SOIL SURVEY OF THE COLUMBIA COUNTY AREA, WASHINGTON

BY EVEARD T. HARRISON, FRED R. McCREARY, AND FRANK L. NELSON, SOIL CONSERVATION SERVICE

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

THE COLUMBIA COUNTY AREA covers slightly more than the northern two-thirds of Columbia County, in southeastern Washington (fig 1). The total land area is about 388,270 acres, of which about 200,000 acres is farmland and about 145,000 acres is rangeland. The rest is forest and woodland. In 1960, this Area produced 3,370,000 bushels of wheat, 1,140,000 bushels of barley, and 14,500 tons of green peas for canning.

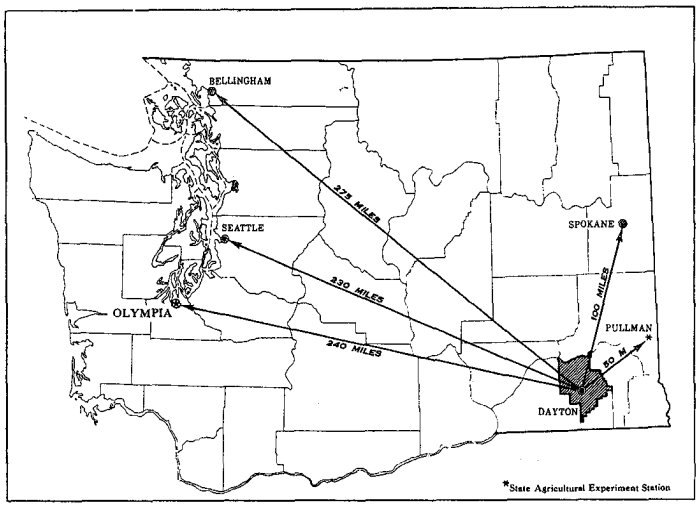

Figure 1.-Location of the Columbia County Area in Washington.

Crops were first produced on the bottom lands. In places the soils are shallow over gravel, and irrigation was necessary for crop production. As more people came into the area, they settled at the timberline where fuel and water were available. Productivity of the woodland soils is low. Many soils are being converted to grass or woodland. The deep fertile soils of the rolling grasslands were the last to be brought under cultivation. They have become the most important for farming in the survey area. Farmers found that wheat yields could be increased by a winter wheat and summer fallow rotation. Together with the practice of burning stubble, this rotation accelerated the loss of soil organic matter and increased soil erosion. High crop yields were maintained through the use of improved wheat varieties and the application of large amounts of nitrogen fertilizer. Recently introduced wheat varieties make efficient use of large amounts of nitrogen, but are very exacting in their soil and water requirements. It is anticipated that farmers will place increasing emphasis on soil type and erosion conditions when choosing wheat varieties and planning control of soil erosion.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in the Columbia County Area, where they are located, and how they can be used. The soil scientists went into the Area knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug 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 into the parent material that has not been changed much by leaching or by the action of plant roots.

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 nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

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. Athena and Mondovi, 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 those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name

of a soil phase indicates a feature that affects management. For example, Athena silt loam, 0 to 8 percent slopes, is one of several phases within the Athena series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication 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 the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. 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 phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Such mapping units shown on the soil map of the Columbia County Area are called soil complexes.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Roloff-Kuhl complex, 8 to 30 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Terrace escarpments is a land type in the Columbia County Area.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland and rangeland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the Columbia County Area. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in an area, who want to compare different parts of an area, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in the Columbia County Area are described on the following pages.

1. Ritzville Association

Dominantly rolling to hilly, well-drained, medium-textured soils that formed in wind-laid silts; 10 to 12 inches annual precipitation

This association is on rolling to hilly uplands, high plateaus, and dissected terraces. It consists mainly of soils that formed in wind-laid silts on the uplands, in wind-laid silts and weathered basalt on the plateaus, and in glacial lake sediments on the terraces. Annual precipitation is 10 to 12 inches. Summers are dry and hot. Only about an inch of rain falls between June 15 and September 15. Winters are cold, and snow falls often, but does not last long. Elevation ranges from 800 to 1,500 feet. The original vegetation was bluebunch wheatgrass, Sandberg bluegrass, needle-and-thread, and gray rabbitbrush.

This association occupies about 9,000 acres, or 2 percent of the survey area. It is about 85 percent Ritzville soils. The rest is soils of minor extent. Of the minor soils, about 7 percent is Farrell soils, 6 percent is Roloff soils, and about 2 percent is Kuhl and Walla Walla soils.

Ritzville soils are very deep and medium textured. The minor soils are mainly deep and very deep and are medium textured and moderately coarse textured.

The Ritzville and Farrell soils are suited to winter wheat that is grown in a summer fallow system. The Roloff soils are not suited to wheat and barley unless irrigated. If properly managed, areas of these soils furnish good grazing in winter or early in spring. Farms in this association average 2,000 acres in size.

2. Kuhl-Farrell-Roloff Association

Dominantly strongly sloping to steep, well-drained, medium-textured and moderately coarse textured soils that formed in wind-laid silts and glacial outwash; many of these soils are rocky and are underlain by bedrock; 10 to 16 inches annual precipitation

This association is in the lower part of the Tucannon Valley and in the Snake River Canyon below Little Goose Dam. The soils are on remnants of dissected terraces, rough basalt plateaus, steep canyon walls, river bars, and stream bottoms. The parent materials were wind-laid silts, weathered basalt, glacial lake sediments, and recent alluvium. Annual precipitation ranges from 10 to 16 inches. Only about 1.5 inches of rain falls between June 15 and September 15. Summers are hot, and winters are cold. Some snow falls each winter, but it melts quickly. Elevation ranges from 400 to 1,200 feet. The original vegetation was mainly bluebunch wheatgrass, Sandberg bluegrass, and needle-and-thread. A small amount of Idaho fescue grows on the north-facing slopes.

This association occupies about 33,000 acres, or 9 percent of the survey area. The Kuhl soils make up about 40 percent of the association. About 21 percent is Farrell soils, 17 percent is Roloff soils, and the rest is soils of minor extent.

Kuhl soils are medium textured and 12 to 20 inches deep over basalt. Farrell soils are very deep and medium textured and moderately coarse textured. They occur on old dissected lake terraces that formed in the backwaters of ancient glacial lakes. Roloff soils are medium textured. They formed in silt loam 20 to 40 inches deep over basalt.

Minor soils in the association include the Ellisforde, Stratford, Ritzville, Walla Walla, Esquatzel, and Yakima soils. There are also numerous rock outcrops and steep terrace escarpments.

Most of the association is used for grazing and dryland farming (fig. 2). Farms are large, and livestock is an important part of each farm enterprise. Most ranchers have irrigated land along the Snake River. Small areas of the Farrell soils are irrigated with water pumped from the Snake or Tucannon Rivers. The Esquatzel, Yakima, and other soils on bottom land also are irrigated. Alfalfa hay and asparagus are the principal crops on these soils.

3. Walla Walla-Asotin-Chard Association

Dominantly strongly sloping to steep, well-drained, medium-textured soils that formed in wind-laid silts; some of these soils are underlain by bedrock; 12 to 16 inches annual precipitation

This association is in the northern and northeastern parts of the survey area. It consists mainly of strongly sloping to steep soils that formed mainly in wind-laid silts. Some shallower soils formed in weathered basalt, and soils in the narrow valley bottoms formed in alluvium. Slopes range from 8 to 30 percent on south aspects and 30 to 60 percent on north aspects. Annual precipitation is 12 to 16 inches. Summers are hot and dry. Only about 1.5 inches of rain falls between June 15 and September 15. Winters are cold, and generally the soils are frozen for a short period in winter. Elevation ranges from 550 to 2,400 feet. The original vegetation was bluebunch wheatgrass, Sandberg bluegrass, and Idaho fescue. Sandberg bluegrass increases on the shallow, rocky areas, and Idaho fescue increases on the north-facing slopes.

This association occupies about 57,000 acres, or 15 percent of the survey area. It is about 55 percent Walla Walla soils, 15 percent Asotin soils, 12 percent Chard soils, 10 percent Kuhl soils, and 8 percent soils of minor extent.

Walla Walla soils are deep and very deep and medium textured. Asotin soils are medium textured and are underlain by basalt bedrock at a depth of 20 to 40 inches. In most places they have a limy layer 2 to 6 inches thick just above the bedrock. Kuhl soils are medium textured and rocky and are underlain by bedrock at a depth of 12 to 20 inches. Chard soils arc deep and medium textured. They contain rather large amounts of coarse sand and gravel lenses in the lower part of the profile.

The soils of minor extent include Roloff and Linville soils on uplands and the Patit Creek soils which are 20 to 40 inches deep over gravelly material, and the very deep Hermiston and Covello soils, all of which are on bottom land. Rock crops out on the uplands.

About half of the association is used for grazing and most of the rest is used for dryland farming. Many of the fields are small and irregular in shape. Most of the soils on bottom land are irrigated. Alfalfa, asparagus, grasses, and sweet corn or silage corn are the principal crops. The average farm is about 2,500 acres in size.

4. Walla Walla Association

Dominantly strongly sloping to steep, well-drained, medium-textured soils that formed in wind-laid silts; 12 to 16 inches annual precipitation

This association (see cover picture) is mostly in the western part of the survey area. It consists of hilly to steep soils on uplands and soils that formed in alluvium along bottom lands. Most slopes range from 8 to 40 percent, but the north-facing slopes range from 40 to 65 percent and are generally rough and broken. Annual precipitation is 12 to 16 inches. Summers are dry and hot. Only about 1.5 inches of rain falls between June 15 and September 15. Winters are cold, and snow and frozen soil can be expected for short periods. Runoff is rapid on frozen soil after a rain or when snow melts. Elevation ranges from 900 to 2,000 feet. The original vegetation was bluebunch wheatgrass, Idaho fescue, blue lupine, and balsamroot. Almost pure stands of Idaho fescue grow on some north-facing slopes.

This association occupies about 66,000 acres, or 17 percent of the survey area. It is more than 90 percent Walla Walla soils. The rest is soils of minor extent.

Walla Walla soils are very deep, medium textured, and well drained. They have a thick, dark-colored surface layer.

Figure 2.-View of Kuhl-Farrell-Roloff association along the Tucannon River, a mile upstream from the Snake River. Esquatzel and Yakima soils are on the valley floor. Rock land and an extremely rocky phase of Kuhl soils are on the steep slopes. Farrell soils occupy the terraces. Small areas of Walla Walla soils are on the ridges in the upper right.

Among the minor soils are limy Ritzcal soils and ashy Walvan soils. Also of minor extent are Hermiston and Onyx soils on bottom lands and steep rocky Kuhl soils and moderately deep Asotin soils on south-facing slopes. About 95 percent of this association is cultivated. Winter wheat and barley, the major crops, are grown in a summer-fallow system. Farms average 1,800 acres in size. Little use is made of many small, isolated areas in the canyons. Mostly steep Walla Walla soils are on north-facing slopes in the canyons.

5. Patit Creek-Hermiston-Onyx Association

Nearly level, well-drained, medium-textured soils that formed in alluvium; some of these soils are gravelly or cobbly; 14 to 20 inches annual precipitation

This association is in the Touchet Valley. It consists of nearly level silt loams that formed in alluvium. Most slopes are less than 3 percent. Annual precipitation is 14 to 20 inches. Summers are dry and hot. Winters are slightly milder than in the adjacent uplands. Elevation ranges from 1,300 to 2,000 feet. The original vegetation in open areas was bluebunch wheatgrass and wildrye. Willows, cottonwoods, and alder grew along the streams. Ponderosa pine and Douglas-fir grew at the higher elevation.

This association occupies about 8,000 acres, or 2 percent of the survey area. Patit Creek soils make up about 50 percent of the association, Onyx soils 25 percent, and Hermiston soils about 15 percent. The rest is Walla Walla, Covello, and Mondovi Soils.

Patit Creek soils are very dark, medium textured, well drained, and 20 to 40 inches deep over gravel. Many areas of these soils are gravelly or cobbly. Onyx and Hermiston soils are very deep, well drained, and medium textured. Onyx soils are subject to occasional stream overflow. These floods seldom cover large areas, but fresh deposits of silt are common.

Asparagus, alfalfa, apples, pasture grasses, and grains are suitable irrigated crops (fig. 3).

Figure 3.-View of Patit Creek-Hermiston-Onyx association down Touchet River Canyon toward Dayton. The orchards are on Patit Creek soils.

6. Athena-Palouse Association

Dominantly strongly sloping to moderately steep, well-drained, medium-textured soils that formed in wind-laid silts; 16 to 23 inches annual precipitation

This association is mostly in the central part of the survey area. It consists mainly of hilly to moderately steep soils on uplands and wide ridges separated by deep canyons. The annual precipitation ranges from 16 inches northwest of Dayton to 23 inches at the Blue Mountains. About a third of the precipitation is snow. July and August are dry months in which there is less than an inch of rainfall. Summers are hot, and winters are cold. Elevation ranges from 1,500 feet in the canyons to 3,500 feet on some of the high ridges. The original vegetation was Idaho fescue, bluebunch wheatgrass, lupine, and balsamroot. Many of the north-facing slopes are brushy; hawthorn and wild rose are dominant.

This is the largest association in the survey area. It occupies about 140,000 acres, or 36 percent of the survey area. Athena soils make up about 50 percent of the association, Palouse soils 18 percent, Gwin soils 10 percent, and Tucannon and Waha soils each make up about 5 percent. Soils of minor extent make up 12 percent.

Athena soils are typically very deep and medium textured. They have a very dark brown surface layer. Palouse soils are very deep and medium textured and have a very dark brown or black surface layer. Gwin soils are shallow and extremely rocky. Tucannon and Waha soils are 20 to 40 inches deep over basalt.

Among the minor soils are Linville and Larkin soils on uplands and Patit Creek, Covello, Mondovi, and Hermiston soils on bottom lands. Basalt rock crops out on the uplands.

Most of the acreage of the Athena and Palouse soils and some areas of the Tucannon and Waha soils are cultivated. The Linville, Larkin, and Gwin soils are generally too steep or rocky for cultivation and are used for grazing.

Farms average 800 to 1,500 acres in size. At higher elevations the farms are larger and include a larger proportion of the Tucannon, Waha, Linville, and Larkin soils and rock outcrops. The Athena and Palouse soils are suitable for annual cropping. Winter wheat and green peas are the principal crops (fig. 4) .

Figure 4.-View looking south-southeast from one mile south of Turner. Soil in the foreground is Athena silt loam, 8 to 25 percent slopes. Palouse soils are on the right and on the ridges in the upper middle part of the picture. The Couse-Larkin association is in the background, and the Tolo-Gwin association is in the mountains in the far background.

