopes and outcrops of rock make the areas unsuitable for cropping or for cultivation to establish grasses. If properly grazed, native grasses produce high yields of forage. (Capability unit VIIs-6; range site, Rockland, 6 to 16 inches precipitation.)

**Basalt rock outcrop (Bk).**-Outcrops of basalt cover 90 percent or more of this land type. Areas large enough to map are generally on extremely steep slopes, basalt escarpments, or small basalt buttes. The native vegetation is mainly lichen on the rocks and sparse stands of bunchgrass and Sandberg bluegrass between rocks. (Capability unit VIIIs-1.)

## Beverly Series

The Beverly series consists of somewhat excessively drained, coarse and moderately coarse textured soils that

formed in recent alluvium. The soils are on low bars and bottom lands along the main streams and, in places, on low terraces and second bottoms. The parent material is a mixture of basaltic, granitic, and quartzitic rocks.

The Beverly soils are characteristically grayish-brown loamy sand or sandy loam over unsorted loose, coarse sand, gravel, and cobbles. They have little, if any, development of the profile, and they are noncalcareous and moderately alkaline. They are used for range.

Irrigation is necessary for the production of crops.

**Beverly sandy loam, 0 to 3 percent slopes (BoA).**-This soil occurs on nearly level to very gently sloping stream bottoms.

Representative profile:

0 to 6 inches, grayish-brown sandy loam, dark grayish-brown when moist; single grained; loose; many fibrous roots; moderately alkaline.

6 to 17 inches, similar to horizon above in color and texture; massive; contains few grass roots.

17 to 35 inches, grayish-brown fine sandy loam or sandy loam.

35 inches +, loose, rounded pebbles and cobbles of basalt and granite.

This soil is somewhat excessively drained and is rapidly permeable. The water-supplying capacity and fertility are low. Roots can penetrate to the layer of pebbles and cobbles, which is at a depth of 30 inches or less in most places. Runoff is very slow. The hazard of wind erosion is moderate.

The soil is too droughty for the production of crops without irrigation. It is best suited to grazing. (Capability unit VIIs-1; Sand range site.)

**Beverly fine sandy loam and Riverwash (Bm).**-This mapping unit consists of small areas of Beverly fine sandy loam and Riverwash-a coarse, gravelly material that occurs in recent alluvial fans. It is not practical to map the components separately at the scale used. In Beverly fine sandy loam, gravel is at a depth of about 12 inches. Areas of this mapping unit are very droughty and are not suitable for cultivation. (Capability unit VIIs-1; Sand range site.)

**Beverly loamy fine sand, 0 to 3 percent slopes (BnA).**-This soil occurs on a terrace about 20 to 30 feet above the high water line of the Snake River. It has a profile similar to that of Beverly sandy loam, 0 to 3 percent slopes, except that the surface layer has been reworked by wind. The hazard of further wind erosion is high.

The soil is too droughty, for the production of crops without irrigation. It is suitable for a limited amount of grazing. (Capability unit VIIs-1; Sand range site.)

## Borrow Pits

Borrow pits (Bp).-This mapping unit is in two areas. The soil or overlying material has been removed from each of these for construction purposes. Many such areas exist that are too small to map. They are of little value for cultivation or grazing. (Capability unit VIIIs-1.)

## Catherine Series

The Catherine series consists of imperfectly drained soils on nearly level valley bottoms. The soils have formed in medium-textured alluvium derived mainly from loess and under the influence of a high water table. The surface layer is very dark gray (nearly black when



moist) silt loam over a subsoil of heavy silt loam or silty clay loam that contains numerous iron stains and clay films.

The Catherine soils are similar to the generally strongly alkaline Pedigo soils. They are not so well drained as the dark-colored Hermiston soils.

Wildrye, beardless wheatgrass, and rabbitbrush grew on the better drained sites; water-loving grasses were dominant where the water table was near the surface.

In recent years, the water table has been lowered by stream cutting, and most areas of the Catherine soils produce good yields of alfalfa hay, sugar beets, and small grain.

**Catherine silt loam, 0 to 3 percent slopes (CaA).**-This is the only soil in the Catherine series that was mapped in Walla Walla County. The largest areas of it are in the central Walla Walla Valley and along Dry Creek.

Representative profile in a cultivated field along Dry Creek:

- 0 to 8 inches, dark-gray silt loam, nearly black when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; neutral.
- 8 to 13 inches, similar to layer above but has blocky structure.
- 13 to 21 inches, grayish-brown silt loam, very dark grayish brown when moist; massive; hard when dry, very firm when moist, sticky when wet, moderately alkaline.
- 21 to 32 inches, gray silt loam, black when moist; moderate, fine, subangular blocky to weak, prismatic structure; very hard when dry, very firm when moist, slightly sticky and plastic when wet; the large aggregates are stained with iron and coated with thin deposits of clay; mildly to moderately alkaline.
- 32 to 44 inches, light brownish-gray silt loam, very dark grayish brown when moist; massive; hard when dry, friable when moist; few roots; moderately to strongly alkaline.

Small areas of this soil covered by overwashed material are included. In the vicinity of Valley Chapel, small areas have iron-stained gravel at a depth of 30 inches.

This soil is high in fertility and has a high water-supplying capacity. It is slowly permeable or moderately slowly permeable. Runoff is very slow, and there is little or no hazard of erosion. Root penetration is deep to moderately deep. In a few small basins, the water table is close to the surface during the growing season. In most areas, however, the water table is below the root zone of all plants grown on the soil.

Large yields of alfalfa hay, small grains, and sugar beets are obtained. (Capability unit IIw-1, dryland; capability unit IIw-1, irrigated; range site, Bottomland, 12 to 23 inches precipitation.)

## Couse Series

The Couse series consists of well drained and moderately well drained, medium-textured soils over a dense layer of slowly permeable silty clay loam. The dense layer is strongly weathered loess and basalt residuum that was the subsoil of a former, much older soil. The upper material is loess of more recent origin. The Couse soils are at elevations 3,200 to 4,000 feet on undulating to strongly sloping ridgetops that have a slight north or northeast exposure.

These soils have a dark grayish-brown surface layer and a brown or light-gray subsoil. The pores and fracture planes at the boundary between the subsoil and substratum are lined with gray silty material.

The Couse soils occur between the Palouse soils, which are at lower elevations, and the Klicker, Gwin, and Helmer soils, which are at higher elevations. The Couse soils are deeper to basalt than the Klicker and Gwin soils. They have a less permeable substratum than the Helmer soils, which have formed under a dense forest.

The Couse soils support an open stand of ponderosa pine and some Douglas-fir and an understory of shrubs, forbs, and grasses.

**Couse silt loam, 3 to 8 percent slopes (CoB).**-This soil occurs on long, sloping ridges of the Blue Mountains.

Representative profile in a cutover area:

- 1/2 inch to 0, old grass, pine needles, leaves, and twigs in varying stages of decomposition.
- 0 to 4 inches, dark grayish-brown silt loam, very dark brown when moist; granular structure; slightly hard when dry, friable when moist, and slightly sticky when wet; a dense mat of fine, fibrous grass roots; slightly acid to neutral.
- 4 to 8 inches, similar to layer above except structure is subangular blocky.
- 8 to 25 inches, brown silt loam, dark brown when moist; weak, medium, prismatic structure; slightly hard when dry, friable when moist; patchy films of clay in pores and on large aggregates; slightly acid to neutral.
- 25 to 35 inches, slightly grayer silt loam than that of horizon above; weak, subangular blocky structure; dark-colored stains from organic matter in vertical fractures; slightly hard when dry, friable when moist; slightly acid to neutral.
- 35 to 42 inches, light-gray silt loam, grayish brown when moist; fine and medium mottles of reddish brown and olive gray; weak, medium, prismatic to moderate, fine, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; slightly acid.
- 42 to 55 inches, light brownish-gray silty clay loam, dark, grayish brown when moist; moderate, medium, prismatic to fine, blocky structure; hard when dry, firm when moist, plastic and sticky when wet; slightly acid to neutral.
- 55 to 70 inches, clay loam that has a color similar to that in horizon above; strong, fine, blocky structure.
- 70 inches +, basalt bedrock.

This soil is moderately well drained. The surface layer and subsoil are moderately permeable; the substratum, slowly permeable. Root penetration is moderately deep. The soil is moderately fertile and has a high water-supplying capacity. Runoff is slow, and the hazard of erosion is slight to moderate.

Large areas of this soil were cleared of trees and cropped to wheat and peas. It was one of the important soils in the county for the production of late peas. Many fields were planted to peas 2 or 3 years in succession. The yield of peas declined rapidly, however, because the soil was used too intensively and was allowed to erode.

This soil is suited to trees. It can be cultivated if erosion is controlled. (Capability unit IIIe-2; Mixed Forest-Pine range site.)

**Couse silt loam, 3 to 8 percent slopes, eroded (CoB2).**-This soil is similar to Couse silt loam, 3 to 8 percent slopes, except that the surface layer has been eroded, and the plow layer is mostly subsoil material. It has low fertility and a fair water-supplying capacity. Runoff is slow to medium, and the hazard of erosion is moderate.

This soil has been cultivated intensively. Fair yields of wheat can still be obtained if enough fertilizer is used and if stubble and green-manure crops are plowed under to maintain enough organic matter. Yields of green peas are not good, so the crop is now seldom grown. Capability unit IVe-4; Mixed Forest-Pine range site.)

**Couse silt loam, 8 to 15 percent slopes (CoC).**-On north slopes the dark-colored surface layer is thinner

than on south slopes, and the soil is lighter colored and deeper than Couse silt loam, 3 to 8 percent slopes. South slopes have an open stand of ponderosa pine; north slopes have Douglas-fir in the stand.

This soil is suited to trees and to a limited amount of grazing. It can be used for wheat and pasture if soil-building crops are grown from one-half to three-fourths of the time. (Capability unit IIIe-2; Mixed Forest-Pine range site.)

**Couse silt loam, 8 to 15 percent slopes, eroded (CoC2).**-This soil is similar to Couse silt loam, 3 to 8 percent slopes, except for slopes and the color of the surface layer. The surface layer is grayish brown instead of dark grayish-brown, and over most of the area the brown subsoil is turned up in plowing. The soil is cultivated but is low in fertility and only fair in water-supplying capacity. Runoff is medium, and the hazard of further erosion is high. Runoff rills form each spring during thaws.

The soil was once heavily cropped to green peas for canning. Yields of peas are now low, and those of winter wheat are also generally low. The soil is suited to trees or pasture. (Capability unit IVe-4; Mixed Forest-Pine range site.)

**Couse silt loam, 15 to 30 percent slopes (CoD).**-This soil occurs on north-facing slopes in the foothills of the Blue Mountains. It is covered by a dense growth of Douglas-fir, ponderosa pine, ocean-spray, and spirea. It has a profile similar to that of Couse silt loam, 3 to 8 percent slopes, except that most of the soil horizons are thinner and basalt bedrock is nearer the surface. A few small areas of rock outcrop have been included in the mapping.

Runoff is medium to rapid, and the hazard of erosion is high. Erosion is slight in the forest, but may become severe in cultivated fields. This soil is well suited to trees. Cleared areas should be seeded to hay and pasture to control erosion. (Capability unit IVe-5; Mixed Forest-Pine range site.)

**Couse silt loam, 15 to 3.0 percent slopes, eroded (CoD2).**-This soil is similar to Couse silt loam, 15 to 30 percent slopes, except that it is eroded as the result of having been cleared and cultivated. The present surface layer is distinctly brown instead of dark grayish brown. Severe rilling is common during the spring thaw. Small areas on which basalt or the dense, slowly permeable substratum are exposed were mapped with this soil.

This soil is no longer suitable for cultivation; the hazard of erosion is high. It should be seeded to perennial grass or planted in trees. (Capability unit VIe-6 ; Mixed Forest-Pine range site.)

**Couse silt loam, 15 to 30 percent slopes, severely eroded (CoD3).**-This soil is more severely eroded than Couse silt loam, 15 to 30 percent slopes, eroded. In many places the substratum or basalt bedrock is exposed. The soil is not suitable for cultivation. (Capability unit VIe-6; Mixed Forest-Pine range site.)

**Couse silt loam, 30 to 45 percent slopes (CoE).**-This soil is similar to Couse silt loam, 3 to 8 percent slopes, except that it is on the sides of steep canyons. In addition, it varies more in depth, has thinner horizons, and has basalt bedrock nearer the surface. Numerous areas of basalt outcrop were mapped with this soil.

The water-supplying capacity of this soil is good. Runoff is rapid, and the hazard of erosion is high.

The soil supports good stands of Douglas fir and ponderosa pine. When the trees are cut, brush soon invades the area. (Capability unit VIe-6; Mixed Forest-Pine range site.)

**Couse silt loam, 30 to 45 percent slopes, eroded (CoE2).**-This soil is similar to Couse silt loam, 30 to 45 percent slopes, except that it has eroded after the timber was logged. It is low in fertility. The hazard of erosion is very high. This soil is suitable for a limited amount of grazing until woodland is reestablished. (Capability unit VIe-6; Mixed Forest-Pine range site.)

**Couse silt loam, 45 to 60 percent slopes (CoF).**-This soil occupies steep north-facing slopes where the substratum is generally not so dense as in Couse silt loams with gentler slopes. Otherwise it is similar to Couse silt loam, 30 to 45 percent slopes. Runoff is very rapid, and the hazard of erosion is very high. Steepness makes logging difficult and keeps livestock from grazing the forage efficiently. (Capability unit VIIe-3; Mixed Forest-Pine range site.)

**Couse-Rock land complex, 30 to 60 percent slopes (CrF).**-This mapping unit consists of areas of the Couse soils and Basalt rock land in a pattern that is too complex to map separately. It occupies north-facing slopes in deep, steep-walled canyons. The areas of Couse soil support stands of Douglas-fir and ponderosa pine and those of Basalt rock land support a cover of grass. This complex is suitable for a limited amount of grazing. The cost of harvesting the timber might be excessive because of the steep slopes. (Capability unit VIIe-5; Mixed Forest-Pine range site.)

## Ellisforde Series

The Ellisforde series consists of medium-textured, well-drained or somewhat excessively drained soils. These soils occupy strongly dissected lake terraces at elevations 500 to 1,000 feet above sea, level. They have formed in loess that was deposited over stratified, calcareous silt and sand. The material under the loess is commonly referred to as the Touchet beds.

The Ellisforde soils developed under 9 to 12 inches of rainfall per year. Only a few small relic areas of the native bunchgrasses have survived burning and overgrazing. The present vegetation in the noncultivated areas is mainly gray rabbitbrush and cheatgrass.

The soils are grayish-brown to light brownish-gray silt loams and very fine sandy loams, which rest abruptly on the stratified terrace material. The boundary is gradual where lime is in the horizon just above the substratum.

The Ellisforde soils are widely distributed in south-central Walla Walla County and on some of the terraces in the canyon of the Snake River. They occur between the Sagemoor and Ritzville soils. The Sagemoor soils developed mainly from the Touchet beds and are generally more calcareous, especially in the upper horizons, than the Ellisforde soils. The Ritzville soils developed in loess that was too deep to be influenced by the Touchet beds.

**Ellisforde silt loam, 3 to 8 percent slopes (EfB).**-This soil occurs just north of Touchet and Lowden and on terrace remnants in the middle Walla Walla Valley at elevations of 600 to 800 feet above sea level.

**Representative profile in a cultivated field:**

- 0 to 8 inches, grayish-brown silt loam, very dark grayish brown when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; mildly alkaline.
- 8 to 16 inches, pale-brown silt loam, brown when moist; massive; slightly hard when dry, friable when moist; moderately alkaline.
- 16 to 24 inches, light brownish-gray silt loam, dark grayish brown when moist; massive to very weak, prismatic structure; slightly hard when dry, friable when moist; noncalcareous and moderately alkaline.
- 24 inches +, light-gray silt loam alternating with light-gray fine sand, brownish gray when moist; massive; hard when dry, firm when moist; strongly alkaline.

In some places, the loess is calcareous above the stratified material.

This well-drained soil is moderately permeable in the surface layer and subsoil and slowly permeable in the substratum. It is moderately fertile and has a good water-supplying capacity. Root penetration is moderately deep. Runoff is slow, and the hazard of erosion is slight. The surface layer is moderately low in organic matter. Soil aggregates are fairly unstable. An adequate supply of organic matter is needed to help control erosion.

The supply of moisture determines the crops that can be grown. Winter wheat and drought-resistant grasses are grown without irrigation. However when water for irrigation is available, alfalfa hay, sugar beets, lima beans, and green peas make excellent yields. (Capability unit IIIe-3, dryland; capability unit IIe-5, irrigated; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde silt loam, 0 to 3 percent slopes (EfA).**-This soil is similar to Ellisforde silt loam, 3 to 8 percent slopes, except for slopes. The stratified lake deposits are about 4 feet below the surface. Runoff is very slow, and the hazard of erosion is slight.

This soil is very productive when it is irrigated. Stubble mulching for dryland crops and careful use of water when irrigating help to control erosion. (Capability unit IIIc-1, dryland; capability unit I-1, irrigated; range site Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde silt loam, 8 to 15 percent slopes (EfC).**-This soil is on the first break in slope between the gently sloping terraces and the deep canyons that have eroded into the terraces. It has a profile that is similar to that of Ellisforde silt loam, 3 to 8 percent slopes. The substratum is nearer the surface on south-facing slopes than on north-facing slopes. Runoff is medium, and the hazard of erosion is moderate.

The choice and yield of crops is limited by the supply of moisture. For good yields, most crops need irrigation. Careful use of water when irrigating helps to control erosion. (Capability unit IIIe-3, dryland; capability unit IVe-14, irrigated; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde silt loam, 8 to 15 percent slopes, eroded (EfC2).**-This soil is similar to Ellisforde silt loam, 8 to 15 percent slopes, except that most of the dark-colored surface layer has been lost through erosion. The gray color and lime in the plow layer distinguish this soil from the uneroded soil.

This soil is low in fertility and fair in water-supplying capacity. Intensive use of soil-building crops is needed to increase organic matter to the level that will help to control erosion. (Capability unit IVe-6, dryland; capa-

bility unit IVe-12, irrigated; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde silt loam, 15 to 30 percent slopes (EfD).**-This soil is shallower to the substratum, and it is steeper than Ellisforde silt loam, 3 to 8 percent slopes. It occupies the fronts of terraces and the walls of canyons that have eroded into the terraces. Many areas of this soil are north of Touchet on the tops of hills and on the north slopes with the Ritzville soils. On many south slopes, the transition of this soil to the Sagemoor soils is almost imperceptible.

Root penetration is moderately shallow. The water-supplying capacity is fair to good. Runoff is medium, and the hazard of erosion is moderate. Most of the erosion occurs when the snow melts in spring.

The principal crop is winter wheat. Grass is the important soil-building crop. Unless irrigation water is applied carefully, the soil will erode. (Capability unit IIIe-3, dryland; capability unit VIe-8, irrigated; range site, Deep Upland 9 to 12 inches precipitation.)

**Ellisforde silt loam, 15 to 30 percent slopes, eroded (EfD2).**-This soil is similar to Ellisforde silt loam, 15 to 30 percent slopes, except that most of the surface layer has been lost through erosion and the substratum is nearer the surface. This eroded soil is low in fertility and fair in water-supplying capacity. When it is dry farmed, crop failures are common. When it is irrigated, yields are low. Fair stands of soil-building crops can be grown under irrigation. (Capability unit IVe-6, dryland; capability unit VIe-8, irrigated; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde silt loam, 30 to 45 percent slopes (EfE).**-This soil has rapid runoff, and the hazard of erosion is high. The water-supplying capacity is low to fair. Farm machinery makes large, furrowlike wheel tracks when used on this soil. In many places these deep tracks cause more movement of soil than water erosion. (Capability unit VIe-2; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde silt loam, 30 to 45 percent slopes, eroded (EfE2).**-This soil is on south-facing slopes. It is easily distinguished from Ellisforde silt loam, 30 to 45 percent slopes, by its grayish color and by lime on the surface. In places this eroded soil is difficult to distinguish from the Sagemoor soils.

This eroded soil is somewhat excessively drained. It is slowly permeable. The fertility and water supplying capacity are low. Root penetration is shallow. The soil is unproductive, and soil-building practices are needed to restore maximum forage production. (Capability unit VIe-2; range site. Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde silt loam, hardpan variant, 0 to 3 percent slopes (EhA).**-This soil formed in the same type of loess and stratified sediment as the typical Ellisforde soils. It differs in having a cemented alkali hardpan in the subsoil, just above the stratified materials. It occupies low terraces where it is subject to a high water table arid saline-alkali conditions. The soil occurs on only a few irrigated farms in the Walla Walla Valley.

Representative profile in a field that has been irrigated

- 0 to 9 inches, grayish-brown silt loam, very dark grayish brown when moist; medium to fine, granular structure; soft when dry, friable when moist; mildly alkaline.

9 to 25 inches, pale-brown silt loam, brown when moist; massive; friable when moist; moderately alkaline.

25 to 33 inches, pale-brown silt loam, brown when moist; strongly cemented to indurated hardpan, which contains several layers, 1/2 inch to 1 1/2 inches thick. The upper surface of the hardpan is generally coated with a thin deposit of lime; in places the pan has a layer of loose, friable silt loam between the plates or it is nodular in the lower part; moderately alkaline.

33 to 44 inches, light brownish-gray silt loam, dark grayish brown when moist; fine, subangular blocky structure; hard when dry, firm when moist; calcareous; moderately to strongly alkaline.

This soil is well drained. Above the hardpan it is moderately permeable. The hardpan, however, is impermeable to roots. A perched water table accumulates above the hardpan, but it eventually drains away through natural fractures in the pan.

Runoff is very slow, and the hazard of erosion is slight. The soil is moderately fertile and has a low water-supplying capacity. In dry seasons, crops are short on moisture. deep-rooted crops do not grow well in this soil. (Capability unit IIIc-1, dryland; capability unit IIIs-1, irrigated; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde silt loam, hardpan variant, 3 to 8 percent slopes (EhB)**-This soil is associated with Ellisforde silt loam, hardpan variant, 0 to 3 percent slopes. It is similar to the associated soil but it is slightly steeper, has a hardpan nearer the surface, and generally is not so thick. Runoff is slow and the erosion hazard is slight to moderate. (Capability unit IIIe-3, dryland; capability unit IIIe-1, irrigated; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde very fine sandy loam, 3 to 8 percent slopes (EvB)**-This soil occupies small areas along the Touchet Valley, Just north of the town of Touchet. It is similar to Ellisforde silt loam, 3 to 8 percent slopes, except that the surface layer contains more sand and less organic matter.

This very fine sandy loam soil is moderate in fertility and fair to good in water-supplying capacity. Permeability is moderately rapid, and root penetration is moderately deep. The annual rainfall is not enough for the production of most farm crops, and it is nearly marginal for winter wheat.

Runoff is slow. The hazard of water erosion is slight, and that of wind erosion is high. Special practices are needed to control wind erosion if the soil is cropped in a system of winter wheat and summer fallow. Irrigated fields need management that controls both wind and water erosion. (Capability unit IIIe-3, dryland; capability unit IIIe-8, irrigated; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde very fine sandy loam, 8 to 15 percent slopes (EvC)**-This soil is similar to Ellisforde very fine sandy loam, 3 to 8 percent slopes, but the steeper slopes make irrigation water more difficult to manage. (Capability unit IIIe-3, dryland; capability unit IVe-14, irrigated; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde very fine sandy loam, 8 to 15 percent slopes, eroded (EvC2)**-This soil is similar to Ellisforde very fine sandy loam, 3 to 8 percent slopes, except that it is steeper and has lost part of its surface soil through erosion. It is more difficult to irrigate. This eroded soil

is low in fertility and fair in water-supplying capacity. (Capability unit IVe-6, dryland; capability unit IVe-14, irrigated; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde very fine sandy loam, 15 to 30 percent slopes (EvD)**-This soil has the same profile characteristics as Ellisforde very fine sandy loam, 3 to 8 percent slopes. Because of the slopes, the very fine sandy loam surface soil is unstable. Harvesters and other farm machinery slide downhill and make large, deep tracks that often expose subsoil.

This soil can be used for winter wheat if enough organic matter is maintained and erosion is controlled. (Capability unit IIIe-3, dryland; capability unit VIe-8, irrigated; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde very fine sandy loam, 15 to 30 percent slopes, eroded (EvD2)**-This soil has lost most of its dark-colored surface layer through erosion, and patches of the lighter colored subsoil have been exposed. Otherwise this soil is similar to Ellisforde very fine sandy loam, 15 to 30 percent slopes.

Fertility and the water-supplying capacity are low. The hazard of further erosion is high. The soil is not suitable for a continuous winter wheat-summer fallow rotation. Yields of wheat are low. (Capability unit IVe-6, dryland; capability unit VIe-8, irrigated; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ellisforde very fine sandy loam, 30 to 45 percent slopes, eroded (EvE2)**-This soil has been severely eroded. In many places the gray calcareous subsoil material is at or near the surface. Fertility and the water-supplying capacity are low. Intensive use of soil-building practices are needed to make the soil productive. Grazing ought to be deferred for several years when areas of this soil are reseeded to grass. (Capability unit VIe-2; range site, Deep Upland, 9 to 12 inches precipitation.)

## Esquatzel Series

The Esquatzel series consists of well-drained, medium-textured soils that have formed in alluvium derived from loess. The soils occur on wide stream bottoms along the Touchet River below the Shaw Bridge along the lower part of Dry Creek, and in the Walla Walla Valley below Lowden. Small areas are located along the minor drainageways in the west-central part of the county.

Esquatzel soils are silt loams or very fine sandy loams with a dark-colored surface layer. They are adjacent to the Stanfield and Umapine soils, which are both saline and alkali.

The native vegetation of the Esquatzel soils was bluebunch wheatgrass. Along the large perennial streams, a few willows and cottonwoods were part of the native vegetation. Most of the Esquatzel soils are cultivated. In the dry farming areas, winter wheat is grown. In the irrigated areas, alfalfa, sugar beets, small grains, and sweet corn are grown.

**Esquatzel silt loam, 0 to 3 percent slopes (EzA)**-A representative profile of this soil from a cultivated field on the wide Touchet River bottom land, about 3 miles north of Touchet, follows

0 to 7 inches, grayish-brown silt loam, very dark grayish brown when moist; fine, granular structure; friable when moist; moderately alkaline.

7 to 18 inches, silt loam with a color similar to that in horizon above; friable when moist; moderately alkaline.

18 to 45 inches, pale-brown silt loam or very fine sandy loam, brown to dark brown when moist; massive; friable when moist; calcareous and moderately alkaline.

45 to 70 inches, very fine sandy loam or silt loam with a color similar to that in horizon above.

A few small saline areas, too small to map separately, are included with this soil.

This well-drained soil is moderately permeable. Roots penetrate deeply. Fertility and the water-supplying capacity are high. Runoff is very slow. The hazard of erosion is slight. The soil is subject to overflow about once in 10 years. The lack of moisture restricts the choice of crops. (Capability unit IIIc-1, dryland; capability unit I-1, irrigated; range site, Bottomland, 6 to 12 inches precipitation.)

**Esquatzel very fine sandy loam, 0 to 3 percent slopes** (EyA).-This soil occurs on some bottom lands along the large intermittent streams. It is lighter colored and coarser textured than Esquatzel silt loam, 0 to 3 percent slopes. In addition, it contains a higher percentage of fine and very fine sand and less silt. In most places the coarse material is pumice.

Permeability is moderately rapid, water-supplying capacity is good, and fertility is moderate. The soil should be protected against blowing, which is a moderate hazard. (Capability unit IIIe-3, dryland; capability unit IIe-6, irrigated; range site, Bottomland, 6 to 12 inches precipitation.)

## Farrell Series

The Farrell series consists of deep, friable, well-drained to somewhat excessively drained very fine sandy loams. The soils are generally brown, and they are calcareous at a depth of about 25 inches. They have formed from material deposited in the backwater of ancient lakes. This material was predominantly loess, mixed with basaltic, granitic, and quartzitic sand, gravel, and cobblestones. Loess is the dominant material in most horizons, but the amount of sand, gravel, and cobblestones in any horizon varies widely.

The Farrell soils occupy remnants of terraces and alluvial fans at an elevation of 775 to 1,100 feet above sea level. The largest areas are east of Vansycle Canyon and south of the Walla Walla River.

The Farrell soils are at lower elevations than the Ritzville and Ellisforde soils. They differ from the Ritzville soils in having formed from reworked material, and from the Ellisforde in not having a compact, stratified substratum.

The Farrell soils are not extensive, and nearly all the area is rangeland. Beardless wheatgrass, Sandberg bluegrass, yarrow, balsamroot, and rabbitbrush are the main plants.

**Farrell very fine sandy loam, 3 to 15 percent slopes** (FaC).-This is the most extensive soil of the Farrell series. It occupies high, gently sloping terrace remnants, which in many places are covered by native grasses.

Representative profile in an area of grassland, in the southwest corner of section 11, T. 6 N., R. 32 E., of the Willamette meridian

0 to 3 inches, brown very fine sandy loam, dark brown when moist; soft when dry, friable when moist; thin, platy structure; roots abundant and fibrous; mildly alkaline.

3 to 8 inches, color and texture similar to those in above horizon; layer breaks to large, fragile blocks; contains fewer roots than layer above.

8 to 25 inches, light brownish-gray very fine sandy loam or silt loam, dark grayish brown when moist; breaks to large prisms; friable when moist, slightly hard when dry; moderately alkaline.

25 inches +, very pale brown very fine sandy loam or silt loam, brown when moist; massive; very friable; weakly stratified; about 5 percent of mass consists of fragments of basalt and granite, 1/2 to 3/4 inch in diameter; few roots below 48 inches; calcareous and strongly alkaline.

The amount of sand, gravel, and cobbles in any horizon varies widely. From 15 to 20, or more, basaltic and granitic cobbles and stones per acre are scattered over the surface.

This soil is well drained, is moderately fertile, and has a fair water-supplying capacity. Permeability is moderately rapid. Root penetration is deep. Runoff is slow to medium, and the hazard of erosion is moderate. This soil is not well suited to wheat, but it produces excellent grass. (Capability unit IVE-1; range site, Deep Upland, 9 to 12 inches precipitation.)

**Farrell very fine sandy loam, 15 to 30 percent slopes** (FaD).-This soil is similar to Farrell very fine sandy loam, 3 to 15 percent slopes, but it occupies the steeper terrace slopes and contains more gravel and cobbles. The surface is rough and hummocky, and there are a few outcrops of basalt. Runoff is medium. The soil is not well suited to wheat. (Capability unit IVE-1; range site, Deep Upland, 9 to 12 inches precipitation.)

**Farrell very fine sandy loam, 30 to 60 percent slopes** (FaF).-This soil occurs on eroded remnants of old terraces, alluvial fans, and basalt canyons. The amount of basaltic and granitic material mixed with the loess is variable, and there are many basalt rocks. Within a short distance, the depth of this soil ranges from several inches to many feet. The areas of this soil on north-facing slopes support a denser stand of grass than those on south-facing slopes.

The soil is somewhat excessively drained. Runoff is rapid, and the hazard of erosion is high. The soil is unstable, and stockmen have learned that 50 to 60 percent of the forage should be left to control erosion. (Capability unit VIe-2; range site, Deep Upland, 9 to 12 inches precipitation.)

## Gwin Series

The Gwin series consists of well-drained and somewhat excessively drained, shallow and very shallow, rocky soils that have developed from weathered basalt mixed with a small amount of loess. The soils have a dark grayish-brown, medium-textured surface layer and a moderately fine textured, thin subsoil. In only a few places is bedrock more than 15 inches below the surface. Rock outcrops are numerous.

The Gwin soils occupy steep to very steep, south-facing slopes of deep canyons in the Blue Mountains. The Couse and Helmer soils occupy the adjacent ridgetops and some north-facing slopes where the soil material is thicker. The reddish-colored Klicker soils are on rocky north-, northeast-, and east-facing slopes.

The plant cover is bluebunch wheatgrass, Sandberg bluegrass Idaho fescue, elk sedge, balsamroot, yarrow, and lupine. Gwin soils are too rocky for tillage and are used for grazing early in summer.

**Gwin rocky silt loam, 0 to 30 percent slopes (GrD).**- This soil occurs mainly on the upper third of south-facing slopes in the Blue Mountains. In this position, the soil is deeper and rock outcrops are less numerous than on the steeper parts of the slope. In places this soils joins the moderately deep phases of the Palouse soils.

Representative profile in an area of grassland along the Lewis Peak Road, about 6 miles east of Dixie:

- 0 to 5 inches, dark grayish-brown silt loam, very dark brown when moist; granular structure; slightly hard when dry, friable when moist, sticky when wet; many fibrous roots; slightly acid to neutral.
- 5 to 12 inches, silty clay loam that has a color similar to that in horizon above; prismatic structure; hard when dry, firm when moist, sticky when wet; slightly acid to neutral.
- 12 to 17 inches, brown silty clay loam, dark brown when moist; sticky and plastic when wet; many fragments of basalt; thin clay films and stains of dark-colored organic matter on the rocks; slightly acid to neutral.
- 17 inches +, fractured basalt.

This soil is well drained. It is low in fertility and fair in water-supplying capacity. Permeability is slow. Runoff is medium to rapid, and the hazard of erosion is high.

Grass roots follow the cracks of the fractured basalt down to the solid rock. This is probably the reason bluebunch wheatgrass, a deep-rooted plant, can grow well in such a shallow soil. This soil cannot be cultivated, but it is good for grazing if properly managed. (Capability unit VIIIs-4; range site, Shallow Upland, 18 to 24 inches precipitation.)

**Gwin rocky silt loam, 0 to 30 percent slopes, eroded (GrD2).**-This soil is similar to Gwin rocky silt loam, 0 to 30 percent slopes, but it has lost 2 to 3 inches of surface soil through erosion. The soil is now thin, and it is soon saturated with moisture when snow melts in spring. As a result, runoff is rapid.

A large part of the soil surface is covered by rock. The plant cover is not dense enough to control erosion. The soil is somewhat excessively drained, and its water-supplying capacity is low. Included are small areas of Gwin rocky silt loam, 0 to 30 percent slopes.

The vegetation on the eroded areas is now mainly Sandberg bluegrass. (Capability unit VIIIs-4; range site, Shallow Upland, 18 to 24 inches precipitation.)

**Gwin rocky silt loam, 30 to 60 percent slopes (GrF).**- This is the most extensive of the Gwin soils in Walla Walla County. It occupies the steeper slopes below Gwin rocky silt loam, 0 to 30 percent slopes, and it is rockier and shallower. It grades to Basalt rock land, which was mapped wherever the rock outcrops occupy more than 40 percent of an area.

Runoff is rapid. The capacity to store water is severely limited by the underlying basalt. Most of the plants mature by the time the soil is dry early in summer. The yield of forage is low. A large percentage of the forage cannot be grazed, as it must be left on the soil to control erosion. (Capability unit VIIIs-4; range site, Shallow Upland, 18 to 24 inches precipitation.)

**Gwin very rocky silt loam, 0 to 30 percent slopes, eroded (GvD2).**-This soil consists of a thin deposit of loess over rough, uneven basalt. Rock outcrops occupy from 25 to 40 percent of the surface. Runoff is rapid, and a large part of the original, dark-colored surface layer has been lost through erosion. The present surface layer be-

comes very hard when dry. The soil is suitable for a limited amount of grazing. (Capability unit VIIIs-4; range site, Shallow Upland 18 to 24 inches precipitation.)

**Gwin very rocky silt loam, 30 to 60 percent slopes, eroded (GvF2).**-This soil is similar to Gwin very rocky silt loam, 0 to 30 percent slopes, eroded, except that slopes are much steeper and rock outcrops are more numerous. The surface layer and subsoil are thin. Runoff is very rapid, and a large part of the original, dark-colored surface soil has been lost through erosion. Fragments of basalt make up about 50 percent of the volume of the present surface layer. This layer is very hard when dry.

The soil is suitable for a limited amount of grazing, but enough plant residue must be left on the surface to control erosion. (Capability unit VIIIs-4; range site, Shallow Upland, 18 to 24 inches precipitation.)

**Gwin-Rock land complex, 45 to 60 percent slopes (GwF).**-This mapping unit consists of Gwin rocky silt loam and Basalt rock land. It occurs in steep canyons in the Blue Mountains. On the short, steep, north- or northeast-facing slopes are moderately deep soils and many large outcrops of rock. On the south-facing slopes is Rock land. Runoff is rapid following the melting of snow.

The dominant vegetation on south-facing slopes is short-lived perennial grasses and a few annual forbs. Grasses, shrubs, and trees are on the north-facing slopes. (Capability unit VIIIs-4; range site, Shallow Upland, 18 to 24 inches precipitation.)

## Helmer Series

The Helmer series consists of well-drained, medium-textured soils that have developed from loess pumice, and weathered basalt. The soils occupy gently sloping ridgetops and adjacent steep north slopes in the Blue Mountains at elevations of more than 3,000 feet above sea level.

The Helmer soils are characteristically dark-brown or yellowish-brown silt loam underlain by compact layers of pale-brown yellowish-brown, or light brownish-gray, heavy silt loam or silty clay loam. The lower horizons are part of a buried profile. At the lower elevations, the Helmer soils join the darker colored Couse soils.

The Helmer soils support dense stands of grand fir mixed with some Douglas-fir; spruce, western larch, and ponderosa pine. When the timber is logged or burned over, alder, willow, rose, spirea, ocean-spray, and other brushy plants invade the area.

**Helmer silt loam, 3 to 15 percent slopes (HeC).**-This soil occurs on broad ridgetops that have a gentle northerly slope. The original vegetation was a dense stand of white fir. Some spruce, larch, Douglas-fir, and ponderosa pine grew where the stand of white fir was not so dense.

Representative profile in a wooded area in the northwest corner of the SE1/4SE1/4, sec. 14, T. 7 N., R., 38 E., of the Willamette meridian.

1 1/2 inches to 0, partly decomposed pine and fir needles, twigs, and leaves and pinegrass.

0 to 2 inches, dark-brown silt loam, darker brown when moist; granular structure; very friable; slightly acid; in several places less than 100 feet from sample site, this layer is ashy gray and 1/4 to 1/2 inch thick.

2 to 21 inches, yellowish-brown silt loam, dark brown when

moist; granular; very friable; many, coarse roots; concentration of iron; slightly acid.

21 to 24 inches, light brownish-gray silt loam, grayish brown when moist; massive to granular structure; hard when dry, firm when moist; few, faint mottles.

24 to 44 inches, pale-brown silt loam, brown when moist; prismatic structure; thin clay films and iron stains on the faces of prisms; grayish-brown accumulations of silt in the vertical cleavage planes; few, shotlike concretions of manganese.

44 to 72 inches, yellowish-brown silty clay loam, dark yellowish brown when moist; subangular blocky structure; light-gray silt coatings on aggregates; clay films in the pores.

72 inches +, basalt bedrock.

This soil is well drained and moderately permeable. It is moderately fertile and has a high water-supplying capacity. Root penetration is deep. Runoff is medium, and the hazard of erosion is moderate.

Small areas of this soil have been cleared and are cropped. The yields of grain and alfalfa are low. Hay and pasture crops are best suited to the soil. If pastures are overgrazed or otherwise mismanaged, they are soon invaded by fern and woody shrubs. This soil is suitable for trees. (Capability unit IVe-7; Mixed Forest-Fir range site.)

**Helmer silt loam, 15 to 30 percent slopes (HeD).**- This soil occupies steeper slopes and rougher terrain than Helmer-silt loam, 3 to 15 percent slopes. In addition, the substratum is thinner or is absent, and basalt bedrock is nearer the surface. The profile of the two soils is similar to a depth of 20 to 24 inches. Areas that have basalt bedrock near the surface are included with this soil.

The forest on this soil consists of grand fir mixed with a large percentage of Douglas-fir. Ponderosa pine, however, is more prevalent where the soil is shallow.

Runoff is medium to rapid, and the hazard of erosion is moderate to high. The soil is best suited to trees. (Capability unit VIe-7; Mixed Forest-Fir range site.)

**Helmer silt loam, 30 to 45 percent slopes (HeE).**-This soil is similar to Helmer silt loam, 3 to 15 percent slopes, except that it occupies rough, broken topography and its depth to bedrock ranges from 30 to more than 72 inches. The soil is thickest in covers where large quantities of loess and pumice have accumulated. Outcrops of rock are numerous and occur in small grassy glades or on small ridges having a definite southern exposure.

On this soil, Douglas-fir is more abundant than grand fir. Ponderosa pine, however, is dominant in some of the more droughty areas. Runoff is rapid, and the hazard of erosion is high. Root penetration in most places is moderately deep. The soil is low to moderate in fertility. It is best suited to trees. (Capability unit VIe-7; Mixed Forest-Fir range site.)

**Helmer silt loam, 45 to 60 percent slopes (HeF).**-This soil is similar to Helmer silt loam, 30 to 45 percent slopes, except that it is steeper and has more rock outcrops that make logging difficult. Runoff is very rapid. (Capability unit VIe-4; Mixed Forest-Fir range site.)

**Helmer-flock land complex, 45 to 60 percent slopes (HfF).**-This mapping unit consists of about 75 percent Helmer soils and 25 percent Basalt rock land. It occurs at high elevations. The vegetation is a fairly dense forest on the Helmer soils and grass and shrubs on the Basalt rock land. (Capability unit VII-5; Mixed Forest-Fir, range site.)

## Hermiston Series

The Hermiston series consists of well-drained, medium-textured soils that developed from alluvium. This alluvium is mainly loess that washed from the adjacent upland. As a rule, the Hermiston soils have a grayish-brown silt loam surface layer, 7 to 9 inches thick, and a slightly lighter colored, friable, silt loam subsoil. They are calcareous at a depth of 20 to 30 inches. In places pumice in the alluvium gives Hermiston soils a decidedly grayer color and coarser texture than is typical of the soils of this series.

The Hermiston soils occupy wide stream bottoms and are associated with the Walla Walla soils. All the acreage of Hermiston soils in Walla Walla County is cultivated.

**Hermiston silt loam, 0 to 3 percent slopes (HmA).**-This soil is the most extensive of the Hermiston series. It occupies the valley floor, above the high water line. There is no evidence of a high water table.

Representative profile in a cultivated field south of Cottonwood Creek and east of Powerline Road, in sec. 9, T. 6 N., R. 36 E., of the Willamette meridian.

0 to 9 inches, grayish-brown silt loam, very dark grayish brown to very dark brown when moist; weak, fine, granular structure; friable when moist, slightly sticky when wet; mildly to moderately alkaline.

9 to 23 inches, grayish-brown silt loam, very dark grayish brown when moist; massive or weak, blocky structure; slightly hard when dry, friable when moist, slightly sticky when wet; mildly to moderately alkaline.

23 to 38 inches, grayish-brown silt loam, very dark grayish brown when moist; weak, coarse, prismatic structure; friable when moist, slightly sticky when wet; moderately calcareous and moderately to strongly alkaline.

38 to 66 inches, light brownish-gray or pale-brown silt loam, brown when moist; massive; firm when moist, slightly sticky when wet; many, fine pores; few lime veins; moderately alkaline.

This soil is deep, well drained, and moderately permeable. It is moderately to highly fertile and has a high water-supplying capacity. Runoff is very slow, and the hazard of erosion is slight.

Low rainfall somewhat restricts the choice of crops. Good yields of wheat and peas can be obtained without irrigation. Excellent yields of alfalfa hay, sugar beets, carrots, and asparagus are obtained through irrigation. (Capability unit IIc-1, dryland; capability unit I-1, irrigated; range site, Bottomland, 12 to 23 inches precipitation.)

**Hermiston very fine sandy loam, 0 to 3 percent slopes (HnA).**-This soil is similar to Hermiston silt loam, 0 to 3 percent slopes, except that the surface layer is lighter colored and coarser textured. The water-supplying capacity is good. Because of the pumice in this soil, wind erosion is a moderate hazard. Unless the soil is irrigated, crops are limited to grains, peas, or grasses. Irrigated areas should be protected at all times by a living crop or by the residue of a crop. (Capability unit IIc-1, dryland; capability unit IIe-6, irrigated; range site, Bottomland, 12 to 23 inches precipitation.)

## Hezel Series

The soils of the Hezel series are somewhat excessively drained and gently sloping to somewhat hilly. They have formed from mixed material derived from basalt, granite,

and other igneous rocks. These soils consist of 15 to 30 inches of loamy fine sand over compact, stratified fine sand and silt of the Touchet beds. They occur on gently sloping terraces and on the short slopes of terraces between the loess uplands and the river flood plains, in the western part of the county.

The Hezel soils are in the same general area as the Quincy soils and at lower elevations than the Sagemoor soils. They developed under a sparse stand of Indian ricegrass, needle-and-thread, and Sandberg bluegrass. The moisture-supplying capacity of these soils is too low for the production of crops without irrigation.

**Hezel loamy fine sand, 0 to 15 percent slopes, eroded (HoC2).** The largest areas of this soil are just north of the Walla Walla River and east of Wallula, and just south of Snake River on the west side of the Union Pacific Railroad tracks.

Representative profile in overgrazed, wind-eroded rangeland in the southwest corner of sec. 25, T. 9 N., R. 31 E., of the Willamette meridian.

0 to 3 inches, grayish-brown loamy fine sand, very dark grayish brown when moist; very weak, platy structure; soft; most of the grass roots in profile are in this layer; moderately alkaline.

3 to 20 inches, grayish-brown loamy fine sand, very dark grayish brown when moist; massive; soft; few roots; moderately alkaline.

20 to 31 inches, light brownish-gray sandy loam or loamy fine sand; massive; soft; calcareous and strongly alkaline.

31 inches +, light brownish-gray, compact silt loam, dark grayish brown when moist; platy structure; in alternate layers with light brown fine sand; strongly calcareous and strongly alkaline.

This somewhat excessively drained soil is rapidly permeable above the stratified substratum. Plant roots rarely penetrate the substratum. Fertility and the water-supplying capacity are low. Runoff is very slow. The hazard of wind erosion is high.

Heavy grazing and fires in the last 10 or 15 years have destroyed the native plant cover. Downy brome grass and annual weeds cover most of the area. The soil is too droughty for dryland farming. It is suitable for a limited amount of grazing if enough vegetation is left to control wind erosion. If irrigated, the soil is suitable for hay and pasture crops and an occasional grain crop. (Capability unit VIIIe-1, dryland; capability unit IVs-2, irrigated; Sand range site.)

**Hezel loamy fine sand, 1 to 30 percent slopes, eroded (HoD2).**-This soil occupies short southwest-facing slopes that get the full force of the southwest winds. The depth of the soil to lake-laid material is about half that of Hezel loamy fine sand, 0 to 15 percent slopes, eroded. The native vegetation has been replaced by downy brome grass and annual weeds. The soil is suitable for limited amount of grazing late in ring. (Capability unit VIIe-1, dryland; capability unit VIIe-9, irrigated; and range site.)

**Hezel loamy fine sand, 30 to 45 percent slopes, eroded (HoE2).**-This soil occurs in small, widely scattered areas and is not extensive. In many places, the lake-laid substratum is but a few inches below the surface in other places it is 3 to 4 feet. A large percentage of the annual growth of forage must be left on the soil to control wind erosion. (Capability unit VIIIe-1; Sand range site.)

**Hezel-Quincy complex, eroded (Hp2).**-This mapping unit consists of areas of Hezel soils that have been severely

reworked by wind. The sandy material has been blown from some areas and deposited nearby in large hummocks and small dunes, which resemble the Quincy soils. Plant cover is very sparse and the annual growth of vegetation is too light to control soil blowing effectively. This mapping unit is not suitable for cultivation or grazing. (Capability unit VIIIe-1.)

## Klicker Series

The Klicker series consists of shallow to moderately deep, rocky, well-drained and somewhat excessively drained soils in the forest-grassland transition area. The soils formed in a thin mantle of loess underlain by basalt and andesite residuum that weathered in place. They have a dark-colored medium-textured surface layer and a brownish, moderately fine textured subsoil. They occupy steep northwest-, north-, and northeast-facing slopes.

The native vegetation of the Klicker soils is an open stand of ponderosa pine and Douglas-fir with an understory of shrubs and grasses. Douglas-fir and shrubs grow on the deep Klicker soils, which can supply more moisture for plants than the shallow Klicker soils.

**Klicker rocky silt loam, 0 to 30 percent slopes (KkD).**-This rocky soil occurs in many small areas. Many of these areas are too small to be mapped separately and were included with other soils.

Profile on a northeast slope covered by brush, trees, and grass, about 100 yards east of the road junction in sec. 24, T. 7 N., R. 38 E., of the Willamette meridian:

1 inch to 0, partly decomposed leaves, pine and fir needles, dry grass, and small twigs.

0 to 4 inches, dark grayish-brown silt loam, very dark brown when moist; coarse, granular structure; slightly hard when dry, friable when moist, slightly sticky and nonplastic when wet; fine roots abundant; slightly acid.

4 to 18 inches, brown silty clay loam, dark brown when moist; medium to coarse, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; few roots; numerous fine pores; clay films on blocks; neutral to slightly acid.

18 to 28 inches, similar to the above horizon, but about 50 percent of volume is basalt.

28 inches +, basalt bedrock.

This soil is well drained and has moderately slow permeability. It is low in fertility and fair in water-supplying capacity. Root penetration is shallow to moderately deep. Runoff is medium, and the hazard of erosion is moderate. There is considerable runoff during spring thaws. Soil losses are slight, however, because the vegetation controls erosion.

This soil is too rocky for cultivation. It produces good: ponderosa pine and Douglas-fir timber in rather open stands. It is suitable for grazing and forestry. (Capability unit VIIs-5; Forested Upland-Pine range site.)

**Klicker rocky silt loam, 30 to 60 percent slopes (KkF).**-This is the most extensive soil of the Klicker series. It has a thinner and more rocky profile than Klicker rocky silt loam, 0 to 30 percent slopes. It occupies rough broken topography that includes short, steep, south- and southwest-facing slopes, intermingled with large areas of north-facing slopes. The north-facing slopes, and especially the coves where the soil is deepest, are forested, whereas the south-facing slopes are in grass. The soil on the steep south-facing slopes grades to the Gwin soils.



Runoff is rapid, and the hazard of erosion is high. This soil is suitable for grazing and forestry. Enough vegetation should be left on the soil to control erosion. (Capability unit VIIs-5; Forested Upland-Pine range site.)

**Klicker-Gwin-Rock land complex, 30 to 60 percent slopes (KrF).**-This mapping unit consists of areas of Klicker soils, Gwin soils, and basalt Rock land that were too small to map separately. From 25 to 50 percent of the mapping unit is Rock land; the rest is Klicker and Gwin soils.

Runoff is rapid, and the hazard of erosion is high. The Gwin soils and basalt Rock land areas have good stands of grass and are suitable for a limited amount of grazing. The areas of Klicker soils are brushy or forested. (Capability unit VIIs-4; range site, Shallow Upland, 18 to 24 inches precipitation.)

**Klicker-Gwin-Rock land complex, 60 percent and steeper slopes (KrG).**-This mapping unit is similar to Klicker-Gwin-Rock land complex, 30 to 60 percent slopes, except that the slopes are too steep for grazing and support little or no merchantable timber. (Capability unit VIIIs-1.)

## Made Land

**Made land (Ma).**-This is a land type that consists of artificially graded or filled areas. The two areas mapped in Walls Walla County were filled with material excavated from McNary Lake and the Snake River to build industrial sites and pumping stations. (Capability unit VIIIs-1.)

## Magallon Series

The Magallon series consists of well-drained and somewhat excessively drained soils that have developed from alluvium over glacial outwash. They occupy old terraces in the Snake River Canyon at an elevation of 800 to 1,000 feet above sea level. Most of the parent material came from basalt and loess; but a small amount came from granitic and sedimentary rocks. Where the outwash occurred as a thin layer over basalt bedrock, the Magallon soils are thinner than usual.

The Magallon soils have a brown surface layer and a pale-brown subsoil that is calcareous at a depth of about 3 feet. Coarse sand in the soil ranges from a trace to about half of the soil volume.

The Magallon soils are at lower elevations than the Ritzville soils which developed in deep, uniform loess. A good stand of beardless wheatgrass, Sandberg bluegrass, and sagebrush covers the Magallon soils. The annual rainfall ranges from 8 to 10 inches.

**Magallon very fine sandy loam, 0 to 15 percent slopes (MsC).**-This soil, in an area of grass about one-half mile southeast of the Magallon elevator, has the following profile:

- 0 to 6 inches, brown very fine sandy loam, dark brown when moist; weak, platy to weak, fine, granular structure; soft when dry, very friable when moist; many, fine, fibrous roots; neutral to mildly alkaline.
- 6 to 18 inches, brown very fine sandy loam, dark brown when moist; weak, coarse, blocky structure; soft when dry, very friable when moist; roots plentiful; moderately alkaline.

18 to 33 inches, pale-brown very fine sandy loam, brown when moist; massive or weak, prismatic structure; soft when dry, very friable when moist; about 10 percent of volume is coarse sand; roots plentiful; moderately alkaline.

33 to 38 inches, pale-brown gravelly sandy loam; massive; slightly hard when dry, friable when moist; few roots; moderately alkaline.

38 to 53 inches, pale-brown or grayish-brown fine sandy loam or sandy loam; massive; slightly hard when dry, friable when moist; few pebbles; few roots; calcareous and strongly alkaline.

53 inches +, irregularly stratified gravel, coarse sand, and silt, largely from basalt; lime in veins.

Some small areas have a silt loam surface layer. In these areas the soil has a larger percentage of silt than is typical for Magallon soils.

Magallon very fine sandy loam, 0 to 15 percent slopes, is deep, well drained, and moderately rapidly permeable. It is low in organic matter, moderate in fertility, and has a fair to good water-supplying capacity. Runoff is slow. The hazard of wind erosion is moderate to high.

Areas of this soil adjacent to the Ritzville soils are used for wheat in a winter wheat-summer fallow rotation. The yield of wheat is slightly less than that of the Ritzville soils. Areas still in native grass furnish good grazing for livestock. (Capability unit IIIe-3, dryland; range site, Deep Upland, 9 to 12 inches precipitation.)

**Magallon very fine sandy loam, 15 to 30 percent slopes (MsD).**-This soil has a profile similar to that of Magallon very fine sandy loam, 0 to 15 percent slopes, except that all horizons have slightly more sand and gravel.

Magallon very fine sandy loam, 15 to 30 percent slopes, occupies the strongly sloping remnants of old terraces in the canyon of the Snake River and in the canyons of tributary streams.

Runoff is medium but is no problem so long as there is a plant cover. Small areas adjacent to the Ritzville soils are used in a rotation of winter wheat and summer fallow. Areas still in native grasses are suitable for grazing. (Capability unit IIIe-3, dryland; range site, Deep Upland, 9 to 12 inches precipitation.)

**Magallon very fine sandy loam, 15 to 30 percent slopes, eroded (MsD2).**-This soil is similar to Magallon very fine sandy loam, 0 to 15 percent slopes, but it is steeper, contains a higher percentage of sand and gravel, and the sandy and gravelly subsoil is exposed by severe erosion.

Vegetation is sparse and provides little protection to the soil. Runoff is rapid, and the hazard of further erosion is high. Fertility is low, and the water supplying capacity is low to fair. Root penetration is moderately deep.

This soil needs a long period of improvement before it is suitable for wheat. After grass has been established, this soil produces good pasture. (Capability unit IVe-6, dryland; range site, Deep Upland, 9 to 12 inches precipitation.)

**Magallon very fine sandy loam, 30 to 60 percent slopes (MsF).**-This soil has formed in steep deposits of terrace material piled against the basalt walls of the Snake River Canyon. Its profile is similar to that of Magallon very fine sandy loam, 0 to 15 percent slopes, except that irregularly bedded sand and coarse gravel are at a depth of 1.5 to 30 inches. This material is 2 feet to

more than 100 feet thick. On north slopes, the surface layer is generally darker than on other slopes, and the stand of native bunchgrass is more vigorous.

This soil is somewhat excessively drained. Fertility is low, and the water-supplying capacity is fair. Root penetration is moderately deep. Runoff is rapid, and the hazard of erosion is high if the vegetation is destroyed. The soil is too steep and unstable for cultivation. (Capability unit VIe-2, dryland; range site, Deep Upland, 9 to 12 inches precipitation.)

**Magallon fine sandy loam, 0 to 15 percent slopes (MfC).**-This soil occupies high river terraces southwest of Magallon. The parent material was apparently coarser textured than that of Magallon very fine sandy loam, 0 to 15 percent slopes but not so coarse as that of the moderately deep Quincy soils that are underlain by coarse sand or gravel.

Magallon fine sandy loam, 0 to 15 percent slopes, has a grayish-brown surface layer and a slightly lighter colored subsoil. The subsoil is limy at a depth of 3 to 4 feet and is underlain by stratified gravel, coarse sand, and silt.

The precipitation on this soil is 8 to 9 inches a year and occurs mostly as light showers or as snowstorms from November through February. The soil is well drained and rapidly permeable. It is low to moderate in fertility and has a fair water-supplying capacity. Root penetration is moderately deep. Runoff is slow. The hazard of soil blowing is moderate.

Wheat yields are satisfactory when grassland is first broken, but those of succeeding crops gradually decrease. In years of low rainfall, there is seldom enough stubble produced to prevent wind erosion. This soil is suitable for perennial grasses, and for an occasional crop of grain if protected from wind erosion. If irrigate the soil should be very productive. (Capability unit IVe-1; Sandy Upland range site.)

**Magallon fine sandy loam, 15 to 30 percent slopes (MfD).**-This soil is steeper and generally shallower to very coarse material than Magallon fine sandy loam, 0 to 15 percent slopes. In addition, it usually has more pebbles and fragments of basalt throughout the profile. In some areas outcrops of rock are common.

Runoff is slow to medium, and the hazard of erosion is moderate to high. Suitable crops are winter wheat, rye, or grass. The soil is well suited to grass. (Capability unit IVe-1; Sandy upland range site.)

**Magallon fine sandy loam, 15 to 30 percent slopes, eroded (MfD2).**-This soil is similar to Magallon fine sandy loam, 15 to 30 percent slopes, except that it generally occurs on short, south-facing slopes. In addition, it has lost the cover of native plants and has been severely eroded, mainly by wind. The fine soil has been blown away, and the surface layer is now a thin gravelly or coarse sandy mulch, an inch or so in thickness.

This soil is low in fertility and water-supplying capacity. Runoff is medium. The hazard of further wind erosion is very high. This soil has only a small amount of vegetation and needs revegetation to protect and improve it. Where grass has been reestablished, the soil is suitable for grazing. (Capability unit VIe-1; Sandy Upland range site.)

**Magallon fine sandy loam, 30 to 45 percent slopes (MfE).**-This soil occurs on the steep remnants of old ter-

aces. It is somewhat excessively drained, and its water-supplying capacity is low to fair. Runoff is rapid, and the hazard of wind and water erosion is high. The soil is best suited to grazing. (Capability unit VIe-1; Sandy Upland range site.)

**Magallon rocky very fine sandy loam, basalt substratum, 0 to 30 percent slopes (MgD).**-This soil is similar to Magallon very fine sandy loam, 0 to 15 percent slopes, except that basalt bedrock is within 30 to 40 inches of the surface, and rock outcrops occupy as much as 25 percent of the surface. The boundary between very fine sandy loam or coarse silt loam and bedrock is abrupt, and the thickness of the soil varies considerably within a short distance. This soil is low to moderate in fertility and low to fair in water-supplying capacity.

In most places this soil is too rocky and shallow for tillage, but small areas can be tilled in preparation for the reseeding of grass. There is little runoff so long as the vegetation is in good condition. This soil is best suited to grazing. (Capability unit VIIs-3; range site, Shallow Upland, 9 to 12 inches precipitation.)

**Magallon rocky very fine sandy loam, basalt substratum, 30 to 60 percent slopes (MgF).**-This soil is steeper and generally shallower to bedrock than Magallon rocky very fine sandy loam, basalt substratum, 0 to 30 percent slopes. It is low in fertility and water-supplying capacity. Runoff is rapid where vegetation is depleted. The hazard of wind erosion is high. A large part of the annual growth of native forage plants must be left on the ground to control erosion. (Capability unit VIIs-3; range site, Shallow Upland, 9 to 12 inches precipitation.)

**Magallon very rocky very fine sandy loam, 0 to 30 percent slopes (MvD).**-This soil is too rocky for tillage. Rock outcrops are roughly 30 to 100 feet apart, and they cover about 25 percent of the surface. The depth to underlying rock is variable; it ranges from a few inches to 6 feet.

The soil is low in fertility and water-supplying capacity. Runoff is medium, and the hazard of erosion is high. The soil is all in native grass and is used for grazing, its only suitable use. (Capability unit VIIs-3; range site, Shallow Upland, 9 to 12 inches precipitation.)

**Magallon very rocky very fine sandy loam, 30 to 60 percent slopes (MvF).**-This soil is steeper than Magallon very rocky very fine sandy loam, 0 to 30 percent slopes but it is otherwise similar. Runoff is rapid. The soil is all in native grass and is used for grazing. Its only suitable use is for grazing. (Capability unit VIIs-3; range site, Shallow Upland, 9 to 12 inches precipitation.)

## Onyx Series

The Onyx series consists of deep, well-drained, medium-textured soils that formed in alluvium. The parent material washed mainly from adjacent dark-colored soils that had formed in loess on the uplands. Recent accumulations of silt, as much as 2 feet thick, are common on the surface. The soils have little profile development, but they may be stratified. They are typically noncalcareous. Precipitation is about 12 to 15 inches per year.

The native vegetation was probably bluebunch wheatgrass, Idaho fescue, and giant wildrye. Willow and

cottonwood grew along the streams. Only one soil of the Onyx series was mapped in Walla Walla County.

**Onyx silt loam, 0 to 3 percent slopes (OnA).**-Large areas of this soil occur along Spring Creek, Dry Creek, and the Touchet River; a small acreage occurs along the minor streams. Much of this soil is near the high water line and may be flooded for a few days every 10 or 15 years.

Profile in a cultivated field in Spring Valley about one-half mile east of Hadley Station

0 to 9 inches, brown silt loam, dark brown when moist; very fine, granular structure; soft when dry, very friable when moist; neutral.

9 to 28 inches, brown silt loam, dark brown when moist; massive; soft when dry, very friable when moist; generally in layers that are from one to several inches in thickness; neutral.

28 to 60 inches +, pale-brown silt loam, brown when moist; massive; soft when dry, very friable when moist; lenses of coarse-textured material; strongly stratified; mildly alkaline.

The material below 6 feet may be gravel, loess, or basalt rock.

This soil is deep, well drained, and moderately permeable. It is high in fertility and very high in water-supplying capacity. Runoff is very slow, and the hazard of erosion is slight.

Nearly all of this soil is cultivated. The low rainfall restricts slightly the kinds of crops that can be grown by dryland methods. Excellent crops, particularly of alfalfa, sugar beets sweet corn, and onions, are grown under irrigation. Capability unit IIc-1, dryland; capability unit I1, irrigated; range site, Bottomland, 12 to 23 inches precipitation.)

## Palouse Series

The Palouse series consists of dark-colored, well-drained, medium-textured soils that have developed in loess on gently sloping to steep ridges. The loess covers the long basalt ridges that extend north and west of the Blue Mountains. In this county, the Palouse soils formed at elevations of 2,000 to 3,500 feet above sea level and under 19 to 24 inches of precipitation per year.

The Palouse soils characteristically are dark grayish-brown to dark-gray (very dark brown to black when moist) silt loams. The percentage of clay is slightly higher in the subsoil than in the surface layer. Thin films of clay have accumulated in the pores and on the larger soil aggregates. The soil profile has been leached of lime. It is slightly acid to neutral.

The native vegetation on these soils was bluebunch wheatgrass, Idaho fescue, prairie junegrass, big bluegrass, balsamroot, yarrow, rose, and snowberry. All but the very steepest slopes are cultivated. Wheat is the principal crop. Barley and green peas for canning and freezing are also grown.

**Palouse silt loam, 0 to 8 percent slopes (PaB).**-This soil occupies broad, gently sloping ridgetops.

Profile in a cultivated field at the top of the Scenic Loop Grade

0 to 8 inches, dark grayish-brown to dark-gray silt loam, very dark brown to black when moist; granular structure; slightly hard when dry, friable when moist, slightly sticky when wet; slightly acid.

8 to 13 inches, dark-gray silt loam, very dark brown when moist; granular structure; hard when dry, friable when moist, slightly sticky when wet; slightly acid.

13 to 32 inches, dark grayish-brown silt loam, very dark brown when moist; prismatic structure; hard when dry, friable to firm when moist; thin gray coatings of silt and clay on the surfaces of aggregates in the lower part of horizon; neutral.

32 to 40 inches, brown silt loam, dark brown when moist; prismatic structure; hard to very hard when dry, firm when moist, sticky and plastic when wet; thin to moderate clay films in pores and on prisms; coating of gray silt on the vertical faces of prisms; neutral.

40 to 48 inches, pale-brown silt loam, dark brown when moist; subangular blocky structure; patchy clay films on blocky surfaces; neutral.

48 to 60 inches, light yellowish-brown silt loam, dark yellowish brown when moist; subangular blocky structure; hard when dry, friable when moist; neutral.

This is one of the more productive soils in the county. It is deep, well drained, and moderately permeable, and it is high in fertility and water-supplying capacity. After 50 to 60 years of cropping, which included fallowing in summer and burning of stubble, the soil still contains 3 to 4 percent of organic matter. Runoff is slow, and the hazard of erosion is slight. Rough tillage and the utilization of stubble and green-manure crops are needed to control erosion. (Capability unit IIe-2 ; range site, Deep Upland, 16 to 24 inches precipitation.)

**Palouse silt loam, 8 to 30 percent slopes (PaD).**-This soil is steeper and generally has a thinner surface layer than Palouse silt loam, 0 to 8 percent slopes. On north-facing slopes, the surface layer is thicker and darker than on south-facing slopes. Runoff is medium and the hazard of erosion is moderate. Stubble utilization, rough tillage, farming across the slope or along the contour, stripcropping, and frequent use of soil-building crops are needed to control erosion. (Capability unit IIIe-4; range site, Deep Upland, 16 to 24 inches precipitation.)

**Palouse silt loam, 8 to 30 percent slopes, eroded (PaD2).**-This is the most extensive Palouse soil in the county: It is similar to Palouse silt loam, 0 to 8 percent slopes, but is moderately eroded and steeper. Although part of the dark-colored surface layer has been lost through erosion, enough remains to produce good crops. The lighter colored subsoil is occasionally brought to the surface by plowing. The soil is moderately fertile and moderate in water-supplying capacity. Runoff is medium to rapid, and the hazard of further erosion is moderately high.

Erosion is most severe early in spring when the snow melts. Losses of soil are greatest in fields of winter wheat that have been worked into a dust mulch the previous summer. Yields of crops are high, but they decline rapidly after subsoil is mixed with surface soil by plowing. The use of soil-improving crops and other intensive practices are needed to control erosion. (Capability unit practices range site, Deep Upland, 16 to 24 inches precipitation.)

**Palouse silt loam, 30 to 45 percent slopes (PaE).**-This soil has a profile similar to that of Palouse silt loam, 0 to 8 percent slopes, except that the surface layer varies in thickness from a few inches to several feet. The surface layer is thinner on the narrow ridges and points and thickest in the crescent-shaped coves at the heads of small canyons. The soil occurs mainly on irregular and broken north-facing slopes.

Rose, ocean-spray, snowberry, chokecherry, and thornbrush originally grew in the coves; bluebunch wheatgrass and Idaho fescue were the main plants on the ridges.

This soil is somewhat excessively drained. Its water-supplying capacity is high. Runoff is rapid, and the hazard of erosion is high. "Snowbank" erosion and soil slips cause considerable loss of soil.

The soil is best suited to hay and pasture. It is not suitable for peas. Grain may be grown if the soil is carefully managed. (Capability unit IVe-3; range site, Deep Upland, 16 to 24 inches precipitation.)

**Palouse silt loam, 45 to 60 percent slopes (PaF).**-This soil occurs on steep north-facing slopes. It has a profile similar to that of Palouse silt loam, 0 to 8 percent slopes. Included are a few shallow spots and rock outcrops.

The soil is somewhat excessively drained. It is moderately fertile and has a moderate to high water-supplying capacity. Runoff is very rapid, and the hazard of erosion is very high.

Very little of this soil is cultivated. Shrubs make up a large part of the native vegetation. When the desirable forage plants are overgrazed, shrubby invaders take over and may become too dense to permit grazing. (Capability unit VIe-4; range site, Deep Upland, 16 to 24 inches precipitation.)

**Palouse silt loam, moderately deep, 0 to 8 percent slopes (PbB).**-This soil occurs on the lower slopes of the Blue Mountains, at an elevation of 2,700 to 3,500 feet above sea level. It is 20 to 48 inches thick over basalt. Its profile is similar to that of the deep Palouse soils except that it is not so thick and contains some small fragments of basalt.

Profile in grassland along the Pikes Peak Road in NE1/4NW1/4 sec. 16, T. 6 N., R. 37 E., of the Willamette meridian:

0 to 3 inches, dark grayish-brown silt loam, very dark brown to black when moist; platy structure; slightly hard when dry, friable when moist; mat of fibrous roots; neutral.

3 to 10 inches, similar to horizon above, except that it has prismatic structure and contains fewer roots.

10 to 30 inches, dark grayish-brown silt loam; prismatic to subangular blocky structure; hard when dry, friable to firm when moist, sticky and plastic when wet; patchy to continuous clay films on the large aggregates.

30 to 41 inches, color and texture same as horizon above; dark-colored deposits of organic material in pores, and on the faces of prisms; few roots.

41 inches +, dark-colored basalt, usually fractured to a depth of 18 to 24 inches from upper boundary; roots extend into the fractures.

The soil is well drained and moderately permeable. Roots penetrate to bedrock. The water-supplying capacity is high, and fertility is moderate to high. Runoff is slow. The hazard of erosion is slight. In places the soil is too shallow to hold the moisture from melting snow. Simple practices are needed to control erosion. Soil-building crops should be grown about one-fourth of the time in the rotation. (Capability unit IIe-3; range site, Moderately Deep Upland, 18 to 24 inches precipitation.)

**Palouse silt loam, moderately deep, 8 to 30 percent slopes (PbD).**-This soil is similar to Palouse silt loam, moderately deep, 0 to 8 percent slopes, but it is steeper and has a slightly thinner profile and a slightly lighter colored surface layer. It is generally on south-facing slopes. It is moderately fertile and has a good water-

supplying capacity. Runoff is medium, and the hazard of erosion is moderate. Wheat and peas can be grown if the soil is carefully managed. (Capability unit IIIe-5; range site, Moderately Deep Upland, 18 to 24 inches precipitation.)

**Palouse silt loam, moderately deep, 8 to 30 percent slopes, eroded (PbD2).**-This soil is similar to Palouse silt loam, 0 to 8 percent slopes, but it is shallower to bedrock because the surface soil has been eroded. Subsoil is occasionally brought to the surface by plowing. The soil has a fair water-supplying capacity and is low to moderate in fertility. Runoff is medium to rapid, and the hazard of additional erosion is moderate to high. Melting snow and spring rains are generally more than enough to fill the soil with water. Runoff then occurs. There is a shortage of moisture in summer, and yields of crops are reduced. The soil is suitable for a year each of wheat and peas if a mixture of grass and alfalfa is grown for several years. (Capability unit IVe-2; range site, Moderately Deep Upland, 18 to 24 inches precipitation.)

**Palouse silt loam, moderately deep, 30 to 45 percent slopes (PbE).**-This soil is on north- or northwest-facing slopes. It is similar to Palouse silt loam, moderately deep, 0 to 8 percent slopes, except for slopes. Its depth varies from 20 inches to 6 feet within a short distance. A few outcrops of rock are included. The areas of deep soil are in brushy coves.

This soil is somewhat excessively drained. It has a good water-supplying capacity. Runoff is rapid, and the hazard of erosion is high. Cultivated areas are small. The soil is suitable for a year of wheat if grass is grown 4 or 5 years. Many fields have been seeded to grass for livestock grazing. (Capability unit VIe-5; range site, Moderately Deep Upland, 18 to 24 inches precipitation.)

**Palouse silt loam, moderately deep, 30 to 45 percent slopes, eroded (PbE2).**-This soil is like Palouse silt loam, moderately deep, 30 to 45 percent slopes, except that it is eroded. Over most of the area, the subsoil is exposed, and in some areas, rock is exposed.

The soil is low to moderate in fertility and fair in water-supplying capacity. It is suitable for a limited amount of grazing, but several years are required to establish grass. (Capability unit VIe-5; range site, Moderately Deep Upland, 18 to 24 inches precipitation.)

**Palouse silt loam, moderately deep, 45 to 60 percent slopes (PbF).**-This soil is more variable in depth than, Palouse silt loam., moderately deep, 30 to 45 percent slopes. In addition, outcrops of rock are more numerous. The soil grades to the Kicker soils, but it is mapped with the Palouse soils because it is dark colored, nearly free of rocks, and has formed under grass. Runoff is very rapid, and the hazard of erosion is very high. The soil is too steep for cultivation but is suitable for a limited amount of grazing. (Capability unit VIe-5; range site, Moderately Deep Upland 18 to 24 inches precipitation.)

**Palouse silt loam, moderately deep, 45 to 60 percent slopes, eroded (PbF2).**-This soil is similar to Palouse silt loam, moderately deep, 45 to 60 percent slopes, except that most of the surface layer has been lost through erosion. The yield of forage is now too low to allow grazing. When grass is reestablished, a limited amount of grazing may be available. (Capability unit VIe-5; range site, Moderately Deep Upland, 18 to 24 inches precipitation.)

## Patit Creek Series

The Patit Creek series consists of dark-colored, well-drained soils that formed in alluvium washed from loess and weathered basalt. The Patit Creek soils are silt loam or cobbly silt loam and are underlain by loose pebbles and cobbles. They occur along major streams in the foothills of the Blue Mountains at an elevation of 1,400 feet or more above sea level.

The plant cover consists of cottonwood, birch, alder, and a few Douglas-firs or ponderosa pines along the streams. Bluebunch wheatgrass and Idaho fescue are on the wide stream bottoms.

**Patit Creek silt loam, 0 to 3 percent slopes (PkA).**-This soil has the following profile in a small pasture along Mill Creek at the Seven Mile Road in SW1/4SE1/4 sec. 16, T. 7 N., R. 37 E., of the Willamette meridian:

- 0 to 4 inches, dark grayish-brown silt loam, very dark brown when moist; granular structure; friable when moist; many, fine, fibrous roots; neutral to mildly alkaline.
- 4 to 10 inches, similar to horizon above but has massive or weak, prismatic structure.
- 10 to 30 inches, very dark grayish-brown silt loam; massive; friable when moist; few pebbles of basalt; neutral.
- 30 inches +, lose gravel and cobbles.

The range in depth of gravel is 2 to 6 feet.

This soil is well drained. It is moderately permeable and has a fair water-supplying capacity. Roots penetrate to the pebbles and cobbles. Runoff is very slow. The hazard of erosion is slight. If irrigated, the soil is well suited to all the crops grown in the area. It is used mainly for strawberries and garden vegetables. Crops respond well to fertilizer. (Capability unit IIc-1, dryland; capability unit IIs-3, irrigated; range site, Bottomland, 12 to 23 inches precipitation.)

**Patit Creek cobbly silt loam, 0 to 3 percent slopes (PcA).**-This soil is slightly lighter colored and is shallower to the layer of clean pebbles and sand than Patit Creek silt loam, 0 to 3 percent slopes. Otherwise the two soils are similar. This soil contains rounded basalt stones, 10 to 30 inches in diameter, in amounts that interfere with cultivation.

The vegetation is an open stand of ponderosa pine with an understory of bunchgrass. Cottonwood grows along the streams. The soil is moderately rapidly permeable and has a low water-supplying capacity. Where the soil has been cleared, irrigated, and seeded to grass, good pasture is available. (Capability unit VIc-3, dryland; capability unit IVs,-1, irrigated; range site, Bottomland, 12 to 23 inches precipitation.)

## Pedigo Series

The Pedigo series consists of dark-colored, imperfectly drained, medium-textured soils formed in recent alluvium that washed from the uplands. These soils occur along Dry Creek and the Walla Walla River. They characteristically have a uniform profile of silt loam that is calcareous, slightly saline, and moderately to strongly alkaline.

In saline areas the vegetation is mainly giant wildrye and saltgrass, in the wet spots it is alkali bluegrass, and in the dry, fringe, areas it is bluebunch wheatgrass.

The soils are well suited to hay and pasture. Drainage is usually necessary if the soils are to be used for grains and sugar beets.

**Pedigo silt loam, 0 to 3 percent slopes (PmA).**-This soil is widely distributed in valleys of the Walla Walla River and Dry Creek. A large part of it is cultivated.

Profile in a cultivated field just west of the Whitman Monument in the NE1/4SE1/4 sec. 32, T. 7 N., R. 35 E., of the Willamette meridian.

- 0 to 8 inches, dark-gray silt loam, very dark brown when moist; granular structure; slightly hard when dry, firm when moist, slightly sticky and slightly plastic when wet; many, fine roots; strongly alkaline; calcareous.
- 8 to 15 inches, similar to horizon above but has massive to granular structure.
- 15 to 34 inches, grayish-brown silt loam, very dark grayish brown when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few roots; strongly alkaline; calcareous.
- 34 inches +, pale-brown silty clay loam, very dark grayish brown when moist; few, fine mottles of yellowish red; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; moderately alkaline; noncalcareous.

This soil is imperfectly drained. In many places the water table is near the surface during part of the growing season. The soil is moderately permeable and drains easily. Runoff is slow. There is little or no hazard of erosion. The soil is moderately fertile and has a high water-supplying capacity.

Where the soil is adequately drained and water is available for irrigation, the soil produces good yields of alfalfa and sugar beets. Applications of nitrogen and phosphate fertilizers improve yields. (Capability unit IIw-1, dryland; capability unit IIw-1, irrigated; Alkali Bottomland range site.)

**Pedigo silt loam, overwashed, 0 to 3 percent slopes (PoA).**-This soil has a slightly lighter colored surface layer than Pedigo silt loam, 0 to 3 percent slopes. The lighter color is caused by recent deposits of grayish-brown silt, 6 to 24 inches thick, over the dark-colored surface soil. Drainage is moderately good because many streams in the area have deepened their channels. Consequently, the water table is well below the root zone of most crops now grown. Good crops are grown with and without irrigation. Applications of nitrogen fertilizer improve crop yields. (Capability unit IIc-1, dryland; capability unit I-1, irrigated; Alkali Bottomland range site.)

## Quincy Series

The Quincy series consists of excessively drained and somewhat excessively drained, coarse-textured soils derived from reworked eolian sand. The parent materials are mainly granitic and basaltic sand. Quincy soils are characteristically grayish-brown, loose loamy fine sand or fine sand with light brownish-gray subsoil.

The Quincy soils are on broad, gently sloping terraces and river bars along the Snake and Columbia Rivers. The rainfall is 6 to 9 inches per year.

The less severely eroded areas of Quincy soils have a cover of bunchgrasses, consisting mainly of Indian ricegrass, needle-and-thread, and beardless wheatgrass. Thickspike wheatgrass and bitterbrush grow on some of the dunes. The hazard of wind erosion is high to very high on the Quincy soils.

**Quincy loamy fine sand, 0 to 8 percent slopes, eroded (QuB2).**-This soil occurs on fairly uniform, gently sloping terraces. It is on less hummocky topography than the Quincy fine sands and has more of the original plant

cover. Natural drainageways on this soil are occasionally obstructed by small active dunes.

Profile in a heavily grazed area one-fourth mile south of Wallula

0 to 3 inches, grayish-brown loamy fine sand, very dark grayish brown when moist; single grained; few, fine, grass roots; mildly alkaline.

3 to 38 inches, similar to the horizon above but has fewer roots; moderately alkaline.

38 to 70 inches +, light brownish-gray fine sand; single grained; loose; moderately alkaline weakly calcareous.

Most of the dark color is caused by grains of basalt.

This soil is very rapidly permeable. It is very low in fertility and low in water-supplying capacity. Roots readily penetrate the soil. The hazard of wind erosion is high. The soil is somewhat excessively drained. It is too droughty for dryland farming, but it should produce good alfalfa hay and pasture when irrigated and fertilized. (Capability unit VIIe-1, dryland; capability unit IVe-13, irrigated; Sand range site.)

**Quincy loamy fine sand, 8 to 15 percent slopes, eroded (QuC2).**-This soil is like Quincy loamy fine sand, 0 to 8 percent slopes, eroded, except that it occurs on short slopes at the heads of small draws and on the north-facing slopes of small canyons. The erosion hazard is high if irrigation water is carelessly used or if livestock tramples the soil. (Capability unit VIIe-1, dryland; capability unit IVe-13, irrigated; Sand range site.)

**Quincy fine sand, 0 to 30 percent slopes, eroded (QfD2).**-This soil is readily identified by its rough billowy to dunelike topography. It has apparently been worked by wind more than the Quincy loamy fine sands.

Profile in a ridge of sand on the north side of road in NW1/4SW1/4 sec. 24, T. 9 N., R. 33 E., of the Willamette meridian:

0 to 8 inches, brown fine sand, very dark grayish brown when moist; single grained; loose; few fibrous roots of annual grasses; mildly alkaline.

8 inches +, color and texture similar to layer above; very few roots; neutral reaction.

A layer of lime is present in some places, but it does not occur in dunes or in places that have recently been worked by wind.

This soil is very low in fertility and water-supplying capacity. It is rapidly permeable and is excessively drained. The hazard of further wind erosion is very high.

The soil is too droughty for dryland farming, and it is marginal for irrigation because the content of silt, clay, and organic matter is low. It is suitable for a limited amount of grazing if enough plant growth is left on the soil to control wind erosion. (Capability unit VIIe-1, dryland; capability unit VIe-9, irrigated; Sand range site.)

**Quincy fine sand, 30 to 60 percent slopes, eroded (QfF2).**-This soil consists of recently stabilized sand dunes. The forage produced is barely enough to keep the sand from blowing. Grazing is not advisable. (Capability unit VIIIe-1.)

**Quincy complex, 0 to 8 percent slopes, eroded (QcB2).**-This mapping unit consists of areas of Quincy fine sand; Quincy loamy fine sand, moderately deep over coarse sand; and Quincy loamy fine sand, moderately deep over gravel. These components could not be mapped separately, but each is described under the Quincy series.

Wind erosion is the chief problem in the use of these soils. They are too droughty for dryland farming, and, at best, they are marginal for irrigation. (Capability unit VIIe-1, dryland; capability unit VIe-9, irrigated; Sand range site.)

**Quincy-Duneland complex (Qd).**-This mapping unit consists of blowouts, small dunes, and areas of severely eroded Quincy soils. The vegetation is too sparse to control erosion, so grazing is not advisable. The spread of blowing sand to other areas should be controlled. (Capability unit VIIIe-1.)

**Quincy loamy fine sand, moderately deep over coarse sand, 0 to 8 percent slopes, eroded (QmB2).**-This soil is similar to Quincy loamy fine sand, 0 to 8 percent slopes, eroded, except that below a depth of 3 to 4 feet, it is underlain by a thick layer of dark, coarse basaltic sand. It occurs in widely scattered areas on terraces of the Columbia and Snake Rivers, from Attalia to about 6 miles west of Eureka.

Profile in a cultivated field in the E 1/2 sec. 20, T. 9 N., R. 32 E., of the Willamette meridian:

0 to 5 inches, brown loamy fine sand, dark brown when moist; loose; many fibrous roots of annual plants; mildly alkaline.

5 to 31 inches, brown loamy fine sand; massive; few roots; low in organic matter; moderately alkaline.

31 to 34 inches, similar to horizon above but is calcareous and strongly alkaline; abrupt boundary.

34 inches +, dark-gray to almost black, coarse basaltic sand; calcareous and strongly alkaline.

In places the upper 3 or 4 inches of the coarse sand contains a few coarse pebbles or small cobbles. Moisture does not move into the coarse sand until there is enough for downward flow by gravity. Free water was observed early in spring in the layer above the coarse sand, 150 days after the last irrigation, which was made the previous October. In an adjacent nonirrigated field, the loamy fine sand was dry at a depth of 18 inches. This moisture characteristic of the soil should be considered when designing irrigation systems.

Wind erosion is a problem on this soil unless there is enough plant cover to control it. For best results under irrigation, the soil should be given liberal applications of commercial fertilizer. (Capability unit VIIe-1, dryland; capability unit IVs-2, irrigated; Sand range site.)

**Quincy loamy fine sand, moderately deep over coarse sand, 8 to 15 percent slopes, eroded (QmC2).** This soil is steeper than Quincy loamy fine sand, moderately deep over coarse sand, 0 to 8 percent slopes. In addition, it has a slightly thinner layer of loamy fine sand over the coarse sand, and it may also contain a few more coarse pebbles in the top part of the coarse sand.

The hazard of erosion from irrigation is very high. (Capability unit VIIe-1, dryland; capability unit IVs-2, irrigated; Sand range site.)

**Quincy loamy fine sand, moderately deep over coarse sand, 15 to 30 percent slopes, eroded (QmD2).**-This soil is on terrace fronts or on the sides of large draws that have formed in the terraces. It may be somewhat stony. Coarse sand is seldom more than half as deep from the surface as in Quincy loamy fine sand, moderately deep over coarse sand, 0 to 8 percent slopes, eroded.

Irrigation is necessary for the production of crops. Properly designed sprinkler systems must be used for ir-

rigation, as the soil is not suitable for the use of surface distribution systems.

The hazard of wind erosion is very high, especially on south- or southwest-facing slopes. The soil is suitable for a limited amount of grazing. (Capability unit VIIe-1, dryland; capability unit VIe-9, irrigated; Sand range site.)

**Quincy loamy fine sand, moderately deep over gravel, 0 to 8 percent slopes, eroded (QnB2).**-This soil joins Quincy loamy fine sand, moderately deep over coarse sand, 0 to 8 percent slopes, eroded, and is similar to it except that it contains many cobbles and large stones and is underlain by gravel.

Profile in an abandoned field across the road from and south of the Burbank Cemetery

0 to 4 inches, pale-brown loamy fine sand, brown when moist; single grained; loose; many roots; mildly alkaline.

4 to 21 inches, grayish-brown loamy fine sand, dark grayish-brown when moist; single grained; loose; many roots; moderately alkaline.

21 to 26 inches, pale-brown loamy fine sand, brown when moist; massive; soft when dry, very friable when moist; strongly alkaline; weakly calcareous.

26 inches +, rounded pebbles and cobbles intermittently cemented with lime.

The depth to gravel ranges from 15 to 40 inches. Scattered boulders, just under the surface of the soil, damage tillage equipment and make difficult the construction of ditches and the laying of irrigation pipe.

The soil is very low in organic matter, in fertility, and in water-supplying capacity. Runoff is very slow and internal drainage is very rapid. The hazard of water erosion is slight, but that of wind erosion is high if the soil is not covered by vegetation. There is little if any aggregation of soil particles.

The soil is suitable for grazing, if enough plant cover is left to control erosion. Irrigation is necessary for the production of crops. Lenses of cemented pebbles restrict the deep percolation of excess irrigation water. (Capability unit VIIe-1, dryland; capability unit IVs-2, irrigated; Sand range site.)

**Quincy loamy fine sand, moderately deep over gravel, 8 to 15 percent slopes, eroded (QnC2).**-This soil occurs on the sloping faces of terraces or on the sides of small draws that have formed in the terraces. It is shallower to gravel than Quincy loamy fine sand, moderately deep over gravel, 0 to 8 percent slopes, eroded. In addition, it contains as much as twice as many boulders.

The hazard of wind erosion is very high. The moisture-supplying capacity of the soil is too low for dryland farming. For good yields, crops require irrigation at short intervals because the soil is shallow. (Capability unit VIIe-1, dryland; capability unit IVs-2, irrigated; Sand range site.)

**Quincy loamy fine sand, moderately deep over gravel, 15 to 30 percent slopes, eroded (QnD2).**-This soil occupies the fronts of terraces. In places the underlying gravel is exposed on the surface or is mixed with the sandy mantle of soil.

This soil is low in water-supplying capacity. Crops require irrigation. The hazard of erosion is too high to allow the surface application of large amounts of irrigation water. Sprinkler systems that allow water to be applied to soil frequently and in small amounts should be

used. (Capability unit VIIe-1, dryland; capability unit VIe-9, irrigated; Sand range site.)

## Ritzville Series

The Ritzville series consists of well-drained or somewhat excessively drained, uniformly textured silt loams or very fine sandy loams. Free lime is 30 to 36 inches below the surface. The soils have formed in loess on gently sloping to steep uplands, at elevations of 900 to 1,400 feet above sea level. Rainfall is 10 to 12 inches per year. The main native vegetation was bluebunch wheatgrass and Sandberg bluegrass.

The Ritzville soils occupy a wide belt extending from Eureka east to within a few miles of Prescott, and from Dry Creek north to the Snake River. Nearly all Ritzville soils are farmed in a winter wheat-summer fallow cropping system.

**Ritzville silt loam, 0 to 8 percent slopes (RIB).**-This soil comprises about 20 percent of the total acreage of Ritzville soils in Walla Walla County. It is the main soil on the Eureka Flats, and many small areas of it are on gently sloping ridgetops scattered throughout the area in which Ritzville soils were mapped.

Profile in a cultivated field on a ridgetop:

0 to 8 inches, grayish-brown silt loam, very dark grayish brown when moist; granular structure; soft to slightly hard when dry, very friable when moist; neutral.

8 to 14 inches, brown silt loam, dark brown when moist; massive to prismatic structure; soft when dry, very friable when moist; neutral.

14 to 36 inches, pale-brown silt loam, dark grayish brown when moist; massive to prismatic structure; soft when dry, very friable when moist; neutral to mildly alkaline.

36 to 60 inches +, pale-brown to light-gray silt loam, brown to grayish brown when moist; massive to prismatic structure; soft when dry, very friable when moist; calcareous; lime in veins, seams, and nodules; moderately to strongly alkaline.

This soil is deep, well drained, and moderately permeable. It is moderate to high in fertility and has a good water-supplying capacity. There is little runoff except from frozen ground or from fields that have been cultivated to a dust mulch. The hazard of wind erosion is moderate.

The content of organic matter in cultivated fields ranges from 1.0 to 1.3 percent. The utilization of wheat stubble and the use of nitrogen fertilizer are needed for high yields of crops. Climatic conditions limit the use of this soil to a winter wheat-summer fallow cropping system. (Capability unit IIIc-1, dryland; capability unit IIe-5, irrigated; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville silt loam, 8 to 30 percent slopes (RID).**-This is the most extensive Ritzville soil in the county. It has about the same profile as Ritzville silt loam, 0 to 8 percent slopes, except that on the south-facing slopes the depth to lime might be slightly less, and on north-facing slopes, slightly more. The surface layer on north-facing slopes tends to be slightly darker colored than elsewhere.

Runoff is medium, and the hazard of water erosion is moderate to high in the winter and spring following summer fallow. Crops grown following summer fallow should provide a good stubble that will help to control erosion and to maintain a granular structure in the soil.

Nitrogen fertilizer is needed to produce good yields of wheat. Some areas should be tilled across the slope or stripcropped to protect the soil. Long-term rotations that include perennial grasses should be used on steep slopes. (Capability unit IIe-3, dryland; capability unit irrigated: IVE-14 for 8 to 15 percent slopes, and VIe-8 for 15 to 30 percent slopes; range site, Deep Upland, 9, to 12 inches precipitation.)

**Ritzville silt loam, 8 to 30 percent slopes eroded (RID2).**-This soil was originally like Ritzville silt loam, 8 to 30 percent slopes, but most of the surface layer has been lost through erosion. The plow layer is now a mixture of surface soil and subsoil. Lime occurs on or near the surface.

The soil is low in fertility and fair in water-supplying capacity. The hazard of further erosion is high. Wheat yields are low. To maintain and protect the soil, operators should use a cropping system that includes perennial grasses part of the time. Nitrogen fertilizer is needed to obtain a good stand of grass. (Capability unit IVE-6; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville silt loam, 30 to 45 percent slopes (R1E).**-This soil occurs on the steep, southeast-facing slopes of long ridges in the northern part of the county. It has a profile similar to that of Ritzville silt loam, 0 to 8 percent slopes, except that it contains slightly more very fine sand and less fine silt and clay. Wind has caused a moderate amount of erosion. Many spots of volcanic ash are included with this soil.

The soil is moderately fertile. Runoff is medium to rapid, and the hazard of water erosion is moderate to high. The soil is particularly susceptible to erosion in winter and early in spring. Intensive erosion control should be practiced. Cropping systems that include perennial grasses most of the time are desirable. (Capability unit IVE-8; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville silt loam, 30 to 45 percent slopes, eroded (R1E2).**-This soil occurs mainly on south-facing slopes. The combined thickness of the dark-colored surface soil and the noncalcareous subsoil was originally less than that in Ritzville silt loam, 0 to 8 percent slopes. However, the soil was deep enough to support a good stand of bunchgrasses and to produce high yields of wheat. Nearly all the surface soil has now been lost through erosion. In many places, the limy substratum has been mixed in tillage with the plow layer.

The soil is low in fertility and fair in water-supplying capacity. The hazard of further erosion is high. Yields of wheat and grass are low. Grass should be planted to improve the soil and grazing discontinued until erosion is controlled. (Capability unit VIe-2; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville silt loam, 45 to 60 percent slopes (R1F).**-This soil occurs on north-facing slopes. It has a profile similar to that of Ritzville silt loam 0 to 8 percent slopes, except that the surface layer is slightly darker and the depth to lime and basalt is variable in many places.

This soil is somewhat excessively drained. Runoff is rapid, and the hazard of erosion is high. There is very little loss of soil so long as there is a cover of the native vegetation. The soil can produce high yields of forage. Most areas are not cultivated, and the native vegetation is in good condition. In places the vegetation has been

burned or too heavily grazed. (Capability unit VIe-2; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville silt loam, 45 to 60 percent slopes, eroded (R1F2).**-This soil occurs around stock watering places, in corrals, and in driveways. It was originally the same as Ritzville silt loam, 45 to 60 percent slopes, but most of the surface soil has been lost through erosion.

The soil is low in fertility and fair in water-supplying capacity. The hazard of further erosion is very high. Present yields of forage are low but can be increased if the better forage plants are given a chance to reestablish themselves. Grassland in need of revegetation should not be grazed for several years. (Capability unit VIIe-2; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville silt loam, 60 percent and steeper slopes**

**(R1G).**-This soil is on very steep north-facing slopes. It consists of 12 to 14 inches of grayish-brown silt loam over lighter colored subsoil. Rock outcrops are common, and in places the soil above the underlying basalt is free of lime.

The soil is deep, moderately permeable, and somewhat excessively drained. It is moderately fertile and good in water-supplying capacity. Runoff is very rapid, and the erosion hazard is very high. The soil is too steep for cultivation but is suitable for a limited amount of grazing. (Capability unit VIIIe-2; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville silt loam, moderately deep, 8 to 30 percent slopes (RmD).**-This soil occurs in small areas between Ritzville silt loam on the ridgetops and Starbuck rocky silt loam or Basalt rock land on the lower and generally steeper slopes. The thickness of soil to basalt ranges from 14 to 36 inches. Runoff is medium. The hazard of wind and water erosion is moderate. Crop yields are low. (Capability unit IIIe-6; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville silt loam, moderately deep, 30 to 45 percent slopes (RmE).**-On south-facing slopes, this soil has bedrock nearer the surface than elsewhere; on north-facing slopes, it has a darker surface layer. A few outcrops of rock are included.

Runoff is medium to rapid, and the hazard of erosion is high late in winter or early in spring. Fields not protected by growing plants or by the residue of plants are susceptible to erosion. The soil can be used for an occasional crop of grain, but its best use is for range. (Capability unit IVE-8; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville very fine sandy loam, 0 to 8 percent slopes (RtB).**-This soil makes up about one-third of the total acreage of the Ritzville very fine sandy loams in the county. It occurs in the transition area between the Adkins fine sandy loams and the Ritzville silt loams. Ritzville very fine sandy loam, 0 to 8 percent slopes, contains more fine sand and less silt and clay than the Ritzville silt loams. Consequently, it is more susceptible to wind erosion. Some areas mapped as Ritzville very fine sandy loam, 0 to 8 percent slopes, appear to be the result of wind action on coarse silt loam.

Representative profile:

0 to 5 inches, grayish-brown very fine sandy loam, very dark grayish brown when moist; soft when dry, very friable when moist; neutral.



5 to 14 inches, very fine sandy loam or silt loam that has a color similar to that of horizon above; massive; soft when dry, very friable when moist; neutral.

14 to 45 inches, pale-brown silt loam, brown when moist, massive; soft when dry, very friable when moist; moderately alkaline.

45 to 72 inches, very pale brown silt loam, pale brown to brown when moist; massive; soft when dry, very friable when moist; strongly calcareous; strongly alkaline.

Small areas of silt loam containing a large amount of fine sand are included with this soil.

This soil is deep, well drained, and moderately permeable. It is moderately fertile and fair to good in water-supplying capacity. Runoff is very slow. The hazard of wind erosion is high.

Rainfall is inadequate for most crops. The winter wheat-summer fallow cropping system provides fair returns if wind erosion is controlled. The yields of wheat are generally lower than those obtained from the Ritzville silt loams. Nitrogen fertilizer is needed for higher yields. (Capability unit IIIe-3; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville very fine sandy loam, 8 to 30 percent slopes (RtD).**-This soil comprises slightly more than one-third of the total acreage of Ritzville very fine sandy loams in the county. Except for slopes, it is similar to Ritzville very fine sand loam, 0 to 8 percent slopes. It occupies the south-facing slopes of many draws or small canyons that are tributaries of the Touchet River below the Lukinbill Bridge. In the deeper canyons, it overlies the Touchet beds. Areas where these beds are less than 3 feet below the surface were mapped as the Ellisforde soils.

Ritzville very fine sandy loam, 8 to 30 percent slopes, is a soft soil. It slides downhill when crossed by tractors and other farm machinery. The hazard of water and wind erosion is high. Stubble-mulch tillage and cross-slope tillage should be used to control erosion. Nitrogen fertilizer is necessary for maximum yields of crops. An occasional seeding of perennial grass in a long-term rotation will help maintain organic matter in the soil. (Capability unit IIIe-3; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville very fine sandy loam, 8 to 30 percent slopes, eroded (RtD2).**-This soil is similar to Ritzville very fine sandy loam, 8 to 30 percent slopes, except that most of the dark-colored surface layer has been lost through wind and water erosion. This soil is easily recognized by the light color of the surface layer and by the presence of lime on the surface. Fertility and yields are low. The water-supplying capacity is also low.

This soil should be seeded to perennial grasses until it is improved enough for wheat to be grown safely. Nitrogen fertilizer helps to establish a satisfactory stand of grass. (Capability unit IVe-6; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville very fine sandy loam, 30 to 45 percent slopes (RtE).**-Except for slopes, this soil is similar to Ritzville very fine sandy loam, 0 to 8 percent slopes. In places it joins Ritzville very fine sandy loam, volcanic-ash variant, 0 to 8 percent slopes. Runoff is medium, and the hazard of erosion is high.

Many areas of this soil that have been cultivated are now abandoned. Large farm machinery is difficult to handle on the steep slopes. The soil is suitable for occa-

sional cultivation if extreme care is used to control erosion. (Capability unit IVe-8; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville very fine sandy loam, 45 to 60 percent slopes (RtF).**-This soil occupies north-facing slopes. It is steeper and has a slightly darker colored surface soil than Ritzville very fine sandy loam, 0 to 8 percent slopes. Runoff is medium to rapid, and the hazard of wind and water erosion is high.

This soil is too steep for cultivation. The native bunchgrasses are good forage, and they can be grazed if enough of the growth is left to control erosion. (Capability unit VIe-2; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville very fine sandy loam, 30 to 60 percent slopes, eroded (RtF2).**-This soil was originally similar to Ritzville very fine sandy loam, 0 to 8 percent slopes. Enough of the surface layer, however, has been lost through erosion to make the soil unsuitable for crops. The soil has only limited value for grazing.

This soil is low in fertility and water supplying capacity. Runoff is medium to rapid, and the hazard of further erosion is very high. The soil should be reseeded to perennial grasses and not grazed until the grass is well established. Nitrogen fertilizer helps in establishing a desirable stand of grass. (Capability unit VIIe-2; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville very fine sandy loam, volcanic-ash variant, 0 to 8 percent slopes (RvB).**-This soil occurs in small valleys where large amounts of ash are mixed with loess. It is soft, deep, well drained, and rapidly permeable. It is low in fertility and water-supplying capacity. The surface layer is neutral, and the subsoil, mildly alkaline. Runoff is very slow. The hazard of wind erosion is very high. The soil is suitable for grazing and for an occasional crop of wheat. (Capability unit IVe-6; range site, Deep-Upland, 9 to 12 inches precipitation.)

**Ritzville very fine sandy loam, volcanic-ash variant, 8 to 30 percent slopes, eroded (RvD2).**-This soil is similar to Ritzville very fine sandy loam, volcanic-ash variant, 0 to 8 percent slopes, except that it is steeper and has lost most of the dark-colored surface layer. The plow layer is now a mixture of volcanic ash and the remaining original surface soil. It is grayer than that of adjacent soils. Fertility and the water-supplying capacity are very low. The soil is too soft for the use of large farm machinery. It is best suited to grazing. (Capability unit VIIe-2; range site, Deep Upland, 9 to 12 inches precipitation.)

**Ritzville very fine sandy loam, volcanic-ash variant, 30 to 60 percent slopes (RvF).**-This soil occupies many small areas at the heads of steep draws. Except for slopes, it is similar to Ritzville very fine sandy loam volcanic-ash variant, 0 to 8 percent slopes. Runoff is medium. The soil is too soft for use of large farm equipment. Most areas once cultivated are now grown up in weeds; a few have been seeded to grasses. (Capability unit VIIe-2; range site, Deep Upland, 9 to 12 inches precipitation.)

## Riverwash

**Riverwash (Rw).**-This mapping unit consists of nearly level bars of coarse sand and gravel along rivers and small streams. Areas of this material are generally less than

3 feet above the normal level of streams. Most areas are bare or nearly bare of vegetation, but willows and cottonwoods are establishing themselves in some places. Riverwash is subject to change in size and in position, even during the normal flow of streams. It is not suitable for cultivation or grazing. (Capability unit VIIIw-1.)

## Sagemoor Series

The Sagemoor series consists of well-drained medium-textured soils that have formed in loess underlain by stratified deposits of lake-laid material. The Sagemoor soils are characteristically silt loams or very fine sandy loams that have lime at a depth of 8 to 15 inches below the surface. They are uniform in texture above the underlying lake-laid deposits.

The lake-laid deposits, commonly known as Touchet beds, are alternate layers of very compact silt and sand. They are strongly to very strongly alkaline and strongly calcareous, with a slight concentration of soluble salts. The salts have little effect on crop production unless they are leached by deeply percolating irrigation water and redeposited in other soils occupying lower positions.