7. Couse-Larkin Association

Dominantly gently sloping to steep, well-drained and moderately well-drained, medium-textured and moderately fine textured soils that formed in wind-laid silts, volcanic ash, and weathered basalt; 23 to 40 inches annual precipitation

This association consists of gently sloping to steep soils that formed in wind-laid silts, volcanic ash, and weathered basalt on the north aspect of the Blue Mountains. The steep soils are in the rocky canyons. Annual precipitation ranges from 23 inches at the lower elevations to an estimated 35 inches on the higher ridges. At least half of the precipitation is snow. July, August, and early September are dry and hot. One or two thunderstorms that cause forest fires occur each season. The winters are cold, but early snows usually prevent freezing of the soils. Elevation ranges from 3,000 to 4,500 feet. The vegetation in uncleared areas is ponderosa pine, pinegrass, spirea, and huckleberry in the lower, drier part of the association and grand fir, spruce, and larch at higher elevations. The fir canopy is generally too dense for understory plants. The moist areas become brushy after logging.

This association occupies about 31,000 acres, or 8 percent of the survey area. Couse soils make up about 30 percent of the association. About 15 percent is Larkin soils on north-facing slopes and about 25 percent is Larkin, Waha, and Gwin soils on steep slopes of the other aspects and Tolo soils in areas of minor extent.

The Couse soils are moderately well drained and have a medium-textured surface layer and subsoil over a very

slowly permeable substratum. Larkin soils on the north-facing slopes are deep, dark colored, and medium textured and moderately fine textured. Larkin, Waha, and Gwin soils, on slopes that face east, west, and south, are moderately deep. The Gwin soils are extremely rocky.

Most of this association is not suitable for use as cropland. Areas of Couse soils that were formerly cleared for crops are gradually being abandoned. Small areas of Tolo soils were formerly cultivated for homesteads, but they have also been abandoned. Grand fir has taken over areas where there was a suitable seed source.

Farms in this association generally were small, but are being consolidated into large areas for management as grazing or woodland units.

8. Tolo-Gwin Association

Dominantly strongly sloping to very steep, medium-textured soils and extremely rocky soils that formed in wind-laid silts and volcanic ash; some of these soils are underlain by bedrock; 25 to 40 inches annual precipitation

This association is in the Blue Mountains, mainly in the southern fringe areas of the survey area. It consists of strongly sloping to very steep soils on rough mountains and in deep canyons. These soils formed from basaltic materials and tuff and wind-laid silt. Annual precipitation is estimated to range from 25 to 40 inches, and more than half of this is snow. Summers are cool, and winters are cold. Elevation ranges from 3,500 to 4,500 feet. The vegetation is bunchgrass on south-facing slopes, dense stands of Douglas-fir and grand fir on north-facing slopes, and ponderosa pine and Douglas-fir on the drier, east-facing and west-facing slopes.

This association occupies about 44,000 acres, or 11 percent of the survey area. About 40 percent of the association is Tolo soils and 20 percent is Gwin soils. Klicker and Anatone soils and rock outcrops each make up about 10 percent, and about 10 percent is Larkin soils on the uplands and Patit Creek soils on the bottom lands.

Tolo soils are deep, well drained, and medium textured and have a heavy silt loam or silty clay substratum. They are mostly on north-facing slopes under a dense cover of fir trees. Gwin soils are shallow, well drained, and extremely rocky. They are on south-facing slopes, which are treeless. The minor soils are well-drained silt loams or silty clay loams. Klicker and Anatone soils are rocky.

Generally, the soils in this association are not suited to crops and are poorly suited to range. The forest canopy on the Tolo soils is too dense for the growth of vegetation that is palatable to range cattle. Areas of Tolo soils that were cleared for farming during the homesteading period have been almost entirely abandoned. Tolo soils are well suited to woodland, and the Tolo, Gwin, and Klicker soils, where associated, provide good wildlife habitat.

Descriptions of the Soils

This section describes the soil series and mapping units in the Columbia County Area. Each soil series is described and then each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second description, detailed and in technical terms, is for scientists, engineers, and others who need to make thorough and precise studies of soils. Colors are for moist soil unless stated otherwise.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Rock land, for example, does not belong to a soil series, but nevertheless is listed in alphabetic order along with the soil series.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and range site or woodland group in which the mapping unit has been placed. The page for the description of each capability unit, range site, and woodland group can be found by referring to the "Guide to Mapping Units."

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (7) .

Anatone Series

The Anatone series is made up of well-drained cobbly silt loams that are underlain by bedrock at a depth of 10 to 20 inches. These soils formed in weathered basalt mixed with wind-laid silt and volcanic ash. They are in the Blue Mountains in the southern part of the Area on open ridgetops and on south-facing and southwest-facing slopes. Slopes are 30 to 65 percent. Elevation ranges from 3,500 to 4,500 feet. The annual precipitation is 25 to 35 inches, and the mean annual temperature is approximately 47° F. The frost-free season is 90 to 100 days. The vegetation is sparse bunchgrass, wild buckwheat, lupine, low sagebrush, and scattered ponderosa pine. Anatone soils are associated with Tolo soils on north-facing slopes and with Klicker soils along canyon walls.

In a representative profile, the surface layer is dark reddish-brown cobbly silt loam about 2 inches thick. The subsoil is dark reddish-brown cobbly silt loam in the upper part and very cobbly light clay loam in the lower part. The subsoil rests directly on basalt bedrock at a depth of about 18 inches.

Anatone soils are used mainly for grazing, wildlife habitat, and watershed.

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

Anatone extremely rocky silt loam, 30 to 65 percent slopes (AnF).-This soil is on ridgetops and in south-facing and southwest-facing areas. Rock outcrops and areas of very thin soils averaging about 50 feet in diameter make up 25 to 50 percent of the acreage.

Representative profile of Anatone extremely rocky silt loam, 30 to 65 percent slopes, in grassland, SE1/4SW1/4 sec. 32, T. 10 N., R. 41 E., at the center of the quarter section:

A1-0 to 2 inches, dark reddish-brown (5YR 3/3) cobbly silt loam, dark brown (7.5YR 4/2) dry; weak, very fine, granular structure; slightly hard, friable, nonsticky, nonplastic ; many fine roots and many medium roots; 30 percent coarse sand, gravel, and cobble-size fragments; neutral; abrupt, wavy boundary. 1 to 3 inches thick.

B1-2 to 5 inches, dark reddish-brown (5YR 3/2) cobbly silt loam, dark brown (7.5YR 4/2) dry; moderate, coarse, granular and moderate, fine, subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many fine roots and many medium roots; neutral; clear, irregular boundary. 2 to 4 inches thick.

B21-5 to 7 inches, dark reddish-brown (5YR 3/2) cobbly silt loam, dark brown (7.5YR 3/2) dry; moderate, fine, subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many fine roots and many medium roots; neutral; clear, irregular boundary. 2 to 4 inches thick.

B22t-7 to 18 inches, dark reddish-brown (5YR 3/2) very cobbly light clay loam, dark brown (7.5YR 3/2) dry; moderate, fine, subangular blocky structure; hard, firm, sticky, plastic; common fine roots and common medium roots; plant roots and soil in cracks in rocks; thin clay films on rocks; neutral; abrupt, wavy boundary. 5 to 12 inches thick.

R-18 inches, basalt bedrock.

Depth to bedrock is 10 to 20 inches. The hue of the A horizon ranges from 2.5YR to 10YR. The B horizon has a hue of 7.5YR to 5YR. Profiles normally contain enough sand to give textures a gritty feel. Both basaltic and tuffaceous parent materials are present.

This soil is moderately permeable. It holds 1.5 to 3 inches of water that plants can use. Roots penetrate to the bedrock. Runoff is rapid, and the hazard of water erosion is very severe. Included in mapping are areas that have slopes of 15 to 30 percent.

This soil is used mainly for grazing, wildlife habitat, and watershed. Capability unit VIIs-2; Shallow range site (S-3).

Asotin Series

The Asotin series consists of well-drained silt loams that are underlain by basalt bedrock at a depth of 20 to 40 inches. These soils formed in wind-laid silts that contain some material weathered from the basalt. They are between the Tucannon Valley and the Snake River in the northern part of the Area. Slopes are 0 to 65 percent. Elevation ranges from 1,200 to 2,000 feet. Annual precipitation is 12 to 16 inches. The mean annual temperature is about 52° F., and the frost-free season is about 150 to 160 days. The vegetation was largely bluebunch wheatgrass and Sandberg bluegrass. Asotin soils are mainly in areas 5 to 20 acres in size and are associated with Chard, Kuhl, Oliphant, Spofford, and Walla Walla soils.

In a representative profile, the surface layer is very dark grayish-brown silt loam about 13 inches thick. The subsoil, about 15 inches thick, is dark grayish-brown and brown silt loam. The substratum is light brownish-gray, strongly calcareous silt loam about 4 inches thick that rests directly on bedrock at a depth of about 32 inches.

Asotin soils are used mainly for wheat, barley, and grasses and for grazing and wildlife habitat.

Asotin silt loam, 0 to 15 percent slopes (AsC).-This very gently sloping to strongly sloping soil is on ridgetops.

Representative profile of Asotin silt loam, 0 to 15 percent slopes, in grassland, 250 feet southwest of gate, and 300 feet west of Krause Road, SW1/4NE1/4 sec. 36, T. 12 N., R. 38 E.:

A1-0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, very fine, granular and weak, thin, platy structure; slightly hard, very friable, slightly sticky, nonplastic ; many very fine roots and few medium roots; neutral; clear, wavy boundary, 3 to 6 inches thick.

A3-6 to 13 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak blocky structure; slightly hard, friable, slightly sticky, nonplastic; common fine roots and few medium roots; common fine and very fine pores; few pieces of basalt 3 to 25 millimeters in diameter; neutral; gradual, wavy boundary. 4 to 6 inches thick.

B1-13 to 22 inches, dark grayish-brown (10YR 4/2) silt loam, pale brown (10YR 6/3) dry; weak prismatic structure; hard, friable, slightly sticky, slightly plastic common fine roots and few medium roots; 1 to 5 percent small basalt fragments; mildly alkaline; clear, wavy boundary. 8 to 12 inches thick.

B2-22 to 28 inches, brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; weak prismatic structure; hard, friable, slightly sticky, slightly plastic; few medium roots; 5 to 10 percent basalt fragments 10 to 30 millimeters in diameter; moderately alkaline; abrupt, smooth boundary. 5 to 8 inches thick.

CcA-28 to 32 inches, light brownish-gray (10YR 6/2) silt loam, light gray (10YR 7/2) dry; massive; hard, firm, slightly sticky, slightly plastic; few medium and fine roots; 10 percent basalt fragments; pores are partly filled with lime; strongly effervescent; strongly alkaline; abrupt, irregular boundary. 2 to 8 inches thick.

IIRca-32 inches, basalt and loose rock; lime in cracks.

Depth to bedrock is 20 to 40 inches. In some places the A horizon is very dark brown. The B horizon is about 18 to 25 percent clay, or 3 to 10 percent more clay than the A1 horizon. The content of basalt in the Cca horizon ranges from a trace of fine fragments to about 25 percent gravel and small cobblestones.

This soil is moderately permeable. It holds 3.5 to 8 inches of water that plants can use. Roots penetrate to the bedrock. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Included in mapping are a few severely eroded areas.

This soil is used mainly for wheat, barley, and grasses. Most of the acreage is cultivated. Capability unit IIIe-5; Loamy range site (L-2).

Asotin silt loam, 15 to 30 percent slopes (AsD).-This is a rolling soil on uplands. Runoff is medium, and the hazard of erosion is moderate to severe. Most of the acreage is cultivated. This soil is used mainly for wheat, barley, and grasses. Capability unit IVe-7; Loamy range site (L-2) .

Asotin silt loam, 30 to 40 percent slopes (AsE).-This steep soil is on canyon walls. It has numerous rock outcrops that are as much as 12 feet in diameter. Runoff is rapid, and the hazard of erosion is severe. Most of the acreage is used for grazing and for wildlife habitat. Capability unit VIe-2; Loamy range site (L-2).

Asotin silt loam, 40 to 65 percent slopes (AsF).-This very steep soil is on rough, broken canyon walls that face north and northeast. It has numerous rock outcrops that are as large as 15 feet in diameter. Runoff is very rapid, and the hazard of erosion is very severe. This soil is used for grazing and for wildlife habitat. Capability unit VIIe-1; Loamy range site (L-2).

Asotin silt loam, 15 to 40 percent slopes, severely eroded (AsE3).-This soil is in small areas within larger areas of uneroded and slightly eroded soils. Most of the original surface layer of this soil has been lost through water erosion. Bedrock is at a depth of 20 to 34 inches. In some places rock outcrops are 5 to 10 feet in diameter. This soil holds 3 to 5 inches of water that plants can use. Runoff is medium to rapid, and the hazard of erosion is moderate to severe. This soil is used for wheat and for grazing. Capability unit VIe-2; Loamy range site (L-2).

Athena Series

The Athena series consists of well-drained silt loams that formed in wind-laid silts. Most of the Athena soils are more than 60 inches deep. In small areas they are underlain by bedrock at a depth of 40 to 60 inches. These soils are the principal soils in a large area bordered by the Tucannon Valley on the north, Whetstone Hollow on the west, and the foothills of the Blue Mountains on the southeast. Slopes are 0 to 55 percent. Elevation ranges from 1,300 to 2,200 feet, Annual precipitation is 16 to 19 inches. The mean annual temperature is approximately 51° F., and the frost-free season is 155 to 165 days. The original vegetation was largely bluebunch wheatgrass and Idaho fescue. Athena soils are associated with Gwin and Tucannon soils on the uplands and with Covello, Mondovi, and Patit Creek soils on the bottom lands.

In a representative profile, the surface layer is very dark brown silt loam about 13 inches thick. The subsoil, about 37 inches thick, is very dark grayish-brown to brown silt loam. The substratum is brown, slightly calcareous silt loam to a depth of 70 inches.

Most of the acreage of Athena soils is cultivated. A rotation of winter wheat and summer fallow or winter wheat and green peas for canning is most common. Other crops include barley, corn for silage, and alfalfa and grasses.

Athena silt loam, 8 to 25 percent slopes (AtD).-This hilly soil is on uplands. Most slopes range from 400 to 600 feet in length.

Representative profile of Athena silt loam, 8 to 25 percent slopes, in a cultivated area, three-fourths mile north of Whetstone Road and 150 west of Hinchcliffe Road, NE1/4SW1/4 sec. 32, T. 11 N., R. 39 E.:

Ap-0 to 9 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; slightly hard, friable, slightly sticky, slightly plastic; common fine and medium roots; many fine pores between peds ; neutral; abrupt, smooth boundary. 6 to 10 inches thick.

A1-9 to 13 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, medium, blocky structure; slightly hard, friable, ,slightly sticky, slightly plastic; common fine roots; neutral; clear, wavy boundary. 3 to 8 inches thick.

B21-13 to 24 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; moderate, medium, prismatic structure; hard, friable, slightly sticky, slightly plastic; common fine roots, few thin coatings on vertical ped surfaces; neutral; gradual, wavy boundary. 9 to 15 inches thick.