Sagemoor soils have formed under 6 to 9 inches of rainfall, most of which falls in the period of November through March. Under natural conditions, the soil is rarely wet below a depth, of 15 to 20 inches.

The native vegetation consisted of bluebunch wheatgrass, Sandberg bluegrass, and a small amount of hopsage, big sagebrush and rabbitbrush. The plant cover on overgrazed and abandoned areas is now cheatgrass, mustard, and rabbitbrush.

**Sagemoor silt loam, 3 to 8 percent slopes (SgB).**-This soil occupies undulating to gently, sloping terraces. Large areas occur south of Touchet on the Gardena terrace, west of Touchet, and north of the Walla Walla River.

Profile along a county road in the SE1/4 sec. 12, T. 6 N., R. 33 E.:

- 0 to 4 inches, light brownish-gray silt loam, dark grayish brown when moist; platy structure; soft when dry, very friable when moist; moderately alkaline.
- 4 to 13 inches, silt loam that is slightly lighter in color than that in horizon above; massive; soft when dry, very friable when moist; moderately alkaline.
- 13 to 18 inches, gray silt loam, grayish brown when moist; massive; soft when dry, friable when moist; moderately calcareous; strongly alkaline.
- 18 inches +, alternate layers of grayish-brown silt loam and fine sand; the silt loam has a platy structure, the sand is massive; hard when dry, firm to very firm when moist; strongly calcareous; strongly alkaline.

This soil is well drained, moderately fertile, and fair in water-supplying capacity. It is moderately permeable above the substratum and very slowly permeable in the substratum. Moisture and roots penetrate only a few inches into the substratum. Runoff is slow. The hazard of erosion is moderate.

When irrigated, this soil will produce good yields of alfalfa hay, alfalfa seed, barley, sugar beets, and sweet corn. Phosphate is needed to obtain the highest yields of alfalfa. (Capability unit IVe-9, dryland; capability unit IIIe-8, irrigated; range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor silt loam, 0 to 3 percent slopes (SgA).**-The largest areas of this soil are on the Gardena terrace. The

soil has a slightly deeper profile and more gentle slopes than Sagemoor silt loam, 3 to 8 percent slopes. The hazard of erosion is slight. (Capability unit IVe-9, dryland; capability unit IIs-2, irrigated; range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor silt loam, 8 to 15 percent slopes (SgC).**-This soil occupies the first break in slope between the undulating terrace soils and the terrace escarpments. It is steeper and generally shallower to the lake-laid material than Sagemoor silt loam, 3 to 8 percent slopes. Soluble salts sometimes collect on this soil when the area above is overirrigated. Careless handling of irrigation water can cause severe erosion. (Capability unit IVe-9, dryland; capability unit IVe-14, irrigated; range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor silt loam, 8 to 15 percent slopes, eroded (SgC2).**-This soil was the same as Sagemoor silt loam, 8 to 15 percent slopes, but erosion, caused by careless handling of irrigation water, has removed much of the surface soil. In most places, calcareous subsoil is brought to the surface in tillage. This soil occurs as small areas, widely distributed in irrigated fields. Many areas are too small to map.

This soil is low in fertility and in water-supplying capacity. Root penetration is generally shallow. Infiltration and permeability are slow. To moisten the root zone, farmers have to irrigate a field for 12 to 24 hours. This greatly aggravates the erosion problem.

Large amounts of fertilizer are needed to obtain even moderate yields of crops. Phosphate is rapidly fixed by lime in the soil and made unavailable to plants. Alfalfa and barley are about the only crops grown at present. The soil is suitable for alfalfa and grass and an occasional crop of barley. (Capability unit VIe-8, dryland; capability unit IVe-12, irrigated; range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor silt loam, 15 to 30 percent slopes (SgD).**-This soil occupies short, steep slopes in small drainageways that have formed in the terraces. It is steeper, generally shallower, and grayer in color than Sagemoor silt loam, 3 to 8 percent slopes.

Sagemoor silt loam, 15 to 30 percent slopes, is suitable for sprinkler irrigation. Improper application of irrigation water causes serious erosion. Soluble salts tend to accumulate in this soil. When irrigated, the soil is best suited to pasture consisting of perennial grass and legumes. (Capability unit VIe-8, dryland; capability unit VIe-8, irrigated; range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor silt loam, 15 to 30 percent slopes, eroded (SgD2).**-This soil was like Sagemoor silt loam, 15 to 30 percent slopes, but most of the original surface layer has been lost through erosion resulting from tillage and irrigation. The soil has the same use restrictions as Sagemoor silt loam, 8 to 15 percent slopes, eroded. In addition, the greater slopes increase the hazard of erosion.

The yields of hay and pasture are very low. Many farmers find it more profitable to use the available irrigation water on better soils. (Capability unit VIe-8, dryland; capability unit VIe-8, irrigated, range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor silt loam, 30 to 45 percent slopes (SgE).**-This soil generally occupies north-facing slopes. It is

steeper, darker colored, and in most places, deeper to the lake-laid material than Sagemoor silt loam, 3 to 8 percent slopes. In places the profile of Sagemoor silt loam, 30 to 45 percent slopes, resembles that of the Ellisforde soils, which are deeper to the lake-laid material and generally not so calcareous. On the south-facing slopes, this soil joins Sagemoor silt loam, 30 to 45 percent slopes, eroded.

Root penetration is moderately deep. Runoff is medium to rapid, and the hazard of erosion is high. (Capability unit VIe-8 ; range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor silt loam, 30 to 45 percent slopes, eroded (SgE2).**-This soil occurs on south-facing slopes that are transitional to terrace escarpments. It is slowly permeable and low in fertility and water-supplying capacity. Root penetration is shallow. Runoff is medium to rapid. The hazard of further erosion is high.

This soil is exposed to the direct rays of the sun and to the prevailing winds. As a consequence, the soil is more droughty than the Sagemoor soils on the terraces and on north-facing slopes. In addition, the yields of forage are lower. (Capability unit VIe-8; range site, Deep Silty Upland 6 to 9 inches precipitation.)

**Sagemoor silt loam, saline-alkali, 0 to 3 percent slopes (SkA).**-This soil occurs in many small areas. Except for slope, it is similar to Sagemoor silt loam, saline-alkali, 3 to 8 percent slopes. Most areas are in small depressions and are too small to be mapped separately. The salt in this soil has been carried into it by deeply percolating irrigation water. (Capability unit IVs-4, irrigated.)

**Sagemoor silt loam, saline-alkali, 3 to 8 percent slopes (SkB).**-This soil occurs in small areas on the edge of terraces. It was originally the same as Sagemoor silt loam, 3 to 8 percent slopes, but it has received deposits of soluble salt carried in irrigation water from higher lying areas.

This soil is slowly permeable. It is low to moderate in fertility and low to fair in water-supplying capacity. The hazard of erosion is high. Hay and pasture crops common to the area grow fairly well on this soil if plenty of water is available for irrigation. (Capability unit IVs-4, irrigated.)

**Sagemoor silt loam, saline-alkali, 8 to 15 percent slopes (SkC).**-This soil is common in the areas of irrigated Sagemoor soils. Except for slope, it is similar to Sagemoor silt loam, saline-alkali, 3 to 8 percent slopes. Deep-percolating irrigation water that owed laterally along one of the strata of sand to the face of the terrace has carried soluble salts from the Touchet formation to this soil. Wherever. this water comes near the surface, it evaporates and leaves salts in the soil. Entire slopes are often affected by salts. Yields, including those for salt-tolerant crops, are very low. In years when irrigation water is short, only alkaliweed grows on the soil.

Clean-tilled crops should not be grown, as the rate at which salty water evaporates is increased when the ground is not shaded. Salt-tolerant grasses are best for this soil because they shade the ground, reduce evaporation, and furnish some pasture. (Capability unit IVs-4, irrigated.)

**Sagemoor silt loam, saline-alkali, 15 to 30 percent slopes (SkD).**-This soil occurs in areas of irrigated Sage-

moor soils. It has formed from the same parent material and under the same alkali conditions as Sagemoor silt loam, saline-alkali, 8 to 15 percent slopes. It occupies the steeper, lower part of the slopes in small canyons that were cut in old lake terraces. This soil has a higher erosion hazard and generally a greater salt concentration than Sagemoor silt loam, saline-alkali, 8 to 15 percent slopes.

The plant cover is largely alkaliweed, which has little value for grazing. Areas of this soil are usually considered to wasteland. If water is available for irrigation, alkali-tolerant grasses should be established for grazing. (Capability unit IVs-4, irrigated.)

**Sagemoor very fine sandy loam, 8 to 15 percent slopes (SmC).**-This soil occurs most commonly between the Sagemoor silt loam soils and the sandy soils of the terraces. It occupies slightly lower elevations than the Sagemoor silt loams.

Profile in an area along U.S. Highway No. 410, about 3 miles east of Wallula Junction:

0 to 3 inches, light brownish-gray very fine sandy loam, dark grayish brown when moist; platy structure; soft when dry, very friable when moist; moderately alkaline.

3 to 8 inches, very fine sandy loam with a color similar to that of horizon above; massive; soft when dry, very friable when moist; few fragments of calcareous material are dispersed throughout the horizon; moderately alkaline.

8 to 34 inches, grayish-brown very fine sandy loam, very dark grayish brown when moist; massive; soft when dry, very friable when moist; moderately calcareous; strongly alkaline; few hard nodules.

34 to 40 inches, light brownish-gray silt loam that has a few irregular streaks of lighter colored material, dark grayish brown when moist; massive to laminated or platy structure; hard when dry, firm when moist; strongly calcareous and strongly alkaline; lower materials are very strongly alkaline and are alternately sandy and silty.

40 to 52 inches, very fine sand and silt that are stratified and similar in color to horizon above; massive; hard when dry, firm when moist; very strongly alkaline.

In this soil Touchet beds begin 34 inches from the surface, and these beds are more sandy than those from which the Sagemoor silt loams have formed. Small areas of Sagemoor silt loams that contain a high percentage of fine sand are mapped with this soil.

This soil is well drained. It is moderately permeable above the substratum. As a rule, water and roots penetrate the substratum only a few inches. The soil is moderately fertile and is fair in water-supplying capacity. Runoff is slow to medium. The hazard of wind erosion is high. Truck roads, stock trails, overgrazed areas, and bare fields are very susceptible to wind erosion. (Capability unit IVc-9, dryland; capability unit IVe-14, irrigated; range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor very fine sandy loam, 0 to 3 percent slopes (SmA).**-Except for slopes, this soil is similar to Sagemoor very fine sandy loam, 8 to 15 percent slopes. Runoff is very slow. (Capability unit IVe-9, dryland; capability unit IIs-2, irrigated; range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor very fine sandy loam, 3 to 8 percent slopes (SmB).**-Except for slopes, this soil is similar to Sagemoor very fine sandy loam, 8 to 15 percent slopes. Runoff is slow. (Capability unit IVe-9, dryland; capability unit

IIIe-8, irrigated; range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor very fine sandy loam, 8 to 15 percent slopes, eroded (SmC2).**-This soil is on short, south-facing slopes where the material above the Touchet beds was slightly thinner than normal. The original surface layer was lost through erosion following the burning or overgrazing of the vegetation.

Forage yields are low and are barely enough to prevent additional erosion. Drought-resistant grasses should be seeded to improve the soil. (Capability unit VIe-8, dryland; capability unit IVe-12, irrigated; range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor very fine sandy loam, 15 to 30 percent slopes (SmD).**-This soil makes up about one-third of the Sagemoor very fine sandy loams. It occurs mainly on north-facing slopes. Except for slopes, it is similar to Sagemoor very fine sandy loam, 8 to 15 percent slopes. Runoff is medium.

If irrigated, this soil is suitable for pasture consisting of grasses and legumes. (Capability unit VIe-8, dryland; capability unit VI-8, irrigated; range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor very fine sandy loam, 15 to 30 percent slopes, eroded (SmD2).**-This soil generally occurs on south-facing slopes. The original surface layer has been lost, mainly through wind erosion. Lime is on the surface, and in places the Touchet beds are exposed.

The soil is slowly permeable. It is low in fertility and low to fair in water-supplying capacity. Root penetration is shallow. Runoff is medium. The hazard of additional wind and water erosion is very high. Plants produce a very low yield of forage. The soil is suitable for a limited amount of grazing. (Capability unit VIe-8, dry land, capability unit VIe-8, irrigated; range site, Deep Silty Upland, 6 to 9 inches precipitation.)

**Sagemoor rocky very fine sandy loam, 3 to 30 percent slopes (SfD).**-This soil formed in lake-deposited material that overlies basalt bedrock. Outcrops of rock occupy up to 25 percent of the soil areas. In most places the soil is 12 to 15 inches thick over bedrock. Areas in which the soil is as much as 30 inches thick are included. The areas of shallow soil are very rocky.

This soil is too rocky and droughty for crops. It is suitable for grazing if the vigor of the forage plants is maintained. (Capability unit VIIs-2; range site, Shallow Upland, 6 to 9 inches precipitation.)

**Sagemoor rocky very fine sandy loam, 8 to 30 percent slopes, eroded (SfD2).**-This soil is inextensive, and most areas are very small. The original surface layer has been lost through erosion and the soil now consists of a thin layer of calcareous lake sediment over basalt bedrock. In its present condition, the soil produces little usable forage. (Capability unit VIIs-2; range site, Shallow Upland, 6 to 9 inches precipitation.)

**Sagemoor rocky very fine sandy loam, 30 percent and steeper slopes (SfE).**-This soil occurs in small canyons or in large draws that have formed in the basalt. The soil material consists of remnants of lake deposits left on rocky slopes. The soil joins Basalt rock land. It is suitable for a limited amount of grazing. (Capability unit VIIs-2; range site, Shallow Upland, 6 to 9 inches precipitation.)

**Sagemoor very fine sandy loam, saline-alkaline, 3 to 8 percent slopes, eroded (SnB2).**-This soil was like Sagemoor very fine sandy loam, 3 to 8 percent slopes; before it was cultivated and irrigated. It has a grayer color and is generally more calcareous than the noneroded soils with which it is associated. The soil is easily recognized by the sparse stands of alkaliweed and saltgrass growing on cropped fields.

This soil has been eroded through poor management of irrigation water. The head of water in each furrow or corrugation was generally too large. Salts that washed from higher lying soils have made this a saline-alkali soil.

The weed cover is seldom enough to control erosion, so the hazard of erosion is high. Fair yields of hay or pasture can be obtained if alkali-tolerant grasses are planted and irrigation water is carefully applied. (Capability unit IVs-4, irrigated.)

## Snow Series

The soils of the Snow series are deep, well drained, and medium textured. They have formed on stream bottoms and low terraces in alluvium that washed from the uplands. The soils have been in place longer and have undergone more weathering than the Hermiston and Onyx soils.

The Snow soils have a dark-colored (nearly black when moist) silt loam surface layer and a lighter colored silt loam or light silty clay loam subsoil. They are about neutral.

Almost all of the Snow soils are cultivated, generally in a rotation consisting of winter wheat and green peas. Remnants of the native vegetation are few. Bluebunch wheatgrass, big bluegrass, and Idaho fescue grew on the wide stream bottoms. Willow, cottonwood, and rose were the main plants near the streams.

**Snow silt loam, 0 to 3 percent slopes (SoA).**-This is the only soil of the Snow series mapped in the county. It is associated with Athena silt loam of the uplands. It joins the Hermiston soils, which are of more recent origin and have a calcareous subsoil.

Profile in a cultivated field, east of the Maxson School:

0 to 9 inches, very dark grayish-brown silt loam, nearly black when moist; granular structure; hard when dry, friable when moist; neutral.

9 to 23 inches, silt loam that has a color slightly lighter than horizon above; breaks to prism-shaped aggregates; hard when dry, friable when moist; neutral.

23 to 36 inches, grayish-brown silt loam or light silty clay loam, very dark grayish brown when moist; breaks to blocky or prismlike aggregates; hard when dry, firm when moist; pores and fractures coated with dark organic matter and deposits of clay; neutral.

36 to 78 inches, brown silt loam or light silty clay loam, dark brown when moist; breaks to blocky aggregates; hard when dry, firm when moist; dark-brown stains and patchy deposits of clay in root channels and fractures; mildly alkaline.

This soil is deep, well drained, and moderately permeable. It is high in fertility and very high in water-supplying capacity. Runoff is very slow, and the hazard of erosion slight. This is one of the best soils for wheat in the county. (Capability unit I-1, dryland; capability unit I-1, irrigated; range site, Deep Upland, 16 to 24 inches precipitation.)

## Spofford Series

The Spofford series consists of moderately well drained and well drained, medium-textured soils that have a dense prismatic or columnar subsoil. The soils have formed in loess and stratified lake sediment on undulating to gently rolling terraces.

Spofford soils characteristically have a grayish-brown silt loam surface layer, 6 to 12 inches thick, that has an abrupt boundary with a very, hard silt loam subsoil. Below the subsoil, the material is hard and strongly alkaline.

The Spofford soils have developed from the same type of material as Walla Walla silt loam, lacustrine substratum. The latter soil, however, does not have the columnar subsoil.

Almost all the Spofford soils are cultivated in a cropping system consisting of winter wheat and summer fallow. The original plant cover is difficult to determine, but bluebunch wheatgrass, wildrye, rabbitbrush, and Sandberg bluegrass grow along the roads and in the railroad right-of-way.

**Spofford silt loam, 0 to 3 percent slopes (SpA).**-This is the most extensive soil in the Spofford series. It occurs on nearly level terraces between the Braden School and the Oregon State line.

Profile in an area about 300 feet west of the Union Pacific Railroad tracks, along the 'State Line Road:

- 0 to 7 inches, grayish-brown silt loam, very dark grayish brown when moist; granular structure; slightly hard when dry, friable when moist; neutral.
- 7 to 12 inches, silt loam that has a color similar to that of horizon above; prismatic structure; hard when dry, firm when moist; thin deposits of clay in pores and vertical fractures; mildly alkaline.
- 12 to 20 inches, dark grayish-brown, heavy silt loam, dark brown when moist; prismatic or columnar structure, very hard when dry, very firm when moist; deposits of clay in fine pores and on the surfaces of aggregates; moderately alkaline.
- 20 to 25 inches, light brownish-gray silt loam, dark grayish brown when moist; subangular blocky structure; hard when dry, firm when moist; strongly alkaline.
- 25 to 36 inches, pale-brown silt loam, dark brown when moist; massive; slightly hard when dry, friable when moist; lime in seams, strongly alkaline.
- 36 to 84 inches, light-gray silt loam, grayish brown when moist; massive; soft to slightly hard when dry, friable when moist; strongly calcareous; strongly alkaline.

Small fragments of basalt and granite, 1/4 to 1 inch in diameter, are scattered throughout the profile. The layer of columnar subsoil varies from 2 to 12 inches in thickness.

This soil is moderately well drained. It is moderately fertile and fair in water-supplying capacity. Permeability is slow, and root penetration is moderately deep. Runoff is slow, but there is considerable runoff when the snow melts or when the thin surface layer is saturated. The hazard of erosion is slight. Only a few acres are irrigated. (Capability unit IIIe-7, dryland; capability unit IIIs-1, irrigated.)

**Spofford silt loam, 3 to 8 percent slopes (SpB).**-This soil occupies the first distinct break in slope into the drainageways. It occurs in smaller areas and is less extensive than Spofford silt loam, 0 to 3 percent slopes. In addition, the subsoil is nearer the surface. The soil is well drained. Runoff is medium, and the hazard of erosion is moderate. (Capability unit IIIe-7, dryland ; capability unit IIIe-1, irrigated.)

## Stanfield Series

The Stanfield series consists of medium-textured, moderately well drained, saline-alkali soils with an alkali hardpan. These soils have formed from alluvium on very gently sloping valley bottoms under the influence of a high water table. As streams deepened their channels, these soils were drained. In many places they stayed dry until attempts were made to irrigate them. The Stanfield soils characteristically are light brownish-gray or light-gray silt loam or very fine sandy loam that is strongly or very strongly alkaline and low in organic matter.

The vegetation is mainly saltgrass and greasewood. In small areas, the concentration of salt is too high for any type of plants. In these areas, the salt must be leached before even salt-tolerant crops will grow. If adequate drainage is established, 1 or 2 years of leaching will reduce the salt concentration to the level where sugar beets, barley, and alfalfa can be grown. Continued leaching is necessary to keep the concentration of salt below the critical level.

**Stanfield silt loam, 0 to 3 percent slopes (SrA).**-Large areas of this soil occupy old valley bottoms just above the present flood plain of the Walla Walla River. On the outer edge of the valley, this soil borders the Sagemoor and Ellisforde soils that overlie stratified lake sediment. The surface of Stanfield silt loam, 0 to 3 percent slopes, is slightly hummocky-an indication that it may have been slightly reworked by wind. The vegetation consists of greasewood, saltgrass, sowthistle, and cheatgrass.

Profile in a saltgrass pasture in NE1/4SE1/4 sec. 35, T. 7 N., R. 34 E., of the Willamette meridian:

- 0 to 4 inches, light brownish-gray silt loam, dark grayish brown when moist; platy structure; soft when dry, friable when moist; fine grass roots and saltgrass rhizomes abundant; strongly calcareous; very strongly alkaline.
- 4 to 13 inches, silt loam that has a color slightly lighter than that of horizon above; massive; slightly hard when dry, very friable when moist; fewer roots than horizon above; strongly calcareous; very strongly alkaline.
- 13 to 26 inches, pale-brown silt loam, dark brown when moist; massive; soft when dry, friable when moist; few roots; strongly calcareous; very strongly alkaline.
- 26 to 33 inches, light-gray silt loam, dark grayish brown when moist; massive; soft when dry, friable when moist; few roots; strongly calcareous; strongly alkaline.
- 33 to 40 inches, light-gray, strongly cemented alkali hardpan, dark grayish brown when moist; strongly calcareous; strongly alkaline.
- 40 inches +, light brownish-gray silt loam, dark brown when moist; massive; slightly hard when dry, friable when moist; moderately alkaline; occasional, high water table.

The depth from the surface to the hardpan ranges from 16 to 48 inches; the thickness of the hardpan ranges from 2 to 12 inches. In places the hardpan is mainly cemented pumice and is generally thicker and harder than elsewhere. South of Lowden, both types of hardpan are present in the soil.

This soil is moderately well drained and moderately permeable above the hardpan. In most places roots cannot penetrate the hardpan. The soil is low to moderate in fertility and low in water-supplying capacity. Runoff is slow. The hazard of erosion is slight. Unless reclaimed, the soil is too saline (salty) for most cultivated crops. If the soil is not overgrazed, good saltgrass pasture can be developed. (Capability unit VIIs-1, dryland; capa-

bility unit IVs-4, irrigated; Alkali Bottomland range site.)

**Stanfield silt loam, leached surface, 0 to 3 percent slopes (SsA).**-This soil is similar to Stanfield silt loam, 0 to 3 percent slopes, except that it has been leached by irrigation water. The salt content has been reduced from about 4,000 parts per million to approximately 700 parts per million. Continued irrigation and adequate drainage are required to keep the salt concentration at the lower figure.

This soil is moderately fertile and is fair to good in water-supplying capacity. Where the hardpan is more than 24 inches below the surface, sugar beets, alfalfa, and grass pasture are grown. Alfalfa stands do not last more than 3 years. (Capability unit IIIs-1, irrigated.)

**Stanfield very fine sandy loam, 0 to 3 percent slopes (StA).**-This soil is lighter colored, coarser textured, and more friable than Stanfield silt loam, 0 to 3 percent slopes. The hardpan is mainly cemented pumice and is porous and light in weight.

Permeability is moderately rapid above the hardpan. Fertility of the soil is low. The hazard of wind erosion is moderate. This soil is not suitable for most crops until the salts are leached out. (Capability unit VIIs-1, dryland; capability unit IVs-4, irrigated; Alkali Bottomland range site.)

**Stanfield very fine sandy loam, leached surface, 0 to 3 percent slopes (SvA).**-This soil is like Stanfield very fine sandy loam, 0 to 3 percent slopes except that most of the excess salts have been leached from the upper horizons. It is low to moderate in fertility. Adapted crops under irrigation include sugar beets, alfalfa for hay, and grass for pasture. If leaching and irrigation are discontinued, the concentration of salts increases again. (Capability unit IIIs-1, irrigated.)

## Starbuck Series

The Starbuck series consists of well-drained and somewhat excessively drained, medium-textured, rocky soils that formed in a mixture of loess and basalt. The soils are in steep rocky canyons adjoining the Ritzville soils. The surface is broken by numerous rock outcrops. Starbuck soils typically have a brown silt loam surface layer over a lighter colored, massive, silt loam subsoil. The bedrock in most places is less than 30 inches from the surface. The depth to bedrock averages between 15 and 20 inches.

The plant cover consists of bluebunch wheatgrass, Sandberg bluegrass, and big sagebrush. Overgrazed areas are covered mainly by cheatgrass and sagebrush. Starbuck soils are too rocky for cultivation and are used for range.

**Starbuck rocky silt loam, 0 to 30 percent slopes (SyD).**-This soil occurs in many small areas in Snake River Canyon and in the area adjacent to the Wallula Gap.

Profile in an area of overgrazed range, 1 1/2 miles south of Wallula Junction on U.S. Highway No. 410:

0 to 4 inches, brown rocky silt loam, dark brown when moist; small amount of basaltic sand, pebbles, and cobbles; granular structure; soft when dry, very friable when moist; mildly alkaline.

4 to 19 inches, pale-brown silt loam, brown when moist; massive; soft when dry, very friable when moist; mildly to moderately alkaline; many small fragments of basalt.

19 to 30 inches, light brownish-gray silt loam; dark grayish brown when moist; massive; slightly hard when dry, friable when moist; weakly calcareous; moderately to strongly alkaline.

30 inches +, basalt bedrock; some lime in cracks.

Sharp angular fragments of basalt are scattered throughout the profile. As much as 25 percent of the mapping unit consists of outcrops of rock.

This soil is well drained and moderately permeable. It is low to moderate in fertility and is fair in water-supplying capacity. Roots penetrate the soil to bedrock. Runoff is medium, and the hazard of erosion is moderate. The soil is too rocky for tillage, but it makes fair range late in spring. (Capability unit VIIIs-3; range site, Shallow Upland, 9 to 12 inches precipitation.)

**Starbuck rocky silt loam, 30 to 45 percent slopes (SyE).**-This soil is similar to Starbuck rocky silt loam, 0 to 30 percent slopes, except that it is steeper contains more rock, and is extremely variable in depth. It joins Basalt rock land. Drainage is somewhat excessive. Runoff is rapid and the hazard of erosion is high. Grazing should be restricted so that enough plant residue is left on the surface to protect the soil from erosion. (Capability unit VIIIs-3 ; range site, Shallow Upland, 9 to 12 inches precipitation)

## Taunton Series

The Taunton series consists of somewhat excessively drained, moderately coarse textured soils over indurated caliche. Small chunks of caliche are scattered throughout the profile. The Taunton soils are light brownish-gray fine sandy loams or loamy fine sands over a layer of lighter colored calcareous material.

The Taunton soils are inextensive. They occur in small areas associated with the Adkins soils, which do not have the caliche layer. They have a limited use for grazing.

**Taunton fine sandy loam, 0 to 30 percent slopes, eroded (TaD2).**-This soil occurs in small areas. The native vegetation has been destroyed by burning and grazing.

Representative profile:

0 to 15 inches, light brownish-gray fine sandy loam, dark grayish brown when moist; granular structure; soft when dry, very friable when moist; moderately alkaline.

15 to 27 inches, light brownish-gray fine sandy loam, grayish brown when moist; massive; soft when dry, very friable when moist; moderately alkaline.

27 inches +, white, indurated caliche ranging in thickness from 6 to more than 24 inches.

The surface soil has been sorted by wind and in places is a loamy fine sand. This somewhat excessively drained soil is rapidly permeable above the caliche. It is very low in fertility and in water-supplying capacity. Roots do not penetrate the caliche. Runoff is slow. The hazard of wind erosion is high. The soil is suitable for a limited amount of grazing. (Capability unit VIe-1; Sandy Upland range site.)

**Taunton fine sandy loam, 30 to 45 percent slopes, eroded (TaE2).**-This very inextensive soil occupies steep slopes in narrow canyons in the western part of the county in association with the Adkins soils. It is similar to Taunton fine sandy loam, 0 to 30 percent slopes, eroded, except for slopes. The depth to caliche is extremely variable. In some places the caliche is exposed on the surface; in other places, it is only a few inches below the surface.

The native vegetation has largely been destroyed by grazing and burning. Because of shallowness, steep slopes, and low rainfall, the soil is suitable for only a limited amount of grazing. (Capability unit VIe-1; Sandy Upland range site.)

## Terrace Escarpments

Terrace escarpments (Tc).-This mapping unit consists of very steep or severely eroded banks or escarpments. It occurs on the Touchet formation in the Walla Walla Valley and on the gravelly river deposits in the canyon of the Snake River. Slopes are generally steeper than 60 percent, but severely eroded areas of 45 to 60 percent have been included. Runoff is very rapid, and the hazard of erosion is very high. Most areas are almost bare of vegetation. (Capability unit VIIIs-1.)

## Touchet Series

The Touchet series consists of moderately well drained, medium-textured soils of the stream bottom lands. The soils have formed in deep deposits of alluvium that washed from the uplands. The Touchet soils are deep, grayish-brown silt loams with a lighter colored, friable subsoil, often marked with faint mottles of dark reddish brown. Many areas are gravelly. The soils are subject to a seasonal water table that is seldom within 3 feet of the surface.

The vegetation was largely cottonwood, willow, and alder. Bluebunch wheatgrass may have grown on the drier fringes. Almost all the Touchet soils have been cleared for cultivation.

**Touchet silt loam, 0 to 3 percent slopes (TsA).**.-This is the main soil in the Touchet series.

Representative profile in an area near the Walla Walla River, just north of the Whitman Bridge:

- 0 to 8 inches, grayish-brown silt loam, very dark brown when moist; granular structure; slightly hard when dry, friable when moist, slightly sticky when wet; mildly alkaline.
- 8 to 39 inches, silt loam that has a color similar to that of horizon above; massive to platy structure; slightly hard when dry, friable when moist, slightly sticky when wet; neutral to mildly alkaline.
- 39 to 64 inches, grayish-brown or gray silt loam, very dark grayish brown when moist; faint mottles of reddish brown; massive; slightly hard when dry, friable when moist, slightly sticky when wet; neutral.
- 64 inches +, unsorted and rounded basaltic pebbles; stains of iron.

The seasonally high water table rises into the 39 to 64 inch layer, but it seldom stays long enough to affect the crops commonly grown in the area. The soil is moderately permeable. It is moderate to high in fertility and high in water-supplying capacity. Runoff is slow. There is little or no hazard of erosion. The soil is very productive, and good yields of alfalfa hay, sugar beets, and sweet corn are obtained under irrigation.. (Capability unit IIc-1, dryland; capability unit I-1, irrigated; range site, Bottomland, 12 to 23 inches precipitation.)

**Touchet gravelly silt loam, 0 to 3 percent slopes**

(ToA).-This soil is similar to Touchet silt loam, 0 to 3 percent slopes, except that it contains a large amount of well-rounded gravel throughout the profile. It is moderately fertile and very productive. Permeability is moderately rapid. The water-supplying capacity is good, but

in dry years the soil may be somewhat droughty unless it is irrigated. (Capability unit IIIs-1, dryland; capability unit IIs-3, irrigated; range site, Bottomland, 12 to 23 inches precipitation.)

## Umapine Series

The Umapine series consists of moderately well drained, medium-textured, saline-alkali soils on gently sloping terraces and alluvial fans elevated from the flood plain. The soils formed in old alluvium derived mainly from loess and pumice mixed with a small amount of basaltic material. The Umapine soils are characteristically light brownish-gray silt loams or very fine sandy loams that are low in organic matter. The subsoil is soft and is lighter colored than the surface soil. The Umapine soils are uniform in appearance, calcareous, and strongly to very strongly alkaline.

The concentration of soluble salts is about equal to that in soils of the Stanfield series, but Umapine soils can be more easily reclaimed because they do not have a hardpan. Under natural conditions the salt content is too high for cultivated crops. Greasewood, salt grass and alkaliweed are the principal plants on these soils. Under irrigation, a variety of row crops, grains, hay, and pasture crops are grown.

**Umapine very fine sandy loam, 0 to 3 percent slopes**

(UvA).-This soil is widely distributed in the Walla Walla Valley below Lowden. It is associated with the Stanfield and Esquatzel soils.

Profile in a saltgrass meadow, 1 1/2 miles west of Touchet on the old highway:

- 0 to 4 inches, light brownish-gray very fine sandy loam, dark grayish brown when moist; massive to platy structure; soft when dry, very friable when moist; many fine roots and rhizomes of saltgrass; high in soluble salts; very strongly alkaline.
- 4 to 18 inches, pale-brown very fine sandy loam, brown when moist; massive; soft when dry, very friable when moist; few roots; high in soluble salts; strongly calcareous; very strongly alkaline.
- 18 inches +, light-gray fine sandy loam that contains pumice, grayish brown when moist; massive; soft when dry, very friable when moist; few roots; very strongly alkaline.

In places the soil contains enough pumice to give it a much grayer color. This soil is moderately well drained and is moderately permeable. It is very low in fertility and low in water-supplying capacity. Root penetration is moderately shallow. Runoff is slow. Wind erosion is a moderate hazard, but very little occurs so long as the saltgrass cover is maintained. (Capability unit VIIs-1, dryland; capability unit VIIs-1, irrigated; Alkali Bottomland range site.)

**Umapine very fine sandy loam, leached surface, 0 to 3 percent slopes (UwA).**-This soil is the same as Umapine very fine sandy loam, 0 to 3 percent slopes, except that a large part of the salt has been leached from the upper horizons. Root penetration is moderately deep. The water-supplying capacity is fair, and fertility is moderate.

Good crops of alfalfa, sugar beets, and barley can be grown after one or two seasons of leaching. Leaching must be accompanied by adequate drainage. If irrigation is discontinued, the salt increases rapidly. The soil blows easily when there is no vegetation on the surface. (Capability unit IIs-2, irrigated.)

**Umapine silt loam, 0 to 3 percent slopes (UmA).**-This soil is similar to Umapine very fine sandy loam 0 to 3 percent slopes, but it is finer textured, has a thicker and darker surface layer, and is generally less saline. It is low in fertility. The hazard of erosion is slight. The content of salt is, too high for cultivated crops. (Capability unit VIIs-1, dryland; capability unit VIIs-1, irrigated; Alkali Bottomland range site.)

**Umapine silt loam, leached surface, 0 to 3 percent slopes (UpA).**-This soil is the same as Umapine silt loam, 0 to 3 percent slopes, except that a large part of the soluble salts has been removed by leaching with irrigation water. It is moderate in fertility and good in water-supplying capacity. Root penetration is moderately deep. Enough salt can generally be removed during the first irrigation season to improve the soil and obtain a good crop of sugar beets the second year. Alfalfa can be established in the third or fourth year. If irrigation is discontinued, the concentration of salt increases. (Capability unit IIIs-2, irrigated; Alkali Bottomland range site.)

## Volcanic-ash Land

Volcanic-ash land consists of small areas of nearly unmodified deposits of pumice. This material has a white or light-gray color and a fine or very fine sandy texture. Where profile development has started, this material has been mapped as a Volcanic-ash variant of the soil occurring in association with this land type. The hazard of erosion is very high. Vegetation is difficult to maintain on the unmodified ash, and most of the areas are barren.

**Volcanic-ash land, steep (VaE).**-This mapping unit occurs in small coves at the heads of drainageways. Runoff from melting snow often forms deep gullies in these areas. The soil is not suitable for use with farm equipment, and large machinery is frequently overturned or stalled when crossing the ash. Areas of Volcanic-ash should be seeded to grass and the cover maintained to control erosion. (Capability unit VIIIs-1.)

**Volcanic-ash land, undulating to hilly (VaC).**-This mapping unit occurs mainly in cultivated fields. The hazard of wind erosion is very high. In most fields, the areas have been allowed to grow up in weeds. In others, the operator continues cultivation, and the size of the areas increases. Practices to control erosion include seeding suitable plants or spreading straw to control blowing. Areas of Volcanic-ash should be protected from livestock. (Capability unit VIIIs-1.)

## Walla Walla Series

The Walla Walla series consists of well-drained and somewhat excessively drained, medium-textured soils that have formed in loess on uplands. Slopes vary from nearly level to steep or hilly (fig. 6). The Walla Walla soils characteristically have a grayish-brown or dark grayish-brown silt loam surface layer and a pale-brown silt loam subsoil. They are neutral to moderately alkaline to a depth of 50 to 60 inches, where lime is encountered. The Walla Walla soils are darker colored, higher in organic matter, and deeper to lime than the Ritzville soils. They are lighter colored and contain less clay than the Athena soils.



Figure 6.-Farming Walla Walla silt loam on steep slopes in the area known as the Skyrocket Hills (north of Prescott).

The Walla Walla soils have formed under 12 to 16 inches of annual precipitation, most of which falls late in fall to early in spring. Only a few north-facing slopes, fence corners, and roadside areas have escaped cultivation. The vegetation in these uncultivated areas consists of bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, balsamroot, yarrow, and lupine.

**Walla Walla silt loam, 0 to 8 percent slopes (WaB).**-The largest area of this soil is just north of the city of Walla Walla. Small areas are widely distributed throughout the area where Walla Walla soils are mapped.

### Representative profile in a cultivated field:

- 0 to 8 inches, dark grayish-brown silt loam, very dark brown when moist; granular structure; soft when dry, friable when moist; neutral.
- 8 to 26 inches, brown to pale-brown silt loam, dark brown when moist; prismatic structure; slightly hard when dry, friable when moist; neutral.
- 26 to 52 inches, pale-brown silt loam, dark brown when moist; massive; soft to slightly hard when dry, friable to very friable when moist; neutral to moderately alkaline.
- 52 inches +, very pale brown silt loam, dark grayish brown when moist; massive; soft when dry, very friable when moist; strongly calcareous; moderately alkaline.

The moist color of the surface layer ranges from very dark grayish brown to very dark brown. In some places the plow layer contains less organic matter than the layer under it. Soil samples from the native grassland have almost twice as much organic matter as samples from cultivated fields. Over much of the area, the layer of lime is more than 60 inches below the surface.

This soil is deep, well drained, and moderately permeable. Its water-supplying capacity is high, and its fertility is moderate to high. Runoff is slow, and areas in native grass have little, if any, erosion. Erosion is extremely variable in cultivated fields. Soil tilled to a dust mulch has considerable runoff and erosion. Rain on frozen ground also results in runoff and erosion. Fields with a good stubble mulch and a rough surface have little runoff or soil loss. This soil responds well to manage-



ment. (Capability unit IIc-2, dryland; capability unit I-1, on 0 to 3 percent slopes, irrigated; capability unit IIe-5, on 3 to 8 percent slopes, irrigated; range site, Deep Upland, 12 to 16 inches precipitation.)

**Walla Walla silt loam, 8 to 30 percent slopes (WaD).**- This soil is one of the most extensive in the county. It is widely distributed throughout the central part of the county, between Walla Walla and Pleasant View. Its profile characteristics are somewhat more variable than those of Walla Walla silt loam, 0 to 8 percent slopes. On south and southwest slopes, the surface layer is lighter in color than that of Walla Walla silt loam, 0 to 8 percent slopes; and on north slopes, it is darker. The depth to lime -ranges from 3 1/2 feet on the points of ridges to more than 6 feet at the tops of slopes and on the north-facing slopes.

Runoff is slow to medium, and the hazard of erosion is moderate. Runoff and soil loss are least from soils that are high in organic matter and that are protected by a stubble mulch. Soil loss is high from areas covered by a dust mulch because rills start forming before the soil is wet to a depth of 3 inches. Erosion can be controlled best by use of good tillage practices, stubble mulch and soil-building crops. (Capability unit IIIe-7, dryland; capability unit IVe-14 on 8 to 15 percent slopes, irrigated; capability unit VIe-8, on 15 to 30 percent slopes, irrigated; range site, Deep Upland, 12 to 16 inches precipitation.)

**Walla Walla silt loam, 8 to 30 percent slopes, eroded (WaD2).**-This soil occurs mainly on the points of ridges and on cultivated, short, south-facing slopes. Most of the dark-colored original surface layer has been lost through water erosion, and in some places lime is exposed. The soil is low to moderate in fertility and fair in water-supplying capacity. The hazard of further erosion is high.. Runoff and erosion progress at an accelerated rate on this eroded soil.

Yields of crops are low. They are considerably reduced wherever plant roots extend to the lime zone. The soil needs intensive improvement to restore it to moderate productivity. (Capability unit IVe-10; range site, Deep Upland, 12 to 16 inches precipitation.)

**Walla Walla silt loam, 30 to 45 percent slopes (WaE).**- This soil is darker colored and steeper than Walla Walla silt loam, 0 to 8 percent slopes. The profile is much like that of the Athena soils, except that the surface layer is not so thick and the subsoil is more friable. Walla Walla silt loam, 30 to 45 percent slopes, occurs extensively in the Skyrocket Hills, which is an area characterized by deep canyons with long, uniform slopes.

This soil was first cultivated when large track-type tractors and hillside combines became available. The hazard of erosion is high, but the loss of soil has been slight.. However, as the supply of organic matter in the soil decreases, erosion increases. Soil-building crops should be grown to maintain organic matter at an adequate level. (Capability unit IVe-11; range site, Deep Upland, 12 to 16 inches precipitation.)

**Walla Walla silt loam, 30 to 45 percent slopes, eroded (WaE2).**-Except for slopes, this soil is similar to Walla Walla silt loam, 8 to 30 percent slopes, eroded. Tillage machinery has caused much of the soil loss, as it works the soil downhill. This soil is low in fertility and in water-supplying capacity. Runoff is very rapid, and the

hazard of further erosion is very high. The farming of this soil has been unprofitable for many operators, so fields are being revegetated with a permanent plant cover. (Capability unit VIe-3 ; range site, Deep Upland, 12 to 16 inches precipitation.)

**Walla Walla silt loam, 45 to 60 percent slopes (WaF).**- Most of this soil occupies rough, steep, north-facing slopes on which the present types of farm machinery are not suitable. Areas are generally small (average size, about 10 acres) and are scattered within large areas of cultivated soils. This soil is not used for grazing while there is a crop on surrounding soils as few areas are fenced separately. (Capability unit VIe-3; range site, Deep Upland, 12 to 16 inches precipitation.)

**Walla Walla silt loam, hardpan variant, 0 to 8 percent slopes (WhB).**-This soil occupies low terraces between the lacustrine substratum phases of Walla Walla soils and the soils of bottom lands. It has formed from loess over old lake sediment. An alkali-cemented hardpan has formed just above the lake sediment. This hardpan limits the penetration of roots and water.

Representative profile:

- 0 to 9 inches, grayish-brown silt loam, very dark brown when moist; granular structure; soft when dry, very friable when moist; moderately alkaline.
- 9 to 24 inches, grayish-brown silt loam, very dark grayish brown when moist; massive; slightly hard when dry, friable when moist; moderately to strongly alkaline.
- 24 to 27 inches, light brownish-gray, strongly cemented hardpan, dark grayish brown when moist; strongly calcareous; strongly to very strongly alkaline; roots do not penetrate the hardpan.
- 27 to 75 inches, grayish-brown silt loam, dark brown when moist; massive; hard when dry, firm when moist; somewhat stratified lake-laid sediment, each layer of which differs slightly in texture, consistence, sand color.

This soil is moderately well drained. It is moderately permeable above the hardpan. The hardpan, however, is essentially impermeable to roots and water. The soil is moderately fertile and fair in water-supplying capacity. Runoff is slow to medium. The hazard of erosion is moderate.

Nearly all this soil is irrigated. Dryland crops are damaged somewhat by drought in seasons of average rainfall. Deep-rooted, irrigated crops are short lived, but shallow-rooted grains and truck crops grow well if they are carefully irrigated. (Capability unit IIIe-7, dryland; capability unit IIIe-1, irrigated; range site, Deep Upland, 12 to 16 inches precipitation.)

**Walla Walla silt loam, lacustrine substratum, 0 to 8 percent slopes (W1B).**-This soil is in the vicinity of Walla Walla and College Place. It is underlain by stratified lake deposits at a depth of 3 to 4 feet from the surface.

Profile in a cultivated field, west of the College Place Cemetery:

- 0 to 9 inches, grayish-brown silt loam, very dark grayish brown when moist; granular structure; soft when dry, friable when moist; neutral.
- 9 to 14 inches, silt loam that has a color similar to that of horizon above; subangular blocky structure; similar to horizon above in consistence.
- 14 to 24 inches, brown silt loam, dark brown when moist; prismatic structure; soft when dry, very friable when moist; moderately to strongly alkaline.
- 24 to 35 inches, pale-brown silt loam, brown when moist; massive; soft when dry, very friable when moist; strongly alkaline.

35 to 38 inches, pale-brown silt loam, brown when moist; moderately calcareous; strongly alkaline.

38 to 80 inches, light brownish-gray silt loam, dark grayish brown when moist; silt loam alternates with layers of fine sandy loam or loamy fine sand; massive; soft to hard when dry, very friable to firm when moist; strongly calcareous; strongly to very strongly alkaline.

All horizons of the profile contain from 0.5 to 3 percent fine basalt and granitic gravel.

Permeability is moderate above the substratum, and slow in the substratum. The water-supplying capacity is good to high, and fertility is moderate to high. Runoff is slow. The hazard of erosion is slight. The soil is well drained, but because of the slowly permeable lake-laid substratum, drainage and salt problems may develop if irrigation water is used too liberally. (Capability unit IIc-2, dryland; capability unit IIe-5, irrigated; range site, Deep Upland, 12 to 16 inches precipitation.)

**Walla Walla silt loam, lacustrine substratum, 8 to 30 percent slopes (W1D).**-This soil is on the slopes of draws that have cut through the terrace. The slopes are short and usually not more than 200 to 300 feet long. The profile of this soil is similar to that of Walla Walla silt loam, lacustrine substratum, 0 to 8 percent slopes, except that the underlying sediment is nearer the surface, and lime is frequently within 2 feet of the surface. The soil is generally shallowest in areas having slopes of more than 20 percent.

Runoff is slow to medium, and the hazard of erosion is moderate. The soil responds well to the use of fertilizer and to soil-building crops. (Capability unit IIIe-7, dryland; capability unit IVe-14, for 8 to 15 percent slopes, irrigated, and VIe-8 for 15 to 30 percent slopes, irrigated; range site, Deep Upland, 12 to 16 inches precipitation.)

**Walla Walla silt loam, lacustrine substratum, 8 to 30 percent slopes, eroded (W1D2).**-This soil occurs mainly on south-facing slopes. It is similar to Walla Walla silt loam, lacustrine substratum, 8 to 30 percent slopes, except that most of the original surface layer has been lost through erosion. The plow layer is now mainly original subsoil. In more than half the area, lime is on the surface. The soil has a good water-supplying capacity and is moderately fertile. The hazard of further erosion is high.

Yields of crops are low. They are about one-half of those obtained from Walla Walla silt loam, lacustrine substratum, 8 to 30 percent slopes. Intensive use of soil-building crops is necessary to improve the soil and make it moderately productive. Hay and pasture crops give the best yields. (Capability unit VIe-3 ; range site, Deep Upland, 12 to 16 inches precipitation.)

## Walvan Series

The Walvan series consists of well-drained and somewhat excessively drained, medium-textured soils that have formed in volcanic ash mixed with loess. Slopes range from nearly level to very steep. These soils normally have a grayish-brown, very fine sandy loam surface layer and a slightly lighter colored, very fine sandy loam subsoil. In many places the soil is nearly pure volcanic ash, and streaks of nearly white ash are common at varying depths in the profile. The principal native plants are bluebunch wheatgrass and Sandberg bluegrass. The Walvan soils are used for dryfarming and grazing.,

**Walvan very fine sandy loam, 0 to 8 percent slopes (WvB).**-This soil contains enough fine pumice to give it a grayish color. In places layers of unmodified ash are in the subsoil.

Representative profile in a cultivated field:

0 to 9 inches, grayish-brown very fine sandy loam, very dark grayish brown when moist; massive; soft when dry, very friable when moist; neutral to slightly acid.

9 to 27 inches, very fine sandy loam that has a color slightly lighter than that of horizon above; massive; soft when dry very friable when moist; neutral.

27 to 47 inches, light brownish-gray very fine sandy loam that contains streaks of pale-brown volcanic ash; dark grayish brown when moist; soft when dry, very friable when moist; mildly alkaline.

47 to 72 inches, nearly white very fine sandy loam, light brownish gray when moist; mainly pumice.

This soil is deep, well drained, and moderately rapidly permeable. It is low in fertility and in water-supplying capacity. It absorbs water rapidly. Runoff is very slow. Sheet erosion ordinarily is not a problem, but a large volume of runoff quickly forms deep, narrow gullies. The hazard of wind erosion is high.

Crops do not respond well to commercial fertilizer. The soil is suitable for an occasional cultivated crop if the dark-colored surface layer is maintained. (Capability unit IVe-10; range site, Deep Upland, 12 to 16 inches precipitation.)

**Walvan very fine sandy loam, 8 to 30 percent slopes, eroded (WvD2).**-This soil is in small draws, where it may extend from the narrow stream bottom land to a point about half way up the north-facing slopes. Individual areas as much as 10 acres in size are common. All of this soil has been cultivated. The color of the plow layer is grayish brown when moist, rather than very dark grayish brown, as in Walvan very fine sandy loam, 0 to 8 percent slopes. Runoff is slow, but that flowing over this soil from higher areas forms deep, narrow gullies. The hazard of wind erosion is very high. The soil is very low in fertility.

Yields of crops are low. Many areas now growing only weeds should be seeded to grass. When grass is established, it should be suitable for a limited amount of grazing. (Capability unit VIe-3; range site, Deep Upland, 12 to 16 inches precipitation.)

**Walvan very fine sandy loam, 30 to 60 percent slopes, eroded (WvF2).**-This soil is similar to Walvan very fine sandy loam, 8 to 30 percent slopes, eroded, except that it is steeper and occurs in smaller areas. It occupies steep to very steep northeast-facing coves. Large farm machinery is very poorly suited to fallowed fields. When used, it makes deep ruts and causes a displacement and mixing of surface soil and subsoil. Many slopes on this soil are difficult or impossible to cross. Tillage machinery should be lifted before crossing such areas. These areas should be reseeded to permanent cover. (Capability unit VIe-3; range site, Deep Upland, 12 to 16 inches precipitation.)

## Yakima Series

The Yakima series consists of excessively drained to somewhat excessively drained, medium-textured soils that have formed in alluvium. The soils occur along Mill Creek and the Walla Walla River below the Ritzville and Walla Walla soils of the uplands. The alluvium consists of basaltic material that has washed from the Blue Moun-

tains and of some loess from the soils of the uplands. The Yakima soils are grayish brown and shallow, and they are underlain by loose pebbles and cobbles of basalt. In many places the soils are gravelly or cobbly on the surface.

The native vegetation consisted of willow and cottonwood along the streams and beardless wheatgrass and wildrye on the dry parts of the bottoms. Sagebrush and sumac grew in the more cobbly areas.

#### **Yakima gravelly silt loam, 0 to 3 percent slopes**

(YkA).-This soil is mostly along Mill Creek, just above the city of Walla Walla, and along Cottonwood Creek.

Representative profile:

- 0 to 6 inches, grayish-brown gravelly silt loam, very dark grayish brown when moist; about 30 percent of volume is gravel; granular structure; slightly hard when dry, friable when moist; neutral.
- 6 to 13 inches, gravelly loam or silt loam that is slightly lighter than that in layer above; massive; hard when dry, friable when moist; neutral.
- 13 inches +, coarse stream pebbles and cobbles.