B22-24 to 39 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; weak, medium, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; mildly alkaline; gradual, wavy boundary. 10 to 17 inches thick.

B3-39 to 50 inches, brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; weak, medium, prismatic structure; soft, friable, slightly sticky, slightly plastic; few fine and very fine roots; mildly alkaline; abrupt, wavy boundary, 10 to 20 inches thick.

Cca-50 to 70 inches. brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; massive; hard, friable, slightly sticky, slightly plastic; few very fine roots; weakly effervescent; strongly alkaline.

In some plowed fields the Ap horizon is very dark grayish brown. The depth to the Cca horizon commonly is more than 50 inches, but in many areas it is at a depth of 60 inches or more.

This soil is moderately permeable. It holds 10 to 12 inches of water that plants can use. Roots penetrate to a depth of more than 60 inches. Surface runoff is medium, and the hazard of erosion is moderate. Included in mapping are small areas that are severely eroded. Small pockets of volcanic ash are also included.

Most of the acreage is used for wheat, peas, and barley. Capability unit IIIe-6; Loamy range site (L-3).

Athena silt loam, 0 to 8 percent slopes (AtB).-This gently sloping soil is on ridgetops and terraces. Runoff is slow, and the hazard of erosion is slight. This soil is used for wheat, peas, and barley. Capability unit IIe-2; Loamy range site (L-3).

Athena silt loam, 25 to 40 percent slopes (AtE).-This steep soil is on long, mostly south-facing slopes. Runoff is rapid, and the hazard of erosion is severe. This soil

is used for wheat and barley. Capability unit IVe-8; Loamy range site (L-3).

Athena silt loam, 40 to 55 percent slopes (AtF).-This very steep soil is on north-facing, mostly rough and broken slopes. The surface layer is very dark brown or black silt loam 16 to 20 inches thick. Runoff is very rapid, and the hazard of erosion is very severe. Most of the acreage is used for grazing; a few acres are cultivated. Capability unit VIe-7; North Exposure range site (N-2).

Athena silt loam, 8 to 25 percent slopes, severely eroded (AtD3).-Most of the original surface layer of this soil has been removed by erosion. In most of the acreage, the surface layer is very dark grayish-brown or brown silt loam, and lime is at a depth of 2 to 3 feet. The subsoil is exposed in some places. Runoff is medium to rapid, and the hazard of further erosion is severe. The soil holds 8 to 10 inches of water that plants can use. Included in mapping are small areas that are not eroded. This soil is used for wheat, peas, and barley. Capability unit IVe-9; Loamy range site (L-3).

Athena silt loam, 25 to 40 percent slopes, severely eroded (AtE3).-This steep soil is on long, mostly south-facing slopes. Most of the original surface layer has been removed by erosion. In most places the surface layer is very dark grayish-brown or brown silt loam, and lime is at a depth of 2 to 3 feet. The subsoil is exposed in places. The soil holds 8 to 10 inches of water that plants can use. Runoff is rapid, and the hazard of further erosion is very severe. This soil is used for wheat, barley, grasses, and legumes. Capability unit VIe-4; Loamy range site (L-3) .

Athena silt loam, 40 to 55 percent slopes, severely eroded (AtF3).-This very steep soil is on sharp crests and ridges of north-facing slopes. The original surface layer has been removed by erosion. The present surface layer is very dark grayish-brown or brown silt loam. In most areas lime is below a depth of 5 feet. Runoff is very rapid, and the hazard of erosion is very severe. Included in mapping are areas as steep as 65 percent and areas that are underlain by bedrock at a depth of 40 to 60 inches. This soil is used for grazing. Capability unit VIe-7 ; North Exposure range site (N-2) .

Athena silt loam, moderately shallow, 0 to 15 percent slopes (AuC).-This soil is on short slopes on the first break in the slope between ridgetops and deep canyons. The surface layer is very dark brown or very dark grayish-brown silt loam. Lime is at a depth of about 30 to 40 inches in much of the acreage. Basalt bedrock is at a depth of 40 to 60 inches. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The soil holds about 7 to 10 inches of water that plants can use. Included in mapping are small areas of Tucannon soils that are underlain by bedrock at a depth of 2 to 10 inches. This soil is used for wheat, barley, grasses, and legumes and for grazing. Capability unit IIIe-7; Loamy range site (L-3) .

Athena silt loam, moderately shallow, 15 to 25 percent slopes, eroded (AuD2).-This moderately steep soil is on long slopes that extend into deep canyons. Part of the original surface layer has been removed by erosion, and in places traces of subsoil have been turned up by plowing. This soil is underlain by basalt bedrock at a depth of 40 to 60 inches. It holds about 7 to 10 inches of water that plants can use. Runoff is medium to rapid, and the hazard of erosion is moderate to severe. Included in mapping are a few areas where outcrops of bedrock cover 2 to 5 percent of the surface. This soil is used for wheat, barley, grasses, and legumes and for grazing. Capability unit IVe-10; Loamy range site (L-3).

Athena silt loam, moderately shallow, 25 to 40 percent slopes, eroded (AuE2).-This steep soil is on long slopes that extend into deep canyons. Part of the original surface layer has been removed by erosion, and in some places the subsoil has been exposed by plowing. Basalt bedrock is at a depth of 40 to 50 inches. The soil holds about 6 to 8 inches of water that plants can use. Runoff is rapid, and the hazard of erosion is severe. Included in mapping are a few areas where outcrops of bedrock make up about 10 percent of the areas. Also included are a few areas where bedrock is at a depth of less than 40 inches. Most of the acreage is used for grazing. Part is used for wheat, barley, grasses, and legumes. Capability unit VIe-4; Loamy range site (L-3).

Chard Series

The Chard series is made up of well-drained silt loams on old terraces in the Tucannon River and Snake River Valleys and their major tributary canyons. These soils formed in wind-laid silts and glacial outwash. Slopes are 3 to 40 percent. Elevation ranges from 900 to 1,400 feet. Annual precipitation is 12 to 16 inches. The frost-free season is 170 to 180 days, and mean annual temperature is 54° F. The original vegetation was largely bluebunch wheatgrass and Sandberg bluegrass. Chard soils are associated with Farrell soils at lower elevations and with Oliphant and Walla Walla soils at higher elevations. They are also associated with Asotin and Kuhl soils.

In a representative profile, the surface layer is silt loam or loam about 19 inches thick. It is very dark brown in the upper part and dark brown in the lower part. The subsoil is brown loam about 17 inches thick. It is underlain by a strongly calcareous, brown to dark grayish-brown loam or fine sandy loam substratum that extends to a depth of 60 inches and more.

Chard soils are used mainly for wheat, barley, and grasses and for grazing.

Chard silt loam, 3 to 8 percent slopes (ChB).-This gently undulating soil is on smooth, dissected terraces.

Representative profile of Chard silt loam, 3 to 8 percent slopes, in grassland along Archer Road, 100 feet from the edge of a cultivated field, NW1/4SE1/4 sec. 34, T. 13 N., R. 39 E.

A11-0 to 4 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; massive or weak, thin, platy structure; slightly hard, very friable, nonsticky, nonplastic ; many fine roots; about 10 percent coarse basaltic sand or fine pebbles; neutral; abrupt, wavy boundary. 3 to 6 inches thick.

A12-4 to 9 inches, very dark grayish-brown (10YR 3/2) coarse silt loam grayish brown (10YR 5/2) dry; weak, medium, blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; many fine roots; about 15 percent coarse sand; neutral; clear, smooth boundary. 4 to 7 inches thick.

A3-9 to 19 inches, dark-brown (10YR 3/3) silt loam or loam, brown (10YR 5/3) dry; massive; slightly hard, friable, nonsticky, nonplastic ; common fine roots; 15 percent coarse basaltic sand and fine pebbles; mildly alkaline; clear, smooth boundary. 10 to 18 inches thick.

IIB2-19 to 36 inches, brown (10YR 4/3) loam, brown (10YR 5/3) dry; massive; soft, very friable, nonsticky, nonplastic; common fine roots; mildly alkaline; abrupt, smooth boundary. 18 to 25 inches thick.

IIC1ca-36 to 55 inches, brown (10YR 5/3) loam, pale brown (10YR 6/3) dry; massive; slightly hard, very friable, nonsticky, nonplastic ; few fine roots; strongly effervescent; strongly alkaline; gradual, wavy boundary. 10 to 20 inches thick.

IIC2-55 to 60 inches, dark grayish-brown (10YR 4/2) fine sandy loam, light gray (10YR 7/2) dry; massive; soft, very friable, nonsticky, nonplastic ; few fine roots; weakly effervescent; strongly alkaline.

The texture of the B horizon ranges from silt loam to fine sandy loam. Structure of the IIB2 horizon is weak prismatic or subangular blocky in places. Lenses of coarse sand and fine pebbles may occur anywhere in the IIB2 and IIC horizons.

This soil is moderately permeable. It holds about 9 to 11 inches of water that plants can use. Roots penetrate to a depth of 60 inches and more. Runoff is slow, and the hazard of erosion is slight.

This soil is used mainly for wheat. Capability unit IIe-1; Loamy range site (L-2).

Chard silt loam, 8 to 15 percent slopes (ChC).-This strongly sloping soil is on short slopes in small canyons of the dissected terraces. Runoff is medium, and the hazard of erosion is moderate. Included in mapping are a few severely eroded areas. Most of the acreage is used for wheat and for grazing. A few small areas are irrigated. Capability unit IIIe-4; Loamy range site (L-2).

Chard silt loam, 15 to 30 percent slopes (ChD).-This moderately steep soil is on short slopes in canyons of the dissected terraces. Runoff is medium, and the hazard of erosion is moderate. Included in mapping are severely eroded areas and areas that have bedrock at a depth of 20 to 40 inches. This soil is used for wheat and for grazing. Capability unit IIIe-I; Loamy range site (L-2).

Chard silt loam, 30 to 40 percent slopes (ChE).-This steep soil is on slopes in canyons of the dissected terraces. Runoff is rapid, and the hazard of erosion is severe. Included in mapping are areas where about 10 percent of the acreage is severely eroded and 10 percent is underlain by bedrock at a depth of 20 to 40 inches. This soil is used mainly for wheat and for grazing. Capability unit IVe-5; Loamy range site (L-2).

Couse Series

The Couse series consists of moderately well drained silt loams that are underlain by a buried, very slowly permeable layer at a depth of 24 to 48 inches. These soils formed in wind-laid silt and volcanic ash. They are on ridgetops in the foothills of the Blue Mountains. Large areas are along the Echler Mountain Road just below the timberline and on Robinette Mountain. Slopes are 0 to 25 percent. Elevation ranges from 3,200 to 3,800 feet. Annual precipitation is 24 to 30 inches. The mean annual temperature is 43° F., and the frost-free season is 100 to 120 days. The vegetation is ponderosa pine, a few Douglas-fir, and an understory of snowberry, rose, elksedge, Idaho fescue, and pinegrass. Couse soils are associated with Larkin, Tolo, and Palouse soils.

In a representative profile, the surface layer is very dark brown silt loam 8 inches thick. The subsoil, about 21 inches thick, is very dark grayish-brown or dark-brown silt loam. Beneath this is a buried subsurface horizon of dark grayish-brown or grayish-brown silt loam that extends to a depth of about 42 inches. It is underlain by a buried subsoil horizon of brown or dark grayish-brown silty clay loam that extends to a depth of 60 inches or more (fig. 5).

Couse soils are used mainly for wheat, barley, grasses, and legumes and for woodland and grazing.

Couse silt loam, 0 to 15 percent slopes (CoC).-This strongly undulating soil is on smooth, broad ridgetops.

Representative profile of Couse silt loam, 0 to 15 percent slopes, in a woodlot west of the road and about 420 feet northwest of the south gate, SW1/4SW1/4 sec. 7, T. 8 N., R. 39 E.:

O-1 to 0, mat of pine needles, dry grass, twigs, and leaves in varying stages of decay; abrupt, smooth boundary. 1/2 to 2 1/2 inches thick.

A11-0 to 3 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine and medium, granular structure; slightly hard, friable, nonsticky, nonplastic ; many fine and very fine roots; neutral; abrupt, wavy boundary. 3 to 6 inches thick.

A12-3 to 8 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, medium and coarse, granular structure; slightly hard, friable, slightly sticky, slightly plastic; many fine and very fine roots; slightly acid; clear, wavy boundary. 3 to 6 inches thick.

B21t-8 to 19 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; many fine roots; many fine and medium pores; few thin clay films and organic-matter stains in large pores; slightly acid; clear, wavy boundary. 6 to 10 inches thick.

B22t-19 to 29 inches, dark-brown (10YR 4/3) silt loam, brown (10YR 5/3) dry; weak, medium to coarse, prismatic structure; hard, friable, sticky, plastic; common medium roots; few, thin patchy clay films; slightly acid; gradual, wavy boundary. 5 to 16 inches thick.

A2-B2-29 to 35 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak, coarse, prismatic structure; hard, friable. sticky, plastic; common medium roots; few, medium, distinct, brown mottles; neutral; gradual, wavy boundary. 3 to 15 inches thick.

A2b-35 to 42 inches, grayish-brown (10YR 5/2) silt loam, light gray (10YR 7/2) dry; massive or weak, coarse, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; common, fine and medium, distinct, brown (7.5YR) mottles; few roots; slightly acid; abrupt, wavy boundary. 6 to 10 inches thick.

B21tb-42 to 47 inches, brown (10YR 4/3) silty clay loam, pale brown (10YR 6/3) dry; strong, medium, prismatic structure; very hard, very firm, very sticky, plastic; few flattened roots between peels ; thick, dark-brown clay films on all peel surfaces; dark organic-matter stains on peels ; neutral; abrupt, wavy boundary. 5 to 10 inches thick.

B22tb-47 to 59 inches, dark grayish-brown (10YR 4/2) silty clay loam, light brownish gray (10YR 6/2) dry; moderate, medium, prismatic structure breaking to strong, fine, blocky; very hard, firm, sticky, plastic; very few roots; thick, dark-brown, continuous clay films on all peel surfaces; neutral; gradual, wavy boundary. 10 to 14 inches thick.