This soil is somewhat excessively drained. It is low in fertility and in water-supplying capacity. It is moderately rapidly permeable above the gravel and very rapidly permeable in the gravel. Root penetration is shallow. Runoff is very slow, and the hazard of erosion is slight.

The soil contains enough gravel to make tillage difficult. The water-supplying capacity is too low for dryland farming. Crops require irrigation. When carefully irrigated, the soil produces good yields of strawberries and of grass for pasture. (Capability unit VIs-2, dryland; capability unit IIIs-2, irrigated; range site, Bottomland, 6 to 12 inches precipitation.)

**Yakima silt loam, 0 to 3 percent slopes (YmA).**-This is a grayish-brown, medium-textured soil that is underlain by coarse stream gravel at a depth of 15 to 24 inches. It is noncalcareous and about neutral in reaction. Irrigation is necessary for the production of crops. There is little hazard of erosion except that caused by overflow or by streambank cutting. The soil responds to management. (Capability unit IIIs-1, dryland; capability unit IIs-3, irrigated; range site, Bottomland, 6 to 12 inches precipitation.)

**Yakima cobbly loam, 0 to 3 percent slopes (YaA).**-This soil contains large cobbles of basalt that interfere with cultivation. It is excessively drained. Yields of pasture forage are low if the crop is not irrigated. Yields are fair if pastures are properly fertilized and irrigated. (Capability unit VIs-2, dryland; capability unit IVs-1, irrigated; range site, Bottomland, 6 to 12 inches precipitation.)

## ***Use and Management of the Soils***

This section of the report describes the use and management of the soils in considerable detail. The first several parts deal with the general principles of soil management; irrigation; the system of classifying soils according to capability; and the estimated yields of crops that can be expected from the soils of Walla Walla County. Following these parts, the section deals with range management; woodland management; and engineering interpretations.

## **General Principles of Soil Management**

Walla Walla County has a wide range of topography, precipitation, native vegetation, and soil. The topography ranges from that of nearly level stream bottoms to steep mountains; the precipitation, from 7 to more than 40 inches per year; the vegetation, from grassland to forest; and the soils, from deep, friable alluvial soils to shallow and stony soils with rock outcrops. The texture of the soils ranges from loamy fine sand to heavy silt loam. The physical factors just mentioned determine to a large extent the use to which the land is suited and the management it receives.

The practical uses of land imposed by these and other physical factors, however, are influenced by prices, markets, acreage allotments, and personal preferences of the landowner. Considering all factors the operator must determine the best ways of using and managing his property to obtain a good income for his work and maintain a high degree of productivity for his soils. Over most areas of the county, the most important problems of management are the improvement and maintenance of fertility, the control of wind and water erosion, and the safe application of water for irrigating crops in those parts of the county where irrigation water is available.

Some of the general principles and practices important in the use and management of the soils of the county are described in the following pages.

### **Crop rotations**

A good crop rotation will help to stabilize the soil, maintain or improve fertility, increase yields, and improve the nutrient value of the crop (16).

In the wheat-producing area of the county, crops are not rotated, but a simple cropping system is used. The main cropping system in use for the past 40 to 50 years consists of winter wheat alternated with summer fallow. Most of the wheat stubble was utilized for feed or was plowed under; some of it was burned. In the past 20 years, about 12,000 to 15,000 acres of the Walla Walla, Athena, and Palouse soils have been farmed in a rotation consisting of winter wheat and green peas. Many farmers realize that this rotation does not maintain soil productivity nor prevent erosion.

New rotations are being tried. Biennial sweetclover is grown in a rotation with winter wheat and summer fallow. In areas of adequate rainfall, alfalfa and grass are grown in a rotation with winter wheat and summer fallow. These new rotations increase the yields of wheat, but they have not yet been widely accepted. Some farmers object to the use of clover and alfalfa because their establishment requires the loss of two or more crops of wheat. Present practice favors the use of stubble and large quantities of nitrogen fertilizer instead of legumes.

In the drier part of the county, sweetclover and alfalfa cannot be grown successfully without irrigation. A long-term rotation that includes adapted perennial grasses is suitable for the Adkins, Ritzville, and similar soils. A soil-improving rotation for use on the Walla Walla and similar soils should include grass and legumes. A winter wheat-green peas rotation is used on some of the more gently sloping areas.

Some farmers in the 16- to 23-inch rainfall belt grow crops every year. The winter wheat-peas rotation is

widely used. In some areas, wheat or barley are grown continuously or until it is necessary to summer fallow the soil to control weeds. Where small grains are grown every year, the stubble is worked into the soil and large amounts of nitrogen are applied.

In the irrigated parts of the county, the principal soil-building crop consists of a mixture of alfalfa and grass. This crop is grown in a rotation with sugar beets, grains, and sweet corn.

As a rule, crop rotations that result in high yields and that maintain soil organic matter protect the soil against runoff and erosion.

### ***Organic matter***

Soil organic matter is a mixture of the remains of plants and animals. In all its stages of decomposition, organic matter influences the physical and chemical properties of the soil. Growing plants, especially trees, grasses, and close-growing crops, protect the soil during the growing season. The litter and residue left on the ground protect the soil from wind and water erosion when there is little or no plant growth. The intermediate products of decomposition cement and bind the soil aggregates to stabilize them and make them resist the slaking effect of hard rains. These materials also make clay soils easier to till and increase the water-holding capacity of sandy and silty soils. They make soil structure more favorable for plant growth and increase resistance to erosion. Some of these intermediate organic products hold mineral plant nutrients in the soil and prevent their leaching. The final decomposition of organic matter releases nitrogen, phosphorus, and sulfur in a form that is readily available to plants. For these reasons, the maintenance of organic matter is one of the most important practices used on soils of Walla Walla County.

In the western part of the county, the Quincy, Hezel, and other coarse-textured soils require the combined effects of growing plants and large amounts of plant litter for protection from wind erosion. The nutrient-supplying power and the moisture-holding capacity of organic matter are important in these soils. On the Adkins and Ritzville soils, organic matter, as a rule, can be maintained by use of a carefully prepared stubble mulch. If additional organic matter is needed, perennial grasses should be included in the rotation. The same is true for the Walla Walla and similar soils, except that sweetclover and alfalfa may be used with or instead of the grasses.

Mixing part of the stubble with the plow layer and using the rest on the surface has proved most suitable for the Athena soils. This practice should be supplemented by plowing under sweetclover and grass, alfalfa and grass, or annual legumes.

The Palouse soils have not responded satisfactorily to the use of stubble mulch. A better practice is to plow under well-broken plant residue. The use of biennial or perennial legumes for green manure is desirable.

### ***Tillage***

The primary purpose of tillage is (a) to prepare a suitable seedbed; (b) to destroy competing weeds; (c) to improve the physical condition of the soil; and (d) to control erosion. Each tilling of the soil should accomplish a given purpose, and the operator should determine that each tilling is essential.

For many years, the moldboard plow, spike-tooth harrow, and the rod weeder were the principal tillage implements used in the county. Most farmers used a "black fallow" system, which consisted of burning the stubble, using a moldboard plow, harrowing one or two times, and eliminating weeds through the use of a rod weeder. These practices made a good seedbed and controlled weeds fairly well, but they pulverized the soil and made it highly susceptible to erosion.

The trend in the county now is toward less tillage, which is referred to locally as minimum tillage. Some farmers can prepare a suitable seedbed in three to five trips over a field in place of six to eight trips. The soil, the amount of plant residue, and the weed growth influence the number of operations needed for making a seedbed.

The loessal soils in Walla Walla County are arranged into three groups on the basis of tillage requirements. The first group consists of the medium-texture and moderately coarse textured Adkins and Ritzville soils, which contain more than 25 percent sand and less than 8 percent clay. There is very little natural aggregation in these soils. The sand makes them highly susceptible to wind erosion. To reduce the hazard of erosion, the following things ought to be done: Till at right angles to the prevailing winds; leave all stubble possible on the soil; and control weeds with the fewest possible trips over the field.

The second group of loessal soils includes the Ritzville and Walla Walla silt loams that contain less than 25 percent sand and have 8 to 15 percent clay. There is enough clay in these soils to form small, fragile aggregates. These aggregates resist wind erosion but break down when wet and when the soil is cultivated too much. Stubble-mulch tillage that does not destroy the aggregates is a help in the control of erosion.

The third group consists of the Athena and Palouse soils, which have more than 15 percent clay and less than 25 percent sand in the surface layer. These soils form aggregates that are quite stable when dry and that can stand considerable tillage. Some of the more progressive farmers of these soils complete their weeding and seeding operations before the start of the fall rains. This leaves the soil aggregates intact, helps to control erosion, and is an accepted conservation practice. Dry fall plowing for spring seeding also helps to control erosion.

Stubble that occurs in large quantities is generally cut or broken into small pieces so that it can mix with soil in tillage.

### ***Fertilizer***

The grassland soils in Walla Walla County originally contained a generous supply of plant nutrients. Operators could grow from 25 to 30 crops of wheat before these soils needed commercial fertilizer. Tests showed that nitrogen was the only element short in supply.

Each year more farmers test their soils to determine which plant nutrients are needed. Soils are tested in commercial laboratories or in the laboratory of Washington State University. Tests on more than 100 samples of loess soils by the laboratory at Washington State University showed that only six samples needed phosphorus and none needed potassium. Nearly all soil samples showed a need of nitrogen. These tests and the experiences of farmers show that soils in the dry areas need 30 to 40 pounds of nitrogen per acre per year; those in

areas of high rainfall, from 80 to 100 pounds per acre per year. Irrigated soils may need more nitrogen than nonirrigated soils.

According to the Washington State Agricultural Experiment Station (11), sulfur applied on fallow ground (a) usually did not increase crop yields; (b) generally improved the growth of spring-planted cereals; and (c) is needed for maximum yields of nonirrigated legume crops. Sulfur is generally applied as gypsum.

Recent soil tests by the experiment station indicate that large quantities of available phosphorus are needed for irrigated alfalfa grown on the Sagemoor soils. The station recommends as much as 200 pounds of  $P_2O_5$  per acre. Phosphorus is applied as treble superphosphate.

Nitrogen is used in many forms, but anhydrous ammonia, aqua ammonia, ammonium nitrate, and urea are used by most operators. The use of ammonium sulfate improves the quality and slightly increases the yield of green peas.

### ***Control of erosion***

The soils in most of the county were quite resistant to erosion until a large part of the organic matter had been depleted. Once organic matter has been reduced to the critical level, the hazard of erosion increases rapidly. For example, the steep soils on the Skyrocket Hills, which have been farmed only half as long as the soils in the rest of the county, showed much more rilling in the early 50's than in 1940.

Soil erosion is most severe late in winter and early in spring, when melting snow and spring rains occur at their maximum rates. Rains in November and early in December, however, may cause considerable erosion.

The United States Army, Corps of Engineers, estimated that the spring runoff in 1949 deposited 3,000 acre-feet of silt in the mouth of the Walla Walla River. They also estimate that McNary Reservoir is silting at the rate of 1,000 acre-feet per year. Much of this silt washed from wheat-fields in Walla Walla County.

The hazard of wind erosion is high on soils that contain 25 percent or more sand. The Adkins, Quincy, and Hezel soils are in this group. Soil starts blowing as soon as the cover of living vegetation is destroyed. Blowouts increase in size at a rapid rate, and large dunes soon form. A cover of vegetation should be on these soils at all times. Also, protection from fire and the use of proper grazing practices are essential for the control of erosion. If these soils are irrigated, a cover crop and stubble mulch should be used to prevent wind erosion. When cultivated, the Adkins and the coarse-textured Ritzville soils require stubble-mulch and cross-wind tillage or the growing of crops in strips at right angles to the erosive winds.

Water erosion is more of a problem in the Ritzville soil association than on the sandy terraces because slopes are steeper and rainfall is somewhat higher. Soil loss can be controlled by using a good stubble mulch and by reducing tillage so as to prevent pulverizing the soil aggregates. The Ritzville soils generally contain less than 5 percent clay, so the degree of aggregation and the strength of aggregates depend largely on the supply of organic matter in the soil. The control of erosion becomes less difficult as the supply of soil organic matter increases through the use of crop residues and the inclusion of perennial grass in rotations.

The increase of organic matter is even more important in the Walla, Walla soil association because annual rainfall is higher than in the Ritzville association, and erosion during spring runoff may be very severe. However, in the Walla Walla association, there is generally ample stubble and a wider choice of green-manure crops. It is therefore easier to maintain organic matter in the Walla Walla association.

Water erosion is most severe in areas that get 16 inches or more of rain per year. It can be most effectively controlled by annual cropping and initial tillage while the soil is dry. Perennial grasses and legumes for hay and pasture should be grown where erosion is most severe, usually on the steeper slopes.

Erosion on irrigated soils is caused by inadequate control of water and the blowing of soil in the sandy areas. A large head of irrigation water in a corrugation or furrow has power to erode soil. The severity of erosion depends on the gradient of slope and the velocity of flow. Corrugations or furrows should be sloped to the lowest practical gradient, and the water carried should be the amount that will just flow to the low end of the furrow or corrugation. In many places, furrow lengths should be shortened so a smaller head of water can be used.

Little erosion is caused by well-designed sprinkler systems, but poorly designed systems often cause as much soil erosion as severe storms or as corrugations on sloping land.

Wind erosion on irrigated soils is readily controlled by using cover crops, growing hay and pasture on slopes of more than 15 percent, and maintaining adequate moisture at tillage time.

### ***Salts and alkali***

Soils that contain excessive amounts of water-soluble salts and alkali require special reclamation treatment and management. Soluble salts in the soil are the products of the weathering of primary soil minerals. Harmful concentrations of salts occur in places that receive additional salts from other locations. Water is the main carrier of salts, and accumulations in harmful quantities are likely to be associated with poor drainage.

Soils whose productivity is diminished by the presence of sodium, potassium, magnesium, or calcium salts are called *saline soils*. A saline soil that contains an excess of sodium or a high degree of alkalinity has *saline-alkali* characteristics. An *alkali soil* is one that contains a high percentage of exchangeable sodium (15 percent or more of the total exchangeable bases).

Table 5 shows the chemical analyses of several samples of two saline-alkali soils in Walla Walla County—Stanfield silt loam and Umapine very fine sandy loam. Explanation of some of the terms used in table 5 follow.

*Conductivity* is a measure of the content of salt. Saline (salty) conditions are not significant if the conductivity is less than 4 millimhos per centimeter (approximately 0.1 percent salt). Conductivities above 10 indicate that the salt problem is fairly severe. Salts in the Stanfield and Umapine soils of the Walla Walla Valley are particularly detrimental because of their alkali component, which is capable of precipitating calcium from gypsum.

*Gypsum requirement* is a measure of the need of gypsum. It is expressed as tons of gypsum required for

In the original manuscript, there was a table in this space.  
All tables have been updated and are available as a separate document.

2 million pounds of soil, or for an acre to the depth of the plow furrow. Values were determined in the laboratory.

*Exchange capacity* is the capacity of a soil to hold exchangeable ions, generally calcium, sodium, magnesium, or potassium. When 15 percent of the capacity is occupied by sodium ions the soil is considered to be an alkali soil. Exchangeable potassium in amounts of more than 15 percent of the capacity does not cause the serious alkali problem in the growing of plants that a comparable percentage of exchangeable sodium would cause. Reclamation of alkali soil normally involves the replacement of exchangeable sodium by calcium.

The sum of exchangeable ions-sodium and potassium-should not, theoretically, exceed 100 percent. Where it does in table 5, the excess can be attributed to the limitations of laboratory procedure and not to soil characteristics.

A soil with a conductivity of 4 millimhos per centimeter (approximately 0.1 percent salt) is too saline for the production of such salt-sensitive crops as green beans, strawberries, and apples. Alfalfa, sweet corn, wheat, sweetclover, and orchardgrass produce good yields if the conductivity is less than 8 millimhos. Satisfactory yields of sugar beets, barley, asparagus, tall fescue, and tall wheatgrass are possible if the conductivity is less than 12. Only a few salt-tolerant plants, such as western wheatgrass or saltgrass, yield satisfactorily if the conductivity is greater than 12.

Excessive concentrations of salt prevent plants from obtaining enough moisture for growth. Plants growing in a strongly saline soil may wilt while moisture nearly saturates the soil. Many nutrients essential to plant growth are chemically unavailable in an alkali soil. Also, in strongly alkaline soils, some elements are released in the soil solution in toxic amounts.

Some soils in Walla Walla County are both saline and alkaline. The amount of salts and sodium varies widely in a short distance. The work of R. L. Hausenbuiller with soils from the Walla Walla Valley showed that the surface layer of some samples had a conductivity ranging from 1.2 to 85 millimhos per centimeter at 25° C., and the pH in these samples ranged from 8.6 to 10.6. He also found from these samples that the gypsum requirement ranged from 5.3 to 85 tons per acre. The highest gypsum requirement was associated with a high content of soluble salts.

Most of the saline-alkali soils in the county are in the Stanfield and Umapine soil series. In their natural condition, they are of little value except for grazing, because the vegetation is largely saltgrass and greasewood. There are a few small barren areas in which the concentration of salt and alkali is too strong for plants. As a rule, the

salts are easily leached out if adequate drainage is provided. Areas of saltgrass and greasewood have been plowed up, leached for a year or two, and then seeded to sugar beets. Yields of the first crops have been as much as 18 tons per acre, and of the second crop, 25 tons. If the hardpan is 24 inches or more from the surface, good yields of alfalfa can be obtained, but stands will last no longer than 3 or 4 years. Spots that will not grow sugar beets or alfalfa should be treated with gypsum.

The accumulation of salt on the surface of lake terraces has occurred since irrigation was started. The Sagemoor soils and the Touchet beds, in which the Sagemoor soils have formed, contain soluble salts, which are picked up by deeply percolating irrigation water and carried laterally along sandy substrata to the edge of the terrace. The salts are then carried to the surface by the capillary rise of the water. On south slopes, the water is evaporated, and salts are left on the surface. Concentrations of surface salt eventually become too strong for crop plants. Most of the area where salt accumulates on the surface is short of irrigation water in July, August, and September. The large quantities of irrigation water used in this period when it is available apparently increase the movement of salts. During this period, evaporation is very intense. Salt may accumulate in only a small spot, a few feet in diameter, or it may occupy an entire slope. These salty soils are often severely eroded, and the yields of alfalfa and barley are very low.

The more severely affected spots, especially the steeper and severely eroded slopes, are treated as wasteland. Salt-tolerant grasses should be established and maintained on these spots by frequent and uniform applications of irrigation water. Such areas should yield a small amount of forage.

## **Irrigation**

The irrigated valleys of Walla Walla County have smaller farms, different crops, and more diversified agriculture than the semiarid uplands. In addition, a larger percentage of people live on the land they operate. The largest irrigated acreage is on the alluvial and terrace soils in the Walla Walla and Touchet Valleys.

The first irrigation systems in the county were along the streams where water could be obtained easily. Later on, mutual irrigation enterprises were formed, through which groups of landowners built systems large enough to carry water to the higher land. The rights to water for irrigation of agricultural land are administered by a County Water Master, who is under the direction of the Supervisor of Hydraulics, State of Washington.

The most recent expansion of the irrigated acreage occurred when operators drilled their own wells or built pumping plants along streams. Two areas near Burbank are included in the Columbia Basin Project, developed with Federal funds. These areas are known as blocks 2 and 3 of this project.

Most of the irrigation water comes from the Walla Walla River and its tributaries. The rest is obtained from the Snake River and from wells. Regular streamflow provides nearly all of the surface water for irrigation because there are no reservoirs on any of the major streams.

Most irrigation water is distributed through gravity systems and applied to the ground surface, either directly or by sprinklers. At least one-third of the irrigated acreage does not get enough water in July, August, and September—the months in which streamflow is least.

According to the U.S. Census of Agriculture, 37,296 acres were irrigated on 605 farms in 1959. More than 60 percent of the irrigated land was irrigated by sprinklers. Crops were harvested from 27,833 acres on 463 farms. Wheat, barley, corn, alfalfa for hay and seed, other legumes, grasses, and small grains cut for hay, sugar beets, and market vegetables are among the crops grown on irrigated land.

According to the Federal census for 1959, the acreage of the principal crops harvested on irrigated land in the county was as follows: Winter wheat, 2,326; spring wheat, 1,078; barley, 1,713; corn for all purposes, 239; alfalfa and alfalfa mixture cut for hay and dehydrating, 9,439; other legumes, grasses, axed small grains cut for hay, 654; sugar beets for sugar, 4,145; vegetables harvested for sale, 3,708.

Yields of alfalfa seed and sugar beets have been quite high. Those of wheat are lower than on some nonirrigated soils. The shortage of water and quotas on acreage tend to restrict the acreage of sugar beets. The acreage in asparagus is increasing. Some operators grow green peas for processing.

Some unimproved pastures, mainly those in saltgrass, are still irrigated by flooding. Some improved grass pastures have been bordered. Flooding and order irrigation are used in nearly level areas where large heads of water are available. The application of large amounts of water early in spring and late in fall for maximum storage in the soil has caused a high water table and waterlogging in some low areas. This practice is also believed to cause the accumulation of soluble salts on many of the terrace slopes, especially in soils of the Sagemoor series.

Where corrugations and furrows are used on steep slopes, the head of water must be carefully controlled to prevent erosion. Sprinklers are the best way to distribute water in many areas, and their use has increased rapidly in the last 10 years. Sprinklers are expensive to install, but if properly designed, they reduce the amount of labor needed, save water, and distribute the water more evenly.

The small individual irrigation projects are largely on the soils of the bottom lands and low terraces. The large mutual enterprises are mainly on upland soils composed of loess and lake-laid material. Individual pumping plants have brought water to still more of the higher lying land. The Columbia Basin Project includes soils of the sandy terraces and outwash plains.

## **Drainage**

Only a very small acreage in Walla Walla County needs drainage. Most of the poorly drained areas are the result of improper applications of irrigation water or of attempts to leach out soluble salts by flooding, without providing adequate drains. Some operators apply large amounts of water late in fall and early in winter in an attempt to fill the soil with water after a dry summer. As a rule too much water is applied, and the surplus contributes to the high water table. On some of the low-lying areas, the water table rises in spring when streams are high, and then drops to a lower level.

In most wet areas, the soils are at least moderately permeable. Short drains into the main stream or interception ditches built along the foot of terraces make it possible to grow good crops in fields that otherwise produced poor pasture.

## Capability Groups of Soils

The capability classification is a grouping of soils that shows, in a general way, how suitable soils are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soil are grouped at three levels, the capability class, subclass, and unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through VIII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products. There are no class V soils in Walla Walla County.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be up to four subclasses. The subclass is indicated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless a close-growing plant cover is maintained; *w* means that water in or on the soil will interfere with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c* indicates that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c*, because the soils in it have little or no erosion hazard but have other limitations that limit their use largely to pasture, range, woodland, or wildlife.

Within the subclasses are the capability units, groups of soils enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally identified by numbers assigned locally, for example, IIe-1 or IIIe-2.

Soils are classified in capability classes, subclasses and units in accordance with the degree and kind of their permanent limitations; but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soil; and without consideration of possible but unlikely major reclamation projects.

The soils of Walla Walla County are suitable for dryland farming and for irrigated farming, depending mainly on rainfall, the crops to be grown, and the availability of water for irrigation. A soil farmed under irrigation has a different capability than when it is farmed under dryland methods. Some soils in Walla Walla County can be

farmed either way, and some soils are farmed only when irrigation water is available.

The parts of this report that follow provide the capability classifications of soils for dryland and for irrigated farming. The capability classification of Walla Walla County soils is based on a statewide system, and the numbering of capability units in this report may not be consecutive.

### *Management of soils by capability units, dryland*

In this part of the report, the soils are grouped according to their capability without irrigation. Those listed in capability classes VI and VII are suited mainly to range, woodland, or wildlife food and cover. Their management is discussed in the sections "Range Management" and "Woodland Management."

Class I. Soils that have few limitations that restrict their use.

Capability unit I-1.-Deep, medium-textured, moderately permeable soils that have formed on bottom lands and low terraces and have slopes of less than 3 percent; hazard of water erosion is very slight.

Class II. Soils that have some limitations that reduce the choice of plants or require moderate conservation practices.

Subclass IIe.-Soils subject to moderate erosion if they are not protected.

Capability unit IIe-1.-Deep, medium-textured, moderately permeable soils that have formed in loess and have slopes up to 8 percent; precipitation, 16 to 19 inches per year.

Capability unit IIe-2.-Deep, dark-colored, medium-textured soils that have formed in loess and have slopes up to 8 percent; precipitation, 19 to 24 inches per year.

Capability unit IIe-3.-Dark-colored, medium-textured soils on uplands underlain by basalt at a depth of 30 to 48 inches below the surface; precipitation, 19 to 24 inches per year.

Subclass IIw.-Soils that have moderate limitations because of excess water.

Capability unit IIw-1.-Medium-textured, imperfectly drained soils on bottom lands and in low basins; seasonal high water table is within 36 inches of the surface or the soils may be flooded once every 6 to 8 years.

Subclass IIc.-Soils that have moderate limitations caused by climate.

Capability unit IIc-1.-Deep and moderately deep, well-drained alluvial soils; precipitation, 12 to 16 inches per year.

Capability unit IIc-2.-Deep and moderately deep, medium-textured soils that have formed in loess on uplands and have slopes up to 8 percent; precipitation, 12 to 16 inches per year.

Class III. Soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both.

Subclass IIIe.-Soils subject to severe erosion if they are cultivated and not protected.

Capability unit IIIe-1.-Deep, medium-textured soils that have developed in loess on hilly up-



lands and have slopes of 8 to 30 percent; precipitation, 16 to 19 inches per year.

Capability unit IIIe-2.-Moderately deep, medium-textured soils over moderately fine textured, slowly permeable substratum; precipitation, 24 to 30 inches per year.

Capability unit IIIe-3.-Medium-textured soils with slopes up to 30 percent; precipitation, 9 to 12 inches per year.

Capability unit IIIe-4.-Deep, medium-textured soils that have formed in loess and have slopes of 8 to 30 percent; precipitation, 19 to 24 inches per year.

Capability unit IIIe-5.-Moderately deep, medium-textured soils underlain by basalt; precipitation, 19 to 24 inches per year.

Capability unit IIIe-6.-Medium-textured, moderately deep soils that have formed in loess and have slopes up to 30 percent; precipitation, 10 to 12 inches per year.

Capability unit IIIe-7.-Medium-textured soils that have formed in loess and have slopes up to 30 percent; most of soils have a hardpan, a hard, columnar subsoil, or overlie calcareous lake sediment; precipitation, 12 to 16 inches per year.

Subclass IIIs.-Soils that have severe limitations of moisture capacity or tilth.

Capability unit IIIs-1.-Medium-textured soils over gravel.

Subclass IIIc.-Soils subject to moderate limitations because of dry climate.

Capability unit IIIc-1.-Deep, medium-textured soils on gentle slopes; precipitation, 9 to 12 inches per year.

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVe.-Soils subject to very severe erosion if they are cultivated and not protected.

Capability unit IVe-1.-Deep and moderately deep, medium-textured and moderately coarse textured soils that have slopes of 30 percent; precipitation, 8 to 10 inches per year.

Capability unit IVe-2.-Severely eroded soils that have slopes up to 45 percent, have formed in loess, and are more than 24 inches deep.

Capability unit IVe-3.-Deep to moderately deep, medium-textured soils having slopes of 30 to 45 percent; precipitation, 16 to 24 inches per year.

Capability unit IVe-4.-Eroded, moderately deep, medium-textured soils that have slopes up to 15 percent and that are underlain by dense, slowly permeable substratum; precipitation, 24 to 30 inches per year.

Capability unit IVe-5.-Moderately deep, medium-textured soils that are underlain by dense, slowly permeable substratum and that occupy north-facing slopes; precipitation, 24 to 30 inches per year.

Capability unit IVe-6.-Medium-textured soils, mostly eroded, that have slopes up to 30 percent; precipitation, 9 to 12 inches per year.

Capability unit IVe-7.-Deep, medium-textured soils that have slopes a to 15 percent and occupy gently sloping ridges in the Blue Mountains ; precipitation, 30 to 40 inches per year.

Capability, unit IVe-8.-Medium-textured soils that have formed in loess on steep uplands, mainly on north- and west-facing slopes; precipitation, 10 to 12 inches per year.

Capability unit IVe-9.-Shallow to moderately deep soils that have formed in loess underlain by old calcareous lake deposits on nearly level to steep upland terraces; precipitation, 6 to 9 inches per year.

Capability unit IVe-10.-Deep, medium-textured, eroded soils that have formed in volcanic -ash and loess; precipitation, 12 to 16 inches per year.

Capability unit IVe-11.-Deep, dark-colored, medium-textured soils; precipitation, 12 to 16 inches per year.

Class VI. Soils that have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

Subclass VIe.-Soils severely limited, chiefly by risk of erosion if protective cover is not maintained.

Capability unit VIe-1.-Moderately coarse, gently sloping to steep soils of the uplands; precipitation, 8 to 10 inches per year.

Capability unit VIe-2.-Medium-textured, rolling to steep soils of the uplands; precipitation, 9 to 12 inches per year.

Capability unit VIe-3.-Medium-textured, gently sloping to very steep soils of the uplands; precipitation, 12 to 15 inches per year.

Capability unit VIe-4.-Deep, medium-textured, rolling to very steep soils of the uplands; precipitation, 19 to 24 inches per year.

Capability unit VIe-5.-Moderately deep medium-textured, steep to very steep soils of the uplands; precipitation, 19 to 24 inches per year.

Capability unit VIe-6.-Medium-textured, rolling to very steep soils of the uplands; precipitation, 24 to 30 inches per year.

Capability unit VIe-7.-Medium-textured, rolling to very steep soils of the uplands; precipitation, more than 30 inches per year.

Capability unit VIe-8.-Medium-textured, rolling to steep soils of the uplands; precipitation 6 to 9 inches per year.

Subclass VIs.-Soils generally unsuitable for cultivation and limited for other uses by their moisture capacity, stones, or other features.

Capability unit VIs-1.-Medium-textured, very gently sloping soils of the bottom lands that are slightly to strongly saline-alkali; precipitation, 8 to 14 inches per year.

Capability unit VIs-2.-Gravelly and cobbly, medium-textured, very gently sloping soils underlain by gravel at shallow depths; precipitation, 6 to 12 inches per year.

Capability unit VIs-3.-Cobbly, medium-textured, very gently sloping soils of the bottom lands; precipitation, 12 to 24 inches per year.

Class VII. Soils that have very severe limitations that make them unsuited to cultivation and that restrict their use mainly to grazing, woodland, or wildlife.

Subclass VIIe.-Soils very severely limited, chiefly by risk of erosion if protective cover is not maintained.

Capability unit VIIe-1.-Coarse-textured, gently sloping to steep soils that occupy mainly the uplands; precipitation, 6 to 9 inches per year.

Capability unit VIIe-2.-Deep, medium-textured, eroded or steep soils on uplands; precipitation, 9 to 12 inches per year.

Capability unit VIIe-3.-Deep, medium-textured, steep soils on uplands; precipitation, 24 to 30 inches per year.

Capability unit VIIe-4.-Deep, medium-textured, steep soils on uplands; precipitation, more than 30 inches per year.

Subclass VIIs.-Soils very severely limited by moisture capacity, stones, or other soil features.

Capability unit VIIs-1.-Coarse to moderately coarse soils on river terraces; precipitation, 6 to 9 inches per year.

Capability unit VIIs-2.-Rocky and very rocky, moderately coarse textured to medium-textured, gently sloping to hilly soils that overlie basalt at a depth of 10 to 20 inches; precipitation, 6 to 9 inches per year.

Capability unit VIIs-3.-Rocky and very rocky, medium-textured, gently sloping to very steep soils overlying basalt at a depth of 10 to 20 inches; precipitation, 9 to 12 inches per year.

Capability unit VIIs-4.-Rocky and very rocky, medium-textured, gently sloping to very steep soils overlying basalt at a depth of 10 to 20 inches; precipitation, 18 to 24 inches per year.

Capability unit VIIs-5.-Rocky, medium-textured, gently sloping to very steep soils overlying basalt at a depth of 18 to 30 inches; precipitation, 30 inches and more per year.

Capability unit VIIs-6.-Very shallow, rocky land types and soils on undulating to very steep slopes underlain by basalt at a depth of less than 10 inches; precipitation, 6 to 16 inches per year.

Capability unit VIIs-7.-Very shallow, rocky land types on undulating to very steep slopes that are underlain by basalt at a depth of less than 10 inches; precipitation, 16 to 23 inches per year.

Class VIII. Soils and landforms that have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

Subclass VIIIe.-Soils severely limited, chiefly by risk of erosion if protective cover is not maintained.

Capability unit VIIIe-1.-Soils and land types that are sandy and suitable only for wildlife habitat, watershed, recreational, or other nonagricultural uses.

Subclass VIIIw.-Extremely wet or marshy land.

Capability unit VIIIw-1.-Land types that are unsuitable for crops, mainly because they are subject to overflow.

Subclass VIIIs.-Rock or soil materials that have little potential for the production of vegetation,

Capability unit VIIIs-1.-Soils and land types that are too steep, sandy, or rocky for uses other than wildlife habitat, watershed, recreation, or other nonagricultural purposes.

#### **CAPABILITY UNIT I-1**

This capability unit consists of one deep., medium-textured, moderately permeable soil that occupies bottom lands and low terraces and has slopes of less than 3 percent. The hazard of water erosion is very slight. The soil in this unit is-

Snow silt loam, 0 to 3 percent slopes.

This soil produces high yields of wheat and green peas when farmed in a winter wheat-peas rotation. Proper management consists of using all crop residue and occasionally green manure to maintain the supply of organic matter. Nitrogen should be applied to wheat and sulfur to peas.

#### **CAPABILITY UNIT IIe-1**

This unit consists of one deep, medium-textured, moderately permeable soil that has formed in loess and has slopes up to 8 percent. Precipitation is 16 to 19 inches a year, which is enough moisture for all crops commonly grown in the area. The soil in this unit is-

Athena silt loam, 0 to 8 percent slopes.

This soil produces good yields of winter and spring wheats, barley, and green peas. It can be cropped every year. A rotation commonly used consists of winter wheat followed by green peas. A system in which grain follows grain is also suitable. If the grain-after-grain system is used, all crop residue should be returned to the soil and large quantities of nitrogen applied. Light applications of sulfur are good for green peas.

The main problems are controlling water erosion late in winter and early in spring when winter wheat is in the seedling stage, and maintaining the supplies of organic matter and plant nutrients. The management needed to control erosion consists of using crop residue, stubble-mulch tillage, rough tillage in the fall, use of minimum tillage to avoid pulverizing the soil, and seeding along the contour.

#### **CAPABILITY UNIT IIe-2**

This unit consists of one deep, dark-colored, medium-textured soil that has formed in loess and has slopes up to 8 percent. Precipitation is 19 to 24 inches a year. The soil in this unit is-

Palouse silt loam, 0 to 8 percent slopes.

This soil is suitable for annual cropping. It produces high yields of winter and spring wheats, barley, green peas, alfalfa, and grass. A winter wheat-green peas rotation is most widely used. A few farmers use a system of continuous wheat or continuous barley until summer fallow is needed to control annual weeds. Large applications of nitrogen are needed for wheat and for grass when it is grown for seed: Alfalfa and clover need sulfur.

The main problems are controlling erosion late in winter and early in spring, maintaining granular soil structure, and maintaining the supplies of organic matter and plant nutrients. The management needed to control ero-

sion consists of mixing crop residue with the plowed layer, rough tillage in the fall, preparing seedbed and seeding on the contour ahead of fall rains, use of minimum tillage to avoid pulverizing the soil, and establishing grass in waterways.

#### **CAPABILITY UNIT IIe-3**

This capability unit consists of one dark-colored, medium-textured soil on uplands that is underlain by basalt 30 to 48 inches below the surface. Precipitation ranges from 19 to 24 inches a year. The soil is not deep enough to hold all the precipitation that falls in winter and spring. Melting snow always causes large amounts of runoff. The moderate depth restricts the moisture-supplying capacity. The soil in this unit is-

Palouse silt loam, moderately deep, 0 to 8 percent slopes.

This soil does not hold enough moisture for high yields of crops. However, it can be cropped every year and is suitable for winter wheat and green peas. It produces good yields of alfalfa and grass. Many operators follow a winter wheat-summer fallow rotation. The fallow period was formerly used to control weeds, but in most places, weeds can now be controlled through use of chemicals.

The main problems are controlling erosion from spring runoff and maintaining enough plant nutrients and organic matter in the soil. Large amounts of nitrogen are needed for high yields of wheat; light to moderate amounts of sulfur are needed for green peas. Spring tillage is often delayed by wetness.

Management needed to control erosion consists of utilizing crop residue and mixing it with the plowed layer, rough tillage in the fall, preparing seedbed and seeding along the contour ahead of fall rains, use of minimum tillage to avoid pulverizing the soil, and establishing grass in waterways. Mulches delay drying of the soil and reduce soil temperatures in the spring.

#### **CAPABILITY UNIT IIw-1**

This unit consists of medium-textured, imperfectly drained soils on bottom lands and in low basins. These soils have a seasonally high water table that rises to within 36 inches of the surface, or they may be flooded once every 6 to 8 years. The Pedigo soils of this unit are moderately to strongly alkaline and in places slightly saline. However, when drainage is established, the alkalinity and salinity only slightly affect the production of crops. The soils in this unit are-

Catherine silt loam, 0 to 3 percent slopes.  
Pedigo silt loam, 0 to 3 percent slopes.

The largest part of these soils occurs in the irrigated area. If adequate drainage is established and floodwater is diverted, good yields of wheat and green peas can be grown without irrigation. These soils can be cropped every year. A suitable rotation consists of three crops of wheat or barley followed by one crop of green manure. A cropping system that will maintain the supply of organic matter is winter wheat-summer fallow for 4 to 6 years followed by a legume-grass mixture for green manure.

The main management problems are providing adequate drainage, diverting floodwater to keep off deposits of fresh sediment, and maintaining enough organic matter in the soil.

#### **CAPABILITY UNIT IIc-1**

This unit consists of deep and moderately deep, well-drained soils that have formed in alluvium. These soils occur in narrow strips along the large streams. Precipitation is 12 to 16 inches a year. The soils in this unit are-

Hermiston silt loam, 0 to 3 percent slopes.  
Hermiston very fine sandy loam, 0 to 3 percent slopes.  
Onyx silt loam, 0 to 3 percent slopes.  
Patit Creek silt loam, 0 to 3 percent slopes.  
Pedigo silt loam, overwashed, 0 to 3 percent slopes. Touchet silt loam, 0 to 3 percent slopes.

Because of limited rainfall or restricted depth, these soils are suited to only a few crops. Yields of wheat and green peas are good; those of grasses and alfalfa, fair.

The main problems are maintaining supplies of organic matter and available nitrogen and controlling wind erosion on the very fine sandy loam. Management needed consists of utilizing crop residue, using minimum tillage to avoid breaking up soil aggregates, and applying nitrogen in moderate amounts to the nonleguminous crops.

#### **CAPABILITY UNIT IIc-2**

This unit consists of deep and moderately deep, medium-textured soils on uplands that have formed in loess. Slopes are up to 8 percent. Precipitation ranges from 12 to 16 inches a year. The amount of clay in these soils is fairly low, so the formation of durable aggregates depends on organic matter. The soils in this unit are-

Walla Walla silt loam, 0 to 8 percent slopes.  
Walla Walla silt loam, lacustrine substratum, 0 to 8 percent slopes.

These soils can be cropped every year. Winter wheat and barley are the main crops, and high yields are produced. Green peas are grown for canning and freezing. Yields are generally high, but early hot weather ripens peas too fast and occasionally spoils the crop. Processors allot a certain percentage of the pea acreage to the soils of this unit to take advantage of early maturing of the crop.

Cropping systems consist of winter wheat followed by green peas or of wheat grown every year. If wheat is grown every year green manure may be needed occasionally to maintain the supply of organic matter. Cropping systems that will maintain organic matter are winter wheat-summer fallow for 4 or 6 years followed by a legume-grass mixture for green manure or wheat followed by a biennial legume.

The main problems are controlling erosion early, in spring, maintaining granular soil structure, and supplying enough organic matter and available nitrogen. Moderate amounts of nitrogen are needed to produce high yields of crops. The management needed consists of using crop residue and stubble-mulch tillage, tilling only to control weeds and to prepare the seedbed, and seeding along the contour.

#### **CAPABILITY UNIT IIIe-1**

This capability unit consists of a deep, medium-textured soil that has developed in loess under grass on hilly uplands. Slopes are from 8 to 30 percent. Precipitation ranges from 16 to 19 inches a year. The soil in this unit is-

Athenia silt loam, 8 to 30 percent slope.

This soil is very productive. It can be cropped every year. Spring and winter wheats, green peas, and barley

are the main crops. Intermediate wheatgrass and alfalfa are good soil-building crops. A commonly used rotation consists of winter wheat and green peas, or a system in which grain follows grain. If the grain-after-grain system is used, all crop residue should be returned to the soil and large amounts of nitrogen applied. Peas and other legumes need moderate amounts of sulfur. Commercial nitrogen is applied in moderate amounts to wheat.

Many operators use a rotation consisting of winter wheat and summer fallow. This rotation controls erosion if conservation is practiced. However, supplies of organic matter are difficult to maintain.

The main problems are controlling erosion late in winter and early in spring, preventing the formation of gullies and channels in drainageways, and maintaining adequate organic matter, nitrogen, and sulfur in the soil.

The management needed to control erosion consists of utilizing crop residue; stubble-mulch tillage that mixes part of the stubble with the plowed layer and leaves the rest on the surface; use of minimum tilling that does not pulverize the soil; seeding along the contour; plowing by turning the furrow slice uphill; stripcropping or divided-slope farming (field stripcropping) on slopes longer than 400 feet; and establishing grass in waterways.

#### **CAPABILITY UNIT IIIe-2**

This unit consists of moderately deep, medium-textured soils over a moderately fine textured, slowly permeable substratum. Precipitation ranges from 24 to 30 inches a year. The soils formed under a cover of ponderosa pine, shrubs, and grasses. They are generally too wet for tillage until late in spring. Melting snow always causes considerable runoff early in spring. Late rains keep the soils wet and cold and retard the growth of crops until early in summer. The soils in this unit are-

Couse silt loam, 3 to 8 percent slopes.

Couse silt loam, 8 to 15 percent slopes.

These soils are suitable for cropping every year if soil-building crops are grown occasionally. They are moderately productive for wheat and green peas that are grown in an annual cropping system. A suitable rotation is orchardgrass and red clover for 2 years followed by wheat and peas for 4 years. Alfalfa may be used instead of red clover, but it is not well adapted.

These soils were formerly used mainly for peas, but as yields declined, the growing of peas as the main crop was discontinued. The system of wheat and summer fallow is no longer widely used. A few operators are seeding grasses. When stands of grass get thin, grain can be grown 1 or 2 years and the pasture can be reseeded. These soils are suited to trees, and a large acreage has been planted in ponderosa pine.

The main problems are controlling runoff and erosion in cultivated fields and maintaining enough organic matter in the soil. The management needed to control erosion consists of utilizing crop residue; stubble-mulch tillage that mixes part of the stubble with the plowed layer and leaves the rest on the surface; use of rough tillage in the fall; seeding along the contour; and disposing of water through grassed waterways and diversion ditches. Commercial nitrogen is applied in moderate amounts to wheat.

#### **CAPABILITY UNIT IIIe-3**

This unit consists of medium-textured soils having slopes up to 30 percent. Precipitation ranges from 9 to 12 inches per year. Cultivated fields composed of these soils generally have about 1 1/2 percent of organic matter in the surface layer. These soils erode, but the runoff that causes erosion does not occur so often as in areas that have more precipitation. The hazard of wind erosion is a constant problem, particularly on the very fine sandy loams. Soils in this unit are-

Ellisforde silt loam, 3 to 8 percent slopes.

Ellisforde silt loam, 8 to 15 percent slopes.

Ellisforde silt loam, 15 to 30 percent slopes.

Ellisforde silt loam, hardpan variant, 3 to 8 percent slopes.

Ellisforde very fine sandy loam, 3 to 8 percent slopes.

Ellisforde very fine sandy loam, 8 to 15 percent slopes.

Ellisforde very fine sandy loam, 15 to 30 percent slopes.

Esquatzel very fine sandy loam, 0 to 3 percent slopes.

Magallon very fine sandy loam, 0 to 15 percent slopes.

Magallon very fine sandy loam, 15 to 30 percent slopes.

Ritzville silt loam, 8 to 30 percent slopes.

Ritzville very fine sandy loam, 0 to 8 percent slopes.

Ritzville very fine sandy loam, 8 to 30 percent slopes.

Low rainfall restricts the choice of crops to winter wheat and drought-tolerant grasses. The soils of this unit are suitable for a cropping system consisting of winter wheat and summer fallow. Nitrogen is applied to wheat. Yields are moderate, but the required hours for labor and machinery per acre are less for these soils than for those that receive higher rainfall. Barley grown on these soils does little more than pay the costs of production.

These soils are also suitable for a long-term rotation consisting of 4 to 6 years of crested wheatgrass or beardless wheatgrass followed by winter wheat and summer fallow until four crops of wheat are grown. Nitrogen is applied to wheat in amounts depending on soil moisture.

The main problems are controlling erosion, maintaining enough organic matter, and controlling weeds with the least amount of tillage. Management needed consists of stubble-mulch tillage; seeding along the contour between August 20 and September 15, and a minimum amount of tillage.

#### **CAPABILITY UNIT IIIe-4**

This unit consists of deep; medium-textured soils that have formed in loess and have slopes of 8 to 30 percent. Precipitation ranges from 19 to 24 inches a year. The subsoil has very little more clay than the surface layer, but it is denser, is harder when dry, and is firmer when moist. The buildup of soil moisture early in spring is sometimes so rapid that runoff occurs before the subsoil is filled to field capacity. Soils in this unit are-

Palouse silt loam, 8 to 30 percent slopes.

Palouse silt loam, 8 to 30 percent slopes, eroded.

These soils can be cropped every year if all plant residue is returned to the soil and large amounts of nitrogen are applied. They are suitable for rotations of wheat and peas or barley and peas. Wheat and barley are seldom grown in the same rotation. A suitable rotation consists of winter wheat and green peas for 6 years or a grain-fallow system for 3 years, followed by perennial grasses and legumes for 2 to 4 years. Smooth brome grass and alfalfa are a good combination on these soils. Light applications of sulfur are good for alfalfa and green peas. Nitrogen is applied to wheat.

The main problems are controlling runoff and erosion early in spring when soil is frozen, maintaining granular soil structure, and supplying enough plant nutrients. The management needed to control erosion consists of mulch tillage that mixes some of the stubble with the plowed layer, rough tillage in the fall, use of minimum tillage that prevents pulverizing the soil, seeding along the contour, stripcropping or divided-slope farming (field stripcropping) on slopes more than 400 feet long, plowing by turning furrow slices uphill, and establishing grass in waterways.

#### **CAPABILITY UNIT IIIe-5**

This unit consists of one moderately deep, medium-textured soil that is underlain by basalt at a depth of 2 to 4 feet from the surface. Precipitation is 19 to 24 inches a year. The soil cannot hold all the moisture that falls in winter, nor does it hold enough moisture needed for late-maturing crops. A large amount of runoff occurs each spring, and the loss of soil from unprotected fields is high. The loss of soil from grassland is low. The soil in this unit is-

Palouse silt loam, moderately deep, 8 to 30 percent slopes.

This soil can be cropped every year. There is generally enough moisture for early maturing crops like winter wheat and green peas. Spring wheat, however, does not yield well because moisture is short later in the growing season. In addition the soil is wet until late in spring, and this delays planting of spring-sown crops.

A suitable rotation consists of winter wheat and green peas for 6 years followed by perennial grass and legumes for 4 years. Large amounts of nitrogen are needed for high yields of wheat. Light applications of sulfur are good for green peas and alfalfa. Alfalfa and orchardgrass or smooth brome grass are good soil-improving crops on this soil.

The main problems are controlling runoff and erosion early in spring, maintaining good soil structure, and supplying enough nitrogen and organic matter in the soil. Management practices needed to control erosion are plowing in fall and leaving the surface rough in winter, mixing stubble with the plowed layer, plowing by turning the furrow slice uphill, seeding along the contour, divide-slope farming (field stripcropping) on slopes longer than 400 feet, fertilizing the crop to be grown, and establishing grass in waterways and diversion ditches.

#### **CAPABILITY UNIT IIIe-6**

This unit consists of one medium-textured, moderately deep soil that has formed in loess and has slopes up to 30 percent. It is underlain by bedrock at a depth of 2 to 4 feet. The soil generally does not hold enough moisture to produce good yields of wheat. High yields are produced only when precipitation is above normal in May and June. The soil in this unit is-

Ritzville silt loam, moderately deep, 8 to 30 percent slopes.

This soil generally is in fields that are composed mainly of larger areas of soils in capability unit IIIe-3. Yields of wheat from this soil range from about 10 to 15 bushels per acre. Those of rye are higher. Operators do not like to grow rye and wheat in the same field because volunteer rye must be rogued from winter wheat by hand.

The best cropping system consists of 4 to 6 years of crested wheatgrass followed by winter wheat and summer

fallow until four crops of wheat are grown. The most important problems are controlling runoff and erosion and conserving moisture. Nitrogen is applied to wheat in quantities that depend on moisture in the soil.

#### **CAPABILITY UNIT IIIe-7**

This capability unit consists of medium-textured soils that have formed in loess and have slopes up to 30 percent. Most of the soils are underlain by calcareous lake sediment, hardpan, or hard, columnar subsoil. These soils have a slight to moderate hazard of erosion. Considerable runoff occurs late in winter and early in spring if the soils are frozen or finely pulverized. Soils in this unit are-

Spoffard silt loam, 0 to 3 percent slopes.

Spoffard silt loam, 3 to 8 percent slopes.

Walla Walla silt loam, 8 to 30 percent slopes.

Walla Walla silt loam, hardpan variant, 0 to 8 percent slopes.

Walla Walla silt loam, lacustrine substratum, 8 to 30 percent slopes.

These soils produce good crops of winter wheat and fair crops of spring wheat and barley. Small quantities of early green peas are grown, but the acreage of this crop is limited by the capacity of the processing plants. Most farmers use a rotation consisting of winter wheat and summer fallow. This rotation helps to control erosion if stubble mulch, minimum tillage, contour seeding, and weed control are practiced. Green peas may be grown instead of practicing summer fallow.

A rotation consisting of winter wheat and summer fallow for 4 to 6 years followed by biennial or perennial legumes and grass grown as green manure helps to control erosion and increases the yields of wheat. This rotation, with sweetclover as the legume, was once popular in this area. In recent years, farmers have been using the winter wheat-summer fallow system. Wheat is given moderate amounts of nitrogen. It is advisable, however, to include a green-manure crop where the winter wheat-summer fallow does not maintain enough organic matter.

The main problems are controlling runoff and erosion, maintaining granular soil structure, and supplying adequate amounts of nitrogen. The management needed to control erosion consists of stubble mulching that keeps all residue on the surface; tilling a field not more than five times, including the tillage required for seeding; seeding along the contour; divide-slope farming (field stripcropping) in fields more than 400 feet long; and applying sulfur to legumes and nitrogen to wheat and grass in amounts determined by soil tests.

#### **CAPABILITY UNIT IIIs-1**

This unit consists of two medium-textured soils over gravel. In one soil, the gravel is 12 to 24 inches below the surface; in the other, gravel is scattered throughout the profile. The moisture-supplying capacity of these soils is limited by these conditions. The soils in this unit are-

Touchet gravelly silt loam, 0 to 3 percent slopes.