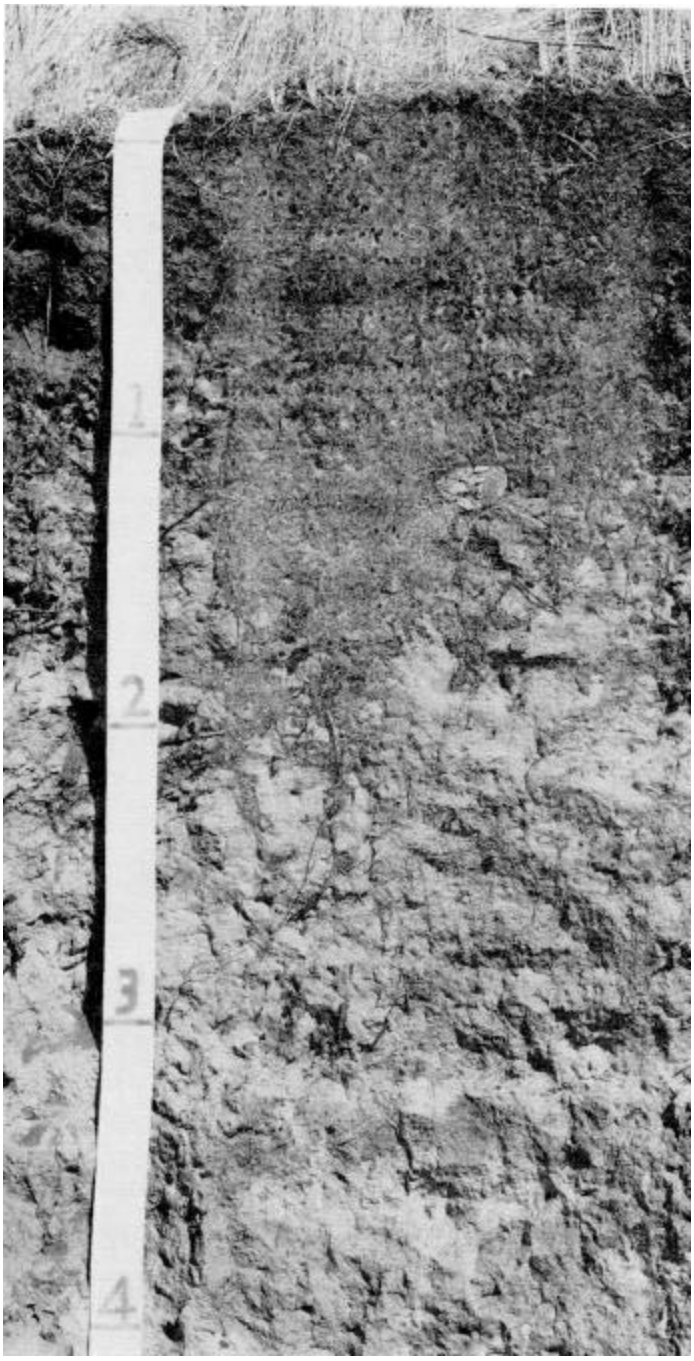

Figure 5.-Profile of Couse silt loam. The dark surface layer is about 8 inches thick. A very slowly permeable layer is at a depth of 42 inches.

B23tb-59 to 72 inches, brown (10YR 4/3) silty clay loam, brown (10YR 5/3) dry; strong, fine, blocky structure; very hard, very firm, very sticky, plastic ; no roots; thick continuous clay films on all ped surfaces; neutral; clear, wavy boundary.

Thickness of the upper sequum ranges from 20 to 40 inches. The A horizon has a color value of 2 or 3 ; lower values occur under the more open stands of timber. Horizons that have a value of 2 are nowhere more than 12 inches thick and commonly are 4 to 6 inches thick. The boundary of the B2t ranges from gradual to tongued. The A2b horizon ranges from 2 to 15 inches in thickness and has an abrupt or clear boundary. The B2tb horizon is silt loam or silty clay loam, but in either case, it is very dense and hard. Basalt bedrock is at a depth of 66 to 96 inches. Contact of the substratum with the bedrock is generally abrupt, but in places there is a weathered transitional zone.

The soil is moderately permeable above the buried subsoil and very slowly permeable in the buried subsoil. It is saturated above the buried subsoil in winter and early in spring. It holds about 8 to 10 inches of water that plants can use. Root penetration is restricted by the buried subsoil, which is at a depth of 36 to 48 inches. Roots penetrate this horizon mainly along ped surfaces and through cracks. Runoff is slow to medium, and the hazard of erosion is moderate. Included in mapping are small areas of wet spots.

This Couse soil is used for growing timber. Capability unit IIIe-8 ; woodland group 3d.

Couse silt loam, 15 to 25 percent slopes (CoD).-This gently sloping to moderately steep soil is on short slopes of broad ridgetops. Depth to the buried soil ranges from 20 to 30 inches. Runoff is medium, and the hazard of erosion is moderate to severe. This soil is used for growing timber. Capability unit IVe-11; woodland group 3d.

Couse silt loam, 0 to 15 percent slopes, eroded (CoC2).-This soil is cultivated. About 25 to 75 percent of its original surface layer has been removed by erosion. In most places the buried subsoil is at a depth of 25 to 36 inches. The soil holds about 5 to 9 inches of water that plants can use. Runoff is slow to medium, and the hazard of further erosion is moderate to severe. Included in mapping are small areas where slope is as much as 25 percent.

Most of the acreage is used for wheat and barley. Capability unit IVe-11; woodland group 4d.

Couse silt loam, 3 to 25 percent slopes, severely eroded (CoD3).-This gently sloping to moderately steep soil is on short slopes of broad ridgetops. Nearly all of the original surface layer has been removed by erosion. This soil holds about 4 to 6 inches of water that plants can use. Runoff is medium to rapid, and the hazard of further erosion is moderate to very severe. Some areas of this soil are abandoned. The rest of the acreage is used for wheat, barley, grasses, and legumes. Capability unit VIe-5 ; woodland group 4d.

Covello Series

The Covello series consists of somewhat poorly drained silt loams that formed in alluvium on valley bottoms in the central part of the county. Typical areas are in Whetstone and Johnson Hollows. Slopes are 0 to 3 percent. Elevation ranges from 1,200 to 2,100 feet. Annual precipitation is 16 to 23 inches. The mean annual temperature is about 51° F., and the frost-free season is 150 to 165 days. The original vegetation was basin wildrye, bluegrass, willows, sedges, and cottonwoods. Covello soils are associated with Mondovi and Patit Creek soils on the bottom lands and with Athena and Palouse soils on the uplands.

In a representative profile, the surface layer is very dark brown silt loam about 10 inches thick. Beneath the surface layer, to a depth of about 50 inches, are stratified

layers of very dark brown to black silt loam. The lower of these layers are strongly calcareous.

Covello soils are used mainly for wheat, barley, grasses, and legumes and for grazing. These soils are greatly improved where drainage is provided.

Covello silt loam, 0 to 3 percent slopes (CvA).-This nearly level soil is on smooth bottom lands.

Representative profile of Covello silt loam, 0 to 3 percent slopes, in a cultivated area on a wide valley bottom, 120 feet north of Highway 3L, 400 feet southwest of Enger Road, SE1/4NW1/4 sec. 34, T. 11 N., R. 39 E.:

Ap-0 to 10 inches, very dark brown (10YR 2/2) silt loam, dark grayish-brown (10YR 4/2) dry; moderate, fine and medium, granular structure; slightly hard, friable, slightly sticky, slightly plastic; common fine and medium roots; moderately alkaline; abrupt, wavy boundary. 6 to 11 inches thick.

C1-10 to 21 inches, very dark brown and very dark grayish-brown (10YR 2/2 and 3/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, coarse, blocky structure; slightly hard, friable, slightly sticky. slightly plastic; common fine and very fine roots; moderately alkaline; abrupt, wavy boundary. 8 to 18 inches thick.

C2-21 to 30 inches, very dark brown (10YR 2/2) silt loam, grayish brown (10YR 4/2) dry; weak, medium, prismatic structure; soft, very friable, nonsticky, nonplastic; common fine and very fine roots; black (10YR 2/1) deposits in coarse pores; moderately alkaline; abrupt, wavy boundary. 6 to 10 inches thick.

AIb-30 to 50 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak, coarse, prismatic or blocky structure; hard, firm, slightly sticky, slightly plastic; few fine roots; common wormholes; strongly effervescent; strongly alkaline; clear, wavy boundary. 14 to 27 inches thick.

IIC-50 to 72 inches, dark-gray (10YR 4/1) very fine sandy loam or silt loam (appears to be mainly volcanic ash), gray (10YR 6/1) dry; massive; soft. very friable, nonsticky, nonplastic ; moderately alkaline. 0 to 30 inches thick.

The recent C1 and C2 overwash is 20 to 30 inches thick. In places the abrupt boundary is masked by the action of earthworms. Texture of the buried A1 horizon ranges from very fine sandy loam to silty clay loam.

This soil is moderately permeable. It holds 10 to 12 inches of water that plants can use. Root penetration is restricted by the water table that is within 24 to 48 inches of the surface most of the time. Runoff is very slow, and there is little or no hazard of erosion. Included in mapping are small spots of volcanic ash that make up about 10 percent of the acreage.

Most of the acreage of this soil is used for grazing. Capability unit IIw-1; Bottomland range site.

Covello silt loam, drained, 0 to 3 percent slopes (CwA).-This soil is similar to Covello silt loam, 0 to 3 percent slopes, but it has been drained, and the water table in most places is below a depth of 60 inches. It holds 10 to 12 inches of water that plants can use. This soil is used mainly for wheat, barley, and peas. Capability unit IIc-2.

Dune Land

Dune land (Du) consists of unstratified or irregularly stratified dunes of fine and very fine sands along the Snake River. The dunes are made up mostly of material eroded from Farrell and Ellisforde soils. They are mostly 5 to 15 feet high and have slopes of 10 to 30 percent.

Dune land supports little or no vegetation, and most of the acreage is idle. Capability unit VIIIe-1.

Ellisforde Series

The Ellisforde series consists of well-drained silt loams that formed in wind-laid silts. These soils are underlain by strongly calcareous, stratified old lakebeds. They are on terraces in the lower part of the Tucannon Valley and the Snake River Canyon. Slopes are 0 to 8 percent. Elevation ranges from 500 to 1,000 feet. The annual precipitation is 10 to 12 inches. The mean annual temperature is 52° F., and the frost-free season, 150 to 180 days. The original vegetation was largely bluebunch wheatgrass and Sandberg bluegrass. Ellisforde soils are associated with Farrell, Kuhl, and Ritzville soils.

In a representative profile, the surface layer is very dark grayish-brown silt loam 7 inches thick. The subsoil is dark-brown or dark grayish-brown silt loam that extends to a depth of 34 inches. The substratum is grayish-brown or dark grayish-brown, strongly calcareous silt loam or very fine sandy loam that extends to a depth of 60 inches or more.

Ellisforde soils are used for wheat, barley, and grasses and for grazing. Part of the acreage is irrigated.

Ellisforde silt loam, 0 to 8 percent slopes (EwB).-This nearly level and gently sloping soil is on river and lake terraces.

Representative profile of Ellisforde silt loam, 0 to 8 percent slopes, in a cultivated field about 750 feet south of the northeast corner of section 30, NE1/4NE1/4 sec. 30, T. 13 N., R. 39 E.:

Ap-0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, very fine, granular grading to weak, fine, blocky structure; slightly hard to hard, very friable, slightly sticky, nonplastic ; common medium and coarse roots; mildly alkaline; abrupt, wavy boundary. 6 to 14 inches thick.

B21-7 to 22 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; weak, coarse, prismatic structure; slightly hard, very friable, slightly sticky, slightly plastic; many coarse and medium roots; mildly alkaline; clear, wavy boundary. 8 to 14 inches thick.

B22-22 to 34 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak, coarse, prismatic structure; slightly hard, very friable, slightly sticky, nonplastic ; common medium and coarse roots; moderately alkaline; abrupt, smooth boundary. 8 to 12 inches thick.

IIC1-34 to 48 inches, grayish-brown (2.5Y 5/2) silt loam, light gray (2.5Y 7/2) dry; massive; very hard, friable, slightly sticky, slightly plastic; very few roots; some pores filled with lime; violently effervescent; strongly alkaline; abrupt, smooth boundary. 10 to 16 inches thick.

IIC2-48 to 66 inches, dark grayish-brown (10YR 4/2) very fine sandy loam, light brownish gray (10YR 6/2) dry; massive; hard, friable, nonsticky, nonplastic; no roots; violently effervescent; strongly alkaline.

The Ap horizon is silt loam or very fine sandy loam.

This soil is moderately permeable above the substratum and moderately slowly permeable in the substratum. It holds about 6 to 9 inches of water that plants can use. Roots penetrate the substratum mostly through cracks. Runoff is slow, and the hazard of erosion is slight. In-

eluded in snapping are some areas that are severely eroded and some areas where slopes are 30 percent.

This soil is used for wheat, barley, and grasses. Small areas are irrigated. Capability unit IIIe-1; Loamy range site (L-2).

Ellisforde very fine sandy loam, 0 to 8 percent slopes, eroded (EvB2).-Except for texture of the surface layer, this soil is similar to Ellisforde silt loam, 0 to 8 percent slopes. It holds about 5 to 8 inches of water that plants can use. The hazard of soil blowing is moderate. This soil is used for wheat, barley, and grasses. Small areas are irrigated. Capability unit IIIe-2; Loamy range site (L-2).

Esquatzel Series

The Esquatzel series consists of well-drained silt loams and very fine sandy loams that formed in alluvium. These soils are on flood plains crossed by old, shallow, meandering stream channels. The largest areas are in the lower part of the Tucannon Valley. Smaller areas are along drainageways in the northwestern part of the county. Slopes are 0 to 3 percent. Elevation ranges from 600 to 1,000 feet. Annual precipitation is 10 to 12 inches. The mean annual temperature is 53° F., and the frost-free season is 150 to 180 days. The vegetation was largely bluebunch wheatgrass, Sandberg bluegrass, and giant wildrye. Esquatzel soils are associated with Ritzville and Farrell soils.

In a representative profile, the surface layer is very dark grayish-brown silt loam 15 inches thick. The underlying material to a depth of 60 inches or more, is weakly stratified,, dark grayish-brown to dark-brown very fine sandy loam or silt loam that is strongly calcareous in the upper part.

Esquatzel soils are used mainly for wheat, barley, and grasses in nonirrigated areas and for alfalfa, asparagus, and sweet corn in irrigated areas.

Esquatzel silt loam, 0 to 3 percent slopes (EzA).-This nearly level soil is on valley bottoms along larger streams.

Representative profile of Esquatzel silt loam, 0 to 3 percent slopes, in a cultivated field, about 800 feet from the section line down the center of the section, 250 feet north of the road, NE1/4NE1/4 sec. 10, T. 12 N., R. 37 E.:

Ap-0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, medium, granular structure; slightly hard, friable slightly sticky, slightly plastic; common fine, medium, and coarse roots; weakly effervescent; moderately alkaline; abrupt, smooth boundary. 5 to 12 inches thick.

A1-7 to 15 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; slightly hard, friable, slightly sticky, slightly plastic; many fine, medium, and coarse roots; strongly effervescent; strongly alkaline; abrupt, smooth boundary. 5 to 8 inches thick.

C1-15 to 31 inches, dark grayish-brown (10YR 4/2) very fine sandy loam, light brownish gray (10YR 6/2) dry; massive; slightly hard, very friable, slightly sticky, nonplastic; common medium and coarse roots; strongly effervescent; strongly alkaline: abrupt, smooth boundary. 7 to 16 inches thick.