Yakima silt loam, 0 to 3 percent slopes.

These soils are suited to wheat and grass. A suitable cropping system is intermediate wheatgrass or big bluegrass for 4 to 6 years and then wheat and fallow until three crops of wheat have been grown. Yields of nonirrigated crops are almost entirely dependent on May and June rains.

Management needed to conserve moisture and to maintain or increase fertility and organic matter consists of use

of all crop residue, use of stubble-mulch tillage, and applying nitrogen fertilizer to wheat.

#### **CAPABILITY UNIT IIIc-1**

This capability unit consists of medium-textured soils having slopes up to 8 percent. Precipitation ranges from 9 to 12 inches per year. The surface layer in cultivated fields generally contains less than 1 1/2 percent organic matter. The soils are subject to wind and water erosion. Their use is limited by lack of moisture during the growing season. Ellisforde silt loam, hardpan variant, 0 to 3 percent slopes, has hardpan at a moderate depth. It is the only soil of this kind in the survey area. Soils in this unit are-

Ellisforde silt loam, 0 to 3 percent slopes.  
Ellisforde silt loam, hardpan variant, 0 to 3 percent slopes. Esquatzel  
silt loam 0 to 3 percent slopes.  
Ritzville silt loam, 0 to 8 percent slopes.

Low rainfall restricts the crops to winter wheat and drought-tolerant grasses. A suitable cropping system is winter wheat and summer fallow. Yields are moderate, but the inputs of labor and machinery per acre are less for the yields obtained on these soils than for those obtained on soils that get more rain. Wheat gets small amounts of nitrogen. Barley grown on the soils of this unit barely pays the cost of production.

These soils are also suitable for rotations consisting of 4 to 6 years of crested wheatgrass or beardless wheatgrass, followed by winter wheat and summer fallow until four Crops of wheat are grown. Enough nitrogen is applied to balance that needed for the decay of grass roots.

The main problems are conserving moisture, maintaining enough organic matter, and controlling weeds with minimum tillage. The amount of nitrogen used depends on the amount of moisture in the soil. The management needed is stubble-mulch tillage, control of weeds with the least tillage, and seeding at right angles to the prevailing wind between August 20 and September 15.

#### **CAPABILITY UNIT IVe-1**

This unit consists of deep and moderately deep, medium-textured and moderately coarse textured soils that have slopes up to 30 percent. Precipitation is 8 to 10 inches a year. The water-supplying capacity is fair to good. The hazard of wind erosion is moderate to high. Farm machinery is difficult to handle on the steeper slopes. Soils in this unit are-

Adkins fine sandy loam, 0 to 15 percent slopes.  
Adkins fine sandy loam, 15 to 30 percent slopes.  
Farrell very fine sandy loam, 3 to 15 percent slopes.  
Farrell very fine sandy loam, 15 to 30 percent slopes.  
Magallon fine sandy loam, 0 to 15 percent slopes.  
Magallon fine sandy loam, 15 to 30 percent slopes.

A winter wheat-summer fallow rotation is used on these soils. However, it is not known whether enough organic matter can be maintained in the soil through the use of this rotation. These soils are suitable for occasional cropping in a rotation consisting of winter wheat and summer fallow for 8 years followed by crested wheatgrass or beardless wheatgrass for 4 to 6 years.

The main problems are recontrolling wind erosion, producing enough stubble for a good protective mulch, and maintaining enough organic matter and plant nutrients in the soil. The management needed to control erosion consists of stubble mulching that does not break up the stub-

ble; tilling a field not more than four times, including that required for seeding; wind stripping in fields producing wheat; seeding early; and applying nitrogen at seeding time.

#### **CAPABILITY UNIT IVe-2**

This unit consists of severely eroded soils that have slopes up to 45 percent, have formed in loess, and are more than 24 inches deep. Soils in this unit are-

Athena silt loam, 8 to 30 percent slopes, eroded.  
Athena silt loam, 30 to 45 percent slopes, eroded.  
Palouse silt loam, moderately deep, 8 to 30 percent slopes, eroded.

These soils are suitable for a long-term rotation that consists of the soil-improving crops (smooth bromegrass and alfalfa) for 3 to 6 years followed by grain and summer fallow for 6 years. For the first two cycles, grass and alfalfa should be grown for 6 years. As yields of grain improve, the rotation can be adjusted to 4 years of grass and alfalfa followed by 4 years of grain and summer fallow. Nitrogen will be needed for the wheat crop that follows immediately the plowing under of a large growth of grass and alfalfa. The crops of wheat in following years will need less nitrogen. The amount can be determined by a soil test. Sulfur is needed for the best growth of alfalfa.

The main problems are controlling erosion, increasing supplies of organic matter, and maintaining the supply of plant nutrients. The management practices needed consists of rough tillage in the fall, use of all crop residue, plowing under the growth of soil-improving crops in the last year of cycle, seeding along the contour, improving the supply of plant nutrients, and plowing by turning the furrow slice uphill.

#### **CAPABILITY UNIT IVe-3**

This unit consists of deep and moderately deep, medium-textured soils that have 30 to 45 percent slopes. Precipitation is 16 to 24 inches a year. The soils in this unit are-

Athena silt loam, 30 to 45 percent slopes.  
Palouse silt loam, 30 to 45 percent slopes.

These soils are nearly marginal for cultivation. A suitable rotation consists of 4 years of smooth bromegrass and alfalfa followed by 2 years of wheat. Wheat and grass respond to additions of nitrogen; alfalfa needs sulfur.

The main problems are controlling erosion, increasing the supply of organic matter, and maintaining enough plant nutrients in the soil.

#### **CAPABILITY UNIT IVe-4**

This unit consists of eroded, moderately deep, medium-textured soils that have slopes up to 15 percent and that have a dense, slowly permeable substratum. Precipitation is 24 to 30 inches a year. These soils are saturated until late in spring and are too wet and cold until early in summer for more than limited growth of crops. Soils in this unit are-

Couse silt loam, 3 to 8 percent slopes, eroded.  
Couse silt loam, 8 to 15 percent slopes, eroded.

These soils are suited to trees. Some old fields have been planted to ponderosa pine. In addition, many areas of this unit are being seeded to perennial grasses for pasture. Areas not taken from cultivation are suitable for a rotation consisting of orchardgrass and red clover for 6 years followed by grain for 2 years. As the yield of grain increases,

the soil-improving part of the rotation can be reduced to 4 years. In their eroded condition, the soils are not suited to green peas.

The main problems are controlling runoff and erosion and improving the supplies of organic matter and plant nutrients. The management needed to control erosion consists of mixing the grain-crop residue with the plowed layer, rough tillage in the fall, seeding along the contour, plowing under a season's growth of soil-improving crops in the last year of cycle, and using diversion ditches or grassed waterways, or both, to control runoff.

#### **CAPABILITY UNIT IVe-5**

This unit consists of one moderately deep, medium-textured soil that has a dense, slowly permeable substratum. This soil occupies north-facing slopes. Precipitation is 24 to 30 inches a year. Runoff in large amounts occurs each spring, but the loss of soil is low. The soil in this unit is-

Couse silt loam, 15 to 30 percent slopes.

A large part of this soil is in forest. Because this soil is not eroded, a suitable rotation is 4 years of orchardgrass and red clover followed by 2 years of grain. Another less intensive rotation is orchardgrass and red clover for 6 years followed by grain for 2 years. Suitable management practices include mixing all grain-crop residue with the plowed layer, rough tillage in the fall, plowing under the growth of soil-improving crops in the last year of cycle for green manure, and using diversion ditches or grassed waterways, or both, where applicable.

#### **CAPABILITY UNIT IVe-6 1**

This unit consists of medium-textured soils, mostly eroded, that have slopes of as much as 30 percent. In most places the surface layer has been washed away, and light-colored subsoil is exposed in tillage. The soils in this unit are-

Ellisforde silt loam, 8 to 15 percent slopes, eroded.  
Ellisforde silt loam, 15 to 30 percent slopes, eroded.  
Ellisforde very fine sandy loam, 8 to 15 percent slopes, eroded.  
Ellisforde very fine sandy loam, 15 to 30 percent slopes, eroded.  
Magallon very fine sandy loam, 15 to 30 percent slopes, eroded.  
Ritzville silt loam, 8 to 30 percent slopes, eroded.  
Ritzville very fine sandy loam, 8 to 30 percent slopes, eroded.  
Ritzville very fine sandy loam, volcanic-ash variant, 0 to 8 percent slopes.

These soils are all cultivated. Yields of wheat are low, and those in dry years seldom pay the costs of harvesting. The soils should be seeded to perennial grass and not grazed until they are improved. After improvement, they can be farmed in a rotation that consists of 4 to 6 years of crested wheatgrass or beardless wheatgrass followed by grain and fallow until four crops of grain are grown.

The main problems are controlling runoff and erosion and increasing the supply of organic matter. Management practices needed are stubble mulching that keeps all residue on the surface, minimum amount of tillage, seeding along the contour in the period between August 20 and September 15, and applying nitrogen to grain and to start grass.

#### **CAPABILITY UNIT IVe-7**

This unit consists of a deep, medium-textured soil that has slopes up to 15 percent. This soil occupies gently sloping ridges in the Blue Mountains. Precipitation is 30 to 40 inches per year. The soil in this unit is-

Helmer silt loam, 3 to 15 percent slopes.

Most of this soil is still in forest. Cleared areas that are intended for pasture should be seeded with orchardgrass and red clover. Pastures in need of improvement should be cultivated and planted to grain for one or two seasons and then reseeded with orchardgrass and red clover.

The main problems in areas used for pasture are maintaining a good cover of grass, keeping the pasture free of ferns and other unpalatable plants, and controlling erosion while reestablishing the stand of grass. Management practices needed are seeding grass in fall in summer-fallowed soil, using all plant residue, applying nitrogen for grass and sulfur for clover, and grazing within the carrying capacity of the pasture.

#### **CAPABILITY UNIT IVe-8**

This unit consists of medium-textured soils that have formed in loess on steep uplands, mainly on north- and west-facing slopes. Precipitation is 10- to 12 inches per year. The soils in this unit are-

Ritzville silt loam, 30 to 45 percent slopes.  
Ritzville silt loam, moderately deep, 30 to 45 percent slopes.  
Ritzville very fine sandy loam, 30 to 45 percent slopes.

These soils are suitable for a rotation consisting of 4 to 6 years of crested wheatgrass or beardless wheatgrass followed by winter wheat and summer fallow until four crops of wheat are grown.

The main problems in cultivated areas are controlling water erosion late in winter or after heavy rains in summer, controlling wind erosion on the very fine sandy loam, and maintaining enough organic matter in the soil. Management practices needed are stubble mulching that holds most of the straw on the surface, tilling a field no more than four times per season, seeding along the contour in the period between August 20 and September 15, and applying nitrogen to grain and to start grass.

#### **CAPABILITY UNIT IVe-9**

This unit consists of shallow to moderately deep soils that have formed in loess underlain by old calcareous lake deposits. These soils occupy nearly level to steep upland terraces. Precipitation ranges from 6 to 9 inches per year. The soils have a low water-supplying capacity and do not produce high yields of crops unless irrigated. The soils in this unit are-

Sagemoor silt loam, 0 to 3 percent slopes.  
Sagemoor silt loam, 3 to 8 percent slopes.  
Sagemoor silt loam, 8 to 15 percent slopes.  
Sagemoor very fine sandy loam, 0 to 3 percent slopes.  
Sagemoor very fine sandy loam, 3 to 8 percent slopes.  
Sagemoor very fine sandy loam, 8 to 15 percent slopes.

These soils can be farmed in a rotation consisting of 8 years of winter wheat and fallow followed by 4 to 6 years of crested wheatgrass or beardless wheatgrass. The grass should be seeded in fall in the wheat stubble. Rye can be grown instead of wheat to get enough stubble to protect the soil until grass is established.

The main problems are controlling water erosion late in winter and early in spring, controlling wind erosion on the very fine sandy loams, and maintaining enough organic matter in the soil. Management practices needed are use of stubble-mulch fallow that leaves unbroken stubble on the surface, use of a minimum amount of tillage, growing wheat in strips that run at right angles to the direction of the erosive winds, seeding early in the season, and applying nitrogen when seeding grass.

**CAPABILITY UNIT IVe-10**

This unit consists of deep, medium-textured, eroded soils that have formed in volcanic-ash and loess. Precipitation is 12 to 16 inches per year. Only a small part of the original surface soil is left, and during tillage this has been mixed with the subsoil. The soils in this unit are-

Walla Walla silt loam, 8 to 30 percent slopes, eroded.  
Walvan very fine sandy loam, 0 to 8 percent slopes.

These soils should be kept in soil-improving vegetation for a long time. A suitable rotation consists of 6 years of intermediate wheatgrass or big bluegrass followed by one crop of grain and fallow. After two cycles, this rotation should be changed to 4 to 6 years of grasses followed by three crops of grain and fallow. Areas that are intended for pasture can be seeded to big bluegrass or intermediate wheatgrass. When it is necessary to improve the stand of grass, one or two crops of grain can be grown.

The main problems are controlling wind and water erosion and increasing the supplies of organic matter and plant nutrients. Management needed consists of stubble mulching; tilling a field no more than five times per season, including the seeding operation; seeding along the contour in the period between August 20 and September 15, divide-slope farming (field stripcropping) on slopes more than 500 feet long; and applying nitrogen to grain and grass according to the result of soil tests.

**CAPABILITY UNIT IVe-11**

This unit consists of a deep, dark-colored, medium-textured soil. Precipitation is 12 to 16 inches a year. Areas of this soil on south-facing slopes are generally cultivated; those on north-facing slopes have been left in grass because the terrain is too rough and broken for tillage. The soil in this unit is-

Walla Walla silt loam, 30 to 45 percent slopes.

Cultivated areas should be in grasses and legumes about half the time. A suitable rotation consists of big bluegrass or intermediate wheatgrass for 4 to 6 years followed by grain and fallow alternated for 4 to 6 years. Large amounts of nitrogen are needed for good yields of wheat; moderate amounts should be applied to grass at seeding time to improve the stand for pasture.

The main management problems are controlling erosion, maintaining soil structure, and providing enough organic matter in cultivated fields. The management practices needed are stubble-mulch tillage that does not break up the stubble and pulverize the soil, seeding along the contour in the period between August 20 and September 15, divide-slope farming (field stripcropping) on slopes longer than 500 feet, and applying nitrogen to grain and grass.

**CAPABILITY UNIT VIe-1**

This unit consists of moderately coarse-textured, gently sloping to steep soils of the uplands. Precipitation is 8 to 10 inches per year. The soils in this unit are-

Adkins fine sandy loam, 0 to 15 percent slopes, eroded.  
Adkins fine sandy loam, 30 to 45 percent slopes.  
Magallon fine sandy loam, 15 to 30 percent slopes, eroded.  
Magallon fine sandy loam, 30 to 45 percent slopes.  
Taunton fine sandy loam, 0 to 30 percent slopes, eroded.  
Taunton fine sandy loam, 30 to 45 percent slopes, eroded.

These soils are best suited to range and are in the Sandy Upland range site.

**CAPABILITY UNIT VIe-2**

This unit consists of medium-textured, rolling to steep soils of the uplands. Precipitation is 9 to 12 inches per year. The soils in this unit are-

Ellisforde silt loam, 30 to 45 percent slopes.  
Ellisforde silt loam, 30 to 45 percent slopes, eroded.  
Ellisforde very fine sandy loam, 30 to 45 percent slopes, eroded.  
Farrell very fine sandy loam, 30 to 60 percent slopes.  
Magallon very fine sandy loam, 30 to 60 percent slopes.  
Ritzville silt loam, 30 to 45 percent slopes, eroded.  
Ritzville silt loam, 45 to 60 percent slopes.  
Ritzville very fine sandy loam, 45 to 60 percent slopes.

The soils in this unit are best suited to range and are in the Deep Upland range site, 9 to 12 inches precipitation.

**CAPABILITY UNIT VIe-3**

This unit consists of medium-textured, gently sloping to very steep soils of the uplands. Precipitation is 12 to 16 inches a year. The soils in this unit are-

Walla Walla silt loam, 30 to 45 percent slopes, eroded.  
Walla Walla silt loam, 45 to 60 percent slopes.  
Walla Walla silt loam, lacustrine substratum, 8 to 30 percent slopes, eroded.  
Walvan very fine sandy loam, 8 to 30 percent slopes, eroded.  
Walvan very fine sandy loam, 30 to 60 percent slopes, eroded.

These soils are best suited to range and are in the Deep Upland range site, 12 to 16 inches precipitation.

**CAPABILITY UNIT VIe-4**

This capability unit consists of a deep, medium-textured, rolling to very steep soil of the uplands. Precipitation is 19 to 24 inches per year. The soil in this unit is-

Palouse silt loam, 45 to 60 percent slopes.

This soil is best suited to range and is in the Deep Upland range site, 16 to 24 inches precipitation.

**CAPABILITY UNIT VIe-5**

This capability unit consists of moderately deep, medium-textured, steep to very steep soils of the uplands. Precipitation is 19 to 24 inches a year. The soils in this unit are-

Palouse silt loam, moderately deep, 30 to 45 percent slopes.  
Palouse silt loam, moderately deep, 30 to 45 percent slopes, eroded.  
Palouse silt loam, moderately deep, 45 to 60 percent slopes.  
Palouse silt loam, moderately deep, 45 to 60 percent slopes, eroded.

These soils are best suited to range and are in the Moderately Deep Upland range site, 18 to 24 inches precipitation.

**CAPABILITY UNIT VIe-6**

This unit consists of medium-textured, rolling to very steeply sloping soils of the uplands. Precipitation is 24 to 30 inches a year. The soils in this unit are-

Couse silt loam, 15 to 30 percent slopes, eroded.  
Couse silt loam, 15 to 30 percent slopes, severely eroded.  
Couse silt loam, 30 to 45 percent slopes.  
Couse silt loam, 30 to 45 percent slopes, eroded.

These soils are suited to range and woodland and are in Mixed Forest-Pine range site.

**CAPABILITY UNIT VIe-7**

This capability unit consists of medium-textured, rolling to very steep soils of the uplands. Precipitation is more than 30 inches a year. The soils in this unit are-

Helmer silt loam, 15 to 30 percent slopes.  
Helmer silt loam, 30 to 45 percent slopes.



These soils are suited to woodland and range and are in the Mixed Forest-Fir range site.

**CAPABILITY UNIT VIe-8**

This capability unit consists of medium-textured, rolling to steep soils of the uplands. Precipitation is 6 to 9 inches per year. The soils in this unit are-

- Sagemoor silt loam, 15 to 30 percent slopes.
- Sagemoor silt loam, 8 to 15 percent slopes, eroded.
- Sagemoor silt loam, 15 to 30 percent slopes, eroded.
- Sagemoor silt loam, 30 to 45 percent slopes.
- Sagemoor silt loam, 30 to 45 percent slopes, eroded.
- Sagemoor very fine sandy loam, 8 to 15 percent slopes, eroded.
- Sagemoor very fine sandy loam, 15 to 30 percent slopes.
- Sagemoor very fine sandy loam, 15 to 30 percent slopes, eroded.

These soils are best suited to range and are in the Deep Silty Upland range site, 6 to 9 inches precipitation.

**CAPABILITY UNIT VIe-1**

This unit consists of medium-textured, very gently sloping soils of the bottom lands. These soils are slightly to strongly saline-alkali. Precipitation ranges from 8 to 14 inches per year. The soils in this unit are-

- Ahtanum silt loam, 0 to 3 percent slopes.
- Stanfield silt loam, 0 to 3 percent slopes.
- Stanfield very fine sandy loam, 0 to 3 percent slopes.
- Umapine silt loam, 0 to 3 percent slopes.
- Umapine very fine sandy loam, 0 to 3 percent slopes.

These soils are best suited to range and are in the Alkali Bottomland range site.

**CAPABILITY UNIT VIe-2**

This unit consists of gravelly and cobbly, medium-textured, very gently sloping soils of the bottom lands. These soils are underlain by gravel at shallow depths. Precipitation is 6 to 12 inches per year. The soils in this unit are-

- Yakima gravelly silt loam, 0 to 3 percent slopes.
- Yakima cobbly loam, 0 to 3 percent slopes.

These soils are best suited to range unless irrigated. They are in the Bottomland range site, 6 to 12 inches precipitation.

**CAPABILITY UNIT VIe-3**

This unit consists of a cobbly, medium-textured, very gently sloping soil of the bottom lands. Precipitation is 12 to 24 inches per year. The soil in this unit is-

- Patit Creek cobbly silt loam, 0 to 3 percent slopes.

This soil is best suited to range and is in the Bottomland range site, 12 to 23 inches precipitation.

**CAPABILITY UNIT VIIe-1**

This capability unit consists of coarse-textured, gently sloping to steep soils that are mainly on the uplands. Precipitation is 6 to 9 inches per year. The soils in this unit are-

- Adkins loamy fine sand, 0 to 15 percent slopes.
- Adkins loamy fine sand, 0 to 15 percent slopes, eroded.
- Adkins loamy fine sand, 15 to 30 percent slopes.
- Adkins loamy fine sand, 15 to 30 percent slopes, eroded.
- Adkins loamy fine sand, 30 to 45 percent slopes.
- Hezel loamy fine sand, 0 to 15 percent slopes, eroded.
- Hezel loamy fine sand, 15 to 30 percent slopes, eroded.
- Hezel loamy fine sand, 30 to 45 percent slopes, eroded.
- Quincy complex, 0 to 8 percent slopes, eroded.
- Quincy fine sand, 0 to 30 percent slopes, eroded.
- Quincy loamy fine sand, 0 to 8 percent slopes, eroded.

- Quincy loamy fine sand, 8 to 15 percent slopes, eroded.
- Quincy loamy fine sand, moderately deep over coarse sand, 0 to 8 percent slopes, eroded.
- Quincy loamy fine sand, moderately deep over coarse sand, 8 to 15 percent slopes, eroded.
- Quincy loamy fine sand, moderately deep over coarse sand, 15 to 30 percent slopes, eroded.
- Quincy loamy fine sand, moderately deep over gravel, 0 to 8 percent slopes, eroded.
- Quincy loamy fine sand, moderately deep over gravel, 8 to 15 percent slopes, eroded.
- Quincy loamy fine sand, moderately deep over gravel, 15 to 30 percent slopes, eroded.

These soils are best suited to range and are in the Sand range site.

**CAPABILITY UNIT VIIe.-2**

This capability unit consists of deep, medium-textured, eroded or steep soils of the uplands. Precipitation ranges from 9 to 12 inches per year. Soils in this unit are-

- Adkins fine sandy loam, shallow, 8 to 30 percent slopes, eroded.
- Ritzville silt loam, 45 to 60 percent slopes, eroded.
- Ritzville silt loam, 60 percent and steeper slopes.
- Ritzville very fine sandy loam, 30 to 60 percent slopes, eroded.
- Ritzville very fine sandy loam, volcanic ash variant, 8 to 30 percent slopes, eroded.
- Ritzville very fine sandy loam, volcanic ash variant, 30 to 60 percent slopes.

The Ritzville soils are in the Deep Upland range site, 9 to 12 inches precipitation; and the Adkins soil, in the Shallow Upland range site, 6 to 9 inches precipitation.

**CAPABILITY UNIT VIIe-3**

This capability unit consists of deep, medium-textured, steep soils of the upland timbered areas. Precipitation is 24 to 30 inches per year. The soil in this unit is-

- Couse silt loam, 45 to 60 percent slopes.

This soil produces a small amount of forage for grazing but is suited to woodland. It is in the mixed Forest-pine range site. Cleared or logged areas are highly susceptible to water erosion. Skid trails and roads need protection during and after logging. Structures to control runoff and grass to provide a vegetative cover are needed to protect this soil.

**CAPABILITY UNIT VIIe-4**

This capability unit consists of deep, medium-textured, very steep soils of the uplands. Precipitation is more than 30 inches per year. The soil in this unit is-

- Helmer silt loam, 45 to 60 percent slopes.

This soil is suited to woodland and range and is in the Mixed Forest-Fir range site. During and after logging, skid trails and roads are highly susceptible to water erosion. Structures to control runoff and grass to provide a vegetative cover are needed to protect this soil.

**CAPABILITY UNIT VIIe-1**

This capability unit consists of coarse and moderately coarse textured soils on river terraces. Precipitation is 6 to 9 inches per year. The soils are droughty and low in fertility. Soils in this unit are-

- Beverly loamy fine sand, 0 to 3 percent slopes.
- Beverly sandy loam, 0 to 3 percent slopes.
- Beverly fine sandy loam and Riverwash.

These soils are best suited to range and are in the Sand range site.

**CAPABILITY UNIT VIIe-2**

This unit consists of rocky and very rocky, moderately coarse to medium-textured, gently sloping to hilly soils

overlying basalt at a depth of 10 to 20 inches. Precipitation is 6 to 9 inches per year. The soils in this unit are-

- Adkins rocky sandy loam, moderately deep, 3 to 30 percent slopes, eroded.
- Adkins very rocky sandy loam, moderately deep, 0 to 30 percent slopes.
- Sagemoor rocky very fine sandy loam, 3 to 30 percent slopes.
- Sagemoor rocky very fine sandy loam, 8 to 30 percent slopes, eroded.
- Sagemoor rocky very fine sandy loam, 30 percent and steeper slopes.

These soils are best suited to range and are in the Shallow Upland range site, 6 to 9 inches precipitation.

#### **CAPABILITY UNIT VIIIs-3**

This unit consists of rocky and very rocky, medium-textured, gently sloping to very steep soils overlying basalt at a depth of 10 to 20 inches. Precipitation is 9 to 12 inches per year. The soils in this unit are-

- Magallon rocky very fine sandy loam, basalt substratum, 0 to 30 percent slopes.
- Magallon rocky very fine sandy loam, basalt substratum, 30 to 60 percent slopes.
- Magallon very rocky very fine sandy loam, 0 to 30 percent slopes.
- Magallon very rocky very fine sandy loam, 30 to 60 percent slopes.
- Starbuck rocky silt loam, 0 to 30 percent slopes.
- Starbuck rocky silt, loam, 30 to 45 percent slopes.

These soils are best suited to range and are in the Shallow Upland range site, 18 to 24 inches precipitation.

#### **CAPABILITY UNIT VIIIs-4**

This capability unit consists of rocky and very rocky, medium-textured, gently sloping to very steep soils overlying basalt at a depth of 10 to 20 inches. Precipitation is 18 to 24 inches per year. Soils in this unit are-

- Gwin rocky silt loam, 0 to 30 percent slopes.
- Gwin rocky silt loam, 0 to 30 percent slopes, eroded.
- Gwin rocky silt loam, 30 to 60 percent slopes.
- Gwin very rocky silt loam, 0 to 30 percent slopes, eroded.
- Gwin very rocky silt loam, 30 to 60 percent slopes, eroded.
- Gwin-Rock land complex, 45 to 60 percent slopes.
- Klicker-Gwin-Rock land complex, 30 to 60 percent slopes.

These soils are best suited to range and are in the Shallow Upland range site, 18 to 24 inches precipitation.

#### **CAPABILITY UNIT VIIIs-5**

This capability unit consists of rocky, medium-textured, gently sloping to very steep soils overlying basalt at a depth of 18 to 30 inches. Precipitation is 30 inches or more per year. Soils in this unit are-

- Couse-Rock land complex, 30 to 60 percent slopes.
- Helmer-Rock land complex, 45 to 60 percent slopes.
- Klicker rocky silt loam, 0 to 30 percent slopes.
- Klicker rocky silt loam, 30 to 60 percent slopes.

These soils are best suited to range and woodland.

#### **CAPABILITY UNIT VIIIs-6**

This capability unit consists of very shallow, rocky land types and soils on undulating to very steep slopes underlain by basalt at a depth of less than 10 inches. Precipitation is 6 to 16 inches per year. In this unit are-

- Basalt rock land, undulating to hilly.
- Basalt rock land, steep.
- Basalt rock land-Walla Walla complex, 30 to 60 percent slopes.

These soils and land types are best suited to range.

#### **CAPABILITY UNIT VIIIs-7**

This capability unit consists of very shallow, rocky land types on undulating to very steep slopes. These land types are underlain by basalt at a depth of less than 10 inches. Precipitation is 16 to 24 inches per year. In this unit are-

- Basalt rock land, undulating to hilly.
- Basalt rock land, steep.

These land types are best suited to range.

#### **CAPABILITY UNIT VIIIe-1**

This capability unit consists of soils and land types that are too sandy for other than recreational, watershed, wildlife habitat, or other nonagricultural uses. In this unit are-

- Active dune land.
- Hezel-Quincy complex, eroded.
- Quincy fine sand, 30 to 60 percent slopes, eroded.
- Quincy-Duneland complex.

#### **CAPABILITY UNIT VIIIw-1**

This capability unit consists of land types that are unsuitable for crops, mainly because they are subject to overflow. In this unit are-

- Alluvial land.
- Riverwash.

#### **CAPABILITY UNIT VIIIIs-1**

This capability unit consists of soils and land types that are too steep, sandy, or rocky for uses other than wildlife habitat, watershed, recreation, or other nonagricultural purposes. In this unit are-

- Badland.
- Basalt rock land, very steep.
- Basalt rock outcrop.
- Borrow pits.
- Hezel loamy fine sand, 30 to 45 percent slopes, eroded.
- Klicker-Gwin-Rock land complex, 60 percent and steeper slopes.
- Made land.
- Terrace escarpments.
- Volcanic-ash land, steep.
- Volcanic-ash land, undulating to hilly.

### **Management of soils by capability units, irrigated**

In this part of the report, the soils are grouped according to their capability under irrigation.

Class I. Soils that have few limitations that restrict their use. (No subclasses.)

Capability unit I-1.-Well drained and moderately well drained, medium-textured soils on nearly level terraces and along streams.

Class II. Soils that have some limitations that reduce the choice of-plants or require moderate conservation practices.

Subclass IIe.-Soils subject to moderate erosion if they are not protected.

Capability unit IIe-5.-Well-drained, medium-textured, deep and moderately deep soils on gently sloping uplands.

Capability unit IIe-6.-Well-drained, medium-textured soils on bottom lands and terraces.

Subclass IIw.-Soils that have moderate limitations because of excess water.

Capability unit IIw-1.-Dark-colored, medium-textured, imperfectly drained soils along streams; in places, water table is near surface during part of the growing season.

Subclass IIs.-Soils that have moderate limitations of moisture capacity or tilth.

Capability unit IIs-2.-Medium-textured, moderately well drained, saline-alkali soils.

Capability unit IIs-3.-Medium-textured soils underlain by gravel.

Class III. Soils that have severe limitations that reduce the choice of plants or require special conservation practices, or both.

Subclass IIIe.-Soils subject to severe erosion if they are cultivated and not protected.

Capability unit IIIe-1.-Medium-textured, well drained to moderately well drained, shallow to moderately deep soils on gentle slopes; alkali-cemented hardpan or hard, dense, columnar subsoil.

Capability unit IIIe-8.-Well-drained, medium-textured, moderately deep soils underlain by compact, stratified, lake-laid material.

Subclass IIIs.-Soils that have severe limitations of moisture capacity or tilth.

Capability unit IIIs-1. Medium-textured, well drained and moderately well-drained, shallow to moderately deep soils on nearly level slopes.

Capability unit IIIs-2.-Shallow, somewhat excessively drained soils with coarse, gravelly subsoil.

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management or both.

Subclass IVe.-Soils subject to very severe erosion if they are cultivated and not protected.

Capability unit IVe-12.-Well-drained, medium-textured, shallow to moderately deep, eroded soils on uplands.

Capability unit IVe-13.-Deep, somewhat excessively drained, wind-worked soils; very low in organic matter.

Capability unit IVe-14.-Well-drained, medium-textured, deep and moderately deep soils on strongly sloping uplands and terraces.

Subclass IVs.-Soils that have very severe limitations of stoniness, low moisture capacity, or other soil features.

Capability unit IVs-1.-Well-drained or excessively drained, cobbly soils underlain by layers of pebbles or cobbles.

Capability unit IVs-2.-Moderately deep, coarse-textured, excessively drained and somewhat excessively drained soils on gravel, coarse sand, or compact silty substrata; considerably wind worked.

Capability unit IVs-4.-Well-drained, moderately shallow soils on rolling lake terraces; alkali salts present.

Class VI. Soils that have severe limitations that make them generally unsuited to cultivation and limit their

use largely to pasture or range, woodland, or wildlife food and cover.

Subclass VIe.-Soils severely limited, mainly by risk of erosion if protective cover is not maintained.

Capability unit VIe-8.-Well-drained, medium-textured soils that have slopes of 15 to 30 percent.

Capability unit VIe-9.-Excessively drained and somewhat excessively drained, strongly wind worked, sandy soils; very low in organic matter.

Subclass VIs.-Soils generally unsuitable for cultivation and limited for other uses by their moisture capacity, stones, or other features.

Capability unit VIs-1.-Moderately well drained, shallow to moderately deep, saline-alkali soils.

#### **CAPABILITY UNIT I-I (IRRIGATED)**

This unit consists of well drained and moderately well drained, medium-textured soils along streams and on nearly level terraces. The soils are moderate to high in fertility. There is little or no hazard of erosion. Salts and alkali are not present in amounts that are harmful to the commonly grown farm crops. The soils in this unit are-

Ellisforde silt loam, 0 to 3 percent slopes.

Esquatze silt loam, 0 to 3 percent slopes.

Hermiston silt loam, 0 to 3 percent slopes.

Onyx silt loam, 0 to 3 percent slopes.

Pedigo silt loam, overwashed, 0 to 3 percent slopes.

Snow silt loam, 0 to 3 percent slopes.

Touchet silt loam, 0 to 3 percent slopes.

Walla Walla silt loam, 0 to 8 percent slopes (0 to 3 percent part only).

These soils are suited to continuous row crops if fertility is maintained. High yields of sugar beets, lima beans, sweet corn, green peas, small grains, alfalfa, and improved-pasture forage are produced. Irrigation water can be applied safely by use of corrugations, furrows, borders, or controlled flooding without causing serious erosion. Little grading is needed to prepare fields for irrigation.

The management needed consists of using all crop residue, applying nitrogen and phosphate according to the needs of crops, and alternating crops each year to help control insects and diseases. Drainage problems are easily corrected by regulating the amount of water used in irrigating or by installing short drains.

The Pedigo soils in this unit are moderately well drained and, in most places, have a water table that is below the root zone of most crops grown on this soil.

#### **CAPABILITY UNIT IIe-5 (IRRIGATED)**

This unit consists of well-drained, medium-textured, deep and moderately deep soils on gently sloping uplands. The soils are moderate to high in fertility and have a slight to moderate erosion hazard. Those having slopes of 0.95 to 3 percent can be managed according to the suggestions given in capability unit I-1, irrigated. Salts and alkali are not present in amounts that are harmful to the crops commonly grown in the area. The soils in this unit are-

Ellisforde silt loam, 3 to 8 percent slopes.

Ritzville silt loam, 0 to 8 percent slopes.

Walla Walla silt loam, 0 to 8 percent slopes (3 to 8 percent part only).

Walla Walla silt loam, lacustrine substratum, 0 to 8 percent slopes.

Lima beans, green peas, and asparagus, grown for canning and freezing, as well as alfalfa, small grain, sweet corn, and grasses, yield well in these soils. A suitable cropping system is 3 to 4 years of alfalfa grown for hay or grass grown for pasture, 2 years of row crops, 2 years of green peas and sweet corn grown together, and 1 year of green peas. The alfalfa or grass is seeded after the third crop of peas is harvested.

Irrigation water can be applied safely by use of sprinklers, corrugations, or furrows. Sprinklers are preferred and are the most widely used. Irrigation water must be distributed with care or it will cause erosion.

The main problems are controlling erosion, maintaining good soil structure, and providing adequate supplies of organic matter and plant nutrients. The management needed consists of using all crop residue, applying irrigation water through a sprinkler system, and adding large amounts of nitrogen and phosphate. The soils respond well to management.

#### ***CAPABILITY UNIT IIc-6 (IRRIGATED)***

This unit consists of well-drained, medium-textured soils on bottom lands and terraces. In places these soils contain enough finely divided pumice to have a gray color. The soils are low to moderate in fertility. As a rule, they have a slight susceptibility to water erosion and moderate susceptibility to wind erosion. The very fine sandy loams contain enough sand to be highly susceptible to blowing. Salts and alkali may be present in amounts that slightly restrict the choice of crops. The soils in this unit are-

Esquatzel very fine sandy loam, 0 to 3 percent slopes. Hermiston very fine sandy loam, 0 to 3 percent slopes.

Good yields of alfalfa, sweet corn, and small grain are produced. Special practices that control the blowing of soil are needed when sugar beets, lima beans, and asparagus are grown. A suitable rotation is 2 years of sugar beets, 1 year of grain, 2 years of sweet corn (or 1 year of sweet corn and 1 year of lima beans), and 1 year of a green-manure crop.

Irrigation water can be applied safely by use of sprinklers, borders, corrugations, or furrows.

The main problems are controlling wind erosion, increasing and maintaining supplies of organic matter and plant nutrients, and preventing excessive leaching and the formation of a high water table. The management needed consists of applying manure or straw to sandy areas, using all crop residue, preparing a seedbed when the soils are moist, controlling the amount of water used for irrigation, and applying nitrogen and phosphate according to the needs of the crop.

#### ***CAPABILITY UNIT IIw-1 (IRRIGATED)***

This unit consists of dark-colored, medium-textured, imperfectly drained soils along streams. In places the water table is near the surface during part of the growing season. In most years it will delay spring tillage. The Pedigo soils of this unit are generally strongly alkaline and occasionally slightly saline. However, when drainage is established, these salts do not affect crop production. Soils in this unit are-

Catherine silt loam, 0 to 3 percent slopes.  
Pedigo silt loam, 0 to 3 percent slopes.

Good to excellent yields of alfalfa, barley, sugar beets, carrots, onions, and sweet corn can be grown if the soils

are drained and properly irrigated. Continuous row crops can be grown if fertility is maintained. A suitable rotation, however, is 2 years of sugar beets, 1 year of grain, 2 years of sweet corn (or 1 year of sweet corn and 1 year of lima beans), and 1 year of a green-manure crop.

Interception ditches or short drains generally can remove enough water to allow production of most crops commonly grown in the area.

#### ***CAPABILITY UNIT IIs-2 (IRRIGATED)***

This unit consists of medium-textured, moderately well drained, saline-alkali soils. The hazard of erosion is slight on these soils. The Ahtanum soil in this unit has a cemented alkali hardpan at a depth of 30 to 48 inches. Soils in this unit are-

Sagemoor silt loam, 0 to 3 percent slopes.  
Sagemoor very fine sandy loam, 0 to 3 percent slopes.  
Ahtanum silt loam, 0 to 3 percent slopes.  
Umapine silt loam, leached surface, 0 to 3 percent slopes.  
Umapine very fine sandy loam, leached surface, 0 to 3 percent slopes.

Good yields of alfalfa, sugar beets, sweet corn, and barley are grown. High yields of forage are produced in irrigated pastures. A suitable short-term rotation is 1 year of winter wheat or barley, 1 year of green peas (the residue plowed under for green manure), and 2 years of row crops. A suitable long-term rotation is 3 or 4 years of alfalfa grown for hay or grass grown for pasture, 2 to 5 years of row crops, and 1 year of grain. Alfalfa and sugar beets require large amounts of phosphate for highest yields. Grains respond to additions of nitrogen.

Irrigation water can be applied safely by use of sprinklers, corrugations, furrows, or borders. Borders are generally used for meadow and pasture.

The main problems are holding the concentration of salts low enough to produce crops and increasing and maintaining the supplies of organic matter and plant nutrients. The management needed consists of providing adequate drainage, applying enough water to leach salts from the soil, using all crop residue, and applying nitrogen and phosphate according to crop needs.

#### ***CAPABILITY UNIT IIs-3 (IRRIGATED)***

This unit consists of medium-textured soils underlain by gravel. The Touchet soil in this unit is gravelly throughout and is underlain by coarse gravel below a depth of 48 inches; the Yakima soil is underlain by coarse gravel below a depth of 15 inches; and the Patit Creek soil by gravel at a depth of 24 inches. These soils can hold only small amounts of water. The hazard of erosion is slight. The soils in this unit are-

Patit Creek silt loam, 0 to 3 percent slopes.  
Touchet gravelly silt loam, 0 to 3 percent slopes.  
Yakima silt loam, 0 to 3 percent slopes.

Alfalfa hay and pasture are the most important crops on these soils. Sugar beets, strawberries, and truck crops are grown on a small acreage. Farmers prefer to grow the crops that need the least tillage. A suitable rotation is 2 to 4 years of alfalfa grown for hay or a grass-legume mixture grown for pasture, 4 years of row crops, and 1 year of a small grain. Frequent, light applications of irrigation water and split applications of fertilizer are more efficient and result in less leaching of fertilizer than infrequent, heavy applications of water and fertilizer.

Plowing under all crop residue helps to maintain or increase the supply of organic matter and to improve soil structure.

**CAPABILITY UNIT IIIe-1 (IRRIGATED)**

This capability unit consists of medium-textured, well drained to moderately well drained, shallow to moderately deep soils that have either an alkali-cemented hardpan or a dark, dense, columnar subsoil. The subsoil is generally too deep and too hard to be broken economically by use of available equipment. Hardness also limits the root zone. The soils contain soluble salts in amounts large enough to lower the yields of many crops. The soils in this unit are-

Ellisforde silt loam, hardpan variant, 3 to 8 percent slopes.  
Spofford silt loam, 3 to 8 percent slopes.  
Walla Walla silt loam, hardpan variant, 0 to 8 percent slopes.

Suitable crops are sugar beets, grasses, and legumes. These soils need careful irrigation that controls erosion and allows salts to leach. Only the soil above the hardpan should be moistened. Frequent applications of small amounts of water are best. It is advisable to use all crop residue to shade the soil. Shading reduces the rate of evaporation and the return of salts to the soil surface.

**CAPABILITY UNIT IIIe-8 (IRRIGATED)**

This unit consists of well-drained, medium-textured, moderately deep soils that are underlain by compact, stratified, lake-laid deposits. This material severely retards the downward movement of water and the growth of roots. The very fine sandy loams are subject to severe soil blowing if not protected by a cover of living plants. Improperly applied irrigation water severely erodes the soil and may cause salts and alkali to accumulate in amounts that reduce crop yields. The soils in this unit are-

Ellisforde very fine sandy loam, 3 to 8 percent slopes.  
Sagemoor silt loam, 3 to 8 percent slopes.  
Sagemoor very fine sandy loam, 3 to 8 percent slopes.

These soils are suitable for the production of alfalfa hay and seed, grasses and legumes, an occasional crop of sugar beets or sweet corn, and wheat or barley. A suitable rotation is 3 years of orchardgrass and ladino clover seeded late in summer, 2 years of sugar beets, 1 year of sweet corn, and 1 year of barley. Alfalfa and clover respond well to phosphate applied at seeding time. Irrigation is best applied through sprinklers. Corrugations and furrows can be used if the runs are on slopes of 3 percent.

The main problems are maintaining enough mulch or other protection to control soil blowing while a crop is being seeded and established, preventing soil loss from irrigation, and increasing and maintaining supplies of organic matter and plant nutrients. Management needed consists of using all crop residue and plowing under a good growth of grasses or legumes, applying irrigation water carefully, and applying fertilizer according to crop needs.

**CAPABILITY UNIT IIIs-1 (IRRIGATED)**

This capability unit consists of medium-textured, well drained and moderately well drained, shallow to moderately deep soils. The hardpan limits the root zone. This pan is generally too deep and too hard to be broken economically by use of available equipment. The soils in this unit contain soluble salts in amounts large enough to lower the yields of many crops. Salt in the Stanfield soils is too concentrated for many crops. The soils in this unit are-

Ellisforde silt loam, hardpan variant, 0 to 3 percent slope.;  
Spofford silt loam, 0 to 3 percent slopes.  
Stanfield silt loam, leached surface, 0 to 3 percent slopes.  
Stanfield very fine sandy loam, leached surface, 0 to 3 percent slopes.

Suitable crops include sugar beets, barley grasses and legumes. A suitable cropping system is tall wheatgrass and alta fescue grown for pasture, 2 or 3 years of sugar beets, and one crop of barley.

The main problems are preventing the formation of a high water table, preventing the accumulation of salts on and in the soil, and maintaining the supply of organic matter. The management needed consists of draining, controlling the use of irrigation water by applying enough to leach the salts but not enough to raise the water table, shading the soils as much as possible, and using all crop residue.

**CAPABILITY UNIT IIIs-2 (IRRIGATED)**

This unit consists of a shallow, somewhat excessively drained, gravelly soil that has a coarse, gravelly subsoil. The soil is low in fertility and in water-supplying capacity. It is too gravelly for intensive cultivation. The soil in this unit is-

Yakima gravelly silt loam, 0 to 3 percent slopes.

This soil is best suited to hay, pasture, and specialty crops. The most common crops are alfalfa for hay, a grass-and-legume mixture for pasture, strawberries, and tree fruits. Large amounts of fertilizer are required. Furrows or sprinklers are the best methods of irrigating. Frequent light applications of water and split applications of fertilizer are more efficient and result in less leaching of fertilizer than infrequent, heavy applications of water and fertilizer.

**CAPABILITY UNIT IVe-12 (IRRIGATED)**

This unit consists of well-drained, medium-textured, shallow to moderately deep, eroded soils on uplands. Very little of the dark-colored surface soil remains, and over much of the area, the limy subsoil or substratum has been exposed in tillage. The soils are very unproductive in their present condition, and most farmers prefer to use their available irrigation water on better soils if they have them. The soils in this unit are-

Ellisforde silt loam, 8 to 15 percent slopes, eroded.  
Sagemoor silt loam, 8 to 15 percent slopes, eroded.  
Sagemoor very fine sandy loam, 8 to 15 percent slopes, eroded.

These soils are suited to hay and pasture and an occasional crop of a small grain. A suitable rotation is 4 years of alfalfa and crested wheatgrass and 1 year of a small grain. After the soil has improved, orchardgrass and two crops of grain can be grown. Grass and small grains respond to large applications of nitrogen; alfalfa responds to phosphate.

The main problems are controlling erosion and improving and maintaining the supplies of organic matter and plant nutrients. The management needed consists of irrigating carefully, preferably by sprinklers; using all crop residue; plowing under a green-manure crop; and adding fertilizer according to crop needs.

**CAPABILITY UNIT IVe-13 (IRRIGATED)**

This unit consists of deep, somewhat excessively drained, wind-worked soils that are very low in organic matter. The soils are very low in fertility and low in water-supply-

ing capacity. The hazard of wind erosion is high. The soils this unit are-

Quincy loamy fine sand, 0 to 8 percent slopes, eroded.  
Quincy loamy fine sand, 8 to 15 percent slopes, eroded.

Alfalfa is the main crop. A suitable cropping system is 4 to 6 years of alfalfa grown for hay or seed, or mixtures of grass and alfalfa for hay or grass legumes for pasture; 1 year of grain sorghum; 1 year for winter wheat; 2 years of clover grown for seed; and 1 year of winter wheat. As the soil improves, it may be practical to plow strips in an alfalfa field and use them for early potatoes or early sweet corn.

Although similar cropping systems can be used, these soils need lighter and more frequent irrigations than those in capability unit IVs-2 (irrigated.) because much of the water drains through the deep, sandy subsoil.

#### **CAPABILITY UNIT IVe-14 (IRRIGATED)**

This unit consists of well-drained, medium-textured, deep and moderately deep soils on strongly sloping uplands and terraces. Salts and alkali are not present in concentrations that harm the important crops commonly grown on these soils. The hazards of wind and water erosion are moderate to high. The soils in this unit are-

Ellisforde silt loam, 8 to 15 percent slopes.  
Ellisforde very fine sandy loam, 8 to 15 percent slopes.  
Ellisforde very fine sandy loam, 8 to 15 percent slopes, eroded.  
Ritzville silt loam, 8 to 30 percent slopes (only that part having slopes of 8 to 15 percent).  
Sage Moor silt loam, 8 to 15 percent slopes.  
Sage Moor very fine sandy loam, 8 to 15 percent slopes.  
Walla Walla silt loam, 8 to 30 percent slopes (only that part having slopes of 8 to 15 percent).  
Walla Walla silt loam, lacustrine substratum, 8 to 30 percent slopes (only that part having slopes of 8 to 15 percent).

Good crops of alfalfa hay, alfalfa seed, and small grain are grown. An occasional crop of sugar beets or sweet corn can be grown if erosion is controlled. A cropping system for these soils should include, for a period of 3 to 5 years, alfalfa and grass for hay, or grass-legume pasture, or alfalfa grown for seed. One rotation meeting this requirement is 4 years of alfalfa and grass grown for hay, 1 year of sugar beets, 1 year of sweet corn, and 1 year of barley. The perennial crop should be seeded late in summer in-the barley stubble.

The main problems are controlling erosion that is caused naturally and by irrigation water and increasing and maintaining the supplies of organic matter and plant nutrients. The management needed consists of irrigating carefully, using all crop residue, protecting the very fine sandy loam soils from blowing at seeding time, and applying fertilizer according to crop needs. Sprinkler irrigation is best suited to these soils, but furrow irrigation can be used if runs are on a slope of 3 percent.

#### **CAPABILITY UNIT IVs-1 (IRRIGATED)**

This unit consists of well-drained or excessively drained, wobbly soils that are underlain by layers of pebbles or cobbles. The water-holding capacity is low to very low. There is little hazard of erosion. The soils in this unit are-

Patit Creek cobbly silt loam, 0 to 3 percent slopes.  
Yakima cobbly loam, 0 to 3 percent slopes.

These soils contain cobbles that interfere with tillage. However, they are suitable for pasture or special crops.

Orchardgrass and ladino clover make excellent growth. Orchards occupy large areas of the Yakima soil.

Sprinkler or furrow irrigation is preferred on the soils of this unit. Small amounts of water applied frequently prevent excessive losses of water and the leaching of large amounts of plant nutrients.

#### **CAPABILITY UNIT IVs-2 (IRRIGATED)**

This unit consists of moderately deep, coarse-textured, excessively drained and somewhat excessively drained soils resting abruptly on gravel, coarse sand, or compact silt substrata. The soils are low or very low in fertility and water-supplying capacity. The hazard of wind erosion is high or very high. These soils have been considerably worked by wind. The soils in this unit are-

Hezel loamy fine sand, 0 to 15 percent slopes, eroded.  
Quincy loamy fine sand, moderately deep over coarse sand, 0 to 8 percent slopes, eroded.  
Quincy loamy fine sand, moderately deep over coarse sand, 8 to 15 percent slopes, eroded.  
Quincy loamy fine sand, moderately deep over gravel, 0 to 8 percent slopes, eroded.  
Quincy loamy fine sand, moderately deep over gravel, 8 to 15 percent slopes, eroded.

Many areas of these soils have recently been brought under irrigation. Alfalfa is the main crop, and yields are high. Bean and potato yields have been low, so these crops are no longer grown. The basic cropping system consists of 4 to 6 years of alfalfa grown for hay or seed, or of mixtures of grass and alfalfa for hay, or of grass and legumes for pasture; 1 year of grain sorghum; 1 year of winter wheat; 2 years of clover grown for seed; and 1 year of winter wheat. As the soils improve, it may be practical to plow strips in an alfalfa field and use them for early potatoes or early sweet corn.

Proper distribution of irrigation water is a problem on these coarse soils. Irrigating through sprinklers gives the best results. Light, frequent applications of water and split applications of fertilizer are needed for good crop production. Other management needed is protecting the soil at all times from wind erosion and using all crop residue to improve the supply of organic matter.

#### **CAPABILITY UNIT IVs-4 (IRRIGATED)**

This unit consists of well-drained, moderately shallow soils on rolling lake terraces. Alkali salts have accumulated as the result of irrigation water seeping from higher soils. The hazard of erosion is moderate to high. The soils in this unit are-

Sage Moor silt loam, saline-alkali, 0 to 3 percent slopes.  
Sage Moor silt loam, saline-alkali, 3 to 8 percent slopes.  
Sage Moor silt loam, saline-alkali, 8 to 15 percent slopes.  
Sage Moor silt loam, saline-alkali, 15 to 30 percent slopes.  
Sage Moor very fine sandy loam, saline-alkali, 3 to 8 percent slopes, eroded.  
Stanfield silt loam, 0 to 3 percent slopes.  
Stanfield very fine sandy loam, 0 to 3 percent slopes.

These soils are suited to a rotation consisting of 4 years of alfalfa and tall wheatgrass, followed by 2 years of barley to control weeds. The perennial crops should be seeded in the barley stubble.

The corrugation system of irrigation is the most practical on these soils. A sprinkler system distributes the water better, but yields of crops are seldom good enough to justify the expense of installing it. These soils need more water than the adjacent nonsaline soils.

**CAPABILITY UNIT VIe-8 (IRRIGATED)**

This unit consists of well-drained, medium-textured soils that have slopes of 15 to 30 percent. The hazard of erosion is very high. Soils in this unit are-

Ellisforde silt loam, 15 to 30 percent slopes.  
Ellisforde silt loam, 15 to 30 percent slopes, eroded.  
Ellisforde very fine sandy loam, 15 to 30 percent slopes.  
Ellisforde very fine sandy loam, 15 to 30 percent slopes, eroded.  
Ritzville silt loam, 8 to 30 percent slopes (15 to 30 percent part only).  
Sagemoor silt loam, 15 to 30 percent slopes.  
Sagemoor silt loam, 15 to 30 percent slopes, eroded.  
Sagemoor very fine sandy loam, 15 to 30 percent slopes.  
Sagemoor very fine sandy loam, 15 to 30 percent slopes, eroded.  
Walla Walla silt loam, 8 to 30 percent slopes (15 to 30 percent part only).  
Walla Walla silt loam, lacustrine substratum, 8 to 30 percent slopes (15 to 30 percent part only).

Water used in irrigating is difficult to control when it is allowed to flow over the surface. Consequently, these soils are suitable for irrigation only if water is applied through sprinklers. They can then be used for alfalfa and grass grown for hay or grass and for legumes grown for pasture. The plants should be left growing as long as a productive stand can be maintained. After that, a crop of a small grain should be grown to control weeds before the reseeding of forage plants. Grains and grass respond to nitrogen; legumes, to phosphate.

**CAPABILITY UNIT VIe-9 (IRRIGATED)**

This unit consists of excessively drained and somewhat excessively drained, strongly wind-worked, sandy soils that are very low in organic matter. Fertility is low to very low, and the hazard of wind erosion is high or very high. The soils in this unit are-

Hezel loamy fine sand, 15 to 30 percent slopes, eroded.  
Quincy complex, 0 to 8 percent slopes, eroded.  
Quincy fine sand, 0 to 30 percent slopes eroded.  
Quincy loamy fine sand, moderately deep over coarse sand, 15 to 30 percent slopes, eroded.  
Quincy loamy fine sand, moderately deep over gravel, 15 to 30 percent slopes, eroded.

These soils are best suited to hay and pasture. Alfalfa and orchardgrass are the best plants for hay; ladino clover and orchardgrass are good for pasture. The plants should be left growing as long as a productive stand can be maintained. After that, wheat or barley should be grown to control weeds before the reseeding of forage plants.

The management needed consists of plowing under a good growth of hay or pasture when forage plants are to be replaced by small grain, seeding in strips that run at right angles to the prevailing winds, reseeding hay or pasture plants early in the fall in wheat or barley stubble, irrigating by sprinkler systems, applying phosphate when alfalfa is seeded, and applying nitrogen in small amounts each year.

**CAPABILITY UNIT VIe-1 (IRRIGATED)**

This unit consists of moderately well drained shallow to moderately deep, saline-alkali soils. The soils in this unit are-

Umapine silt loam, 0 to 3 percent slopes.  
Umapine very fine sandy loam, 0 to 3 percent slopes.

Unless leached, the salts in these soils are too highly concentrated to allow crops to grow. Drainage must also be provided. Many farmers irrigate the saltgrass for about 2 years, or they dike and flood the soil for two winters. They then grow sugar beets for 2 years. In most places the sugar beets can be followed by alfalfa or barley.

When enough salts have been leached so that crops can be grown, these soils can be managed like those described in capability units IIIs-1 (irrigated) or IIs-2 (irrigated).

**Estimates of Yields**

Soil and climate are the main factors that influence the yields of crops in Walla Walla County. Each soil has certain characteristics that influence crop yields. The soil can be improved to produce higher yields or its usefulness can be reduced through poor management. Farming must be adjusted to fit the climate. A good rain in May means that there will be a bumper crop of wheat. A dry May means that the yield will be less than normal. The variations in weather have a greater effect on yields of crops than variations in management.

Table 6 shows the estimated average acre yields of crops commonly grown on the arable soils of Walla Walla County. Yield data are based on the experiences of the farmers and ranchers and on the knowledge of people in the Agricultural Extension Service and Soil Conservation Service.

The yields in columns A are averages of those obtained under prevailing, or ordinal, management. Under such management, the operator is likely to follow a winter wheat-summer fallow system. He burns his stubble or he breaks it up until it affords but little mechanical protection to the soil. Initial tillage is performed by use of a moldboard plow. This is followed by harrowing the field twice and by weeding twice by use of a rod weeder. Nitrogen is applied at the rate of 30 to 40 pounds per acre before crops are seeded.

Yields in columns B are those expected under improved management. This consists of using a winter wheat-summer fallow system or an annual program of cropping. Under either plan, the soil is subsurface tilled to prepare stubble mulch or it is disked to mix stubble with the plow layer. Additional tillage is limited to seeding the crop and to controlling the weeds. Nitrogen is applied in quantities needed by the crop and according to the amount of soil moisture expected to be available for the crop.

In irrigated areas, ordinary management consists of farming without a regular systematic rotation of crops. Not enough commercial fertilizer is used, and fields are not given uniform applications of irrigation water.

Under improved management in irrigated areas, alfalfa-grass or grass pasture is grown for 3 years, sugar beets or other row crops are grown for 2 years, and a small grain is grown for 1 year. Fertilizer is applied according to needs of the crop grown.

## Range Management

Native grassland used for the production of forage is located mainly on the sandy river terraces and lake terraces along the lower parts of the Snake and Walla Walla Rivers; on the steep breaks of the Snake River; and on the steep upland slopes and foothills of the Blue Mountains. These areas of grassland make up 25 to 30 percent of the acreage in Wallop Walla County.

Livestock enterprises are the second largest agricultural industry in the county. The income from livestock is derived mainly from the production of lambs, wool, and feeder cattle. The economy of this important industry depends mainly on the management ranchers give their grassland.

Before the county was settled, the soils supported a lush growth of native grasses consisting mainly of bluebunch wheatgrass, Idaho fescue, needle-and-thread, and Sandberg bluegrass (fig. 7).

Because of overuse, selective grazing by livestock, and other influences, much of this native grass has been replaced by sagebrush, cheatgrass, and weeds. Much of the grassland now produces less than half the potential yield of forage.

This section of the report describes some of the principles of range management, the range sites in the county, the conservation practices that help improve rangeland, and the management of livestock. Soils not classified by range site are of limited extent, occur only in irrigated areas, and are not significant to the management of rangeland.

### *Principles of range management*

Soil and water conservation and high yields of forage on grassland depend mainly on the vigor and composition of vegetation. The composition is improved when management increases the amount of the best native forage plants.

Growth of roots and foliage Production of seed, and storage of food in the roots and lower stems are essential stages in the development of grass. Maximum forage yield and highest animal production are obtained by grazing management that allows these natural sequences of growth to take place.

Livestock graze selectively and constantly seek the more palatable and nutritious plants. If not carefully regulated, grazing will eventually eliminate the better plants. The less desirable or second-choice plants will increase. If overuse continues, the second-choice plants will be thinned out or eliminated, and undesirable plants will take their place.

Research and the experience of ranchers have shown that if grazing consumes less than half the forage produced by the best grasses each year, damage to the better plants is minimized. In addition, grassland can be maintained in a satisfactory condition, or it can improve if deterioration has occurred. A larger percentage of the forage must be left for soil protection where slopes increase or where the soil is less stable. The ungrazed forage provides the following benefits: (a) Serves as a mulch and increases the intake of water; (b) supplies food for good root

This section was written by DEWAYNE J. BECK, range conservationist, SCS, Colfax, Wash.



**Figure 7.--Good stand of bunchgrasses on the Magallon, Ritzville, and Starbuck soils.**

growth and allows the roots to reach deep moisture; (c) protects the soil from wind and water erosion (grass is the best living vegetation for preventing erosion); (d) allows the better grasses to increase and crowd out the less desirable plants; (e) enables plants to store food for spring growth; (f) holds snow where it falls and allows melt water to soak into the soil.

Proper range management requires adjustment in grazing from season to season according to the current production of forage. Operations should provide reserve pasture or other feed for the use of livestock during droughts or other periods of reduced forage production. In addition, it is desirable that part of the herd be readily salable stock. Such flexibility allows the rancher to balance his livestock to the production of forage without sacrificing the breeding animals.

### *Range sites and range conditions*

The operator of a ranch must know the different combinations of plants that rangeland is capable of producing and how grazing affects the growth and vigor of forage-producing plants. To this end, the soils of Walla Walla County have been grouped by range sites. This part of the report explains some of the terms used in range management and describes the various range sites that occur in the county.

A *range site* is an area of range] and sufficiently uniform in climate, soil, and topography to produce a particular climax, or original, vegetation. For this reason a given range site needs management significantly different from that of other sites if its vegetation is to be maintained or improved.

*Climax vegetation*, the most productive growth on rangeland, is the combination of plants that originally grew on a range site. This vegetation is altered under intensive grazing. Livestock graze selectively. They constantly seek out the more palatable and nutritious plants. If grazing is not carefully regulated, the better plants are eventually eliminated. Less desirable plants



take their place. If grazing pressure continues, even these second-choice plants are thinned out or eliminated and are replaced by undesirable weeds, or *invaders*.

Condition classes are used to indicate the degree of departure from the original, or climax, vegetation that has been brought about by grazing or other use. These classes show the present condition of the vegetation on a range site in relation to the vegetation that was on it originally. There are four classes, as follows

<i>Condition, class</i>	<i>Percentage of present vegetation that is climax for the site</i>
Excellent-----	76 to 100.
Good-----	51 to 75.
Fair-----	26 to 50.
Poor-----	0 to 25.

One of the main objectives of good range management is to keep rangeland in *excellent* or *good* condition. If this is done, yields improve, water is conserved, and the soils are protected. Recognizing important changes in the kind of cover on a range site is a problem. These changes take place gradually and can be misunderstood or overlooked. Growth encouraged by heavy rainfall may lead to the conclusion that a range is improving, when actually the longtime trend is toward less desirable cover and lowered production. On the other hand, some rangeland that has been closely grazed for relatively short periods under the supervision of a careful manager may have a degraded appearance that temporarily conceals its quality and ability to recover.

### *Description of range sites*

In the following pages the soils of Walla Walla County have been grouped into range sites. The soils on each site are described, principal forage plants are listed, and suggestions for use and management are discussed.

#### SAND

Soils of this site occur on broad, gently sloping terraces along the lower Snake and Columbia Rivers. They consist of many long, narrow dunes and sand blows. The average annual precipitation ranges from 6 to 9 inches. Three-fourths of this occurs between October and April. Few showers of consequence occur in the hot, dry summers. The temperature ranges from a maximum of 115° to a minimum of -29° F. The frost-free season is about 180 days and extends from April to October. Growing conditions for native plants are best from about March 15 to June 15. There is seldom enough moisture in the fall to produce usable forage.

The soils in this range site are-

- Adkins loamy fine sand, 0 to 16 percent slopes.
- Adkins loamy fine sand, 0 to 15 percent slopes, eroded.
- Adkins loamy fine sand, 15 to 30 percent slopes.
- Adkins loamy fine sand, 15 to 30 percent slopes, eroded.
- Adkins loamy fine sand, 30 to 45 percent slopes.
- Beverly fine sandy loam and Riverwash.
- Beverly sandy loam, 0 to 3 percent slopes.
- Beverly loamy fine sand, 0 to 3 percent slopes.
- Hezel loamy fine sand, 0 to 15 percent slopes, eroded.
- Hezel loamy fine sand, 15 to 30 percent slopes, eroded.
- Hezel loamy fine sand, 30 to 45 percent slopes, eroded.
- Quincy complex, 0 to 8 percent slopes, eroded.
- Quincy fine sand, 0 to 30 percent slopes, eroded.
- Quincy loamy fine sand, 0 to 8 percent slopes, eroded.
- Quincy loamy fine sand, 8 to 15 percent slopes, eroded.

- Quincy loamy fine sand, moderately deep over coarse sand, 0 to 8 percent slopes, eroded.
- Quincy loamy fine sand, moderately deep over coarse sand, 8 to 15 percent slopes, eroded.
- Quincy loamy fine sand, moderately deep over coarse sand, 15 to 30 percent slopes, eroded.
- Quincy loamy fine sand, moderately deep over gravel, 0 to 8 percent slopes, eroded.
- Quincy loamy fine sand, moderately deep over gravel, 8 to 15 percent slopes, eroded.
- Quincy loamy fine sand moderately deep over gravel, 15 to 30 percent slopes, eroded.

These soils consist mainly of mixed sandy alluvium and valley fill materials that were reworked by wind. They are underlain by gravel, coarse basaltic sand, or stratified lake sediment at depths ranging from 30 inches to more than 60 inches. The water-supplying capacity is about 1.1 inches per foot of soil depth. These soils are highly susceptible to wind erosion if not protected by a cover of living plants.

In excellent, or natural condition, about 93 percent of the vegetation is grasses. About 70 percent of this vegetation consists of bluebunch wheatgrass and needle-and-thread, and about 23 percent consists of Indian ricegrass, Sandberg bluegrass, thickspike wheatgrass, cheatgrass, and annual fescue. Common forbs, such as yarrow, balsamroot, lupine, biscuitroot, sanddock, and annual plantain, make up about 5 percent of the vegetation. Rabbitbrush, bitterbrush, and hopsage make up about 2 percent.

The yield of usable forage on a range in excellent condition, as estimated from plot clippings, ranges from 400 pounds per acre in favorable years to 200 pounds per acre in less favorable years. About 25 percent of the ground is covered by plants named previously, 15 percent by litter, and 50 percent by moss. About 10 percent is bare.

A typical area of this site can be seen near the Columbia River in the vicinity of Attalia in the NE1/4 sec: 10, T. 7 N., R. 31 E., W.M.

The Sand range site is commonly used for fall winter, and spring grazing of sheep. During an unusually warm spell, the vegetation frequently becomes green, and the sheep will feed on the short tender shoots. Sheep are held on the range through the lambing season and are moved to the mountains for summer grazing. By this time, the soil moisture is depleted and there is very little regrowth to allow the plant to set seed and store food to start the next year's growth. This practice of grazing contributed much to the deterioration of the valuable range plants.

A program of deferred and rotation grazing would help to maintain and improve this site. For example, one-third of the acreage should be grazed early in spring, one-third, deferred for grazing late in spring, and the other third, deferred for grazing late in fall and in winter. Grazing units should be rotated so that a different one will be grazed during the same period in successive years.

Because of low forage production, ranchers have not developed their range facilities. Pastures are large and watering places are several miles apart. It has been more economical to haul water to the livestock than to develop additional wells.

Reseeding has not been successful on this range site. The present vegetation consists mainly of annual weeds, annual grasses, and deep-rooted shrubs. Rabbitbrush spreads when the perennial grasses are killed out. When

this site is overgrazed, bunchgrasses are the first to yield to less palatable plants. Thickspike wheatgrass occurs mostly on eroded, sandy areas because it reproduces from underground rootstocks.

#### SANDY UPLAND

The Sandy Upland range site is slightly lower than the Deep Upland range site. The largest area of the Sandy Upland range site is south and west of Eureka Flats, and it extends toward the Columbia River. Slopes are mainly in the range of 3 to 15 percent; a few slopes are as steep as 45 percent. The elevation ranges from 600 to 1,000 feet above sea level. The average annual precipitation ranges from 8 to 10 inches, and about 75 percent of this occurs from October through April. Summer showers are generally light, and most of the moisture is lost through evaporation from the surface of the soil. Temperature ranges from a 113 ° to - 29 ° F. The average frost-free season is about 180 days. Growing conditions for native plants are best from about March 15 to June 15. Fall rains are usually not enough to produce usable forage before a killing frost occurs.

The soils in this range site are-

Adkins fine sandy loam, 0 to 15 percent slopes.  
Adkins fine sandy loam, 0 to 15 percent slopes, eroded.  
Adkins fine sandy loam, 15 to 30 percent slopes.  
Adkins fine sandy loam, 30 to 45 percent slopes.  
Magallon fine sandy loam, 0 to 15 percent slopes.  
Magallon fine sandy loam, 15 to 30 percent slopes.  
Magallon fine sandy loam, 15 to 30 percent slopes, eroded.  
Magallon fine sandy loam, 30 to 45 percent slopes.  
Taunton fine sandy loam, 0 to 30 percent slopes, eroded.  
Taunton fine sandy loam, 30 to 45 percent slopes, eroded.

These soils are rapidly permeable and consist mainly of fine sand and coarse silt. They are neutral to mildly alkaline and have a water-supplying capacity of about 1.3 inches per foot of soil depth. Compact lake sediment or basalt substratum is generally at a depth of more than 60 inches.

When this site is in excellent condition, about 94 percent of the vegetation is grasses. About 75 percent of the vegetation consists of bluebunch wheatgrass and needle-and-thread. About 19 percent consists of Sandberg bluegrass, Indian ricegrass, thickspike wheatgrass, Idaho fescue, cheatgrass, and annual fescue. About 4 percent of the vegetation consists of balsamroot, lupine, phlox, biscuitroot, daisy, astragalus, and annual plantain, and about 2 percent is rabbitbrush, big sagebrush, and bitterbrush.

The yield of usable forage on a range in excellent condition, as estimated from plot clippings, ranges from 600 pounds per acre in favorable years to 300 pounds in less favorable years. About 25 percent of the ground is covered by plants listed previously, 15 percent by litter, and 55 percent by moss. About 5 percent is without cover.

A typical area of this site can be seen 6 miles west of Adkins in sec. 21, T. 9 N., R. 33 E., W.M.

This site is generally not adequately watered and fenced for handling all classes of livestock. It has been used mainly as a sheep range, but it can be used for cattle. Water is supplied from wells that are several miles apart and is pumped to the surface by windmills. In recent years, water has been hauled to the herds to eliminate trailing, especially in warm weather when sheep and cattle

need water every day. As a rule, livestock get some supplemental feed in winter and early in spring. In summer, livestock is moved to mountain ranges. In some years, livestock is moved from the spring range early enough to allow the deep-rooted grasses to develop fully and to produce seed. This practice makes it possible to maintain some of the range in fair or good condition.

Big sagebrush and rabbitbrush spread rapidly on the site when the grass is thinned out. If more than half the annual growth of the key management plants (bluebunch wheatgrass and needle-and-thread) is grazed in a season, the forage production is less in the years that follow.

This site can be reseeded by seeding grass in grain stubble or by preparing a clean, firm seedbed and seeding grass with a drill in fall. Crested wheatgrass and beardless wheatgrass are suitable for the soils of this site. The major problems in reseeding are controlling erosion and protecting the new seedlings from drifting sand. Limiting the tillage and seeding at right angles to the prevailing wind help to control erosion. Wind strips maybe needed in some places. Nitrogen fertilizer helps new grass to grow rapidly. Grazing should not be allowed until grass is well rooted.

#### DEEP SILTY UPLAND, 6 TO 9 INCHES PRECIPITATION

This range site is on dissected remnants of the Touchet formation in, the lower part of Walla Walla, Valley. The topography is characteristically that of long, gently sloping ridges separated by deep, steep-walled canyons that have slopes up to 45 percent. Individual areas of this site are small but are spread over a wide area. This site gets 6 to 9 inches of precipitation per year. About 77 percent of precipitation occurs from October 1 through April. Summer showers are generally light, and most of the moisture is lost by evaporation. Temperature ranges from 113 ° to - 36 ° F. The average frost-free season, about 170 days, extends from April through October. Conditions are best for growth of the native range plants from March 15 to June 15. Fall rains seldom come early enough to produce usable forage before the killing frosts occur.

The soils on this site are-

Sagemoor silt loam, 0 to 3 percent slopes.  
Sagemoor silt loam, 3 to 8 percent slopes.  
Sagemoor silt loam, 8 to 15 percent slopes.  
Sagemoor silt loam, 8 to 15 percent slopes, eroded.  
Sagemoor silt loam, 15 to 30 percent slopes.  
Sagemoor silt loam, 15 to 30 percent slopes, eroded.  
Sagemoor silt loam, 30 to 45 percent slopes.  
Sagemoor silt loam, 30 to 45 percent slopes, eroded.  
Sagemoor very fine sandy loam, 0 to 3 percent slopes.  
Sagemoor very fine sandy loam, 3 to 8 percent slopes.  
Sagemoor very fine sandy loam, 8 to 15 percent slopes.  
Sagemoor very fine sandy loam, 8 to 15 percent slopes, eroded.  
Sagemoor very fine sandy loam, 15 to 30 percent slopes.  
Sagemoor very fine sandy loam, 15 to 30 percent slopes, eroded.

These soils are medium textured, and have a calcareous, medium-textured subsoil that has formed from stratified lake sediment. The compact, unweathered lake sediment is from 18 to 36 inches below the soil surface. The surface layer and subsoil are moderately permeable; the lake sediment is slowly permeable. The soils are mildly to moderately alkaline and have a water-supplying capacity of about 1.9 inches per foot of soil depth. If unprotected by living plants, these soils are highly susceptible to wind and water erosion.

When the site is in excellent, or natural condition, grasses make up 95 percent of the vegetation. About 85 percent of the vegetation consists of bluebunch wheatgrass and Sandberg bluegrass, and about 10 percent consists of Idaho fescue, needle-and-thread, and cheatgrass. Common forbs, such as yarrow, balsamroot, biscuitroot, phlox, astragalus, daisy, buckwheat, and annual plantain make up about 4 percent of the vegetation; big sagebrush or rabbitbrush make up about 1 percent. Forbs and brush may become dominant if the better plants are overgrazed.

The yield of forage from range in excellent condition, as estimated from plot clippings, ranges from 500 pounds per acre in favorable years to 300 pounds per acre in less favorable years. About 35 percent of the ground is covered by plants named previously, about 30 percent by litter, and about 20 percent by moss; about 15 percent is without cover.

A typical area of this site can be seen 3 miles northwest of Touchet, in sec. 20, T. 7 N., R. 30 E., W.M.

A large part of this range site is near permanent water and is subject to heavy grazing. On areas of this site grazed by sheep, forbs and Sandberg bluegrass are suppressed and bluebunch wheatgrass is left. On areas overgrazed by cattle and horses, the wheatgrass is killed out and Sandberg bluegrass and forbs increase. When the site is severely overgrazed, big sagebrush and rabbitbrush become the dominant plants. The control of big sagebrush and rabbitbrush is now a problem on a large part of the site. Native forage grasses are best maintained and improved by use of a rotation-deferred system of grazing.

Ranges in poor condition can be reseeded successfully if brush, annual weeds, and grasses are controlled and a good seedbed is prepared. Seeding late in fall has been more successful than seeding in spring.

#### SHALLOW UPLAND, 6 TO 9 INCHES PRECIPITATION

This range site is in small, widely scattered areas in Walla Walla County. It is usually associated with larger areas of the Sandy Upland range site. It has about the same general climate and physiographic characteristics as the Sandy Upland range site but differs in having a restricted root zone and a low water-supplying capacity.

The soils in this range site are-

Adkins fine sandy loam, shallow, 8 to 30 percent slopes, eroded.  
Adkins rocky sandy loam, moderately deep, 3 to 30 percent slopes, eroded.  
Adkins very rocky sandy loam, moderately deep, 0 to 30 percent slopes.  
Sagemoor rocky very fine sandy loam, 3 to 30 percent slopes.  
Sagemoor rocky very fine sandy loam, 8 to 30 percent slopes, eroded.  
Sagemoor rocky very fine sandy loam, 30 percent and steeper slopes.

These soils have coarse- or medium-textured subsoil underlain by basalt bedrock at a depth of 10 to 20 inches. The plant species on this range site are the same as those on the Sandy Upland range site. However, forage yield and density of ground cover are much less.

The yield of usable forage on a range in excellent condition, as estimated from plot clippings, ranges from 200 pounds per acre in favorable years to 100 pounds per acre in less favorable years. About 25 percent of the ground is covered by plants listed previously (see Sandy Upland range site), 10 percent by litter, 40 percent by

moss, and 10 percent by stones; 15 percent is without cover.

A typical area of this range site can be seen 6 miles west of Adkins on the Northern Pacific Railroad in sec. 21, T. 9 N., R. 32 E., W.M.

#### DEEP UPLAND, 9 TO 12 INCHES PRECIPITATION

This is one of the major range sites in the county. Most of it is adjacent to the breaks of the Snake River in the northern part of the county and south of the Walla Walla River in the southwestern corner of the county. The site has strongly undulating to steep slopes with gradients as much as 65 percent. Elevation ranges from 750 to 1,500 feet above sea level.

The average annual precipitation ranges from 9 inches at the lower elevations to 12 inches at the higher elevations. About 76 percent of this occurs from October through April. Summer rains are generally light and are nearly all lost through evaporation. Temperatures range from 113° to -30° F. The average frost-free season is 170 days. Growing conditions for native plants are best between April 1 and July 1. Fall rains are generally too late to produce usable forage before frost occurs.

The soils on this site are-

Ellisforde silt loam, 0 to 3 percent slopes.  
Ellisforde silt loam, 3 to 8-percent slopes.  
Ellisforde silt loam, 8 to 15 percent slopes.  
Ellisforde silt loam, 8 to 15 percent slopes, eroded.  
Ellisforde silt loam, 15 to 30 percent slopes.  
Ellisforde silt loam, 15 to 30 percent slopes, eroded.  
Ellisforde silt loam, 30 to 45 percent slopes.  
Ellisforde silt loam, 30 to 45 percent slopes, eroded.  
Ellisforde silt loam, hardpan variant, 0 to 3 percent slopes.  
Ellisforde silt loam, hardpan variant, 3 to 8 percent slopes.  
Ellisforde very fine sandy loam, 3 to 8 percent slopes.  
Ellisforde very fine sandy loam, 8 to 15 percent slopes.  
Ellisforde very fine sandy loam, 8 to 15 percent slopes, eroded.  
Ellisforde very fine sandy loam, 15 to 30 percent slopes.  
Ellisforde very fine sandy loam, 15 to 30 percent slopes, eroded.  
Ellisforde very fine sandy loam, 30 to 45 percent slopes, eroded.  
Farrell very fine sandy loam, 3 to 15 percent slopes.  
Farrell very fine sandy loam, 15 to 30 percent slopes.  
Farrell very fine sandy loam, 30 to 60 percent slopes.  
Magallon very fine sandy loam, 0 to 15 percent slopes.  
Magallon very fine sandy loam, 15 to 30 percent slopes.  
Magallon very fine sandy loam, 15 to 30 percent slopes, eroded.  
Magallon very fine sandy loam, 30 to 60 percent slopes.  
Ritzville silt loam, 0 to 8 percent slopes.  
Ritzville silt loam, 8 to 30 percent slopes.  
Ritzville silt loam, 8 to 30 percent slopes, eroded.  
Ritzville silt loam, 30 to 45 percent slopes.  
Ritzville silt loam, 30 to 45 percent slopes, eroded.  
Ritzville silt loam, 45 to 60 percent slopes.  
Ritzville silt loam, 45 to 60 percent slopes, eroded.  
Ritzville silt loam, 60 percent -and steeper slopes.  
Ritzville silt loam, moderately deep, 8 to 30 percent slopes:  
Ritzville silt loam, moderately deep, 30 to 45 percent slopes.  
Ritzville very fine sandy loam, 0 to 8 percent slopes.  
Ritzville very fine sandy loam, 8 to 30 percent slopes.  
Ritzville very fine sandy loam, 8 to 30 percent slopes, eroded.  
Ritzville very fine sandy loam, 30 to 45 percent slopes.  
Ritzville very fine sandy loam, 45 to 60 percent slopes.  
Ritzville very fine sandy loam, 30 to 60 percent slopes, eroded.  
Ritzville very fine sandy loam, volcanic-ash variant, 0 to 8 percent slopes.  
Ritzville very fine sandy loam, volcanic-ash variant, 8 to 30 percent slopes, eroded.  
Ritzville very fine sandy loam, volcanic-ash variant, 30 to 60 percent slopes.

The soils in this site have developed from thick loess or from loess that had been redeposited with glacial outwash material. They are medium textured and overlie basalt,

coarse basaltic sand, gravel, or compact lake deposits, at a depth of 3 feet to more than 5 feet below the surface. They are mildly alkaline, moderately permeable, and susceptible to wind and water erosion if unprotected by living plants. The water-supplying capacity is approximately 1.8 inches per foot of soil depth.

When the site is in excellent condition, grasses make up to 95 percent of the vegetation. About 80 percent of the vegetation consists of bluebunch wheatgrass and Idaho fescue, and about 15 percent consists of Sandberg bluegrass, needle-and-thread, short-owned needlegrass, cheatgrass, and annual fescue. About 4 percent of the vegetation consists of yarrow, balsamroot, astragalus, daisy, lupine, phlox, hawksbeard, stoneseed, and annual plantain; about 1 percent consists of big sagebrush and rabbitbrush.

The yield of usable forage when the site is in excellent condition, as estimated from plot clippings, ranges from 700 pounds per acre in favorable years to 350 pounds per acre in less favorable years. About 38 percent of the ground is covered by plants named previously, 26 percent by litter, and 34 percent by moss. About 2 percent is bare.

A typical area of this site can be seen 2 miles northwest of Clyde in NE1/4NE1/4 sec. 8, T. 11 N., R. 35 E., W.M.

Most of this site is suitable for reseeding to crested wheatgrass, big bluegrass, and beardless wheatgrass. Control of erosion, especially on the very fine sandy looms, is a problem in reseeding this site. Seeding in grain stubble in fall or early in spring is satisfactory. Nitrogen helps new grass to grow well. Grazing should not be allowed until grass is well established.

#### SHALLOW UPLAND, 9 TO 12 INCHES PRECIPITATION

This range site is characteristically on ridges and south-facing slopes that are broken by narrow benches and basalt ledges. It occurs as many small areas along the breaks of the Snake River and in the southwest corner of the county. The total acreage is small. Precipitation and temperature characteristics are the same as those for the Deep Upland range site, 9 to 12 inches precipitation. Less moisture is available for plant growth, however, because it is readily lost from the south slopes and rocky ridges.

The soils on this site are-

Magallon rocky very fine sandy loam, basalt substratum, 0 to 30 percent slopes.

Magallon rocky very fine sandy loam, basalt substratum, 30 to 60 percent slopes.

Magallon very rocky very fine sandy loam, 0 to 30 percent slopes.

Magallon very rocky very fine sandy loam, 30 to 60 percent slopes.

Starbuck rocky silt loam, 0 to 30 percent slopes.

Starbuck rocky silt loam, 30 to 45 percent slopes.

These soils are rocky, medium textured, and 10 to 20 inches thick over basalt bedrock. If unprotected by living plants, these soils are highly susceptible to wind and water erosion.

When this range site is in excellent condition, grasses are about 93 percent of the vegetation. About 75 percent of the vegetation consists of bluebunch wheatgrass and Sandberg bluegrass, and 18 percent consists of needle-and-thread, short-owned needlegrass, cheatgrass, and annual fescue. About 5 percent of the vegetation consists of balsamroot, phlox, daisy, astragalus, lupine, pussytoes,

and buckwheat. Big sagebrush and rabbitbrush make up about 2 percent.

The yield of usable forage when the site is in excellent condition, as estimated from plot clippings, ranges from 300 pounds per acre in favorable years to 150 pounds per acre in less favorable years. About 25 percent of the ground is covered by plants named previously, 10 percent by litter, 25 percent by moss, and 30 percent by stones; 10 percent is without cover.

A typical area of this site can be seen 2 miles southeast of Wallula in sec. 36, T. 7 N., R. 31 E., W.M.

#### DEEP UPLAND, 12 TO 16 INCHES PRECIPITATION

This range site is very productive, but only a few small areas, mostly steep, north slopes, are still in grass. These areas are grazed during the summer-fallow year of the wheat-summer fallow system of cropping, or after harvest in the fall. In past years, fire from burning stubble fields has damaged the grasses more than overgrazing. About 76 percent of the annual precipitation occurs between October 1 and April 30. Rainfall during July and August is seldom enough to affect plant growth. The temperature ranges from 113° to -29° F. The frost-free period, 160 to 190 days, extends from April through September. Native plants make their best growth between April 15 and July 15. Fall rains are often early enough for growth of usable forage.

Soils in this site are-

Walla Walla silt loam, 0 to 8 percent slopes.

Walla Walla silt loam, 8 to 30 percent slopes.

Walla Walla silt loam 8 to 30 percent slopes, eroded.

Walla Walla silt loam, 30 to 45 percent slopes.

Walla Walla silt loam, 30 to 45 percent slopes, eroded.

Walla Walla silt loam, 45 to 60 percent slopes.

Walla Walla silt loam, hardpan variant, 0 to 8 percent slopes.

Walla Walla silt loam, lacustrine substratum, 0 to 8 percent slopes.

Walla Walla silt loam, lacustrine substratum, 8 to 30 percent slopes.

Walla Walla silt loam, lacustrine substratum, 8 to 30 percent slopes, eroded.

Walvan very fine sandy loam, 0 to 8 percent slopes.

Walvan very fine sandy loam, 8 to 30 percent slopes, eroded.

Walvan very fine sandy loam, 30 to 60 percent slopes, eroded.

These soils are moderately permeable and neutral to mildly alkaline. They have developed in thick loess and lake-laid sediment. Dominant slopes on the site range from 30 to 60 percent. Elevation ranges from 1,000 to 2,000 feet above sea level. These soils have a water-supplying capacity of about 1.9 inches per foot of soil depth. They are susceptible to water erosion if not protected by a cover of living plants.

When this range site is in excellent condition, grasses account for about 95 percent of the vegetation. About 85 percent of the vegetation consists of Idaho fescue and bluebunch wheatgrass. Idaho fescue is most abundant on the north slopes. Other grasses (10 percent) are Sandberg bluegrass, prairie junegrass, big bluegrass, woolgrass, cheatgrass, and annual fescue. Common forbs, such as yarrow, lupine, balsamroot, annual plantain, hawksbeard, astragalus, daisy, phlox, and buckwheat, make up about 4 percent of the vegetation. Big sagebrush and rabbitbrush make up about 1 percent.

The yield of usable forage when the site is in excellent condition, as estimated from plot clippings, ranges from 960 pounds per acre in favorable years to 600 pounds

per acre in less favorable years. Approximately 40 percent of the ground is covered by plants named previously, 30 percent by litter, and 30 percent by moss. There is little or no bare ground. A typical area of this site can be seen 4 1/2 miles north of Prescott, along the Skyrocket Hill road.

It is difficult to obtain proper distribution of cattle on the steep north slopes. Trails, fences, and water developments help solve this problem. The water supply is usually adequate if springs and seeps are properly developed. Early in winter, when soils are freezing and thawing, stock have been injured or lost by slipping and falling on the steep slopes.

Where reseeding is necessary and the soil can be cultivated, big bluegrass, intermediate wheatgrass, and alfalfa are suitable pasture plants. Control of erosion and weeds are the problems in reseeding. Seeding early in spring on the contour, or across the slope in steeper areas, in a firm seedbed has proved satisfactory. Nitrogen fertilizer helps new grass to grow rapidly. Grazing should not be allowed until the grass is well established.

#### DEEP UPLAND, 16 TO 24 INCHES PRECIPITATION

This range site extends from U.S. Highway No. 410 in Walla Walla County to the Blue Mountains. Very little grassland, other than that on steep north slopes, has not been plowed. About half the north slopes in this area are brushland or woodland. A large part of the brushland was once grass, but overgrazing and fire have destroyed the grass, and brush has taken over. The amount of rainfall increases at the rate of 2 inches per mile as the slope rises toward the Blue Mountains. About 78 percent of the precipitation occurs from October through April, and a significant amount of this is snow. The summers are dry, and there is an occasional violent local storm. The temperature ranges from 100° to about -35° F. The frost-free season, 140 to 170 days, extends from May to September. Native plants make their best growth from May 1 to July 15. Fall rain provides moisture early enough to produce some fall forage.

The soils in this site are-

Athena silt loam, 0 to 8 percent slopes.  
Athena silt loam, 8 to 30 percent slopes.  
Athena silt loam, 8 to 30 percent slopes, eroded.  
Athena silt loam, 30 to 45 percent slopes.  
Athena silt loam, 30 to 45 percent slopes, eroded.  
Palouse silt loam, 0 to 8 percent slopes.  
Palouse silt loam, 8 to 30 percent slopes.  
Palouse silt loam, 8 to 30 percent slopes, eroded.  
Palouse silt loam, 30 to 45 percent slopes.  
Palouse silt loam, 45 to 60 percent slopes.  
Snow silt loam, 0 to 3 percent slopes.

The Palouse and Athena soils are medium textured and have formed in deep wind-deposited material. They have a silt loam subsoil, are slightly acid to neutral, and are moderately permeable. The estimated water-supplying capacity of these soils is about 2.2 inches per foot of soil depth. They occur on nearly level to strongly sloping ridges and on steep to very steep side slopes and are slightly to highly susceptible to erosion by water if not protected by plant cover. The Snow soils are similar to the Palouse and Athena but have formed in alluvium.

When this range site is in excellent condition, grasses are 85 percent of the vegetation. About 75 percent of the vegetation consists of Idaho fescue and bluebunch

wheatgrass. Other grasses are big bluegrass, Sandberg bluegrass, prairie junegrass, timothy, Kentucky bluegrass, and cheatgrass. About 10 percent of the vegetation consists of balsamroot, fivefinger, woollyweed, lupine, phlox, daisy, geranium, and astragalus, and about 5 percent consists of common shrubs-rose, snowberry, chokecherry, serviceberry, sumac, currant, and Oregon-grape. A few ponderosa pine or Douglas-fir trees are on northern exposures.

The yield of usable forage when the site is in excellent condition, as estimated from plot clippings, ranges from 1,400 pounds per acre in favorable years to 800 pounds per acre in less favorable years. About 50 percent of the ground is covered by plants named previously, 35 percent by litter, and 15 percent by moss.

A typical area of this site can be seen on the north-facing slope along Coppei Creek in sec. 33, T. 8 N., R. 38 E., W.M.

This range site is used mainly for summer range. Water generally occurs in the bottoms of the canyons. Livestock prefer to graze close to water instead of scattering over the steep slopes. Fencing and placing salt away from water help to distribute livestock. The spraying of livestock in warm weather to control insects and other pests also helps to improve distribution.

This site has enough moisture to saturate the soil to depths beyond the zone occupied by roots of the dominant perennial grasses. Snowberry and wild rose, however, increase readily after a fire or if the range is overgrazed. When the shrubs become established, the production of the desirable grasses is reduced. Management is needed to prevent the spread of shrubs because the grasses cannot crowd them out once they are established. Mechanical control of the shrubs and reseeding of grasses are difficult on the steep terrain.

Areas that need reseeding to grasses and can be cultivated should be planted to smooth brome grass and alfalfa. Rough plowing and seeding on the contour, or across the slope, will help control erosion on the steep areas until the new seeding is well established.

#### MODERATELY DEEP UPLAND, 18 TO 24 INCHES PRECIPITATION

This is one of the most important forage-producing range sites in the Blue Mountains section of the country. It produces good yields of palatable forage, which is ready for grazing when, the grazing season has ended in areas to the west. Areas of this site at higher elevations or on north or east exposures get more moisture than other parts of the range site. About 75 to 80 percent of the annual precipitation occurs from October through April. July and August are dry months, but summer thunderstorms frequently furnish enough moisture to make plants grow. Fall rains are usually early enough to produce usable forage. Temperature ranges from 100° to -35° F. The frost-free season is 140 to 150 days and extends from May to September. Native plants make their best growth from May 15 to July 15.

The soils on this site are-

Palouse silt loam, moderately deep, 0 to 8 percent slopes.  
Palouse silt loam, moderately deep, 8 to 30 percent slopes.  
Palouse silt loam, moderately deep, 8 to 30 percent slopes, eroded.  
Palouse silt loam, moderately deep, 30 to 45 percent slopes.  
Palouse silt loam, moderately deep, 30 to 45 percent slopes, eroded.

Palouse silt loam, moderately deep, 45 to 60 percent slopes.  
Palouse silt loam, moderately deep, 45 to 60 percent slopes, eroded.

These soils developed in loess over basalt bedrock. They have a medium-textured surface layer and a silt loam or silty clay loam subsoil underlain by fractured basalt. The soil is not deep enough to hold the moisture that accumulates in winter; consequently, there is considerable runoff in spring and very severe erosion on unprotected soils. These soils have a water-supplying capacity of about 2.2 inches per foot of soil depth. They are slightly acid. Slopes of up to 60 percent are common.

When this site is in excellent condition, the vegetation is as much as 85 percent grass. About 75 percent of the vegetation consists of Idaho fescue and bluebunch wheatgrass. Other important grasses are big bluegrass, Sandberg bluegrass, prairie junegrass, Kentucky bluegrass, timothy, and cheatgrass. Balsamroot, fivefinger, woolyweed, yarrow, lupine, phlox, daisy, strawberry, and astragalus make up about 5 percent of the vegetation, and shrubs-spirea, snowberry, chokecherry, serviceberry, currant, and Oregon-grape make up about 9 percent. In narrow coves with a slight east or north exposure there is a small amount of ponderosa pine.

When this range site is in excellent condition, the yield of usable forage, based on plot clippings, ranges from 800 pounds per acre in favorable years to 500 pounds per acre in less favorable years. About 40 percent of the ground is covered by plants named previously, 35 percent by litter, 15 percent by moss, and 10 percent by stone.

A typical area of this site can be seen on the north-facing slopes along Blue Creek in sec. 30, T. 7 N., R. 38 E., W.M.

This site is the winter and early spring range for elk and deer. This fact should be considered in managing the range for domestic livestock.

Areas that need reseeding to grasses and can be cultivated should be planted to smooth bromegrass and alfalfa. Rough plowing and seeding on the contour, or across the slope, will help control erosion on steep slopes until the new seeding is well established.

#### SHALLOW UPLAND, IS TO 24 INCHES PRECIPITATION

This is the largest range site in the Blue Mountains. It occupies the south- and southwest-facing slopes of deep canyons. Slopes of 30 to 60 percent are common. About 75 to 80 percent of the precipitation occurs from October through April. So much moisture is lost through evaporation and runoff from shallow soils on steep slopes that the range site is actually drier than indicated by the annual precipitation. The native plants make most of their growth between April 15 and July 1. Fall rains usually start early enough to enable plants to produce some fall forage. The temperature ranges from about 95 ° to - 35 ° F. The frost-free season is approximately 140 to 160 days and extends from May to September.

The soils in this range site are-

Gwin rocky silt loam, 0 to 30 percent slopes.  
Gwin rocky silt loam, 0 to 30 percent slopes, eroded.  
Gwin rocky silt loam, 30 to 60 percent slopes.  
Gwin very rocky silt loam, 0 to 30 percent slopes, eroded.  
Gwin very rocky silt loam, 30 to 60 percent slopes, eroded.  
Gwin-Rock land complex, 45 to 60 percent slopes.  
Klicker-Gwin-Rock land complex, 30 to 60 percent slopes.

These are shallow, rocky soils that have developed from basalt residuum and loess. They have a medium-textured surface layer and a silt loam, silty clay loam, or clay loam subsoil that overlies fractured basalt at a depth of 10 to 20 inches. They are slowly permeable, slightly acid, and highly susceptible to water erosion if the plant cover is destroyed. The water-supplying capacity of these soils is about 1.6 inches per foot of soil depth.

When this site is in excellent condition, grasses make up as much as 90 percent of the vegetation. About 70 percent of the vegetation consists of bluebunch wheatgrass and Sandberg bluegrass. The other grasses are Idaho fescue, big bluegrass, Columbia needlegrass, prairie junegrass, and cheatgrass. Balsamroot, yarrow, pussytoes, buckwheat, astragalus, daisy, lupine, phlox, and biscuitroot make up as much as 6, percent, and scabland sage, snowberry, rose, sumac, and rabbitbrush make up about 3 percent. Ponderosa pine and Douglas-fir occur in narrow draws or coves.

When this site is in excellent condition, the yield of usable forage, as estimated from plot clippings, ranges from 500 pounds per acre in favorable years to 300 pounds per acre in less favorable years. About 25 percent of the ground is covered by plants named previously, 20 percent by litter, 25 percent by moss, and 30 percent by stone.

A typical area of this site is on the north side of Dry Creek in sec. 8, T. 7 N., R. 38 E., W.M.

Plants start growing early in spring on this site and provide early grazing for deer and elk. Cattle graze on this site first when they are moved into the mountains, and they are often on the range before the soil is firm and the grasses are ready. Repeated early spring grazing in this manner causes this range site to deteriorate rapidly. Desirable grasses disappear if cattle and game harvest more than 30 percent of the current year's growth each spring. The site is usually too steep and rocky for range seeding.

The desirable forage grasses should be grazed by use of a rotation-deferred system to improve the range and keep it in good condition.

#### FORESTED UPLAND-PINE

This is the most extensive dual-use range site in the Blue Mountains. Forage and timber are both harvested from the area. The site occurs at elevations above 3,500 feet. The average precipitation is 30 inches or more a year. More than one-third of this amount falls as snow. A large part of the annual precipitation is lost through runoff from shallow soils on steep slopes. Native plants make their best growth between May 1 and August 1. Temperature ranges from 95° to -40° F. The frost-free period ranges from 90 to 120 days per year, starting late in May and ending early in September.

The soils on this site are-

Klicker rocky silt loam, 0 to 30 percent slopes.  
Klicker rocky silt loam, 30 to 60 percent slopes.

These soils have developed in residuum that weathered from basalt under vegetation that is in the zone between forest and grasses. They have rocky, medium-textured surface soil and silty clay loam or clay loam subsoil underlain by fractured basalt at a depth of 18 to 30 inches from the surface. These soils are slightly acid, moderately permeable to moderately slowly permeable, and extremely

variable in depth. They have a water-supplying capacity of about 1.6 inches per foot of depth. Water erosion is very severe where the vegetation is destroyed.

When this site is in excellent condition, grasses comprise 80 percent of the vegetation. The most abundant grasses are Idaho fescue, pinegrass, and bluebunch wheatgrass, which together make up 60 percent of the vegetation. Other important grasses are prairie junegrass, timothy, big bluegrass, mountain brome grass, Kentucky bluegrass, timber oatgrass, and hairgrass. Fivefinger, balsamroot, lupine, strawberry, arnica, and peavine make up about 10 percent of the vegetation. Snowberry, spirea, rose, Oregon-grape, huckleberry, currant, ocean-spray, and trees also make up about 10 percent. The main species of trees on the site are ponderosa pine and Douglas-fir. There are a few grand fir and western larch. Trees have a combined basal area of about 183 square feet per acre.

The yield of herbage on this site is extremely variable, depending on the area affected by trees. The estimated yield of forage, from the vegetation named previously, ranges from 500 pounds per acre in favorable years to 300 pounds per acre in less favorable years. About 40 percent of the ground surface is covered by grass, 35 percent by litter, and 10 percent by moss. About 5 percent is covered by stone. A typical area of this site is the south side of Blue Creek in sec. 4, T. 6 N., R. 38 E., W.M.

The rough and broken character of this range site interferes with the distribution of livestock. The construction of trails, placement of salt in underutilized areas, and development of water supply help in the proper distribution of livestock. Water is available in most of the deep canyons but seldom on the uplands. Fencing is expensive, and artificial reseeding is not feasible. This range site furnishes important summer and fall grazing for deer and elk, and this fact must be recognized in managing the range.

#### MIXED FOREST-PINE

This range site is in woodland consisting mainly of ponderosa pine and Douglas-fir. The extent to which it is grazed depends on the density of the trees. Open stands of trees have a fair amount of palatable forage species in the plant community. The site gets 24 to 30 inches of precipitation a year. Little rain falls late in summer. Plants grow best from May to August. The temperature ranges from about 90° to -40° F. The frost-free period ranges from 90 to 120 days, generally the period from May to September.

The soils on this site are-

- Couse silt loam, 3 to 8 percent slopes.
- Couse silt loam, 3 to 8 percent slopes, eroded.
- Couse silt loam, 8 to 15 percent slopes.
- Couse silt loam, 8 to 15 percent slopes, eroded.
- Couse silt loam, 15 to 30 percent slopes.
- Couse silt loam, 15 to 30 percent slopes, eroded.
- Couse silt loam, 15 to 30 percent slopes, severely eroded.
- Couse silt loam, 30 to 45 percent slopes.
- Couse silt loam, 30 to 45 percent slopes, eroded.
- Couse silt loam, 45 to 60 percent slopes.
- Couse-Rock land complex, 30 to 60 percent slopes.

The Couse soils have a medium-textured, moderately permeable surface soil and a subsoil underlain by dense, clayey, very slowly permeable substratum at a depth of

40 to 60 inches. If unprotected by a cover of living plants, the soils are extremely susceptible to water erosion. The water-supplying capacity is about 1.6 inches per foot of soil depth.

Under a fairly open stand of trees, 75 percent of the understory vegetation may be grass. The important grasses are pinegrass, Kentucky bluegrass, Idaho fescue, elk sedge, bluebunch wheatgrass, Sandberg bluegrass, mountain brome grass, prairie junegrass, timothy, blue wildrye, and tufted hairgrass. Forbs on this site are lupine, yarrow, fivefinger, buckwheat, peavine, strawberry, arnica, Indian paintbrush, and hawkweed. These comprise about 10 percent of the plant cover. Shrubs, which may comprise from 15 percent to almost 100 percent of the understory, are mainly snowberry, spirea, rose, Oregon-grape, huckleberry, willow, ocean-spray, currant, and princess pine.

Most of this range site can be reseeded. Orchardgrass and clover are suitable. Seeding in fall in a rough seedbed helps to control erosion and weeds. Applications of nitrogen and sulfur will make new grass grow fast. New grass should not be grazed until it is well established.

#### MIXED FOREST-FIR

This site is more suitable for trees than for range forage. Grazing is limited mainly to the clearings and the stream bottoms. This site is generally located on gently sloping to steep north and northeast slopes, at elevations between 3,750 and 4,500 feet above sea level. The precipitation is more than 30 inches per year. More than one-third of this falls as snow. July and August are months of low rainfall. Fall rains usually start in September.

The soils on this site are-

- Helmer silt loam, 3 to 15 percent slopes.
- Helmer silt loam, 15 to 30 percent slopes.
- Helmer silt loam, 30 to 45 percent slopes.
- Helmer silt loam, 45 to 60 percent slopes.
- Helmer-Rock land complex, 45 to 60 percent slopes.

These soils have developed from loess, pumice, and weathered basalt over an old, weathered soil profile. They are susceptible to water erosion if the surface litter is removed.