C2-31 to 46 inches, dark grayish-brown (10YR 4/2) very fine sandy loam, light brownish gray (10YR 6/2) dry; massive; slightly hard, very friable, slightly sticky, nonplastic; common medium and coarse roots; moderately alkaline; abrupt, smooth boundary. 12 to 18 inches thick.

C3-46 to 60 inches, dark-brown (10YR 4/3) silt loam, brown (10YR 5/3) dry; massive; slightly hard, very friable, slightly sticky and nonplastic ; common coarse roots; moderately alkaline.

When moist, the A horizon is dark brown to very dark grayish brown. The texture is silt loam or very fine sandy loam. In places there is a layer of fine sand in the C horizon. Typically, the depth to lime is about 24 inches, but lime may occur in any horizon.

This soil is moderately permeable. It holds about 9 to 11 inches of water that plants can use. Roots penetrate to a depth of 60 inches and more. Surface runoff is very slow, and there is little or no hazard of erosion.

This soil is used for wheat, barley, and grasses in nonirrigated areas and for alfalfa, wheat, and sugar beets in irrigated areas. Capability unit IIIc-1.

Esquatzel very fine sandy loam, 0 to 3 percent slopes, eroded (EyA2).-Except for texture of the surface layer, this soil has the profile described for the series. Runoff is slow, and the hazard of soil blowing is moderate. This soil is used for wheat, barley, and grasses in nonirrigated areas and for alfalfa and wheat in irrigated areas. Capability unit IIIe-2.

Farrell Series

The Farrell series consists of well-drained very fine sandy loams and fine sandy loams that formed in wind-laid silts and very fine sands that overlie glacial outwash. These soils are on terraces and terrace fronts in the lower part of the Tucannon Valley and the Snake River Canyon. Slopes are 0 to 45 percent. Elevation ranges from 700 to 1,700 feet. Annual precipitation is 10 to 12 inches. The mean annual temperature is 55° F., and the frost-free season is 160 to 190 days. In areas that have not been cultivated, the vegetation is bluebunch wheatgrass, needle-and-thread, and Sandberg bluegrass. These soils are associated with Ellisforde, Kuhl, and Ritzville soils.

In a representative profile, the surface layer is very dark grayish-brown very fine sandy loam 8 inches thick. The subsoil is dark-brown very fine sandy loam that extends to a depth of 28 inches. It is underlain by a strongly calcareous, brown to dark grayish-brown substratum of fine sandy loam, silt loam, or very fine sandy loam that extends to a depth of 60 inches and more.

Farrell soils are used for wheat, barley, and grasses and for grazing. Small irrigated areas are used for alfalfa, hay, and asparagus and for grass pasture.

Farrell very fine sandy loam, 3 to 8 percent slopes (FeB).-This gently sloping soil is on terrace remnants.

Representative profile of Farrell very fine sandy loam, 3 to 8 percent slopes, in grassland, in a roadbank of Tucannon Road, a half mile west of Rivera Road and 50 feet west of post No. 50, SE1/4NW1/4 sec. 20, T. 12 N., R. 38 E.:

Ap-0 to 8 inches, very dark grayish-brown (10YR 3/2) very fine sandy loam, grayish brown (10YR 5/2) dry; weak, thin, platy structure; soft to slightly hard, very friable, nonsticky, nonplastic ; common fine roots; mildly alkaline; abrupt, smooth boundary. 6 to 10 inches thick.

B2-8 to 28 inches, dark-brown (10YR 3/3) very fine sandy loam, brown (10YR 5/3) dry; weak, coarse, blocky structure; slightly hard, friable, nonsticky, nonplastic ; common fine roots: moderately alkaline; abrupt, smooth boundary. 8 to 24 inches thick.

C1ca-28 to 36 inches, brown (10YR 4/3) very fine sandy loam, pale brown (10YR 6/3) dry; massive, slightly hard, friable, nonsticky, nonplastic ; few fine roots; strongly effervescent; moderately alkaline; abrupt, wavy boundary. 4 to 10 inches thick.

IIC2ca-36 to 54 inches, dark grayish-brown (10YR 4/2) fine sandy loam, light brownish gray (10YR 6/2) dry; massive; slightly hard, friable, nonsticky and nonplastic; few fine roots; strongly effervescent; strongly alkaline; abrupt, wavy boundary, 16 to 20 inches thick.

IIIC3ca-54 to 60 inches, dark grayish-brown (2.5Y 4/2) silt loam, light brownish gray (25Y 6/2) dry-, massive-, slightly hard, friable, nonsticky, nonplastic ; violently effervescent; strongly alkaline.

The A horizon ranges from dark grayish brown to dark brown in color and from very fine sandy loam to sandy loam in texture. Intermittent lenses of sand and fine pebbles may occur at any location in the IIIC horizon. Depth to the lime layers is commonly 14 to 30 inches.

This soil is moderately permeable. It holds about 9 to 11 inches of water that plants can use. Roots penetrate to a depth of 60 inches and more. Runoff is slow, and the hazard of water erosion is slight. There is a moderate hazard of soil blowing.

Nonirrigated areas of this soil are used for wheat, barley, and grasses and for grazing. Irrigated crops include alfalfa, grasses, and asparagus. Capability unit IIIe-2; Loamy range site (L-2).

Farrell very fine sandy loam, 8 to 15 percent slopes (FeC).-This strongly sloping soil is on terrace remnants. Slopes are short. Runoff is medium, and the hazard of soil blowing and water erosion is moderate. Nonirrigated areas of this soil are used for wheat, barley, and grasses and for grazing. Alfalfa is grown in irrigated areas. Capability unit IIIe-3; Loamy range site (L-2).

Farrell very fine sandy loam, 15 to 30 percent slopes (FeD).-This moderately steep soil is on terrace escarpments. Slopes are short. Runoff is medium, and the hazard of soil blowing and water erosion is moderate. Included in mapping are small areas that have been severely eroded. Nonirrigated areas of this soil are used for wheat, barley, and grasses and for grazing. Alfalfa is grown in irrigated areas. Capability unit IIIe-3; Loamy range site (L-2).

Farrell very fine sandy loam, 30 to 45 percent slopes (FeE).-This steep soil is on terrace escarpments, mostly on short, north-facing slopes. Runoff is rapid, and the hazard of erosion is severe. Included in mapping are areas where slope is steeper than 45 percent. Most of the acreage of this soil is used for grazing. A few very small areas are cultivated. Capability unit IVe-4; Loamy range site (L-2) .

Farrell fine sandy loam, 0 to 3 percent slopes (FaA).-This nearly level soil is on terrace remnants. It is dominantly fine sandy loam throughout, and lime is at a depth of 3 feet or more. Permeability is moderately rapid. This soil holds about 8 to 10 inches of water that plants can use. Surface runoff is very slow. There is little or no hazard of water erosion. The hazard of soil blowing is moderate. Most of the acreage is irrigated alfalfa and asparagus. Some nonirrigated areas are used for wheat and grasses. Capability unit IVe-2; Sandy Loam range site.

Farrell fine sandy loam, 3 to 15 percent slopes, eroded (FaC2).-This gently sloping to strongly sloping soil is on terrace remnants. It is dominantly fine sandy loam throughout, and lime is at a depth of 3 feet or more. Permeability is moderately rapid. The soil holds about 8 to 10 inches of water that plants can use. Most of the acreage is irrigated and used for alfalfa. Part of the nonirrigated acreage is used for wheat and grasses. Capability unit IVe-2; Sandy Loam range site.

Farrell fine sandy loam, 15 to 30 percent slopes, eroded (FaD2).-This moderately steep soil is on short slopes on terrace fronts. It is dominantly fine sandy loam throughout, and lime is at a depth of 3 feet or more. Permeability is moderately rapid. The soil holds about 8 to 10 inches of water that plants can use. Runoff is medium, and the hazard of soil blowing and water erosion is moderate. This soil is used for grazing. Capability unit VIe-1; Sandy Loam range site.

Farrell fine sandy loam, 30 to 45 percent slopes (FaE).-This steep soil is on terrace fronts or escarpments, mostly on north-facing slopes. It is dominantly fine sandy loam throughout. Permeability is moderately rapid. The soil holds about 8 to 10 inches of water that plants can use. Runoff is medium to rapid, and the hazard of erosion is moderate to severe. This soil is used for grazing. Capability unit VIe-1; Sandy Loam range site.

Gwin Series

The Gwin series consists of well-drained gravelly and cobbly silt loams that formed in weathered basalt and wind-laid silts. These soils are underlain by basalt bedrock at a depth of 10 to 20 inches. They are on canyon walls in the central part of the county and in the Blue Mountain foothills. Slopes are 30 to 65 percent. Elevation ranges from 2,000 to 4,000 feet. The annual precipitation is 16 to 23 inches, and the mean annual temperature is about 48° F. The frost-free season is 100 to 150 days. The vegetation is mainly bluebunch wheatgrass, Idaho fescue , and Sandberg bluegrass. At lower elevations the Gwin soils are on north-facing slopes and are associated with Athena soils. At higher elevations they are on south-facing slopes and are associated with Palouse soils.

In a representative profile, the surface layer is black gravelly silt loam about 9 inches thick. The subsoil is dark-brown very gravelly and cobbly silt loam to silty clay that rests directly on basalt bedrock at a depth of about 20 inches.

Gwin soils are used for grazing, wildlife habitat, and watershed.

Gwin extremely rocky silt loam, 30 to 65 percent slopes (GwF).-This steep to very steep soil is on basalt uplands and along canyons. Rock outcrops and areas of very thin soils averaging about 30 feet in diameter make up 20 to 30 percent of the acreage.

Representative profile of Gwin extremely rocky silt loam, 30 to 65 percent slopes, in grassland, about 500 feet south and 600 feet east of the west quarter corner of the section, and 250 feet northwest of Ridge Road, NW1/4 SW1/4 sec. 28, T. 10 N., R. 41 E.:

A1-0 to 5 inches, black (10YR 2/1) silt loam, very dark grayish brown (10YR 3/2) dry; moderate, fine, granular structure; slightly hard, friable, sticky, plastic; many fine and very fine roots; about 10 percent is angular basalt fragments 1/2 inch to 2 inches in di-

ameter ; neutral; abrupt, wavy boundary. 2 to 5 inches thick.

A12-5 to 9 inches, black (10YR 2/1) gravelly and cobbly silt loam, very dark grayish brown (10YR 3/2) dry; moderate, fine, granular structure; slightly hard, friable, sticky, plastic; many fine roots; approximately 40 percent is basalt fragments 1 inch to 5 inches in diameter; neutral; clear, wavy boundary. 0 to 8 inches thick.

B21t-9 to 15 inches, dark-brown (10YR 3/3) very gravelly and cobbly silt loam, dark grayish brown (10YR 4/2) dry; moderate, coarse, granular and moderate, fine, blocky structure; hard, friable, sticky, plastic; many fine roots; thin almost continuous clay films; about 60 percent` is basalt fragments 1 inch to 5 inches in diameter; neutral; clear, wavy boundary. 4 to 10 inches thick.

B22t-15 to 20 inches, dark-brown (10YR 3/3) very gravelly and cobbly silty clay, brown (10YR 4/3) dry; moderate, medium, prismatic and moderate, fine, blocky structure; hard, friable, sticky, plastic; common fine roots; 70 percent is basalt, largely attached; thick clay films on basalt, thin continuous clay films on peds; neutral; clear, irregular boundary. 3 to 12 inches thick.

C-20 inches, basalt bedrock.

Depth to bedrock is 10 to 20 inches. The A horizon ranges from black to very dark brown in color.

This soil has moderately slow permeability. It holds about 1.5 to 3 inches of water that plants can use. Roots penetrate to the bedrock. Runoff is rapid, and the hazard of erosion is very severe. Included in mapping are areas where slopes are 0 to 30 percent and a few spots that are severely eroded.

This soil is used mainly for grazing and for wildlife habitat. Capability unit VIIs-2; Shallow range site (S-3).

Hermiston Series

The Hermiston series consists of very deep, well-drained silt loams that formed in alluvium. These soils are on bottom lands. Large areas are along the Touchet River below Dayton and in the lower part of the Whetstone Valley. Slopes are 0 to 3 percent. Elevation ranges from 900 to 2,000 feet. Annual precipitation is 12 to 16 inches. The mean annual temperature is approximately 54° F., and the frost-free season is 160 to 180 days. The original vegetation was largely bluebunch wheatgrass and giant wildrye. Hermiston soils are associated with Onyx soils on the bottom lands and with Walla Walla soils on the uplands.

In a representative profile, the uppermost 21 inches is very dark brown silt loam. This is underlain by silt loam that is very dark grayish brown and extends to a depth of 60 inches or more. The soil is calcareous below a depth of 32 inches.

All of the acreage of Hermiston soils is cultivated. Wheat, peas, and barley are the main crops in nonirrigated areas. Asparagus, alfalfa, and apple orchards are irrigated.

Hermiston silt loam, 0 to 3 percent slopes (HmA).-This nearly level soil is on valley bottom lands.

Representative profile of Hermiston silt loam, 0 to 3 percent slopes, in a cultivated field, 1.5 miles west of Dayton and 200 feet south of State Highway No. 410, SE1/4SW1/4 sec. 35, T. 10 N., R. 38 E.:

AP-0 to 10 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; soft; very friable, slightly sticky, slightly plastic; many fine roots; neutral; abrupt, smooth boundary. 8 to 12 inches thick.

AC-10 to 21 inches, very dark brown (10YR 2/2) silt loam. dark grayish brown (10YR 4/2) dry; weak, coarse, blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many fine roots; neutral; clear, wavy boundary. 10 to 14 inches thick.

C1-21 to 32 inches, very dark grayish-brown (10YR 3/2) silt loam. grayish brown (10YR 5/2) dry; massive; slightly hard, friable, sticky, plastic; many roots; neutral; gradual, wavy boundary. 11 to 18 inches thick.

C2-32 to 50 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; massive; slightly hard, friable, slightly sticky, slightly plastic; common roots; very weakly effervescent; mildly alkaline. 10 to 18 inches thick.

C3-50 to 66 inches, dark grayish-brown (10YR 4/2) silt loam light brownish gray (10YR 6/2) dry; massive; slightly hard, friable, sticky, plastic; few roots; strongly effervescent; strongly alkaline.

The A horizon in some places is very fine sandy loam. Depth to lime is dominantly 16 to 36 inches. The color value of the A1 and Ap horizons is 2 to 3 moist and 4 to 5 dry. In some areas, a mixture of volcanic ash imparts a color that is grayer than typical in the A horizon.

This soil is moderately permeable. Roots penetrate to a depth of 60 inches and more. The soil holds 10 to 12 inches of water that plants can use. Runoff is very slow, and there is little or no hazard of erosion. Included in mapping are strongly alkaline areas.

This soil is used for wheat, barley, peas, and alfalfa. Part of the acreage is irrigated. Capability unit IIc-1.