The shade density of the trees is usually 95 percent. The lack of light severely suppresses all understory plants. The amount of available forage varies according to the density of the tree canopy. As the plant community develops, the tree canopy becomes more dense, and the forage plants decrease.

Major species of trees on this site are grand fir, Douglas-fir, Engelmann spruce, western larch, ponderosa pine, and lodgepole pine.

#### ROCKLAND, 6 TO 16 INCHES PRECIPITATION

This range site consists of Basalt rock land that has slopes up to 60 percent. Outcrops of rock cover 25 to 90 percent of the area. From 70 to 75 percent of the annual precipitation occurs between October and April. Summers are dry and hot. The temperature ranges from 115° to -30° F. The frost-free season, 170 to 180 days, extends from April to October.

The soils in this site are-

- Basalt rock land, steep (part that gets 6 to 16 inches of precipitation).

Basalt rock land, undulating to hilly (part that gets 6 to 16 inches of precipitation).  
Basalt rock land-Walla Walla complex, 30 to 60 percent slopes.

These soils are mainly shallow and rocky; in most places they are less than 10 inches deep.

On one plot of this site, in excellent condition and covered by the minimum amount of rock, grasses made up as much as 65 percent of the vegetation. Sandberg bluegrass made up about 55 percent of the vegetation, and other grasses, including bluebunch wheatgrass, cheatgrass, annual fescue, and squirreltail, made up about 10 percent. Common forbs, such as daisy, phlox, wild onion, buckwheat, biscuitroot, scab balsamroot, and bitterroot, made up 10 percent of the vegetation, and scabland sage and shrubby buckwheat made up 25 percent.

The yield of usable forage, as estimated from plot clippings, ranges from 100 pounds per acre in favorable years to 50 pounds in less favorable years. A typical area of this site is 2 miles south of Wallula in sec. 36, T. 7 N., R. 31 E., W.M.

#### ROCKLAND, 16 TO 24 INCHES PRECIPITATION

From 25 to 90 percent of the surface of this range site is covered by rock outcrops. About 75 to 80 percent of the annual precipitation occurs between April and October. Summers are dry and hot. Native plants grow best in the period between April 15 and June 15. The average frost-free period extends from May to September.

The soils in this range site are-

Basalt rock land, steep (part that gets 16 to 23 inches of precipitation).  
Basalt rock land, undulating to hilly (part that gets 16 to 23 inches of precipitation).

These soils are less than 10 inches deep. They are saturated with moisture in spring but are dry and hard in summer. On a sample plot, 35 percent of which was covered by outcrops of rock, 75 percent of the vegetation consisted of grass. Sandberg bluegrass made up about 60 percent of the vegetation, and other grasses, including bluebunch wheatgrass, Idaho fescue, prairie junegrass, squirreltail, cheatgrass, and annual fescue, made up about 10 percent. Yarrow, pussytoes, phlox, lupine, buckwheat, daisy, onion, biscuitroot, and low larkspur made up about 10 percent of the vegetation; and scabland sage, snowberry, rose, and sumac made up about 5 percent.

When in excellent condition, the yield of forage, as estimated from plot clippings, ranges from 150 pounds per acre in favorable years to 100 pounds per acre in less favorable years.

About 20 percent of the ground is covered by plants named previously, 15 percent by litter, 20 percent by moss, and 35 percent by rocks and stones; about 10 percent is bare. A typical area of this site is on the north side of Dry Creek in sec. 8, T. 7 N., R. 38 E., W.M.

#### ALKALI BOTTOMLAND

The Alkali Bottomland range site occupies low terraces and stream bottoms in which salts have accumulated in amounts that are toxic to all but salt-tolerant plants. Most of the site is located in the Walla Walla Valley west of College Place. The annual precipitation ranges from 8 to 14 inches. Plant growth is influenced by restricted drainage, salts, and a seasonally high water table. Re-

stricted drainage prevents the natural leaching of the soluble salts. The high water table retards early spring growth of plants and extends the growing period into summer and early fall. Plants grow best between May 1 and September 1. The frost-free season is 160 to 175 days, usually from April to October.

The soils in this range site are-

Ahtanum silt loam, 0 to 3 percent slopes.  
Pedigo silt loam, 0 to 3 percent slopes.  
Pedigo silt loam, overwashed, 0 to 3 percent slopes.  
Stanfield silt loam, 0 to 3 percent slopes.  
Stanfield very fine sandy loam, 0 to 3 percent slopes.  
Umapine silt loam, 0 to 3 percent slopes.  
Umapine silt loam, leached surface, 0 to 3 percent slopes.  
Umapine very fine sandy loam, 0 to 3 percent slopes.

These are light-colored, medium-textured, saline-alkali soils. They have formed in alluvium from loess and pumice. They are moderately to slowly, permeable and strongly alkaline. The moisture-supplying capacity is approximately 1.3 inches per foot of soil depth. The Stanfield soils have a moderate to indurated alkali hardpan.

When this site is in excellent condition, grasses are as much as 95 percent of the vegetation. About 75 percent of the vegetation consists of giant wildrye, alkali cordgrass, and alkali bluegrass. Other grasses are saltgrass, Baltic rush, sedge, and quackgrass. Yarrow, aster fivefinger, and dandelion make up about 4 percent of the vegetation; greasewood, rabbitbrush, and hopsage make up about 1 percent.

When this site is in excellent condition, the yield of usable forage, as estimated from plot clippings, ranges from 1,200 pounds per acre in favorable years to 800 pounds per acre in less favorable years. Approximately 65 percent of the ground is covered by plants, and 25 percent by litter. About 10 percent of the ground is bare; it may be covered with a white film of salt during the drier part of the year. The density of the plant cover depends to a large extent on the concentration of salt. Areas high in salt are generally almost barren.

A typical area of this site is along U.S. Highway No. 410 between Lowden and Touchet. In the early history of the livestock industry, ranchers reserved the grass on this site for winter feed for cattle. The site produced abundant feed for winter grazing. The giant wildrye protected cattle from winter winds, and it was used for bedding as well as for forage.

Salts concentrate on the soil if the range is in poor condition because of the excessive evaporation of moisture from the practically bare surface. In places the salt forms a white crust. The crust interferes with the natural reseeding of native grasses, and it retards the rate of natural range improvement. Alkali ranges in poor condition have been reseeded by preparing a good, firm seedbed and then planting the seed with a "deep-furrow opener" type of drill that places the seed in moist soil where the concentration of salts is low. Tall wheatgrass has proved to be the best grass for reseeding this range site.

Production of forage can be increased on this site by rotating the grazing at intervals that allow the grass plants to develop fully after they are grazed. Regrowth is certain because the soil stays moist throughout the frost-free period.



#### BOTTOMLAND, 6 TO 12 INCHES PRECIPITATION

This range site is fairly small in Walla Walla County. It has about the same climate as the upland range sites associated with it. Runoff from the upland usually adds to the moisture that is available for plant growth.

Soils in this site are-

Esquatzel silt loam, 0 to 3 percent slopes.  
Esquatzel very fine sandy loam, 0 to 3 percent slopes.  
Yakima cobbly loam, 0 to 3 percent slopes.  
Yakima silt loam, 0 to 3 percent slopes.  
Yakima gravelly silt loam, 0 to 3 percent slopes.

All of these soils except the Yakima are deep and medium textured. The Yakima soils have a gravel substratum.

When this site is in excellent condition, grasses make up about 90 percent of the vegetation. About 55 percent of the vegetation consists of bluebunch wheatgrass and giant wildrye. Other grasses in the vegetation are Idaho fescue, big bluegrass, prairie junegrass, woolgrass, needle-and-thread, Thurber needlegrass, and Sandberg bluegrass. Annual forage yield from a site in excellent condition ranges from 1,000 pounds per acre in favorable years to 750 pounds in less favorable years.

#### BOTTOMLAND, 12 TO 23 INCHES PRECIPITATION

This range site is located on dark-colored alluvial soils. Many of these soils get additional moisture in runoff from adjacent uplands. The climate is the same as that an adjacent upland range sites. Only a few small areas of this site are not in cultivation.

Soils on this site are-

Catherine silt loam, 0 to 3 percent slopes.  
Hermiston silt loam, 0 to 3 percent slopes.  
Hermiston very fine sandy loam, 0 to 3 percent slopes.  
Onyx silt loam, 0 to 3 percent slopes.  
Patit Creek cobbly silt loam, 0 to 3 percent slopes.  
Patit Creek silt loam, 0 to 3 percent slopes.  
Touchet silt loam, 0 to 3 percent slopes.  
Touchet gravelly silt loam, 0 to 3 percent slopes.

All of these soils except the Patit Creek are deep and medium textured. The Patit Creek soils have a gravel substratum.

When the site is in excellent condition, grasses make up 90 percent of the vegetation. About 70 percent of the vegetation consists of giant wildrye and Idaho fescue. Other grasses are mountain biome, timothy, Kentucky bluegrass, prairie June grass, and bluebunch wheatgrass and rushes and sedges. Common forbs-aster, lupine, fivefinger, yarrow, geranium, strawberry, dandelion, and daisy-make up about 8 percent of the vegetation. Shrubs-rose, snowberry, currant, and willow-make up about 1 percent. Cottonwood, alder, ponderosa pine, and Douglas-fir also make up about 1 percent in places.

This site can produce 1,400 pounds of forage per acre in good years and 1,000 pounds per acre in poor years.

#### *Practices for rangeland*

The practices described in the following paragraphs will help the rancher to, improve vegetation.

*Proper use of rangeland.*-Forage vegetation should be grazed at the intensity that will help the desirable plants to improve in quantity and quality and that will protect the soil from erosion. Proper use allows litter and mulch to accumulate and helps to conserve soil and moisture. The practice can improve range condition and increase

forage production. All native rangeland ought to be grazed properly by game and by domestic livestock.

*Deferred grazing.*-Postponing the grazing on rangeland from the time plants start growing in spring to the time they start their dormant period improves the vigor of the desirable forage plants and allows them to produce seed. This practice provides feed reserves for fall and winter grazing and for use in emergencies.

*Rotation-deferred grazing.*-In this practice one or more grazing units are rested at planned intervals throughout the growing season of the key forage plants. As a rule, no grazing unit is grazed more than half of any growing season or in the same period in successive years. This practice accelerates improvement in range condition and allows full use of the forage on all grazing units. It is needed on all rangeland that is grazed all year, is grazed in any season, or is grazed only in the growing season.

*Range seeding.*-Revegetation of soils suited to the growing of forage plants is an important practice. It will help prevent extensive soil and water losses and increase forage production. It should be done on soils that have a potential for range forage plants but that lack enough of the desired kinds of grasses and other plants to recover within a reasonable time through grazing management alone. The practice can also be done on soils that are in cultivation but not suited to cropping, and should, therefore, be converted to range use. Grasses and legumes suited to the soil and climate are seeded and the resulting stand is maintained through management.

*Spring development.*-This practice consists of cleaning, excavating, and capping springs and providing collection or storage facilities for water at the sites. The practice encourages livestock to utilize all parts of the range. It is needed on all rangeland that does not have enough watering places in relation to the supply of available forage.

*Livestock ponds.*-Ponds help to obtain proper use of the range by encouraging livestock to graze all parts of it. The practice is needed on all rangeland with sites that are suitable for pond construction but that do not have permanent, adequately distributed watering places, or that are not suitable for development of less costly watering facilities. Water can be impounded in natural basins, by constructing dams across watercourses, or by excavating pits.

*Well construction.*-This practice consists of constructing or improving wells for the benefit of livestock. Additional water improves range use by encouraging livestock to graze all parts of the range. The practice is needed on all rangeland that has underground supplies of water but that is without permanent or adequately distributed facilities for watering livestock, provided cheaper methods of supplying water are not available.

*Fencing.*-This practice facilitates proper range use by allowing the operator to control the number of livestock on the range and the season in which the range is grazed. It also makes rotation-deferred grazing possible. Fencing is needed on all rangeland that needs additional boundary or cross fences to help obtain proper use of the range. Fences are needed to protect springs, ponds, and seeded areas and to exclude livestock from areas of erosion and poisonous plants. They are also needed to separate rangeland from land used in other ways.

*Brush control.*-This practice eliminates or reduces the competition of woody plants with the desirable forage plants. It helps to establish a satisfactory type of plant cover to produce forage and to protect the soil. The undesirable brush is usually eliminated by mechanical or chemical methods.

Brush control is needed on native grasslands and savannahs and in old fields intended for conversion to grassland if brush prevents the establishment of desirable plants that can improve the condition of the range. The areas on which brush control is used should be suitable for reestablishing the climax or other adapted forage plants that provide adequate protection. The practice is needed where adjustment in grazing numbers or other management to control brush cannot improve the range in a reasonable period of time.

*Salting.*-This practice helps to obtain proper use of the range by encouraging livestock to graze over all parts of it. The practice is also used to supply livestock with mineral supplements they need to be healthy, productive, and easily managed. Salting is needed on all rangeland where the topography, size of units, location of watering places, and other factors cause uneven utilization of the range.

*Proper grazing of woodland.*-In this practice the woodland is grazed at an intensity that leaves enough cover to, protect the soil and to maintain or improve the quantity and quality of both trees and forage plants. Litter and mulch are allowed to accumulate to conserve soil and moisture and to increase the production of wood and forage. The practice is needed in all woodland that is grazed by game animals or by domestic livestock.

*Trails and roads.*-The construction of these facilities on rangeland increases the accessibility of the range and helps in the handling and movement of livestock and in the control of forest or range fires. Trails are needed in steep, rough topography.

### **Management of livestock**

Some of the management needed for livestock is discussed in the following paragraphs.

*Proper kinds of livestock.*-In Walla Walla County, cattle prefer to graze the large bunchgrasses-Idaho fescue, bluebunch wheatgrass, or bluegrass. Sheep prefer Sandberg bluegrass, needle-and-thread, broad-leaved plants, and browse. Livestock should be adapted to the available forage. Under some conditions a combination of different kinds of animals gives the best utilization of forage.

*Feed and forage.*-Livestock must be kept healthy and productive by a program that includes a balanced ration throughout the year. This consists of range forage, concentrates, hay, and tame pasture. Feed reserves should be adequate for emergencies.

*Breeding.*-The breeding program should provide for the type of livestock suited to the range. Lambing and calving should occur in the season when the temperature is favorable and when forage is abundant.

*Culling.*-Nonproductive animals should be removed from herds to increase income and reduce grazing pressure on the forage. This can contribute much toward improving the range.

## **Woodland Management**

Forest trees good for commercial harvest grow mainly on the Couse, Helmer, and Klicker soils. Foresters and soil scientists studied unmanaged stands of trees on these soils. As the result of this study, the woodland soils are grouped in three degrees of relative productivity called site classes. These classes are designated by Roman numerals II, III, and IV. The capacity of a site for growing trees is based on climate, soil, topography, and other factors. The better the site, the faster is tree growth and the greater is the volume of timber produced per acre.

Table 7 shows the site classes and interpretative ratings of the Couse, Helmer, and Klicker soils for woodland. The information in this table is based on the study of trees in Walla Walla County in addition to the judgment and experience of landowners, foresters, and soil scientists.

Only a small amount of experimental data is available on the growth and returns that can be expected from intensively managed native woodland in Walla, Walla County. The work of Krauter and Baker (7) suggests that the yield of wood from managed woodland may be double that from unmanaged woodland. To realize this increase in production, trees need the following management : ( 1) Thin the stand at an early age to remove competition; (2) thin lightly at frequent intervals to maintain maximum growth; (3) harvest the trees when they no longer increase in value fast enough to earn a satisfactory rate of interest; and (4) regenerate the stand promptly after cutting.

Table 8 provides the measured yield values that can be expected from even-aged stands of ponderosa pine growing in the Western States on each of four specified qualities of sites, called site indexes (8). In this table, site indexes are identified by Arabic numerals 80, 90, 105, and 120. These numerals are the heights to which the average dominant and codominant trees in a forest will grow in 100 years. The height of dominant and codominant trees is the best expression of the productive capacity of forest soil. The tallest trees generally grow on the best soil.

Foresters and soil scientists believe the best woodland soils in Walla Walla County, those rated as site class I (site class I soils generally occur only as inclusions in the Helmer soil areas), can produce yields of wood comparable to those given in table 8 for even-aged forests in which the tallest trees grow to a height of 120 feet in 100 years. Other predictions are that site class II soils in Walla Walla County can produce yields comparable to those of site index 105; site class III soils, the yields of site index 90; and site class IV soils, the yields of site index 80. The correlation of site classes of Walla Walla County soils with site indexes is given in the left-hand column of table 8.

The management for woodland is discussed separately for the Couse, the Helmer, and the Klicker soils in the paragraphs that follow.

**Couse Soils** : The Couse soils support stands of ponderosa pine, which is referred to locally as bull pine or yellow pine. Douglas-fir, also called red fir, is common where additional moisture is available. The understory is made up of forbs and grasses such as lupine, vetch, elk

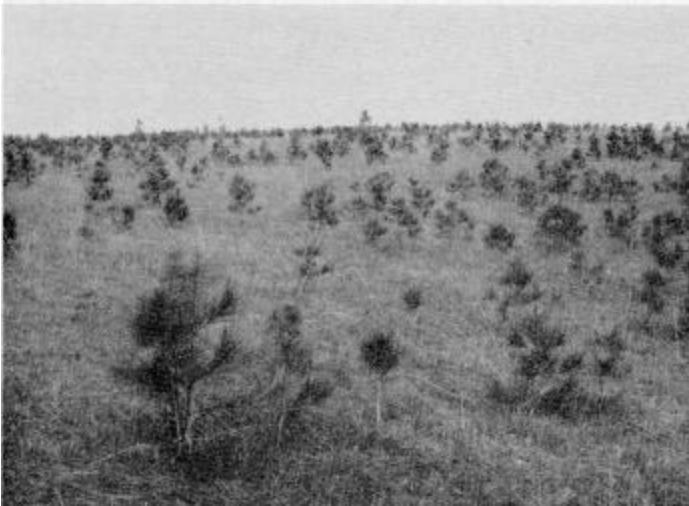


Figure 8.-Natural reseeding of ponderosa pine on Couse silt loam that had been converted from cropland to grassland.

sedge, pinegrass, and mountain brome. Where there is enough moisture, spirea, snowberry, and ocean-spray are present in the understory in many places. These shrubs increase rapidly after logging until they are suppressed by the new stand of trees.

The Couse soils occur at elevations from 2,800 to 3,500 feet above sea level and get 24 to 30 inches of precipitation a year. They are dark colored and medium textured and have a slowly permeable substratum 2 1/2 to 4 feet below the surface.

Large areas have been cleared for the production of

wheat and peas. If not adequately protected by living plants, the Couse soils are highly susceptible to erosion. Many fields on steep slopes are no longer farmed. Plantings of ponderosa pine on abandoned fields have been highly successful. If good seed trees are nearby, pine establishes itself through natural seeding.

The Couse soils are well suited to trees, and they are in site class II. The productive capacity, or site class, is considerably less where the slowly permeable substratum is less than 30 inches from the surface.

This substratum causes a lateral movement of water in the soil after the spring rainy season. Where roadbeds or roadcuts intercept the substratum, mudholes and soft spots may develop. Water bars and small diversions should be built across roads and trails to retard runoff and prevent large accumulations of water. Roads and skid trails should be laid out with variable grades, generally less than 6 percent.

The Couse soils are suitable for both forestry and grazing because many desirable range plants are in the understory. Grazing is discussed under the heading "Mixed Forest-Pine range site."

**Helmer Soils:** Grand fir, locally known as white fir, is the principal commercial tree growing on the Helmer soils. In places it occurs in pure stands. Other species growing on this soil are Douglas-fir, Engelmann spruce, western larch, and ponderosa pine. The tree canopy is dense in well-stocked stands, and the understory consists only of small amounts of shrubs, forbs, and grasses.

When the forest is opened up, as in logging, shrubs such as snowberry, ninebark, ocean-spray, willow, and alder soon are dominant.

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The Helmer soils occur at elevations between 3,500 to 4,500 feet above sea level and get more than 30 inches of precipitation a year. They are well-drained, medium-textured soils containing a large amount of pumice. The substratum is medium textured or moderately fine textured and is moderately slowly permeable. These characteristics do not seriously limit the development of tree roots.

A few gently sloping areas were cleared for crop production but severe erosion caused them to be taken from cultivation. The production of hay and pasture is limited by the rapid encroachment of nonpalatable forbs and woody plants. These plants also limit the grazing in clearings that are made by logging or by fire.

Helmer soils are best suited to trees and to wildlife and watershed protection. They are in site class II, and the yield of wood that can be expected from trees is shown in table 8.

The main problem is the control of brush following logging. Brush in the understory dominates in any area if the overstory is removed. Control consists of scarifying the soil during logging to help natural reseeding, or of planting open areas to seedlings. Both methods favor the regeneration of forest trees. Selective logging may expose the remaining trees to windthrow. Clear

cutting of mature white fir in small blocks reduces windthrow and favors natural seeding from the adjacent uncut trees.

The hazard of erosion is high, especially on roads and skid trails. Roads should have only mild slopes and should be kept free of erosion by controlling runoff through mechanical methods. Trafficability for wheeled equipment is good only during dry summer months. In the rainy season, ruts are easily formed.

**Klicker Soils:** Douglas-fir and ponderosa pine grow on the Klicker soils in stands of varying densities and rates of growth. The most productive sites are in small coves and on the north slopes where the soil is deeper and less rocky than on northeast or east slopes. The understory on the better sites is mainly elderberry, chokecherry, ocean-spray, and Oregon-grape and a few forbs and shade-tolerant grasses. On dry, rocky sites the tree canopy is open, and the understory consists of yarrow, lupine, vetch, elk sedge, pinegrass, mountain brome, bluebunch wheatgrass, and a few low shrubs.

The Klicker soils are shallow to moderately deep, medium textured, and rocky. They occupy steep north, northeast, and east slopes at elevations of more than 3,500 feet above sea level. The precipitation is more than 30

inches per year. Because of differences in exposure, air drainage, runoff, water-holding capacity, and snow accumulation, the amount of water available for tree growth is extremely variable. For the production of trees, the Klicker soils are in site classes III and IV.

The Klicker soils are suitable for the production of trees and range forage. Ponderosa pine reseeds itself very well on these soils. If the soils are managed for both trees and forage, grazing should be carefully controlled to prevent damage to young trees. Range management on the Klicker soils is described under the heading "Forested Upland-Pine range site."

Steep slopes are major problems on the Klicker soils. Logging roads must be carefully built in order to be safe, to control erosion, and to be maintained economically. Special logging equipment may be needed to harvest timber on steep slopes.

### Engineering Interpretations of the Soils

Soil properties affect construction and maintenance of roads, airports, pipelines, foundations, erosion control structures, drainage, sewage disposal, and water-storage facilities. The properties most important to the engineer are permeability to water, shear strength, consolidation characteristics, texture, plasticity, and reaction (pH). Depth to water table, depth to unconsolidated materials, and topography are also important.

The soil survey report of Walla Walla County, Wash., contains information that can be used by engineers to-

1. Make soil and land use studies that will aid in the selection and development of industrial, business, residential, and recreational sites.

2. Assist in designing drainage and irrigation systems, farm ponds, diversion terraces, and other structures for soil and water conservation.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting highway and airport locations and in planning detailed soil surveys for the intended locations.
4. Locate possible sources of sand, gravel, and other construction material as masonry or quarry rock.
5. Correlate performance of engineering structures with soil mapping units and thus develop information that will be useful in designing and maintaining the structures.
6. Determine the suitability of soil units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports and aerial photographs for the purpose of making soil maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area when definite laboratory data are lacking or not available.

*It is not intended that this section of the report will eliminate the need for on-site sampling and testing of sites for design, and construction of specific engineering works. The information in this section should be used primarily in planning more detailed field investigations to determine the in-place condition of soil at the construction site.*

This section of the soil survey report provides engineers with brief descriptions of the soils and their physical properties, with interpretations of these properties for engineering construction, and with laboratory test data for the main soil types in Walla Walla County.

Some of the terms used by the soil scientist may be

CHRISTIAN BAFUS, engineering specialist, SCS, Spokane, Wash., assisted in the writing of this section.

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unfamiliar to the engineer. Most of these terms used are defined in the Glossary at the end of the report.

### **Engineering soil classification systems**

Most highway engineers classify soil materials according to the system approved by the American Association of State Highway Officials (1, 10). In this system, soil materials are classified in seven principal groups. The groups range from A-1, which consists of gravelly soils of high bearing capacity, to A7, which consists of clay soils having low strength when wet. In each group, the relative engineering value of the soil material can be further indicated by a group index number. Group index numbers range from 0 for the best materials to 20 for the poorest. The group index number is shown in parentheses, following the soil group symbol in table 11. It is given for the soil sample on which engineering tests were made.

Some engineers prefer to use the Unified soil classification system (10, 18). In this system, soil materials are identified as coarse grained, eight classes; fine grained, six classes; and highly organic soils. An approximate classification of soils by this system can be made in the field. Soils are classified according to both systems in tables 9 and 11 in this report.

### **Soil properties significant to engineering**

A brief description of the soils mapped in Walla Walla County and estimates of their physical properties that are significant in engineering construction are given in table 9. The engineering classifications of soils in table 9 are estimates based mainly on laboratory data given in table 11 for those soils that were mapped and on experiences with the soils in this and other countries.

Some of the terms used in table 9 are explained as follows.

In this table, the tentative ranges in inches per hour are given for permeability, or the flow of water through the

soil layers. Permeability is a factor to be considered in several kinds of construction, including the construction of irrigation systems.

Available water capacity (or water-holding capacity) is expressed in terms of inches per foot of soil material. It is the amount of water available to plants that is held in a soil after a good rain or after thorough irrigation. It is the amount of water in excess of the wilting coefficient held in a soil against the force of gravity.

Dispersion of the soils is also shown in table 9. It is the degree and rapidity with which soil structure breaks down or slakes in water. For example, high dispersion means that the soil slakes readily.

In addition to, having moderate to high dispersion rates, the Ahtanum, Stanfield, Umapine, and Spofford soils contain appreciable amounts of salts including those of sodium. The pH, or reaction, of these soils below the surface layer may be 8.5 to 9.0. There is evidence of impeded drainage in these soils. Because of the sodium salts, permeability may be slower than is normal for their texture. The Spofford soils have a high shrink-swell potential because the B horizon is high in clay.

The soluble salts and alkali in these soils may affect the useful life of metal and concrete pipe and of other structures in contact with the soil.

In table 9, the shrink-swell potential of the soils is rated. This rating indicates the volume change to be expected of the soil material along with changes in moisture content.

In general, soils classified as CH and A7 have a "High" shrink-swell potential. Clean sands and gravels (single-grain structure) and those having small amounts of nonplastic to slightly plastic fines, as well as most other nonplastic to slightly plastic materials, have a "Low" shrink-swell potential.

No classification was possible for some of the miscellaneous soil types, and estimates of their physical properties were therefore not given in table 9.

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### ***Engineering interpretations of soil properties***

Interpretations of some soil properties significant in engineering are given in table 10. These data are based on information in this and other parts of the report and on experience obtained in working with the same kinds of soils in this and other counties.

Some of the terms used in table 10 are explained as follows.

Adaptability for winter grading indicates whether the soil can be moved by blade machinery and spread evenly in winter.

Subgrade is the prepared and compacted soil immedi-

ately below the pavement system and extends deep enough to benefit the structural system.

Topsoil is generally used to topdress roadbanks, lawns, and gardens and is presumed to be a fertile soil or to be soil material ordinarily rich in organic matter.

The suitability of soil material for winter grading depends mainly on texture of the material and its natural water content and on depth to the water table during winter. When wet, clay soils are difficult to handle and must be dried to proper moisture before they can be compacted. For this reason, clay soils are rated "Poor" for winter grading.

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The susceptibility of a soil to frost action depends on the texture, the depth to water table during the freezing period, and the length of time temperature is below freezing. Silt and fine sand with a high water table are rated "High" in susceptibility to frost action.

The suitability of the soil material for road subgrade and road fill depends mainly on the texture of the soil material and its natural water content. Highly plastic soil material is rated "Poor" for road subgrade and "Poor" or "Fair" for road fill depending on the natural water content and on the ability to handle, dry, and compact the material. Highly erodible soil, composed mainly of fine sand or silt, requires moderately gentle slopes, close control

during compaction, and fast revegetation of side slopes to prevent erosion. These soils are rated "Fair" for road subgrade and "Poor to fair" for road fill.

Basalt is the dominant kind of bedrock in Walla Walla County. The miscellaneous land types consisting mainly of basalt are omitted from table 10. These land types were mapped and can be identified on the detailed soil map by the symbols: BcD, BcF, BcG, BdF, and Bk. All of these basalt land types may be used as a source of rock for crushing if locations are suitable. In addition any of the shallow rocky soils may be a source of quarry material if the overburden is reasonably thin.



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#### ***Soil test data***

Soil samples from four of the most common soil types in Walla Walla County were tested to help evaluate the soils for engineering purposes. The results of these tests and the classification of each sample are given in table 11.

The engineering soil classifications in table 11 are based on data obtained by mechanical analysis and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

The liquid limit and plastic limit tests measure the effect of water on the consistence of soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a solid to a semisolid or a plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the soil material passes from a plastic to a liquid state. The

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lasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition. Nonplastic, indicated by NP, applies to soils that are granular or without cohesion, for which liquid or plastic limits cannot be determined.

Table 11 gives compaction (moisture-density) data for the tested soils. If a soil material is compacted at successively higher moisture content, assuming that

the compactive effort remains constant, the density of the compacted material will increase until the optimum moisture content is reached. After that, the density will decrease with increase in moisture content. The highest density obtained in the compaction test is termed maximum density. Moisture-density data are important in earthwork, for, as a rule, optimum stability is obtained if the soil is compacted to about maximum density when it is at approximately the optimum moisture content.

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## ***Formation, Classification, and Morphology of the Soils***

In this section the soils of the county are classified in higher categories and their outstanding morphologic characteristics are related to the factors of soil formation.

### **Factors of Soil Formation**

Soil is produced by the action of soil-forming processes on materials deposited or accumulated through geologic agencies. The characteristics of the soil at any given

point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since the accumulation, (3) the relief or lay-of-the-land, (4) the plant and animal life in and on the soil, and (5) the length of time the forces of soil development have acted on the soil material.

### ***Parent material***

A wide belt of uniform, medium-textured material, deposited at different times by wind (fig. 9), covers about 800 square miles of Walla, Walla County. This material,

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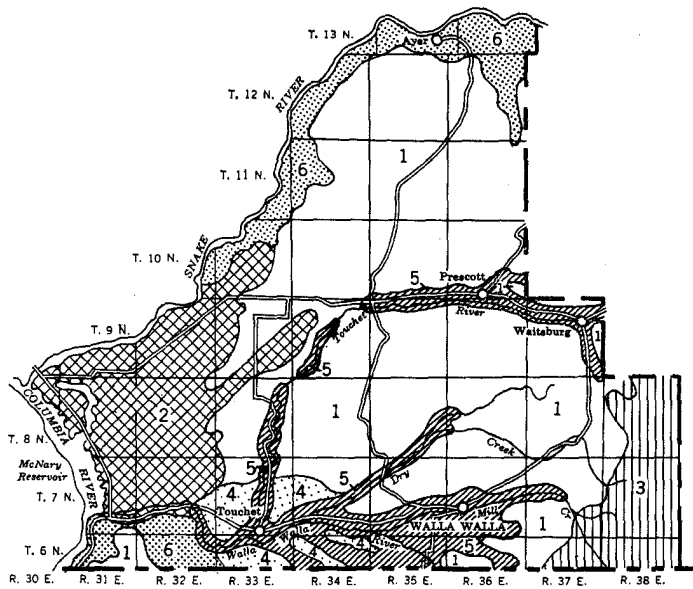
called the Palouse formation (area 1 in fig. 9) covers the county in a layer that ranges from 1 foot to 100 feet or more in thickness. The older deposits are in layers, 18 to 30 inches thick, and they conform to the original contours of the underlying basalt. These deposits were eroded to form steep slopes and escarpments on which the various layers were exposed. Later, another deposit covered the entire landscape to a depth of 0 to 8 feet or more.

The first geologist (10) to study the Palouse formation concluded that the material was residuum from basalt. Later investigators (3, 13) concluded that the material

was of loessal origin. Rieger studied samples taken from two east-west traverses across the formation. He agrees with others that two younger deposits of material are present; one is largely of volcanic nature, and the other is loess from another source.

The minerals in soils formed from loess show but little evidence of weathering. The percentage of silt is fairly constant throughout the Palouse formation, but the per-

RIEGER, SAMUEL. DEVELOPMENT OF THE A2 HORIZON IN SOILS OF THE PALOUSE AREA. 1952. [Unpublished Ph.D. thesis. State College of Washington Library, Pullman, Wash.]



**Figure 9.-Location and extent of the soil-forming materials in Walla Walla County, Wash.:** (1) Fine, floury, wind-deposited loess known as the Palouse formation; (2) river terrace material, out-wash deposits, and eolian sand; (3) basalt residuum, loess, and pumice; (4) lake-laid material consisting of stratified silt and very fine sand known as the Touchet formation; (5) recent alluvium on stream bottoms and low terraces derived mainly from loess; and (6) Basalt rock land and river material laid down in swift, glacial streams.

centage of very fine sand is highest in the west and decreases toward the east. The percentage of clay is highest in the east and decreases toward the west. The soils are high in silt, low to moderate in clay, and high in extractable calcium; they have a base saturation above 70 percent.

In the valley of the Walla Walla River, the loess is underlain by stratified deposits of silt and fine sand, which, according to Rieger, contain minerals that are more characteristic of basalt than of loess. This stratified material appears to be the Touchet formation described by Flint (4). The Touchet formation consists of alternate layers of silt or of fine and very fine sand. The silt is compact and platy or laminated and is permeable to water and roots. Numerous places the laminated layer is covered with a thin film of calcium carbonate, and in these places it is essentially impermeable. The sandy layers are massive, rapidly permeable, and often aquiferous.

Clastic dikes, ranging in thickness from 1 inch to 5 feet, cut across the horizontal strata in a very irregular pattern. The dikes consist of layers of uniformly assorted sand, which are from 1 inch to several inches thick and are separated by dense, compact layers of silt that are from 1/8 to 1 inch thick. Isolated lenses of sand and gravel and a few erratic boulders are other prominent features of the Touchet formation.

Where the loess is more than 4 feet thick, the Touchet formation has had little influence on the formation of soil. However, where the loess is thinner than 4 feet, the soils are alkaline, and lime occurs near the surface in many places.

The stratified sandy and silty materials that make up the terraces west of the city of Walla Walla are known as the Touchet beds (area 4 in fig. 9). The soils that formed directly from this material are moderately alkaline and calcareous to within a few inches of the surface. The Touchet material appears to be the source of much of the salts that have accumulated in many of the soils in the valley of the Walla Walla River.

The sandy terrace soils have developed from material deposited by the Snake and Columbia Rivers. (area 2 in fig. 9). Most of the material is basalt sand and gravel, but granitic, quartzitic, and calcareous materials are present in significant amounts. Valley-fill material is irregularly sorted and stratified with sand at the surface and with coarse sand, gravel, and boulders below the surface: The present surface soil has been so thoroughly worked by wind that there is little difference in material in the top 12 to 18 inches, but there is a wide variation in the underlying material.

The Blue Mountains (area 3 in fig. 9) are an elevated, tilted block of Columbia River basalt that has been dissected into a series of broad, gently sloping ridges separated by deep, steep-walled canons. Residuum that weathered from basalt is the chief soil material. All the soils, however, show some influence of the loess. Those on the north slopes contain a larger percentage of loess than those on the south slopes. On ridgetops and on some north slopes, loess and unconsolidated volcanic material have been deposited over remnants of older soils that probably were residual soils that had formed on the basalt before the uplift occurred.

The valley soils are predominantly alluvium that washed from adjacent uplands (area 5 in fig. 9). Some valley soils are recent and have no development of a profile, and others have developed rather distinct characteristics.

The breaks of the Snake River on the south rim of the canyon, starting from the northeast corner of the county to a point just west of Eureka, consist of basalt cliffs, steep rocky slopes, and river terraces (area 6 in fig. 9). Here, parent material and slope dominate over other soil-forming factors, but the influence of climate is weakly expressed by slightly darker colored surface soils.

### Climate

Climate generally determines the kind and density of plants that can grow in an area. It also directly affects soil formation by its influence on weathering and erosion. Temperature and precipitation are the main climatic factors in soil formation.

The average January temperature below an elevation of 2,500 feet is 32° F. The soil is generally frozen at one time or another during winter. The concentration of a large part of the annual precipitation in a few winter months frequently results in excessive runoff. Rapidly melting snow and rain cause much runoff from frozen ground. The average summer temperature ranges from 8 to 72 degrees. The mean annual temperature ranges from about 45 degrees in the mountains to about 55 degrees near Burbank on the western edge of the county. The highest temperatures occur in the dry western part of the county. Under these conditions, rock weathering and soil formation are very slow.

Annual precipitation ranges from about 6 inches along the Columbia River to 44 inches in the Blue Mountains. This increase occurs in approximately 50 miles. Plant cover increases sharply in density as the available moisture increases. Total precipitation, temperature, and exposure influence the amount of water available for plant growth and the soil-forming processes.

The activity of soil micro-organisms is greatly reduced in hot summers when soil is dry and in fall and winter when the soil is cold and saturated with water. Under these conditions, plant material decomposes slower than in other times of the year, and there is a buildup of humus. These factors have influenced the formation of dark-colored surface layers in soils with otherwise weakly developed profiles.

Water erosion is almost nonexistent in the area of low rainfall, but wind erosion is serious when the plant cover is destroyed. The hazard of water erosion increases rapidly as precipitation increases. In the area of low rainfall, 6 to 8 inches of precipitation has had little effect on soil formation. The surface 2 inches is slightly darker than the material beneath. If the parent material contained lime, the lime is still at or near the surface. Where 8 to 12 inches of precipitation occur, a dark-colored A horizon is forming, and the lime has been leached to a depth of about 30 inches.

In the 12- to 16-inch precipitation zone, the A horizon is darker and thicker and has substantially more organic matter. In the 16- to 24-inch rainfall zone, the A horizon is 12 to 16 inches thick and is nearly black. Here, lime has moved below a depth of 4 1/2 feet. Soils that formed in areas with more than 24 inches of rainfall are forested. The A horizons are lighter colored and generally less than 5 inches thick. Forested soils may have a weak A2 horizon. Also, lime has been leached out of their profile.

Rainfall intensity is low in Walla Walla County. Three-tenths of an inch of rain in 30 minutes occurs about once in 2 years; 1 inch per hour occurs about once in 25 years. These intensities have caused but little erosion in areas covered by a good stand of original vegetation. As a result, some soils on steep slopes have relatively thick A horizons,

### ***Relief***

In Walla Walla County there are nearly level bottom lands, gently sloping to undulating terraces, steep to hilly uplands, and steep mountains. The relief affects soil formation, drainage, erosion, exposure to wind and sunlight temperature, precipitation, and type and amount of vegetation.

Along the Walla Walla and Touchet Rivers and many of the smaller streams, alluvial material has been deposited at or near the high-water line. In times of high water or flooding, these areas receive fresh deposits of silt. The soils that have formed in this material are faintly stratified but do not have genetic horizons. Soils on bottom lands without recent position may have a faint A horizon that is slightly darker than the stratified material below. Many Alluvial soils have a seasonally high water table.

The outwash plains and river terraces of the Columbia and Snake Rivers were rather lightly dissected to form a simple, dendritic drainage system. Since then, sand dunes have formed across the drains, and bowl-like

basins without outlets have resulted. The sandy soils in this area can absorb all the rain because they are permeable.

In the Walla Walla Valley, gently sloping lake terraces have been severely dissected into long narrow ridges having steep north and east slopes and strongly sloping south slopes. The prevailing winds dry out the south and west slopes late in spring and keep them dry until the September or October rains. The north slopes support denser stands of vegetation than south slopes. Soils on the south slopes and rind ridgetops are Sierozem-Regosol intergrades, whereas those on the north slopes intergrade toward the Brown soils.

The loessal uplands are sloping to steep. Soils with a typical profile have developed on slopes of 8 to 25 percent. On slopes steeper than 25 or 30 percent, the available moisture supports a different plant community, and various soils have formed. It is not unusual to have Walla Walla silt loam on a south slope of 8 to 30 percent and Athena silt loam on the adjacent north slope of 30 to 60 percent; or Athena silt loam on a south slope and Palouse silt loam on a north slope. Soils on south slopes that are steeper than 30 percent do not have the lime leached so deeply as they normally do elsewhere. Winter precipitation that often falls on steep slopes when the soil is frozen and sudden spring thaws result in considerable loss of water.

The effect of relief and exposure is even more pronounced in the Blue Mountains. The steep south and west slopes are dry from June through August. The north slopes are often moist all year. Shallow to moderately deep, rocky Brunizem soils with a weak textural B horizon have formed on steep south slopes. On adjacent north slopes are the moderately deep Brown Podzolic and Gray-Brown Podzolic soils covered by dense forests.

### ***Plant and animal life***

Plants and, to a lesser extent, animals have greatly influenced soil formation in Walla Walla County. Plants draw moisture and nutrients from the soil, and they intercept runoff and reduce erosion. The roots penetrate many horizons and improve soil aeration and permeability. When the life cycle is completed, plant remains are returned to the soil to replenish the supply of organic matter.

More than 90 percent of Walla Walla County was originally grassland. The vegetation included deep-rooted bunchgrasses capable of extracting moisture held deeply in the soil and shallow-rooted grasses that mature and produce seed in a short season and go dormant early in summer. Grasses were thus able to survive the dry summers. The native plant cover varied in species, composition, and density. Species like beardless wheatgrass occurred under a wide range of soil and moisture conditions. Idaho fescue or Indian ricegrass grew under a much narrower range of conditions.

In the dry sandy areas were thin stands of Indian ricegrass, needle-and-thread, and Sandberg bluegrass. These grasses were dense enough to prevent wind erosion, and as a result, an A1 horizon started to form in the soil. Many large dunes have formed where the original vegetation was destroyed by fire, grazing, or cultivation.

In areas that got 8 to 12 inches of precipitation per year, beardless wheatgrass and Sandberg bluegrass were dominant, and the soil is darker than where less precipitation

occurred. In areas where the rainfall was greater, Idaho fescue occurred in association with beardless wheatgrass and Sandberg bluegrass, and the soil is dark brown and contains around 2.5 percent organic matter. In subhumid to humid areas, bluebunch wheatgrass, big bluegrass, and prairie junegrass replaced beardless wheatgrass. In these areas, the soil has a dark color, is as much as 18 inches thick, and contains about 6 percent organic matter.

Trees occurred on some of the stream bottoms, on the northwest, north, northeast, and east slopes, and on high, gently sloping ridgetops in the Blue Mountains. Trees had little effect on the formation of stream-bottom soils. Nevertheless, they provided mountain soils with many of the characteristics of forest soils. Mountain soils have a thinner, lighter colored A1 horizon than nonforest soils. Also, they may have an intermittent A2 horizon, and they are more acid.

### **Time**

The length of time that the land surface has been exposed to soil-forming processes is an important factor in the development of soil profiles. All soils require time for the differentiation of distinct horizons. The influence of time, however, may be greatly modified by various soil-forming processes, particularly by erosion, and the deposit of material on the soil surface, by relief, and by the type of parent material.

Generally, the number of horizons together with their thickness and distinctness indicate the maturity of the soil. Most of the soils in Walla Walla County do not have strong genetic horizons. Only a few have a weak textural B horizon. Most of them have a fairly distinct A horizon.

Geologically, the soils of the county are young. The Columbia River basalt that underlies all of the county was extruded in Miocene time. It flowed out in layers that were 10 to 200 feet thick. In some instances, soils formed and trees grew on one layer before it was covered by the next one. A remnant of one of these soils was exposed in a rock quarry about three-fourths of a mile northwest of Hadley in sec. 11, T. 8 N., R. 35 E. The Blue Mountains were formed late in Pleistocene time by the elevation and tilting of a large block of basalt. This was followed by an erosion cycle that cut deep canyons in the tilted basalt. A thick layer of loess fell on the area at this time. Loess has been noted both above and below the Pleistocene lake deposits. The valley fill and more recent alluvium date from the recession of the last of the continental glaciers, which, according to various estimates, occurred 12,000 to 25,000 years ago.

The Alluvial soils along the smaller streams and on some of the low terraces are generally immature. Pieces of willow, cottonwood, and pine bark, as well as many artifacts common to our present culture, are found in many soil profiles. At most, these soils have a thin A horizon that is only slightly darker than the material beneath. Older in years but not in maturity are the soils on the outwash plains and terraces of the Columbia and Snake Rivers. These soils have formed under low rainfall and sparse plant cover. Where not recently disturbed by wind, they have a faint A or AC horizon, generally less than 2 inches thick.

The soils that formed from lake-laid material are some-

what older, and the effect of the climate and vegetation is more pronounced. They have a distinct humus horizon, and lime has started to move downward. These soils are medium-textured, and there has been no movement of clay. These lake deposits join the loess deposits at higher elevations and are approximately the same age. Zonal profiles ranging from those of weak Brown soils to those of Brunizems have developed in the loess. Climate and vegetation are the dominant factors of soil formation in the Ritzville, Walla Walla, Athena, and Palouse soils. The Ritzville soils have a distinct humus A horizon, and lime has moved downward to form a Cca horizon at a depth of 30 inches. In the Walla Walla soils, the A horizon is 8 to 10 inches thick and contains nearly twice as much organic matter as that in the Ritzville. A weak, structural B horizon has developed, but there has been no movement of clay. The Cca horizon is at a depth of 4 1/2 feet or more. In the Athena soils, the A horizon is darker and thicker than that in the Walla Walla soils. There is a distinct increase in clay in the lower part of the dark A horizon. A few, thin clay films are present in the moderate, prismatic B horizon.

In the higher rainfall areas, the Palouse soils have a dark humus horizon that is up to 24 inches thick. The heaviest accumulation of clay is in the lower part of the A horizon. Moderately thick films occur on peds in the moderate, prismatic B horizon. Lime is leached to a depth below 72 inches, and base saturation increases from 70 percent at the surface to 92 percent at a depth of 6 feet.

The degree of horizon development varies widely in the Blue Mountain area. Soils of the Couse series have a distinct A horizon and a weak, textural B2 horizon developed in loess over a strongly weathered buried B2 horizon formed in material that may have been deposited when the Blue Mountains were much lower in elevation. Shallow soils with thin sola have developed on recently exposed basalt.

## **Classification of the Soils**

Soils can be classified a number of ways, depending upon the purpose. They are placed in narrow classes for the organization and application of knowledge about soil behavior on farms and fields. Soils are placed in broad classes, however, for the study and comparison over large areas such as States, counties, and continents, or over the world.

Soils are placed in six different categories, one below the other, according to the system of classification used in the United States by the National Cooperative Soil Survey (2, 15). Beginning at the top, the six categories are: Order, suborder, great soil group, family, series, and type.

Each of these categories consists of a number of classes at the same level. The classes are few and broad in the highest category, and they are many and narrow in the lowest category. In the highest category of the classification system, the soils of the United States are placed in three orders, whereas thousands of soil types are recognized in the lowest category.

Among the six categories, those of order, great soil group, series, and type have been used most. The suborder and family categories have never been fully developed and, therefore, are seldom used. Attention has been

given largely to the classification of soils by soil types and soil series within counties and to the subsequent grouping of the series into great soil groups and orders for States or for the country as a whole.

The classes in the highest category of the, classification system are the zonal, intrazonal, and azonal orders. Each of these orders is represented in Walla Walla County by one or more great soil groups, each of which in turn, represents one or more soil series. Table 12 shows the classification of Walla Walla County soils and some of the factors that have influenced formation of these soils.

Some of the characteristics of the soils in each group are described in the following pages, together with laboratory analyses of a few selected typical soil profiles.

### ***Zonal soils***

Zonal soils have characteristics that reflect the influence of the active factors or soil genesis-climate and living organisms-mainly vegetation: Their profiles have well-

differentiated horizons. The soils are forming in materials that have been in place a long time, are intermediate in physical and chemical properties, and are not subject to extremes in drainage or topography.

In Walla Walla County the great soils groups in the zonal order are Brown Podzolic Gray-Brown Podzolic, Brunizem, Chestnut, Brown, and Sierozem soils.

#### **BROWN PODZOLIC SOILS**

The Brown Podzolic soils occur in the Blue Mountains at elevations above 3,000 feet. Precipitation is more than 30 inches per year, about half of which falls as snow. The average temperature ranges from about 31° F. in January to 68° F. in July. The climax vegetation is an almost pure stand of white fir. Subclimax species are Douglas-fir, larch, spruce, and ponderosa pine.

Brown Podzolic soils are well drained, are slightly acid, and have a thin (usually less than 2 inches thick) A1 horizon or a thin intermittent A2 horizon over a horizon

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of iron concentration. The Helmer soils are the only Brown Podzolic soils in the county. A profile of a Helmer soil in a forested area in the SW1/4SE1/4 sec. 14, T. 7 N., R. 38 E., follows:

AOO-2 inches to 1 inch, loose litter of pine needles and small twigs.

AO-1 inch to 0, partially decomposed forest litter; slightly acid.

A1-0 to 2 inches, dark-brown (7.5YR 4/4) silt loam, darker brown (7.5YR 3/2) when moist; weak, very fine, granular structure; soft, very friable; pH 6.5 ; ranges from 0 to 2 inches thick; occasionally replaced by a thin (1/2 inch) gray A2 layer.

B21ir-2 to 10 inches, yellowish-brown. (10YR 5/4) silt loam, dark brown (7.5YR 3/4) when moist; weak to moderate, fine granular structure; soft, very friable, nonplastic, and nonsticky; abundant roots; pH 6.5 ; gradual, wavy boundary.

B22ir-10 to 21 inches, light yellowish-brown (10YR 6/4) silt loam, dark brown (7.5YR 4/4) when moist; weak, medium, granular structure; soft, very friable, non-

sticky, and nonplastic ; abundant roots; pH 6.4 ; abrupt, wavy boundary.

A2-21 to 24 inches, light brownish-gray (10YR 6/2) silt loam, grayish brown (10YR 5/2) when moist; few, fine, faint mottles; massive to very weak, coarse, granular structure; hard, firm, nonplastic, and nonsticky ; plentiful roots; pH 6.2 ; clear, irregular boundary.

A2B2b-24 to 32 inches, the A2 part is similar to the A2 layer above; the B2 is dark yellowish-brown silt loam (10YR 3/4) when moist; few, fine, faint mottles; weak, medium, prismatic to weak, coarse, subangular blocky structure; hard, firm, slightly plastic, and slightly sticky; few manganese concretions; thin patchy clay films on ped surfaces of B2; pH 6.2 ; gradual, wavy boundary.

B2A2b-32 to 44 inches, similar to above layer, but the B2 is dominant over the A2; gradual, wavy boundary.

B2tb-44 to 72 inches, yellowish-brown (10YR 5/4) silty clay loam, darker yellowish brown (10YR 3/4) when moist; few, fine, distinct mottles; moderate, medium, subangular blocky structure; hard, firm, plastic, and sticky; few roots; few light-gray coats an peds ; con-

tinous clay films on faces of peds and in pores; numerous concretions of manganese; pH 6.0 ; abrupt, smooth boundary.

Dr-72 inches +, fractured basalt bedrock.

This soil is not so strongly acid as the Brown Podzolic soils on the Pacific slope, west of the Cascade Mountains (9). This has been attributed to the high content of lime in the parent material, the residue left from numerous forest fires, and the mixing of surface soil and substratum material caused by windthrow of white fir in forests of the Blue Mountains.

The soil described has a biserial, or two-story, profile. It formed in loess and pumice over an older, strongly weathered profile from weathered basalt. In a few places, the same Brown Podzolic profile occurs directly on unweathered basalt.

#### GRAY-BROWN PODZOLIC SOILS

The Gray-Brown Podzolic soils occur in the grassland-forest transition areas, and they have some characteristics of the Brunizem soils. The transition zone occupies the high ridges where the rolling uplands merge with the Blue Mountains. Precipitation ranges from 23 to 30 inches per year, much of which falls in the form of snow. The native vegetation on dry sites consisted of open stands of ponderosa pine and grass, and on moist sites, of ponderosa pine and Douglas-fir. When the timber is logged, the sites with the most moisture are soon invaded by willow, alder, serviceberry, and other shrubs. Couse silt loam in a field corner in the NE1/4NE1/4 sec. 26, T. 8 N., R. 38 E., is representative of the Gray-Brown Podzolic soils. A profile of this soil follows:

- AOO and AO-1/2 inch to 0, loose accumulation of grass, pine needles, willow leaves, shrubs, and small twigs in varying stages of decomposition.
- A11-0 to 4 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) when moist; weak, thin, platy to weak medium, granular structure; slightly hard, friable, slightly sticky; abundant roots; pH 6.6 ; clear, smooth boundary.
- A12-4 to 8 inches, dark grayish-brown silt loam; weak, medium, prismatic to medium, blocky structure; slightly hard, friable, slightly sticky, and slightly plastic; pH 6.6 ; clear, smooth boundary.
- B1-8 to 13 inches, grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, prismatic to weak, subangular blocky structure; thin patchy clay films in pores; slightly hard, friable, slightly sticky, and slightly plastic; abundant roots; pH 6.6 ; clear, wavy boundary.
- B2-13 to 25 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) when moist; weak, medium, prismatic to moderate, medium, subangular blocky structure; thin, patchy clay films on peds and in pores; slightly hard friable, slightly plastic, and slightly sticky; plentiful roots; pH 6.6 ; gradual, wavy boundary.
- B2A2b-25 to 35 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; few, medium, distinct (10YR 4/4) mottles of dark yellowish brown; massive to weak, subangular blocky structure; dark-brown to black organic stains in vertical fractures and worm casts; slightly hard, friable, slightly plastic, and slightly sticky.
- A2b-35 to 42 inches, light-gray (10YR 7/2) silt loam, grayish brown (10YR 5/2) when moist; few, medium, distinct (10YR 5/6) mottles of yellowish brown; massive to weak, prismatic and weak, fine, subangular blocky structure; slightly hard, friable, nonsticky, and nonplastic; few roots; pH 6.3 ; abrupt, wavy boundary.
- B21tb-42 to 55 inches, dark grayish-brown (10YR 4/2, moist) silty clay loam; dark brown and very dark brown (10YR 3/3 and 2/3) coatings on surfaces of

aggregates; few specks or coatings of light brownish gray (10YR 6/2) from A2b horizon; strong, medium, prismatic to moderate, fine, blocky structure; hard, firm, plastic, and sticky; very few roots; thick continuous clay films on ped surfaces; pH 6.6 ; gradual, wavy boundary.

B22tb-55 to 70 inches, layer is similar to B21tb but has strong fine, blocky structure ; clay flows decrease with depth.

The upper sequum, the profile above 42 inches, appears to have formed in loess, but the lower sequum is apparently much older and more strongly weathered material that developed from loess or basalt residuum, or from a mixture of both. The soil is very slowly permeable, and below a depth of 42 inches, the downward flow of water almost stops. Each spring the B2A2b and A2b horizons are saturated until early in summer. There is considerable lateral movement of water on favorable slopes.

#### BRUNIZEM SOILS

The Brunizem soils characteristically have a granular surface horizon that is very dark brown or grayish brown and that grades through a brown B horizon to a lighter colored material at a depth of 2 to 5 feet. These soils are slightly acid and have no zone of lime accumulation, but they are high in base saturation. In Walla Walla County the Gwin, Klicker, Palouse, Athena, and Snow soils are classified as Brunizems. These soils occur where the winter precipitation is high.

The Palouse soils have developed in deep loess. A profile of Palouse silt loam in a cultivated field at the summit of the Scenic Loop Drive in the NE1/4NE1/4 sec. 34, T. 7 N., R. 37 E., is described as follows:

- A1p-0 to 8 inches, dark grayish-brown to dark-gray (10YR 4/2 to 4/1) silt loam, very dark brown to black (10YR 2/2 to 2/1) when moist; weak, coarse, granular structure; slightly hard, friable, slightly sticky, and slightly plastic; plentiful roots; pH 6.2 ; abrupt, smooth boundary.
- A12-8 to 13 inches, dark-gray (10YR 4/1) silt loam, very dark brown (10YR 2/2) when moist; moderate, medium, granular structure; hard, friable, slightly sticky, and slightly plastic; plentiful roots; pH 6.3 ; clear, wavy boundary.
- B1-13 to 24 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) when moist; weak, medium prismatic or weak medium blocky structure; hard, friable to firm, slightly sticky, and slightly plastic; thin patchy clay films; pH 6.6 ; clear, wavy boundary.
- B21-24 to 32 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak to moderate, coarse to medium, prismatic structure; hard, firm, plastic, and sticky; few roots; thin and moderately thick continuous clay films on ped surfaces, but films not continuous in pores; some gray coatings on ped surfaces; pH 6.7 ; clear, wavy boundary.
- B22-32 to 40 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) when moist; weak to moderate, coarse to fine, prismatic structure; hard to very hard, firm, plastic, and sticky; few roots; thin to moderately thick continuous clay skins; few gray coatings on peds ; pH 6.7 ; gradual, wavy boundary.
- B3-40 to 48 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) when moist; weak, coarse, prismatic to weak, coarse, subangular blocky structure; hard, friable to firm, plastic, and sticky; few roots; occasional large, patchy clay films on ped surfaces; faint gray coatings; pH 6.8 ; gradual, wavy boundary.
- C1-48 to 56 inches, light yellowish-brown (10YR 6/4) silt loam, dark yellowish brown (10YR 4/4) when moist; weak, coarse, prismatic to weak, coarse, subangular

blocky structure; hard, friable, sticky, and plastic; occasional thin, patchy clay films ; pH 6.9.

C2-56 inches +, very pale brown (10YR 7/4) silt loam; yellowish brown (10YR 5/4) when moist; massive; hard, friable, sticky, and plastic; pH 7.0.

Table 13 shows the laboratory analyses of the Palouse silt loam described in the foregoing profile, and of three other zonal soils that have formed in loess. The profile of Palouse silt loam has a dark-colored, granular A1 horizon and a lighter colored, weak B horizon that has no accumulation of lime. All horizons are high in extractable calcium and in base saturation. These characteristics are normal for Brunizem soils. The particle-size distribution, however, does not show an increase of clay in the B horizon. Instead, clay is most abundant in the dark-colored A12 horizon. The horizons at a depth of 24 to 48 inches have a prominent, prismatic structure; firm consistence when wet; continuous clay films to a depth of 40 inches; distinct brown colors in contrast to the yellowish color below and the very dark brown to black color above.

The Gwin soils have developed from basalt covered by a thin mantle of loess. They are characteristically very dark grayish brown or darker, are rocky and shallow, and are neutral to slightly acid. The B horizon in the Gwin soils is usually thin and is commonly found along fracture planes in the basalt.

The Klicker soils have formed in the residuum of basalt and andesite overlain by a thin deposit of loess that had accumulated on the lee side of the mountains. The Klicker soils occur under open stands of coniferous trees and deciduous shrubs, whereas the Palouse and Gwin soils occur under grasses. The Klicker soils are rocky and characteristically dark colored (hues of 7.5YR and 10YR). They have a thin AO horizon and are slightly acid to neutral. The thin solum contains many fragments of basalt.

The Athena and Snow soils are also classified as Brunizems. The Athena soils have a dark-colored surface layer, a yellowish-brown transitional horizon, and a horizon of lime accumulation. They occur in an area of warm, dry

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summers and cool, rainy and snowy winters. Under this environment, lime has accumulated at a depth of 4 to 6 feet. The transitional horizons are 1 to 2 feet thick instead of only a few inches. A profile of Athena silt loam on the west side of the Five Mile Road and about 1 mile south of Mill Creek in the NE1/4NE1/4 sec. 19, T. 7 N., R. 37 E., is described as follows

- Alp-0 to 8 inches, dark-gray (10YR 4/1) silt loam, very dark brown or black (10YR 2/2 to 2/1) when moist; moderate, fine granular structure; slightly hard, friable, slightly sticky, and slightly plastic; numerous roots; pH 7.1; abrupt, smooth boundary.
- A12-8 to 16 inches, silt loam having color similar to that in layer above; massive to weak, coarse blocky or weak, coarse prismatic structure; slightly hard, friable, slightly plastic, and slightly sticky; numerous roots; pH 6.6 ; clear, wavy boundary.
- B1-16 to 24 inches, dark brown (10YR 4/3) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic structure; hard, friable, slightly plastic, and slightly sticky; few, thin, patchy clay films on horizontal and vertical surfaces; few roots; pH 6.8 ; gradual, smooth boundary.

- B2-24 to 36 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) when moist; weak to moderate, coarse, prismatic to weak, coarse, subangular blocky structure; hard, friable, slightly sticky; thin, patchy clay films on horizontal and vertical surfaces; few roots; pH 6.9 ; gradual, wavy boundary.
- B31-36 to 48 inches, brown (10YR 5/ 3) silt loam, dark brown (10YR 4/3) when moist; weak, coarse, blocky structure; hard, friable, slightly sticky; few roots; pH 6.9 ; clear, wavy boundary.
- B3ca-48 to 60 inches, brown (10YR 5/3) silt loam, dark brown (10YR 4/3) when moist; weak, medium, subangular blocky structure; hard, friable, slightly sticky, and slightly plastic; few roots; few veins of lime; pH 7.2.
- C-60 to 72 inches +, pale-brown (10YR 6/ 3) silt loam, dark brown (10YR 4/3) when moist; massive; friable, and slightly hard; no roots; pH 7.2.

A laboratory analysis of Athena silt loam is given in table 13. Athena silt loam contains about twice as much organic matter in the surface layer as Walla Walla, silt loam. The data in table 13 do not show a clay increase large enough to indicate that a textural B horizon has

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All tables have been updated and are available as a separate document.

developed. However, the brown to dark-brown layers at a depth between 16 and 60 inches look very much like a B horizon. When dry, the material breaks into prisms that can stand considerable handling. Patchy clay films are on the prisms at a depth of 16 and 36 inches. The films indicate some movement of clay but raise a question as to why there has been only a very slight movement of clay, whereas lime has moved to considerable depth in the profile. Three possible reasons have been suggested: (a) The soils are forming on recent deposits, and the movement of clay has not progressed far enough to form a textural B horizon; (b) the high calcium content in this soil causes clay particles to flocculate, thereby preventing or retarding their movement; or (c) the clay may have characteristics that interfere with its movement.

The Snow soils are similar to the Athena except that they have formed in alluvium on an old stream bottom. The Snow soils have a thick, dark-colored surface layer and a weak B horizon.

#### CHESTNUT SOILS

The Chestnut soils have a very dark brown to very dark grayish-brown, platy surface horizon that grades to a light-gray or white, calcareous horizon at a depth of 1 1/2 to 4 1/2 feet. The dark surface horizon contains somewhat less organic matter than that of the Brunizems and substantially more than that of the Brown soils. The Chestnut soils occur under a mixture of tall and short grasses and in a temperate to cool, semiarid to subhumid climate.

The Walla Walla soils are the only members of the Chestnut great soil group. They have a dark-colored A1 horizon and a B horizon that grades in color and structure to grayish-brown, calcareous horizons. These horizons are probably not so strong in carbonates as are similar horizons in modal Chestnut soils. A profile of Walla Walla silt loam, in a cultivated field west of the Lower Waitsburg Road and approximately 1 1/4 miles south of Dry Creek in the SW1/4SW1/4 sec. 28, T. 8 N., R. 36 E., is described as follows:

- Alp-0 to 8 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) when moist; weak, very fine, granular structure; soft, friable, slightly sticky, and slightly plastic; numerous roots; pH 6.7; abrupt, smooth boundary.
- A12-8 to 16 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky, and slightly plastic; numerous roots; pH 6.6; clear, wavy boundary.
- B2-16 to 26 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/2) when moist; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky, and slightly plastic; few roots; pH 6.49; gradual, wavy boundary.
- C1-26 to 36 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) when moist; massive to weak, coarse, prismatic structure; slightly hard, friable, slightly sticky, and slightly plastic; few roots; pH 6.9; gradual, wavy boundary.
- C2-36 to 52 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) when moist; massive; soft, very friable; slightly sticky, and nonplastic; few roots; pH 7.9; clear, wavy boundary.
- C3ca-52 to 72 inches, very pale-brown (10YR 7/3) silt loam, dark grayish brown (10YR 4/2) when moist; massive; soft, very friable, slightly sticky, and nonplastic; strongly calcareous, pH 8.3.

Analytical data for Walla Walla silt loam are given in table 13. The slight increase in organic matter in the A12 horizon over that in the Alp horizon may indicate that organic matter has been lost from the Alp layer in cultivation. In virgin conditions, the A12 horizon is slightly lighter colored than the layer above it. Below this, the percentage of organic matter gradually decreases with depth. The unusual amount of organic matter in the C2 horizon (36 to 52 inches) is probably the result of the deep, dense root system of the native bluebunch wheatgrass. The calcium carbonate horizon is deeper than in the modal profile of Chestnut soils.

#### BROWN SOILS

Soils of the Brown great soil group have a grayish-brown to brown surface horizon that grades into a light-colored, friable subsoil with an accumulation of calcium carbonate at a depth of 1 to 3 feet. In virgin soil, the A1 horizon contains 1 to 2 percent of organic matter, which is generally not enough to make the surface layer much darker colored than the layer below. Brown soils form under short grasses, bunchgrasses, and shrubs in a temperate to cool, arid and semiarid climate.

The Ritzville and Ellisforde soils are Brown soils. They have a moderately thick A1 horizon and contain organic matter that is within the range established for the Brown soils. They also have a calcium carbonate horizon, but it is at greater depths than usual for modal Brown soils. Ritzville silt loam in the southeast corner of the NE1/4 sec. 2 T. 7 N., R. 34 E., is representative of the Brown soils. A profile of this soil follows:

- Ap-0 to 8 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, very fine, granular structure; soft to slightly hard, very friable, slightly sticky, and slightly plastic; few roots; pH 6.8; clear, smooth boundary.
- B-8 to 14 inches, brown (10YR 5/3) silt loam, dark brown (10YR 4/3) when moist; massive to very weak, coarse, prismatic structure; soft, very friable, slightly sticky, and slightly plastic; few roots; pH 7.0; gradual, smooth boundary.
- C11 and C12-14 to 36 inches, pale-brown (10YR 6/3) silt loam, dark grayish brown (10YR 4/2) when moist; massive to weak, very coarse, prismatic structure; soft, very friable; few roots; pH 7.3 to 7.7; clear, wavy boundary.
- C3ca-36 to 48 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 4/3) when moist; massive to weak, coarse, prismatic structure; soft, very friable; few roots; weakly calcareous; moderately alkaline, pH 8.2; gradual, wavy boundary.
- C4ca-48 to 60 inches, light-gray (10YR 7/2) silt loam, grayish brown (10YR 5/2) when moist; massive; soft, very friable; no roots; strongly calcareous, pH 8.6; clear, smooth boundary.
- C5-60 to 72 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 4/3) when moist; massive; soft, friable; mildly calcareous, pH 8.1.

Analytical data for Ritzville silt loam are given in table 13.

The Ellisforde soils, also members of the Brown great soil group, have developed in shallow to moderately deep deposits of loess underlain by stratified silt and sand of the Touchet formation. The Ellisforde soils have A1, AC, and, in some cases, a thin C horizon similar to those found in the Ritzville soils. Instead of a Cca horizon at depths of 2 to 4 feet, the Ellisforde soils have a non-

conforming D horizon of strongly alkaline silt and very fine sand. The reaction in all Ellisforde horizons is more alkaline than that in the Ritzville soils. The Ellisforde soils are transitional to the Regosols because they do not have a B horizon.

#### **SIEROZEM SOILS**

Sierozems have a brownish-gray surface horizon that grades through lighter colored material into an accumulation of calcium carbonate at a depth generally less than 1 foot from the surface. The surface horizon is low in organic matter and is seldom more than 5 inches thick. Immediately under this is a horizon of lime accumulation. Sierozems developed under mixed shrubs in a temperate to cool-arid climate.

In most of the Sierozem zone in Walla Walla County, the soil-forming materials were so recently deposited that the development of a zonal profile has not occurred. Of the 10 soil series mapped in the Sierozem zone, only the Sagemoor soils have developed distinct Sierozem characteristics.

The Sagemoor soils have a weak surface horizon, 5 to 8 inches thick, in which there is slight accumulation of organic matter. A calcareous horizon occurs at a depth of about 1 foot, but the soils do not have a B horizon. A profile of Sagemoor very fine sandy loam located just off U.S. Highway No. 410, about 3 miles east of Wallula Junction in NE1/4SW1/4 sec. 30, T. 7 N., R. 32 E., is described as follows

- A1-0 to 3 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam, dark grayish brown (2.5Y 4/2) when moist; layer has vesicular porosity and platy structure in barren areas and is very weakly granular under shrubs and grasses; soft, very friable; pH 8.2 ; clear, smooth boundary.
- AC-3 to 8 inches, fine sandy loam with color similar to that of the layer above; massive; soft, very friable; pH 8.4; few small fragments of soft caliche scattered throughout the horizon; clear, wavy boundary.
- C1ca-8 to 34 inches, grayish-brown (2.5Y 5/2) very fine sandy loam, very dark grayish brown (2.5Y 3/2) when moist; massive; soft, very friable; pH 8.4; moderately calcareous with a few hard, calcareous nodules and lime disseminated through the horizon; clear, wavy boundary.
- C2ca-34 to 40 inches, light brownish-gray (2.5Y 6/2) silt loam with a few irregular streaks of lighter colored material, dark grayish brown (2.5Y 4/2) when moist; massive; hard, firm; pH 8.8 ; strongly calcareous; abrupt, wavy boundary.
- C3-40 to 52 inches, very fine sandy loam with color similar to that of the C2ca horizon; massive, or weak, platy structure; hard, firm; pH 9.9.

Horizons C2ca and C3 are alternate layers of the Touchet formation, which extends to a great depth. Both very fine sandy loam and silt loam types of Sagemoor soils were mapped. Rocky phases were delineated where basalt bedrock outcropped through shallow areas of the Touchet formation. The Sagemoor soils are transitional to Regosols because they do not have a B horizon.

#### ***Intrazonal soils***

The intrazonal soils have more or less well-developed soil characteristics that reflect the dominating influence of some local factor of relief or parent material over the normal effect of climate and vegetation. In Walla Walla County the intrazonal soils are members of the Solonetz, Solonchak, and Humic Gley great soil groups.

#### **SOLONETZ SOILS**

Typical Solonetz soils have a strong, columnar structure in the B2 horizon. Organic and inorganic colloids coat the sides of the structure units. The A1 horizon is relatively thin and commonly is separated from the B2 horizon by a thin, gray A2 horizon. The soil reaction varies from about neutral in the surface layer to a pH of over 8.6 in the B horizon.

The Spofford soils are representative Solonetz soils. A profile of Spofford silt loam, in a cultivated field just north of the State line and about 200 feet west of the Union Pacific Railroad tracks in the SW1/4NW1/4 sec. 17, T. 6 N., R. 36 E., is described as follows:

- Ap-0 to 7 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; slightly hard, friable; plentiful roots; pH 6.8 ; abrupt, smooth boundary.
- B21-A2-7 to 12 inches, grayish-brown (10YR 6/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine and medium, prismatic structure; grayish, granular fillings of A2 material between peds; hard, firm, nonsticky, and nonplastic; plentiful roots; thin, patchy clay films on vertical surfaces of peds and in pores; pH 7.4; abrupt, smooth boundary.
- B22-12 to 20 inches, dark grayish-brown (10YR 4/2) , heavy silt loam or light silty clay loam, dark brown (10YR 3/3) when moist; strong, coarse, prismatic or columnar structure; very hard, very firm, slightly sticky, and slightly plastic; roots few to absent; organic matter and sporadic, thick, patchy clay films in pores; thick, continuous clay films on both horizontal and vertical ped surfaces; pH 8.4 ; clear, wavy boundary.
- B23-20 to 25 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak, medium, prismatic and moderate, fine, subangular blocky structure; hard, firm, slightly sticky, and plastic; roots few to absent; some lime between peds ; clay films are thinner than above horizon; pH 8.6 ; clear, wavy boundary.
- B3-25 to 36 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) when moist; massive; slightly hard, friable; no roots; lime in seams, otherwise noncalcareous; pH 8.8 ; diffuse, wavy boundary.
- C-36 to 84 inches, light-gray (10YR 7/2) silt loam, grayish brown (2.5Y 5/2) when moist; massive; soft to slightly hardy friable; strongly calcareous, pH 9.0.

This soil formed on nearly level lake terraces that have been mantled with loess. Surface drainage is now developed, but internal movement of water is very slow.

#### **SOLONCHAK SOILS**

The Solonchak great soil group consists of soils in which soluble salts have accumulated in great quantities, generally throughout the profile. Soils in this group are usually light colored and do not have the A, B, and C sequence of horizons. The saline-alkali soils in Walla Walla County are members of the Solonchak great soil group. These soils contain exchangeable sodium and soluble salts that interfere with the growth of most crop plants. The percentage of exchangeable sodium is generally more than 15, the electrical conductivity of the saturation extract is more than 4 millimhos per centimeter at 25 degrees C., and the pH of saturated soil paste is usually less than 8.5.

The Stanfield, Ahtanum, and Umapipe soils are classified as Solonchak soils. These are light-colored, low-terrace soils with little, if any, profile development. The Stanfield soils have a cemented, alkali-soluble hardpan

at a depth of 11/2 to 4 feet. The Umapine soils are friable in all horizons.

Stanfield silt loam, in an area covered by saltgrass and greasewood in the NE1/4SE1/4 sec. 35, T. 7 N., R. 34 E., is a representative Solonchak with a hardpan. A profile of this soil is described as follows:

- Al-0 to 4 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak, thin, platy structure; soft, friable, nonsticky, and nonplastic; abundant roots; effervesces violently; pH 9.7; clear, smooth boundary.
- A12-4 to 13 inches, light brownish-gray (10YR 6/2) silt loam containing a high percentage of very fine sand, dark brown (10YR 4/3) when moist; massive; slightly hard, very friable, nonsticky, and nonplastic; numerous roots; effervesces violently; pH 9.8; gradual, smooth boundary.
- C11-13 to 26 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) when moist; massive; soft, friable, nonsticky, and nonplastic; few roots; effervesces violently; pH 9.6; gradual, smooth boundary.
- C12-26 to 33 inches, light-gray (10YR 7/2) silt loam, dark grayish brown (2.5Y 4/2) when moist; massive; soft, friable; few roots; effervesces violently; pH 8.9; abrupt, smooth boundary.
- Mca-33 to 40 inches, light-gray (10YR 7/1), dark grayish brown (2.5Y 4/2) when moist; massive; strongly cemented to almost indurated hardpan; no roots; strongly calcareous, pH 8.8; abrupt and extremely wavy boundary.
- C3-40 inches +, light brownish-gray (10YR 6/2) silt loam, dark brown (10YR 4/3) when moist; massive; slightly hard, friable; no roots; strongly calcareous, pH 8.4; free water may occur in this layer.

Considerable pumice occurs throughout the profile, and in places it is the dominant soil-forming material. In these areas the soil has a markedly grayer color than is typical of the Stanfield series. In places the hardpan appears to be cemented pumice.

The hardpan (Mca), which occurs at a depth of 33 to 40 inches, frequently consists of several layers separated by a softer, more friable material. Anderson, who worked with this type of hardpan in the Yakima Valley in central Washington, suggests that the cementing agent might be an amorphous iron silicate or an iron-aluminum silicate with an outer layer cemented by calcium carbonate. Two hardpans were observed: One, consisting of cemented silt, occurs above another consisting of cemented pumice. Water moved laterally in the friable material between the two hardpans.

The chemical analyses of several samples of Stanfield silt loam and of Umapine very fine sandy loam are shown in table 5.

The dark-colored Ahtanum soils are also classified as members of the Solonchak great soil group. They are saline-alkali soils with a very dark grayish-brown surface layer and an alkali-soluble hardpan. They are darker colored and less saline than the Stanfield and Umapine soils. The Ahtanum soils occur in the Chestnut zone with the Hermiston and Walla Walla soils. The latter soils do not have a hardpan and are neither saline nor alkaline.

ANDERSON, J. U. CHARACTERIZATION OF SOME HALOMORPHIC SOILS AND THEIR NORMAL ASSOCIATES IN THE YAKIMA VALLEY. 1953. [Unpublished Master's thesis. State College of Washington Library, Pullman, Wash.]

#### HUMIC GLEY SOILS

This great soil group consists of dark-colored soils that formed under the strong influence of a seasonally high water table, or of ponded water resulting from rapid spring runoff.

The Catherine soils in this group formed on nearly level stream bottoms under the influence of a high water table. These soils have varied colors below the dark A1 layer. A distinct gleyed horizon has not developed. A representative profile of Catherine silt loam along Dry Creek in the SW1/4SE1/4 sec. 24, T. 8 N., R. 35 E., is described as follows:

- A1p-0 to 7 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) when moist; moderate, fine, granular structure; slightly hard, friable, slightly sticky; plentiful roots; pH 6.6; abrupt, smooth boundary.
- A12-7 to 13 inches, silt loam colored like that in layer above; moderate, medium, blocky structure; hard, friable, slightly sticky; plentiful roots; pH 6.6; clear, smooth boundary.
- ACg-13 to 30 inches; grayish-brown (10YR 5/2), heavy silt loam, very dark grayish brown (10YR 3/2) when moist; few, fine, faint mottles of yellow and brown; massive; hard, very firm, slightly sticky, and slightly plastic; plentiful roots; pH 7.3; diffuse boundary.

The mottling is more distinct at greater depths in the stratified alluvium. The soil is noncalcareous.

#### Azonal soils

The azonal soils have little or no development of a genetic profile because they are young or because conditions of parent material or of relief prevented the development of normal profile characteristics. Under some conditions, steep topography and rapid runoff interfere with soil formation. Azonal soils commonly have some of the characteristics of the associated zonal soils. An Azonal soil in, a Chernozem soil zone will usually be darker colored than one in a Brown soil zone. In this county, the azonal soils are represented by the Alluvial and Regosol great soil groups.

#### ALLUVIAL SOILS

The characteristics of Alluvial soils depend mainly on those of the parent material. Soils that formed in deep, stratified alluvium that washed from loessal uplands are quite different from those that formed in gravelly deposits that originated in the rocky uplands. Some of the Alluvial soils may have some characteristics of the zonal soils with which they are associated. Their formation may be more or less strongly influenced by vegetation and drainage.

Alluvial soils in Walla Walla County are members of the Beverly, Esquatel, Hermiston, Onyx, Patit Creek, Pedigo, Touchet, and Yakima series. Beverly soils consist of loamy sand and sandy loam underlain by gravel and coarse sand. They are associated with Regosols and Sierozems. The Esquatel soils formed in deep alluvium that washed from loess and are associated with the Brown soils. The Onyx, Pedigo, and Touchet soils are associated with the Chestnut soils, and in some places with the Brown soils. The Onyx soils formed in well-drained recent alluvium that washed from loess. The Touchet soils are slightly darker colored than the Onyx soils and have a few faint mottles in the lower subsoil, which indicate the influence of a seasonally high water table. The Pedigo soils have formed in deep alluvium and are more alkaline than the other Alluvial soils. The Patit Creek and Yakima

soils are underlain by gravel at a moderate depth. The Yakima soils are lighter colored than the Patit Creek soils.

Onyx silt loam in Spring Valley about 1 mile east of Hadley station in NW1/4SE1/4 sec. 13, T. 8 N., R. 36 E., is representative of the Alluvial soils that have formed in deep alluvium from loess. A profile of this soil is described as follows:

- Ap-0 to 9 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) when moist; weak, very fine, granular structure; soft, very friable; plentiful roots; pH 6.6 ; clear, smooth boundary.
- C1-9 to 28 inches brown (10YR 5/3) silt loam, dark brown (10YR 3/3) when moist; massive; soft, very friable, nonsticky, and nonplastic ; plentiful roots; pH 6.8 ; gradual, smooth boundary.
- C2-28 to 60 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 4/3) when moist; massive; soft, very friable; few roots; pH 7.8 ; distinctly stratified in layers that are from 2 to 8 inches thick.

#### REGOSOLS

Regosols consist of deep, unconsolidated rock (soft mineral deposits) in which few or no clearly expressed soil characteristics have developed (15). In Walla Walla County, Regosols are confined mainly to recently formed sand dunes and coarse loess. The Adkins, Farrell, Hezel, Taunton; Magallon, Quincy, Starbuck, and Walvan soils are classified as Regosols. The Quincy soils are developing in deep sand associated with the Sierozem soils, and they are characteristically uniformly textured throughout the profile.

A good example of a Regosol is Quincy loamy fine sand, located one-fourth mile south of Wallula in the NE1/4 NW1/4 sec. 23, T. 7 N., R. 31 E. The profile of this soil is described as follows:

- A1-0 to 3 inches, grayish-brown (10YR 5/2) loamy fine sand, very dark grayish brown (10YR 3/2) when moist; single grained; loose; few, fine roots of annual grasses; pH 7.6 ; clear, smooth boundary.
- C1-3 to 38 inches, grayish-brown (10YR 5/2) fine sand, very dark grayish brown (10YR 3/2) when moist; single grained; loose; pH 8.2 ; gradual, wavy boundary.
- C2-38 to 70 inches +, light brownish-gray (2.5Y 6/2) fine sand, dark grayish brown (2.5Y 4/2) when moist; single grained; loose; weakly calcareous, pH 8.4.

Laboratory analyses of Quincy loamy fine sand and of Quincy fine sand are given in table 14. The data illus-

trate the lack of developed horizons. In this county, the Quincy soils contain a large percentage of sand-sized particles of basalt. The Quincy fine sand sample analyzed came from a partly stabilized dune.

In the soil survey of Walla Walla County, two moderately deep soils were mapped with the Quincy soils. One of these rests abruptly on sharp, coarse basalt sand at a depth of 3 to 4 feet, and the other is underlain intermittently by lime-cemented pebbles and cobbles.

The Hezel soils are like the Quincy soils but do not have the deep sandy profile. At a depth of about 20 inches they have a strong lime zone, and at 30 inches they have a substratum of stratified lake-laid material similar to material in the Touchet beds from which the Sagemoor soils have formed.

The Adkins, Magallon, and Farrell soils have formed in parent material that is finer textured than that from which the Quincy soils formed. In the Brown soil zone, the Adkins soils are forming in wind-deposited fine sand and coarse loess; the Magallon soils are forming in alluvium and gravelly outwash material deposited by swift-flowing glacial streams; and the Farrell soils are forming in loess and fine sand in the backwater positions along small streams.

The Taunton soils have a moderately coarse textured surface layer underlain by a caliche hardpan at a depth of 18 to 24 inches. The Starbuck soils are rocky soils forming in a mixture of loess and basalt residuum on high plateaus and steep ridges in the zone of the Brown soils.

## *Additional Facts About the County*

### **Agriculture**

Religious teachers sent to work with the Indians were the first farmers in Walla Walla County. Representatives of the Flathead and the Nez Perce Indian Tribes, visiting in St. Louis in 1833, asked that teachers be sent to help them. The American Board of Commissioners for Foreign Missions, supported by several Protestant churches, sent Dr. and Mrs. Marcus Whitman and the Reverend and Mrs. Henry H. Spaulding on a mission to help these tribes.

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All tables have been updated and are available as a separate document.



Dr. Whitman established his station at Waiilatpu in the Walla Walla Valley about 25 miles east of the junction of the Walla Walla and Columbia Rivers in December 1836 (17) . He immediately started cultivating the rich bottom land to produce food for the station. A wide variety of crops were grown, and several acres of orchard were planted. Water for irrigating crops was obtained through a diversion from the Walla Walla River. A water-powered gristmill was built to grind grain. In time, the station was well stocked with cattle, sheep, and hogs.

The Cayuse Indians massacred the Whitmans and all men of the station in 1847. In 1859 a treaty with the Indians assured the settlers of comparative safety, and an era of rapid settlement followed. White men settled along the major stream bottoms and in the foothills of the Blue Mountains. Each settler grew wheat on the bottom land, pastured sheep and milk cows on the lush grass of the uplands, and kept a few oxen as draft animals.

The discovery of gold in Idaho in 1861 provided settlers of the Walla Walla Valley with a good market for their products. Walla Walla was an outfitting place for the people seeking gold. The valley became a wintering place for large numbers of sheep and cattle.

About 1862, Charles Russel plowed up an area of bunchgrass and produced a good crop of spring wheat. Other settlers soon did the same, and by 1867 the valley produced more wheat than it could use. In 1871 the first railroad in the Pacific Northwest was built to haul grain from Walla Walla to the Columbia River, a distance of 32 miles. In 1866 the Walla Walla Valley was reported to have grown about 250,000 bushels of wheat.

The first plantings of wheat in the Walla Walla Valley consisted mainly of soft white wheat for export and for milling into pastry flour; soft red spring and soft red winter wheats for export and for feed; and hard red and hard white wheats for milling into bread flour. The growing of winter wheat on a large scale did not start until about 1900.

In 1930, 27 horses were needed to pull a large combine harvester. Tractors took the place of horses in the early 1940's. The self-propelled combine harvester, with automatic leveling devices to insure efficient operation on steep land, is now in general use.

### Land use

According to the U.S. Census of Agriculture, the number of fauns in the county decreased from 1,228 in 1950 to 981 in 1959. Other farmland statistics for 1949 and 1959 are as follows

	1949	1959
	Acres	Acres
Land in farms-----	793, 968	822, 729
Average size of farms -----	646.6	838. 7
Cropland harvested -----	283, 062	279, 538
Cropland used only for pasture-----	15, 848	29, 061
Cropland not harvested and not		
Pastured-----	1228, 226	1239, 328
Woodland pastured-----	21, 766	39, 159
Woodland not pastured-----	6, 852	3, 896
Other pasture (not cropland, not		
Woodland-----	218, 352	195, 466
Other land (houseslots roads, waste-		
land, etc.) -----	19, 862	36, 281

Most of this acreage is in summer fallow.

About 20 percent of the farms have less than 10 acres, and about the same percentage have more than 1,000 acres.

About one-half the farms are operated by owners. The rest are operated by part owners, managers, and tenants. The operators of many large farms in the wheat-growing area live in towns, while salaried foremen live on the farms.

### Crops

Wheat is the main crop grown in Walla Walla County. The acreage of wheat is controlled by acreage allotments or marketing quotas established by the Federal Government. Table 15 shows the main crops grown in the county in stated years, according to the U. S. Census of Agriculture.

Wheat yields in Walla Walla County are generally above the national average. Yields in the county in 1959 were 48 bushels per acre. Edible peas for canning and freezing are grown in areas that get more than 16 inches of rain per year. They are alternated in a rotation with wheat. Processing plants for peas are located in Waitsburg and Walla Walla. The large acreage in barley is the result of diverting land to this crop that had been seeded to wheat prior to acreage controls.

The area of irrigated land in Walla Walla County increased from 24,323 acres in 1949 to 37,296 in 1959. Water for the increased acreage is pumped from deep wells and from the major streams. The main crops grown on irrigated land are alfalfa for hay and seed; other legumes, grasses, and small grains cut for hay and pasture; small grains for feed; sugar beets; and market vegetables.

The production of sugar beets started about 1940. A long growing season and the favorable soil conditions produce good yields. The production of sugar beets could be greatly expanded if more water were available for irriga-

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All tables have been updated and are available as a separate document.

tion. A rotation consisting of sugar beets for 2 years and alfalfa for 3 years is used to maintain soil fertility and control the sugar beet nematode. Large amounts of phosphate and nitrogen are applied to sugar beets.

Commercial vegetables, apart from green peas, are grown on small farms west and south of Walla Walla. The well-drained alluvial soils are well suited to this type of agriculture. Fields are managed to produce two crops in a season. The principal vegetables grown commercially are onions, onion plants, spinach, asparagus, sweet corn, lettuce, and carrots.

Spinach and carrots are processed locally; onions and lettuce are sold on the produce market. Large amounts of organic and inorganic fertilizers are used in growing vegetables. Gardeners use pea vines, animal manure, and alfalfa stack bottoms as a source of organic matter, and many operators plant green-manure crops. Commercial fertilizer, mainly nitrogen and phosphate, is applied in sizable amounts. Potash fertilizer has not given significant increases in yield, but some growers believe potash improves the quality of crops, especially onions.

### **Livestock**

Table 16 shows the number of livestock on farms in the county in stated years. The better stock consists of purebred Hereford, Polled Hereford, Shorthorn, and Angus cattle. There are purebred herds of Jersey, Guernsey,

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All tables have been updated and are available as a separate document.

Holstein, and Ayrshire dairy cattle. The county has a Cooperative Artificial Breeders Association and a Dairy Herd Improvement Association, which help to improve the dairy cattle. Milk produced in the county is processed in three large plants.

Horses are raised for handling livestock and for pleasure. The breeds of horses in the county consist of Thoroughbred, American Saddle, Morgan, Arabian, Quarterhorse, Palomino, and Standardbred.

Hampshire, Poland China, and Duroc-Jersey are the main breeds of swine. A new breed, Palouse, developed by the State College of Washington, is popular.

The three commercial hatcheries in the county produce about 7,000 fryers a week.

### **Schools and Churches**

Most small schools in Walla Walla County have been consolidated into large schools. Students are transported to these schools by buses. There are four two-teacher schools in the county. The other schools are considerably larger.

The public school system in the city of Walla Walla operates five grade schools; two new, modern junior high

schools; and one high school. Two grade schools just outside of the city limits enroll many students from this suburban area. Parochial schools within the city consist of one high school, two grade schools, and one school for girls. Grade schools and high schools are also located in Touchet, Prescott, Waitsburg, and Burbank.

Whitman College, located in the city of Walla Walla, is an accredited nonsectarian school that specializes in teaching the liberal arts. It has an average enrollment of about 800 students. Walla Walla College, located in the city of College Place, is a 4-year liberal arts school established and operated by Seventh-Day Adventists. It has an enrollment of about 1,200. The Seventh Day Adventists also have a grade school and high school in College Place.

Walla Walla County has 54 churches that, represent at least 25 denominations. Forty are in the city of Walla Walla, 6 in Waitsburg, 3 in College Place, 3 in Touchet, and 2 in Prescott. Most churches are modern in construction and have youth training programs and recreation centers. Several new churches are under construction.

Two well-equipped general hospitals and a veterans' hospital are in the city of Walla Walla.

### **Transportation**

U.S. Highway No. 410 and State Highway No. 3D run east and west through the county and join in the west at Burbank and in the east at Waitsburg. From Burbank, roads go west to Pasco, Kennewick, and Richland and to the Yakima Valley. Roads also go northeast to connect Walla Walla County with Spokane. From Waitsburg, roads run east and northeast to Pullman, Spokane, Moscow; and Lewiston. U.S. Highway No. 395 runs parallel to the Columbia River in the western part of the county and connects Walla Walla County with the Columbia River Basin to the west. State Highway 3E runs north and south from Walla Walla to near Prescott, where it intersects State Highway 3D.

According to the county engineer, Walla Walla County had 1,194 miles of improved county roads and 139 miles of State highways in 1956.

The Union Pacific and Northern Pacific Railroads provide service for passengers and freight. Buses provide passenger service along the better roads.

A large part of the wheat grown in the county is shipped by barge down the Columbia River to Portland and Vancouver. The shipping point is Port Kelley, located along the pool back of McNary Dam. A port district has been formed and port facilities constructed at Attalia on the north shore of the pool. The port district facilitates water transportation between Walla Walla and Portland and to other points up and down the Columbia River.

A modern airport is maintained by the city and county governments in Walla Walla. Two airlines have several flights a day from Walla Walla to Spokane, Seattle, Portland, Boise, and points along the way.

### **Industries**

Industrial development in Walla Walla County is an aid to agriculture. Electric power is furnished by the Pacific Power & Light Co. and the Columbia County Rural Electrification Administration. These companies are in-

terconnected with the Bonneville Power Administration and the Northwest Power Pool. Nearly all farms have electricity. The pumping of water for irrigation is one of the main uses of electric power.

Natural gas has been piped into Walla Walla. Canneries and milk processing plants use natural gas as an economical source of power.

Food processing is the largest industry. Two large canneries and a commercial freezer are in Walla Walla, and one large cannery and a freezer are at Waitsburg. These plants process green peas, asparagus, sweet corn, carrots, and spinach grown in Walla Walla County. In addition, they process green peas grown in Columbia and Umatilla Counties and fruits and vegetables grown in Yakima and Benton Counties. The city of Walla Walla also has three modern plants for processing milk products and several sheds where fresh fruits and vegetables are packed for shipment.

Walla Walla and Waitsburg have machine shops that specialize in servicing, rewiring, and rebuilding farm machinery. Other plants in the county manufacture implement hitches, grain tanks, stubble cutters, and fertilizer applicators.

Wholesale and retail outlets for fertilizers, insecticides, fungicides, herbicides, and other chemicals used in agriculture are in the county.

Two small sawmills near Walla Walla and a large sawmill 3 miles northeast of Waitsburg cut lumber from logs sawed in the Blue Mountains.

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## Glossary

**Aggregate, soil.** Many fine soil particles held in a single mass or cluster, such as a clod, crumb, block, or prism. Many properties of the aggregate differ from those of an equal mass of unaggregated soil.

**Alluvium.** Sand, mud, and other sediments deposited on land by streams.

**Available water.** The amount of water available to plants that is held in a soil after a good rain or after irrigation. It is the amount of water in excess of the wilting coefficient, held in a soil against the force of gravity.

**Blowout.** An area from which soil material has been removed by wind. Such an area appears as a nearly barren, shallow depression with a flat or irregular floor consisting of a resistant layer, an accumulation of pebbles, or wet soil lying just above a water table.

**Bottom land.** Low land formed by alluvial deposits along a river.

**Calcareous soil.** A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

**Caliche.** A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas as in the Southwestern States. The material may consist of soft, thin layers in the soil or of hard thick beds just beneath the solum, or it may be exposed at the surface by erosion.

**Clay.** As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. (See also texture, soil.) (Engineers define clay as being less than 0.005 millimeter in diameter.)

**Complex, soil.** A mapping unit in a detailed soil survey consisting of different kinds of soils that occur in such small individual areas or in such an intricate pattern that they cannot be shown separately on a publishable soil map.

**Consistence, soil.** The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are-

*Loose.*-Noncoherent; will not hold together in a mass.

*Friable.*-When moist, crushes easily under gentle to moderate pressure between thumb and forefinger and can be pressed together into a lump.

*Firm.*-When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

*Plastic.*-When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a wire when rolled between thumb and forefinger.

*Sticky*.—When wet, adheres to other material, tends to stretch somewhat and pull apart, rather than pull free from other material.

*Hard*.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

*Soft*.—When dry, breaks into powder or individual grains under very slight pressure.

*Cemented*.—Hard and brittle; little affected by moistening.

**Depth, effective soil.** The depth of soil material that plant roots can penetrate readily to obtain water and plant nutrients. It is the depth to a layer that differs from the overlying material in physical or chemical properties to such extent as to prevent or seriously retard the growth of roots. Depth classes are—

*Very shallow*, less than 10 inches.

*Shallow*, 10 to 20 inches.

*Moderately shallow*, 20 to 30 inches.

*Moderately deep*, 30 to 60 inches.

*Deep*, more than 60 inches.

**Drainage class.** The relative terms used to describe natural drainage are explained as follows

*Excessively drained soils* are commonly very porous and rapidly permeable, and have low water-holding capacity.

*Somewhat excessively drained soils* are also very permeable and are free from mottling throughout their profile.

*Well-drained soils* are nearly free of mottling and are commonly of intermediate texture.

*Moderately well drained soils* commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons, and mottling in the lower B and C horizons.

*Imperfectly drained soils* are wet for significant periods, but not all the time. They commonly have a slowly permeable layer in the profile, a high water table, additions through seepage, or a combination of these conditions.

*Poorly drained soils* are wet for long periods of time. They are light gray and generally are mottled from the surface downward, although mottling may be absent or nearly so in some soils.

*Very poorly drained soils* are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts.

**Erosion hazard.** The probable susceptibility to the wearing away of the land surface by detachment and transport of soil and rock materials through the action of moving water, wind, or other geological agents. Relative terms are—*none, slight, moderate, high, and very high*.

**Gravel.** Loose or unconsolidated material consisting of rounded and subrounded fragments of rock ranging from 2 millimeters to 3 inches in diameter.

**Horizon, soil.** A layer of soil, approximately parallel to the soil surface, that has distinct characteristics produced by soil-forming processes.

**Inclusions.** Areas of soil that are too small to be shown separately on a map of the scale used and are, therefore, mapped with a soil of a different type.

**Lacustrine deposit (geology).** Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

**Loess.** A fine-grained eolian deposit, mainly of silt-sized particles.

**Mapping unit.** Any soil, miscellaneous land type, soil complex, or undifferentiated soil group shown on the detailed soil map and identified by a symbol.

**Massive.** Large uniform masses of cohesive soil, sometimes with ill-defined and irregular breakage, as in some of the fine-textured alluvial soils; structureless. (See also Structure.)

**Minimum tillage.** No more tillage than is absolutely necessary for seed-bed preparation, planting, and cultivation.

**Miscellaneous land type.** A mapping unit for areas of land that have little or no natural soil, that are too nearly inaccessible for orderly examination, or that occur where, for other reasons, it is not feasible to classify the soil.

**Mulch tillage.** Tillage or preparation of soil in such a way that plant residue is left on the surface.

**Outwash plains.** Built-up debris, where the land relief is low, that has been brought to a glacier end by melt-water drainage and carried away by the outflow streams where the slope of the land is away from the ice.

**Palouse formation.** A general name applied to the thick deposits of loess in eastern Washington and adjacent Idaho. The par-

ent materials of the Palouse, Athena, Walla Walla, and Ritzville soils.

**Permeability, soil.** The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are—*very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid*.

**Reaction, soil.** The degree of acidity or alkalinity of a soil expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. In words, the degrees of acidity or alkalinity are expressed thus—

<i>pH</i>		<i>pH</i>	
Extremely acid-----	Below 4.5.	Mildly alkaline-----	7.4 to 7.8.
Very strongly acid-----	4.5 to 5.0.	Moderately alkaline-----	7.9 to 8.4.
Strongly acid-----	5.1 to 5.5.	Strongly alkaline-----	8.5 to 9.0.
Medium acid-----	5.6 to 6.0.	Very strongly alka-	9.1 and
Slightly acid-----	6.1 to 6.5.	line.	higher.
Neutral-----	6.6 to 7.3.		

**Rough fall tillage.** An effective erosion control practice in the 16- to 23-inch zone of rainfall. Early in fall, after harvest, the soil is plowed while the ground is dry. For a fall-seeded crop, fertilizer is applied and the soil is seeded without further seedbed preparation. For a spring crop, the soil is left rough through the winter.

**Sand.** Individual rock or mineral fragments in soils having diameters ranging from 0.05 millimeter to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. (See texture, sand.)

**Saline soil.** A soil that contains soluble salts in amounts that impair growth of crop plants but that does not contain excess exchangeable sodium.

**Saline-alkali soil.** A soil that contains harmful concentration of salts and exchangeable sodium, or contains harmful salts and has a highly alkaline reaction, or contains harmful salts and exchangeable sodium and is strongly alkaline in reaction. The salts, exchangeable sodium, and alkaline reaction are so distributed in the soil that growth of most crop plants is less than normal.

**Series, soil.** A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface soil, are similar in differentiating characteristics and in arrangement in the profile.

**Shade density.** The complement of the percentage of light passing through tree crowns, assuming unbroken light to have, at time of measurement, a value of 100 percent.

**Silt.** Individual mineral particles of soil that range in diameter from the upper size of clay, 0.002 millimeter to the lower size of very fine sand, 0.05 millimeter. (See texture, silt.)

**Site index (forestry).** A numerical means of expressing the quality of a forest site that is based on the height of the dominant and codominant trees at an arbitrarily chosen age; for example, the average height in feet attained by dominant and codominant trees in fully stocked stands at the age of 100 years.

**Slope.** The incline of the surface of a soil, usually expressed in percentage of slope, which equals the number of feet of fall per 100 feet of horizontal distance. In this report, slope is expressed as follows—

0 to 3 percent-----	Nearly level.
3 to 8 percent-----	Undulating to gently sloping.
8 to 15 percent-----	Gently sloping to hilly.
15 to 30 percent-----	Hilly.
30 to 45 percent-----	Steep.
45 to 60 percent-----	Very steep.
60 percent and steeper-----	Excessively steep.

**Structure, soil.** The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are *platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are *single grain*, (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage as in many claypans and hardpans).

**Stubble mulch.** Stubble or other crop residues left on the surface of the soil to provide protection from wind and water erosion

after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

**Subsoil.** Technically, the B horizon; roughly, and also in a soil without developed horizons, the part of the profile below plow depth.

**Subsurface tillage.** Tillage with a sweeplike plow or blade that does not turn over the surface cover or incorporate it into the lower part of the surface soil.

**Surface soil.** The soil ordinarily moved in tillage, or its equivalent in an uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

**Terrace (geological).** An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted with flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

**Texture, soil.** The relative proportions of the various size groups of individual soil grains in a mass of soil. Specifically, the proportions of sand, silt, and clay. Following are definitions of soil textural classes-

**Sand.**-Soil material that is 85 percent or more sand; the percentage of silt, plus 1 1/2 times the percentage of clay, does not exceed 15.

**Loamy sand.**-Soil material that, at the upper limit, is 85 to 90 percent sand, and the percentage of silt plus 1 1/2 times the percentage of clay is not less than 15 ; and at the lower limit, is not less than 70 to 85 percent sand and the percentage of silt plus twice the percentage of clay does not exceed 30.

**Sandy loam.**-Soil material that is (1) 20 percent clay or less, and the percentage of silt plus twice the percentage of clay

exceeds 30, and 52 percent or more of the soil is sand; or (2) less than 7 percent clay, less than 50 percent silt, and between 43 percent and 52 percent sand.

**Loam.**-Soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

**Silt loam.**-Soil material that is (1) 50 percent or more of silt and 12 to 27 percent of clay, or (2) 50 to 80 percent silt and less than 12 percent clay.

**Silt.**-Soil material that is 80 percent or more of silt and less than 12 percent clay.

**Sandy clay loam.**-Soil material that is 20 to 35 percent clay, less than 28 percent silt, and 45 percent or more sand.

**Clay loam.**-Soil material that is 27 to 40 percent clay and 20 to 45 percent sand.

**Silty clay loam.**-Soil material that is 27 to 40 percent clay and less than 20 percent sand.

**Sandy clay.**-Soil material that is 35 percent or more clay and 45 percent or more sand.

**Silty clay.**-Soil material that is 40 percent or more clay and 40 percent or more silt.

**Clay.**-Soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

**Type, soil.** A subdivision of the soil series that is made on the basis of differences in the texture of the surface layer.

**Uphill plowing.** Tillage operations in which the furrow slice is turned up the slope instead of down. Effective on soils that have slopes of up to approximately 25 percent.

**Usable forage.** The plant growth that livestock may graze without injuring the vigor of the plant, or approximately 50 percent of the year's