Klicker Series

The Klicker series consists of well-drained gravelly silty clay loams that are underlain by basalt bedrock at a depth of 20 to 40 inches. These soils formed in weathered basalt mixed with wind-laid silts. They are on east-facing and west-facing canyon walls in the Blue Mountains. Slopes are 40 to 90 percent. Elevations ranges from 3,000 to 4,500 feet. Annual precipitation is 30 to 40 inches, and the mean annual temperature is approximately 45° F. The frost-free season is 90 to 115 days. The vegetation is open stands of pine or Douglas-fir and an understory that includes bluebunch wheatgrass, slender wheatgrass, snowberry, and Oregon grape. Klicker soils are associated with Anatone soils on south-facing and southwest-facing slopes and with Tolo soils mostly on north-facing slopes.

In a representative profile, very dark brown silt loam, 1 inch thick, is overlain by a thin layer of partially decomposed pine needles, leaves, grasses, and twigs. The upper part of the subsoil, at a depth of 1 to 10 inches, is dark reddish-brown silt loam. The lower part is dark-brown gravelly or very gravelly silty clay loam or silty clay that rests on basalt bedrock at a depth of 30 inches.

Klicker soils are used mainly for woodland, grazing, and wildlife.

Klicker very rocky silt loam, 40 to 65 percent slopes (KlF).-This very steep soil is on slopes that extend into deep canyons. Rock outcrops and very thin soils make up about 10 to 25 percent of the acreage.

Representative profile of Klicker very rocky silt loam, 40 to 65 percent slopes, in woodland, about 200 feet north-

west of the east sixteenth of the corner of the quarter section, NE1/4SW1/4 sec. 33, T. 10 N., R. 41 E.:

O-2 inches to 0, decaying pine needles, leaves, grasses, and twigs.
A1-0 to 1 inch, very dark brown (10YR 2/2) silt loam, dark brown (10YR 3/3) dry; moderate, medium, granular structure; slightly hard, friable, slightly sticky, slightly plastic; many fine roots; many basalt fragments; slightly acid; abrupt, wavy boundary. 1 to 5 inches thick.
B1-1 to 10 inches, dark reddish-brown (5YR 3/2) silt loam, dark reddish gray (5YR 4/2) dry; moderate, fine, blocky structure; hard, friable, slightly sticky, slightly plastic; many coarse and common fine roots; 5 to 10 percent is basalt fragments an inch in diameter; neutral; clear, wavy boundary. 5 to 10 inches thick.
B21t-10 to 22 inches, dark-brown (7.5YR 3/2) gravelly silty clay loam or silty clay, brown (7.5YR 5/4) dry; weak, medium, prismatic and moderate, fine. subangular blocky structure; hard, friable, sticky, plastic; many coarse roots; moderately thick patchy clay films on vertical surfaces; 30 percent is coarse basalt gravel; neutral; clear, wavy boundary. 6 to 12 inches thick.
B22t-22 to 30 inches, dark-brown (7.5YR 3/2) very gravelly silty clay, strong brown (7.5YR 5/6) dry; moderate, fine, blocky structure; hard, friable, sticky, plastic many coarse roots; thick clay films on rocks; 60 percent is basalt fragments; neutral; broken boundary, gradually merging with basalt. 7 to 14 inches thick.
IIR-30 inches, basalt.

The A horizon ranges from 5YR to 10YR in hue. Hue of 10YR occurs where a large part of the understory is grass. The B2t horizon is finer textured where there are more basaltic materials than wind-laid silt. The depth to bedrock ranges from 20 to 40 inches.

This soil has moderately slow permeability. It holds about 3 to 5 inches of water that plants can use. Roots penetrate to the bedrock. Runoff is rapid, and the hazard of water erosion is very severe. Included in mapping are areas where slope is less than 30 percent and areas that are less than 20 inches deep over bedrock.

This soil is used for grazing, woodland, and wildlife habitat. Capability unit VIIs-2; woodland group 4x.

Klicker-Rock land complex, 65 to 90 percent slopes (KrG).-This complex is about half Klicker silt loam and half Rock land. Rock land consists of rock outcrops and very shallow soils. Numerous escarpments are present in the areas. Runoff is very rapid, and the hazard of erosion is very severe.

Areas of this complex are used mainly as wildlife habitat and watershed. Capability unit VIIIs-1.

Kuhl Series

The Kuhl series consists of well-drained gravelly silt loams that are underlain by basalt bedrock at a depth of 12 to 20 inches. These soils formed in wind-laid silts mixed with some weathered basalt. They are on mostly south-facing slopes at the edges of plateaus. Slopes are 0 to 65 percent. Elevation ranges from 1,400 to 2,400 feet. Annual precipitation is 10 to 17 inches. The mean annual temperature is about 54° F., and the frost-free season is 150 to 160 days. The vegetation is largely bluebunch wheatgrass and Sandberg bluegrass. Kuhl soils are associated mainly with Walla Walla and Chard soils.

In a representative profile, the surface layer is very dark grayish-brown gravelly silt loam about 9 inches thick. The subsoil is dark-brown gravelly silt loam that extends to a depth of about 16 inches. Basalt bedrock is at a depth of about 16 inches.

Kuhl soils are used mainly for grazing and wildlife habitat.

Kuhl very rocky silt loam, 0 to 30 percent slopes (KuD).-This nearly level to moderately steep soil is in areas where rock outcrops and very shallow soils make up about 10 to 25 percent of the acreage. Most areas are less than an acre in size. Some nonrocky areas are as large as 5 acres, but most are smaller.

Representative profile of Kuhl very rocky silt loam, 0 to 30 percent slopes, in grassland, 400 feet north of the second bend of Jackson Road above Willow Creek, SEl/4NW1/4 sec. 16, T. 11 N., R. 39 E.:

A1-0 to 4 inches, very dark grayish-brown (10YR 3/2) gravelly silt loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; slightly hard, friable, nonsticky, nonplastic ; common roots; 20 percent is basalt gravel, cobblestones, and stones; mildly alkaline; gradual, wavy boundary. 2 to 6 inches thick.
A3-4 to 9 inches, very dark grayish-brown (10YR 3/2) gravelly silt loam, grayish brown (10YR 5/2) dry; weak, medium, prismatic structure; slightly hard, friable, slightly plastic; common roots; more than 20 percent is basalt gravel, cobblestones, and stones; mildly alkaline; gradual, wavy boundary. 3 to 6 inches thick.
B2-9 to 16 inches, dark-brown (10YR 3/3) gravelly silt loam, brown (10YR 4/3) dry; weak. fine, subangular blocky structure; hard, friable, slightly sticky, slightly plastic; few fine roots; about 25 percent is basalt gravel, cobblestones, and stones; mildly alkaline; clear, wavy boundary. 6 to 10 inches thick.
IIR-16 inches, basalt bedrock.

Bedrock is at a depth of 12 to 20 inches. The A1 horizon is very dark grayish brown to very dark brown and gravelly to cobbly.

This soil is moderately permeable. It holds about 1.5 to 3 inches of water that plants can use. Roots penetrate to the bedrock. Runoff is slow to medium, and the hazard of erosion is moderate. This soil is used for grazing and wildlife habitat. Capability unit VIIs-2; Shallow range site (S-2).

Kuhl extremely rocky silt loam, 30 to 65 percent slopes (KvF).-Rock outcrops and very shallow soils make up about 25 to 50 percent of this unit. Most such areas are less than an acre in size. Runoff is rapid, and the hazard of erosion is very severe. Vertical escarpments of exposed bedrock are included in mapping. The soil is used for grazing and wildlife habitat. Capability unit VIIs-2; Shallow range site (S-2).

Larkin Series

The Larkin series consists of well-drained soils that have a silty clay loam subsoil. These soils formed in wind-laid silts in the Blue Mountains. Slopes are 0 to 65 percent. Elevation ranges from 2,500 to 4,500 feet. Annual precipitation is 18 to 30 inches. The mean annual temperature is about 48° F., and the frost-free season is 120 to 140 days. The vegetation is largely ponderosa pine and Douglas-fir and an understory of spirea, hawthorn, snowberry, alder, rose, and pinegrass. Larkin soils are associated mainly with Couse, Palouse, Linville, and Tolo soils.

In a representative profile, the surface layer is very dark brown and very dark grayish-brown silt loam that extends to a depth of about 9 inches. The upper part of the subsoil is dark-brown silt loam that extends to a depth of 27 inches. The lower part is dark-brown heavy silt loam or silty clay loam that rests on basalt bedrock at a depth of 50 inches.

Larkin soils are used mainly for woodland, grazing, wildlife habitat, and watershed.

Larkin silt loam, 40 to 65 percent slopes (LaF).-This very steep soil is on north-facing slopes in the foothills of the Blue Mountains.

Representative profile of Larkin silt loam, 40 to 65 percent slopes, in an area of trees, brush, and grasses, 200 feet north of Cahill Mountain Road and about 1,300 feet below the Cahill Ranch Road, SW1/4NE1/4 sec. 18, T. 9 N., R. 40 E.:

O1-1.5 inches to 0, litter of moss, pine needles, leaves from deciduous shrubs, and grasses and twigs.

A11-0 to 3 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine and medium, granular structure; slightly hard, friable, slightly sticky, slightly plastic; many fine and medium roots; neutral; abrupt, wavy boundary, 2 to 4 inches thick.

A12-3 to 6 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak platy structure; slightly hard, friable, slightly sticky, slightly plastic; many coarse, medium, and fine roots; neutral; abrupt, wavy boundary. 2 to 4 inches thick.

A3-6 to 9 inches, very dark grayish-brown (10YR 3/2) silt loam, dark brown (10YR 4/3) dry; weak, medium and fine, blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many medium and coarse roots; bleached grains of silt on vertical ped surface; neutral; abrupt, smooth boundary. 2 to 6 inches thick.

B11-9 to 12 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3 crushed) dry; moderate subangular blocky structure; hard, friable, slightly sticky, slightly plastic; many medium and coarse roots; few gray silt grains on all vertical surfaces; neutral; gradual, wavy boundary. 4 to 6 inches thick.

B12-12 to 27 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 4/3) dry; very dark brown (10YR 2/2) streaks; weak, coarse and medium, prismatic structure; hard, friable, sticky, plastic; many coarse roots; many wormholes 1/4 inch in diameter; neutral; gradual, wavy boundary. 10 to 15 inches thick.

B21t-27 to 35 inches, dark-brown (10YR 3/3 crushed) heavy silt loam or light silty clay loam, brown (10YR 4/3) dry; weak, medium, prismatic and moderate, fine, subangular blocky structure; dark colored (10YR 2/2 moist) films of clay and organic matter on all ped surfaces and in wormholes; neutral; clear, wavy boundary. 8 to 12 inches thick.

B22t-35 to 50 inches, dark-brown (10YR 3/3) silty clay loam, brown (10YR 5/3 crushed) dry; moderate, fine, subangular blocky structure; hard, friable, sticky, plastic; few medium roots; many, thin, patchy clay films; about 10 percent is basalt fragments 1/2 inch to 2 inches in diameter; neutral. 12 to 26 inches thick.

IIR-50 inches, basalt bedrock.

Depth to bedrock ranges from 4 to 6 feet. In some places the A3 horizon has a dry value of 5 or 6 and is much like an A2 horizon. The color of the Bt horizon is dark brown to brown when moist, and hue is 7.5YR.

This Larkin soil is moderately permeable. It holds about 9 to 12 inches of water that plants can use. Roots penetrate to the bedrock. Runoff is very rapid, and the hazard of erosion is very severe.

This soil is used for woodland, grazing, wildlife habitat, and watershed. Capability unit VIIe-4; woodland group 1r.

Larkin silt loam, moderately shallow, 0 to 25 percent slopes (LkD).-This nearly level to moderately steep soil occupies broad ridgetops between deep canyons. Depth to fractured basalt ranges from 30 to 55 inches. A depth of less than 40 inches is outside the defined range for the series, but this difference does not significantly alter the usefulness and behavior of the soil.

This soil holds 5 to 9 inches of water plants can use. Runoff is slow to medium, and the hazard of erosion is moderate.

This soil is used for woodland, grazing, and wildlife habitat. Small areas formerly cultivated along with the Couse soils have been abandoned. Capability unit IVe-11; woodland group 4o.

Larkin silt loam, moderately shallow, 25 to 40 percent slopes (LkE).-This steep soil extends into deep canyons. Depth to fractured basalt bedrock ranges from 30 to 55 inches. A depth of less than 40 inches is outside the defined range for the series, but this difference does not alter the usefulness and behavior of the soil. Runoff is rapid, and the hazard of erosion is severe to very severe. Included in mapping are areas that have bedrock outcrops. Areas of very shallow soils are also included. This soil is used for woodland and for wildlife habitat. Capability unit VIe-5 ; woodland group 4r1.

Larkin silty clay loam, 15 to 25 percent slopes, severely eroded (LrD3).-This moderately steep soil is on sides of ridges near steep canyon walls. Depth to fractured basalt bedrock ranges from 30 to 55 inches. A depth of less than 40 inches is outside the defined range for the series, but this difference does not alter the usefulness and behavior of this soil. Much of the original surface layer of this formerly cultivated soil has been removed by erosion. There are numerous gullies about 18 inches deep and 30 inches across. This soil holds 4 to 8 inches of water that plants can use. Runoff is medium to rapid, and the hazard of erosion is high. This Larkin soil is used for woodland and for wildlife habitat. Capability unit VIe-5; woodland group 4d.

Linville Series

The Linville series consists of very steep, well-drained silt loams that are underlain by basalt bedrock at a depth of 40 inches to more than 60 inches. These soils formed in wind-laid silts that contain some volcanic ash and weathered basalt. They are on north-facing slopes. Slopes are 40 to 65 percent. Elevation ranges from 1,500 to 2,800 feet. Annual precipitation is 16 to 20 inches. The mean annual temperature is about 50° F., and the frost-free season is 140 to 160 days. The vegetation is Idaho fescue, bluebunch wheatgrass, hawthorn, chokecherry, aspen, and rose. Linville soils are associated with Athena and Walla Walla soils on rolling uplands.

In a representative profile, the surface layer is very dark brown silt loam about 35 inches thick. The subsoil, about 25 inches thick, is very dark grayish-brown or dark-brown silty clay loam that rests on basalt bedrock at a depth of about 60 inches.

Linville soils are used mainly for grazing and wildlife habitat.

Linville silt loam, 40 to 65 percent slopes (LvF).-This very steep soil is on north-facing slopes that extend into deep canyons.

Representative profile of Linville silt loam, 40 to 65 percent slopes, in grassland, on a hillside 250 feet south of Hardsack grade and 0.6 mile above Tucannon Road, SW1/4SE1/4 sec. 5, T. 10 N., R. 41 E.:

O-1/2 inch to 0, litter of decaying grass and leaves from deciduous shrubs; abrupt, smooth boundary. 0 to 1 inch thick.

A11-0 to 3 inches, very dark brown (10YR 2/2) silt loam, very dark grayish brown (10YR 3/2) dry; weak, fine, granular structure; soft, very friable, slightly sticky, slightly plastic; many fine roots; neutral; abrupt, wavy boundary. 2 to 4 inches thick.

A12-3 to 12 inches, very dark brown (10YR 2/2) silt loam, very dark grayish brown (10YR 3/2) dry; massive to weak, medium, blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many medium and fine roots; common wormholes 3/8 inch in diameter; neutral; gradual, wavy boundary. 6 to 9 inches thick.

A13-12 to 22 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; common fine and many coarse roots; many wormholes; neutral; clear, wavy boundary. 8 to 14 inches thick.

A3-22 to 35 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, fine, subangular blocky structure; slightly hard, friable, sticky, plastic; common medium and few fine roots; wormholes lined with black organic materials; neutral; clear, wavy boundary. 6 to 14 inches thick.

B21t-35 to 49 inches, very dark grayish-brown (10YR 3/2 rubbed) silty clay loam, dark grayish brown (10YR 4/2) dry; moderate, fine, subangular blocky or moderate, coarse, granular structure; hard, friable, sticky, plastic; few medium roots; wormholes lined with thick, black deposits of organic material and clay; neutral; clear, wavy boundary. 10 to 14 inches thick.

B22t-49 to 60 inches. dark-brown (10YR 3/3) silty clay loam, brown (10YR 4/3) dry; weak, moderate, prismatic structure; hard, friable, sticky, plastic; common fine roots; neutral. 8 to 14 inches thick.

R-60 inches, basalt bedrock.

The depth to basalt ranges from 40 to 60 inches or more. The B horizon ranges from heavy silt loam to light silty clay loam. Pieces of basalt ranging from 1 to 6 inches in size are in all horizons in amounts ranging from 1 percent in the A horizon to 25 percent in some parts of the B horizon.

This soil is moderately permeable. It holds 9 to 12 inches of water that plants can use. Roots penetrate to the bedrock. Runoff is very rapid, and the hazard of erosion is very severe.

The soil is used for grazing and for wildlife habitat. Capability unit VIIe-3; North Exposure range site (N-2).

Mondovi Series

The Mondovi series consists of well-drained silt loams on valley bottoms. These soils formed in alluvium. They are in Whetstone and Johnson Hollows and in the upper part of the Tucannon and Touchet River Valleys. Slopes are 0 to 3 percent. Elevation ranges from 1,600 to 2,400 feet. Annual precipitation is 16 to 20 inches. The mean annual temperature is 50° F., and the frost-free season is 150 to 165 days. The original vegetation was giant wildrye, bluebunch wheatgrass, willows, and cottonwoods. Mondovi soils are associated with Covello and Patit Creek soils on the bottom lands and with Athena, Palouse, Tucannon, and Gwin soils on the uplands.

In a representative profile, the surface layer is very dark brown silt loam about 10 inches thick. The substratum is stratified layers of very dark brown or very dark gray silt loam to a depth of more than 60 inches. In some places the substratum is weakly calcareous at a depth of about 48 inches.

Mondovi soils are used for small grain and peas.

Mondovi silt loam, 0 to 3 percent slopes (MoA).-This nearly level soil is on wide bottom lands.

Representative profile of Mondovi silt loam, 0 to 3 percent slopes, in a cultivated field, 530 feet south and 500 feet west of the northwest corner of the section, NE1/4NE1/4 sec. 34, T.11 N., R. 39 E.:

Ap-0 to 10 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; slightly hard, friable, slightly sticky, slightly plastic; common fine roots; neutral; abrupt, smooth boundary. 8 to 10 inches thick.

C1-10 to 34 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; massive; slightly hard, friable, slightly sticky, slightly plastic; common fine roots; neutral; abrupt, smooth boundary. 18 to 24 inches thick.

C2-34 to 48 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; moderately alkaline; clear, wavy boundary. 14 to 24 inches thick.

C3-48 to 66 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/2) dry; massive; slightly hard, friable, sticky, plastic; few fine roots; weakly effervescent; moderately alkaline.

The profile is weakly to strongly stratified. The horizon that is effervescent is lacking in places. In some places the soil is mottled below a depth of 48 inches.

This soil is moderately permeable. It holds 10 to 12 inches of water that plants can use. Roots penetrate to a depth of 60 inches or more. Runoff is very slow, and there is little or no hazard of erosion.

This soil is used for small grain and peas. Capability unit IIc-2.

Oliphant Series

The Oliphant series consists of well-drained silt loams that are underlain by basalt bedrock at a depth of 40 to 60 inches. These soils formed in wind-laid silts. They are on uplands in the northeastern part of the county. Slopes are 0 to 40 percent. Elevation ranges from 900 to 2,000 feet. Annual precipitation is 12 to 16 inches. The mean annual temperature is about 50° F., and the frost-free season is 135 to 150 days. The original vegetation was largely bluebunch wheatgrass, Sandberg bluegrass, and small amounts of Idaho fescue on the north-facing slopes. Oliphant soils are associated with Asotin, Chard, Spofford, and Walla Walla soils.

In a representative profile, the surface layer is very dark grayish-brown silt loam about 13 inches thick. The subsoil, about 15 inches thick, is very dark grayish-brown to brown silt loam. The substratum is light brownish-

gray to brown, strongly calcareous silt loam and rests on basalt bedrock at a depth of about 50 inches.

Oliphant soils are used for wheat, barley, grasses, and legumes and for grazing.

Oliphant silt loam, 15 to 30 percent slopes (OlD).-This moderately steep soil is on ridgetops and plateaus.

Representative profile of Oliphant silt loam, 15 to 30 percent slopes, in grassland, on the east side of Jackson Road, 900 feet north of the east-west centerline of section 10, T. 11 N., R. 39 E.:

Ap-0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, very fine granular and weak, medium, blocky structure; soft, very friable, nonsticky, nonplastic ; many fine roots; neutral; abrupt, wavy boundary. 5 to 8 inches thick.

A1-6 to 13 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, medium, blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; many fine roots; mildly alkaline; clear, wavy boundary. 6 to 10 inches thick.

B21-13 to 20 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; slightly more clay than in the A1 horizon; weak, medium, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; many fine and very fine roots; few thin coatings (may be clay films) on vertical faces; mildly alkaline; clear, wavy boundary. 4 to 12 inches thick.

B22-20 to 28 inches, brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; moderate prismatic structure; hard, friable, slightly sticky, slightly plastic; common fine roots; trace of fine pebbles; strongly alkaline; abrupt, wavy boundary. 0 to 12 inches thick.

IICa1-28 to 36 inches, light brownish-gray (10YR 6/2) silt loam, white (10YR 8/2) dry; weak, coarse, prismatic structure; hard, friable, sticky, nonplastic ; few fine roots; 5 percent is fine basalt pebbles; effervesces violently with dilute hydrochloric acid; strongly alkaline; clear, wavy boundary. 6 to 12 inches thick.

IICca2-36 to 50 inches, brown (10YR 5/3) silt loam, very pale brown (10YR 7/3) dry; massive or weak, coarse, prismatic structure; hard, friable, sticky, nonplastic ; few fine roots; 10 percent is fine pebbles with lenses of almost pure pebbles; some free water after winter precipitation; effervesces strongly with dilute hydrochloric acid; strongly alkaline; abrupt, wavy boundary. 6 to 18 inches thick.

IIIR-50 inches, basalt bedrock with lime cementation in fractures.

Depth to basalt bedrock is 40 to 60 inches. The moist color of the A horizon ranges from very dark grayish brown on south-facing slopes to very dark brown on north-facing slopes. The Cca horizon is strongest where it rests directly on the basalt and weakest where it overlies silt. The depth to the Cca horizon ranges from 20 to 40 inches.

This soil is moderately permeable. It holds 6 to 9 inches of water that plants can use. Root penetration is restricted by the strongly calcareous substratum. Runoff is medium, and the hazard of erosion is moderate to severe. About 1 percent of the acreage is severely eroded.

This soil is used for wheat, barley, grasses, and legumes and for grazing. Capability unit IVe-7; Loamy range site (L-2).

Oliphant silt loam 0 to 15 percent slopes (OlC).-This nearly level to strongly sloping soil is on ridgetops and plateaus. Runoff is slow to medium, and the hazard of erosion is moderate. This soil is used for wheat, barley, grasses, and legumes and for grazing. Capability unit IIIe-5; Loamy range site (L-2).

Oliphant silt loam, 30 to 40 percent slopes (OlE).-This steep soil is in areas that have a few rock outcrops. Runoff is rapid, and the hazard of erosion is severe to very severe. Most of the acreage is used for grazing. Capability unit VIe-3; Loamy range site (L-2).

Onyx Series

The Onyx series consists of well-drained silt loams that formed in recent alluvium on valley bottoms. The largest areas of these soils are in the lower part of the Whetstone Valley and along the Touchet River below Dayton. Slopes are 0 to 3 percent. Elevation ranges from 500 to 2,000 feet. Annual precipitation is 12 to 18 inches. The mean annual temperature is 52° F., and the frost-free season is 160 to 180 days. The vegetation is mainly bluebunch wheatgrass and some cottonwoods and willows near the streams. Onyx soils are associated mainly with Yakima and Hermiston soils on the bottom lands.

In a representative profile, the surface layer is very dark brown silt loam about 7 inches thick. The substratum is commonly stratified and is very dark grayish-brown silt loam to a depth of 60 inches or more. Some areas near Waitsburg are underlain by gravel at a depth of 40 to 60 inches.

Onyx soils are used mainly for wheat and barley in nonirrigated areas and for alfalfa, grasses, asparagus, and apple orchards in irrigated areas.

Onyx silt loam, 0 to 3 percent slopes (OnA).-This nearly level soil is on bottom lands along perennial and intermittent streams.

Representative profile of Onyx silt loam, 0 to 3 percent slopes, in a cultivated field, 300 feet north of the junction of Whetstone and McKay Roads and west of McKay Road, NW1/4SW1/4 sec. 34, T. 10 N., R. 37 E.:

Ap-0 to 7 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; slightly hard, friable, slightly sticky, slightly plastic; many fine and very fine roots; slightly acid; abrupt, smooth boundary. 6 to 10 inches thick.

C1-7 to 22 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; massive; slightly hard, friable, slightly sticky, slightly plastic; common fine roots; neutral; clear, wavy boundary. 12 to 20 inches thick.

C2-22 to 60 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; massive; soft, very friable, nonsticky, nonplastic ; few fine roots; mildly alkaline; clear, smooth boundary.

In some places, as a result of recent deposits of alluvium, the Ap horizon is a very dark grayish brown. Individual layers in some places contain a maximum amount of sand for a silt loam. In about 500 acres near Waitsburg the Onyx soils are underlain by gravel at a depth of 40 to 60 inches, have a water table within 3 feet of the surface in spring, and are mottled below a depth of about 3 feet.

This soil is moderately permeable. It holds 10 to 12 inches of water that plants can use. Roots penetrate to a depth of 60 inches or more. Runoff is very slow, and there is little or no hazard of erosion. A few areas near Waitsburg are flooded occasionally.

This soil is used for small grain, alfalfa, and asparagus and for orchards. Part of the acreage is irrigated. Capability unit IIc-1.

Palouse Series

The Palouse series consists of well-drained silt loams. Bedrock generally is at a depth of more than 60 inches, but in some areas bedrock is at a depth of 40 to 60 inches. These soils are on uplands in the lower foothills of the Blue Mountains. Slopes are 0 to 5 percent. Elevation ranges from 2,000 to 3,500 feet. Annual precipitation is 19 to 23 inches. The mean annual temperature is approximately 51° F., and the frost-free season is 140 to 165 days. The original vegetation was largely Idaho fescue and bluebunch wheatgrass. Palouse soils are associated with Couse soils at higher elevations. They are also associated with Waha, Gwin, Larkin, and Tucannon soils.

In a representative profile, the surface layer is very dark brown to black silt loam about 20 inches thick. The subsoil is dark-brown silt loam that extends to a depth of 60 inches or more (fig. 6).

Palouse soils are used mainly for wheat, barley, peas, alfalfa, and grasses and for grazing.

Palouse silt loam, 0 to 8 percent slopes (PaB).-This nearly level and gently sloping soil is on ridgetops and foot slopes.

Representative profile of Palouse silt loam, 0 to 8 percent slopes, in a cultivated field, 100 feet east of the gate at the junction of Cavello and Magee Roads, SE1/48W1/4 sec. 2, T. 10 N., R. 40 E.:

Ap-0 to 10 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, fine and medium, granular structure; slightly hard, friable, slightly sticky, slightly plastic; many fine and very fine roots; slightly acid; abrupt, smooth boundary. 7 to 10 inches thick.

A1-10 to 15 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak, medium, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; common fine roots; neutral; clear, smooth boundary. 5 to 10 inches thick.

A3-15 to 20 inches, very dark brown (10YR 2/2) silt loam, grayish brown (10YR 5/2) dry; weak, medium, prismatic structure; hard, friable, sticky, plastic; common fine roots; thin clay films and gray silt on vertical surfaces; neutral; clear, wavy boundary. 5 to 12 inches thick.

B2-20 to 39 inches, dark-brown (10YR 4/3) silt loam, brown (10YR 5/3) dry; moderate, medium, prismatic structure; hard, firm, sticky, plastic; common fine roots; thick continuous coatings of silt and organic matter on peds ; gray silica coatings on vertical surfaces; small krotovinas and dark organic-matter stains; neutral; gradual, wavy boundary. 12 to 24 inches thick.

B3-39 to 60 inches, dark-brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; moderate, medium and coarse, prismatic structure; hard, firm, sticky, plastic; few roots; thin coatings on ped faces; neutral.

The color of the A horizon ranges from very dark brown in cultivated fields to black in native grassland. In nearly level areas, at the foot of slopes, in swales, and in depressions, the surface layer is very dark brown or black and is 20 to 30 inches thick. The B2 horizon is silt loam to light silty clay loam and dark brown to yellowish brown.

This soil is moderately permeable. It holds 10 to 12 inches of water that plants can use. Roots penetrate to a depth of 60 inches or more. Runoff is slow, and the hazard of erosion is slight.

This soil is used for wheat, barley, peas, grasses, and legumes. Capability unit IIe-2; Loamy range site (L-3).

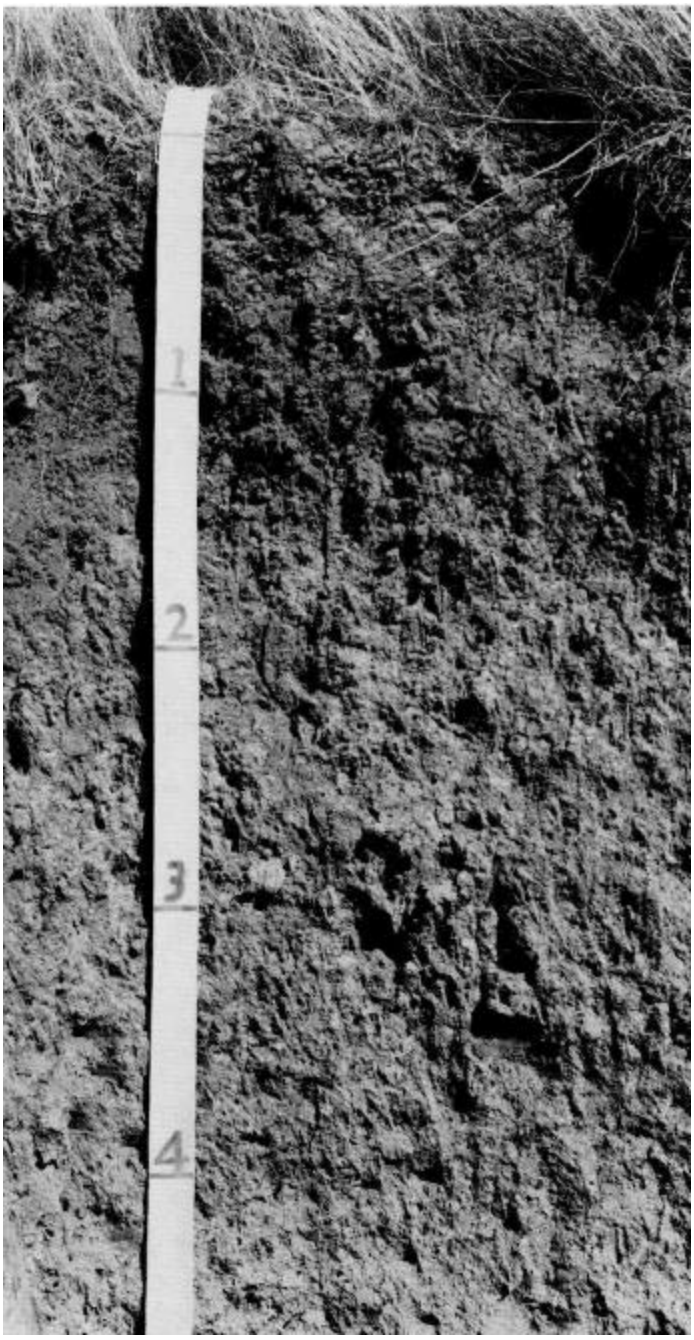

Figure 6.-Profile of Palouse silt loam, that has a dark-colored surface layer about 20 inches thick. The soil is free of lime.

Palouse silt loam, 8 to 25 percent slopes (PaD).-This strongly sloping to moderately steep soil is on uplands. Included in mapping are concave areas where the very dark brown or black surface layer is thicker than 20 inches. Runoff is medium, and the hazard of erosion is moderate. This soil is used for wheat, barley, peas, grasses, and legumes. Capability unit IIIe-6; Loamy range site (L-3).

Palouse silt loam, 25 to 40 percent slopes (PaE).This steep soil is on uplands. Runoff is rapid and the hazard

of erosion is severe. This soil is used for wheat, barley, grasses, and legumes. Capability unit IVe-8 ; Loamy range site (L-3) .

Palouse silt loam, 40 to 55 percent slopes (PaF).-This very steep soil is on north-facing slopes. Included in mapping are areas that have a few rock outcrops and areas where bedrock is at a depth of 40 to 60 inches. Runoff is very rapid, and the hazard of erosion is very severe. This soil is used for grazing. Capability unit VIe-7; North Exposure range site (N-3) .

Palouse silt loam, 8 to 25 percent slopes, severely eroded (PaD3).-This strongly sloping to moderately steep soil is on uplands. More than 75 percent of the original dark-colored surface layer has been removed by erosion, and the dark-brown subsoil is exposed by tillage. Runoff is medium to rapid, and the hazard of further erosion is severe. The soil is used for wheat, barley, grasses, and legumes. Capability unit IVe-9; Loamy range site (L-3).

Palouse silt loam, 25 to 40 percent slopes, severely eroded (PaE3).-This steep soil is on uplands. More than 75 percent of the original dark-colored surface layer has been removed by erosion, and the dark-brown subsoil is exposed by tillage. Runoff is rapid, and the hazard of erosion is very severe. This soil is used for wheat, barley, grasses, and legumes. Capability unit VIe-4; Loamy range site (L-3) .

Palouse silt loam, moderately shallow, 3 to 15 percent slopes (PeC).-This gently sloping to strongly sloping soil is on uplands. Bedrock is at a depth of 40 to 60 inches. The soil holds 7 to 10 inches of water that plants can use. Runoff is medium, and the hazard of erosion is moderate. Included with this soil in mapping are very small, severely eroded areas. This soil is used for wheat, barley, and grasses. Capability unit IIIe-7; Loamy range site (L-3) .

Palouse silt loam, moderately shallow, 15 to 25 percent slopes, eroded (PeD2).-This moderately steep soil is on uplands. Bedrock is at a depth of 40 to 60 inches. About 25 to 75 percent of the original dark-colored surface layer has been lost through erosion. This soil holds 7 to 10 inches of water that plants can use.. Runoff is medium rapid, and the hazard of erosion is severe. This soil is used for wheat, barley, and grasses. Capability unit IVe-10; Loamy range site (L-3).

Palouse silt loam, moderately shallow, 25 to 40 percent slopes, eroded (PeE2).-This steep soil is on uplands. Basalt bedrock is at a depth of 40 to 60 inches. About 25 to 75 percent of the original dark-colored surface layer has been lost through erosion. This soil holds 7 to 10 inches of water that plants can use. Runoff is rapid, and the hazard of erosion is very severe. This soil is used for wheat, barley, and grasses and for grazing. Capability unit VIe-4; Loamy range site (L-3).

Patit Creek Series

The Patit Creek series consists of well-drained silt loam is that are underlain by very gravelly sandy loam at a depth of 20 to 40 inches. These soils formed in alluvium on valley bottoms. Slopes are 0 to 3 percent. Elevation ranges from 1,200 to 2,500 feet. Annual precipitation is 16 to 24 inches. The mean annual temperature is about 50° F., and the frost-free season is 155 to 165 days. The original vegetation was largely bluebunch wheatgrass, cottonwoods, ponderosa pine, and Douglas-fir. Patit Creek soils are associated with Covello and Mondovi soils on the bottom lands and with Athena, Palouse, and Tucannon soils on the uplands.

In a representative profile, the surface layer is very dark brown silt loam about 6 inches thick. The substratum is stratified, very dark brown silt loam to a depth of 36 inches. Below this is dark-brown very gravelly sandy loam that extends to a depth of 60 inches or more. In some places the soil is gravelly or cobbly throughout the profile. The content of cobblestones and stones in Patit Creek soils is outside the defined range of the series, but this difference does not alter the usefulness or behavior of the soils.

Patit Creek soils are used for wheat, barley, alfalfa, grasses, asparagus, and apple orchards and for grazing. Some areas are irrigated.

Patit Creek silt loam, 0 to 3 percent slopes (PkA).-This nearly level soil is on wide bottom lands along streams.

Representative profile of Patit Creek silt loam, 0 to 3 percent slopes, in a cultivated field, a half mile west of Dumas, SE1/4NW1/4 sec. 4, T. 9 N., R. 38 E.:

Ap-0 to 6 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; slightly hard, friable, slightly sticky, slightly plastic; common roots; some earthworm channels and casts; neutral; abrupt, smooth boundary. 5 to 8 inches thick.

C1-6 to 12 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, medium and fine, granular structure; slightly hard, friable, sticky, plastic; common roots; some earthworm channels and casts; about 5 percent is gravel; neutral; clear, wavy boundary. 4 to 8 inches thick.

C2-12 to 24 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, medium, prismatic structure; hard, friable, sticky, plastic; common roots; some earthworm channels and casts; few, faint, fine mottles; very few, thin, patchy clay films on peds; about 5 percent is gravel; neutral; clear, wavy boundary. 5 to 15 inches thick.

C3-24 to 36 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; massive; slightly hard, friable, sticky, plastic; few roots; some earthworm channels and casts; about 5 percent is gravel; neutral; clear, wavy boundary. 8 to 24 inches thick.

IIC4-36 to 66 inches, dark-brown (10YR 3/3) very gravelly sandy loam, brown (10YR 5/3) dry; massive; soft, friable, nonsticky, nonplastic ; few roots; few, faint, fine mottles; about 70 percent is pebbles 1/2 inch to 3 inches in diameter; neutral.

Depth to the very gravelly sandy loam IIC horizon is 20 to 40 inches.

This soil has moderate permeability above the very gravelly sandy loam layer and rapid permeability within that layer. Root penetration is somewhat restricted by the very gravelly layer. The soil holds 5 to 8 inches of water that plants can use. Runoff is very slow, and there is little or no hazard of erosion.

This soil is used for wheat, barley, alfalfa, and grasses and for orchards. Some areas are irrigated. Capability unit IIs-1; Bottomland range site.

Patit Creek gravelly silt loam, 0 to 3 percent slopes (PlA).-This soil is 20 to 40 inches of gravelly silt loam over

a very gravelly sandy loam horizon. It holds about 4 to 7 inches of water that plants can use. Where irrigated, this soil is used for improved pasture and orchards. Nonirrigated areas are used for native pasture. Capability unit IIIs-1; Bottomland range site.

Patit Creek cobbly silt loam, 0 to 3 percent slopes (PoA).-This soil contains 40 to 50 percent rounded cobblestones and stones throughout. It holds about 3 to 6 inches of water that plants can use. Runoff is very slow. This soil is used for grazing. Capability unit VIs-1; Bottomland range site.

Ritzcal Series

The Ritzcal series consists of well-drained silt loams that formed in wind-laid, strongly calcareous silts. These soils are on south-facing and southwest-facing slopes. Slopes are 15 to 40 percent. Elevation ranges from 1,000 to 2,000 feet. Annual precipitation is 10 to 16 inches. The mean annual temperature is about 54° F., and the frost-free season is 140 to 160 days. The original vegetation was largely bluebunch wheatgrass and Sandberg bluegrass. Ritzcal soils are associated with Walla Walla and Ritzville soils that are on the ridgetops and north-facing slopes.

In a representative profile, the surface layer is dark-brown silt loam 12 inches thick. The underlying material is dark grayish-brown, mildly calcareous silt loam to a depth of 20 inches and grayish-brown or brown, strongly calcareous silt loam to a depth of 70 inches. Lime nodules and fragments of caliche are present throughout the profile.

Ritzcal soils are used mainly for wheat and for grazing.

Ritzcal silt loam, 15 to 40 percent slopes (RcE).-This moderately steep and steep soil is on slopes that face south and southwest. The hazard of erosion is moderate.

Representative profile of Ritzcal silt loam, 15 to 40 percent slopes, in a cultivated field, about 1,540 feet northeast of the section line on Pedicord Road and 300 feet northwest of the road, SW1/4NW1/4 see. 32, T. 11 N., R. 38 E.:

Ap-0 to 8 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; weak, fine, granular structure; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; occasional fine lime nodules or fragments of caliche ; neutral; abrupt, smooth boundary. 6 to 10 inches thick.

A1-8 to 12 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; weak blocky structure; slightly hard, friable, slightly sticky, slightly plastic; common fine roots; few fragments of caliche ; mildly alkaline; clear, wavy boundary. 2 to 6 inches thick.

C1-12 to 20 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; common fine roots; many lime nodules or fragments of caliche 1 to 3 millimeters in size; mildly effervescent, moderately alkaline; clear, irregular boundary. 0 to 10 inches thick.

C2ca-20 to 30 inches, grayish-brown (10YR 5/2) silt loam, light gray (10YR 7/2) dry; strong, medium, subangular blocky structure; hard, firm, nonsticky, nonplastic; weakly cemented; mat of fine roots at top of horizon; few fine roots in fractures; violently effervescent; moderately alkaline; diffused, broken boundary. 4 to 12 inches thick.

C3ca-30 to 42 inches, brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; moderate; medium, blocky structure; slightly hard or hard, firm, nonsticky, nonplastic ; few fine roots; pores lined with white lime; strongly effervescent; moderately alkaline; gradual, wavy boundary. 8 to 16 inches thick.

C4ca-42 to 70 inches, brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; massive; slightly hard, very friable, nonsticky, nonplastic ; few fine roots; pores lined with a thin film of lime; strongly effervescent; moderately alkaline.

The depth to the Cca horizon ranges from 8 to 20 inches. In some cultivated fields, the underlying limy material has been mixed into the plow layer. The pale-brown calcareous material is exposed in about 3 percent of the acreage.

This soil is moderately permeable. Root penetration is restricted by the strong lime layer. The soil holds about 5 to 7 inches of water that plants can use. Runoff is medium to rapid, and the hazard of erosion is severe.

This soil is used mainly for wheat and for grazing. Capability unit IVe-3; Loamy range site (L-2).

Ritzville Series

The Ritzville series consists of well-drained silt loams that formed in wind-laid silts on uplands. In most areas these soils are more than 60 inches deep over bedrock. Slopes are 0 to 65 percent. Elevation ranges from 800 to 1,400 feet. Annual precipitation is 10 to 12 inches. The mean annual temperature is about 53° F., and the frost-free season is 140 to 160 days. The original vegetation was largely bluebunch wheatgrass and Sandberg bluegrass. Ritzville soils are associated mainly with Roloff, Stratford, Kuhl, and Farrell soils.

In a representative profile, the surface layer is very dark grayish-brown silt loam 9 inches thick. The subsoil is dark-brown to dark grayish brown silt loam that extends to a depth of 52 inches. The substratum is pale-brown, strongly calcareous silt loam to a depth of 60 inches or more.

Ritzville soils are used for wheat, barley, and grasses and for grazing.

Ritzville silt loam, 0 to 8 percent slopes (ReB).-This nearly level and gently sloping soil is on terraces and ridgetops.

Representative profile of Ritzville silt loam, 0 to 8 percent slopes, in grassland, on Sand Road right-of-way, 2.5 miles southwest of Kellogg Hollow Road, NW1/4NW1/4 sec. 26, T. 12 N., R. 37 E.:

A11-0 to 4 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, very fine, granular structure; soft, very friable, nonsticky, nonplastic ; many fine and very fine roots; neutral; abrupt, wavy boundary. 2 to 4 inches thick.

A12-4 to 9 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, coarse, blocky structure; slightly hard, very friable, slightly sticky, nonplastic ; many fine and very fine roots; mildly alkaline; clear, wavy boundary. 3 to 7 inches thick.

B1-9 to 17 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; weak, medium, prismatic structure; soft, very friable, nonsticky, nonplastic ; many fine roots; mildly alkaline; gradual, wavy boundary. 7 to 10 inches thick.

B2-17 to 52 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak, coarse, prismatic structure; soft, very friable, nonstick, nonplastic ; common fine roots; mildly alkaline; gradual, wavy boundary. 16 to 40 inches thick.

Cca-52 to 72 inches, pale-brown (10YR 6/3) silt loam, white (10YR 8/2) dry; massive; hard, friable, slightly sticky, nonplastic ; very few fine roots; strongly effervescent; strongly alkaline.

The A horizon is silt loam or very fine sandy loam and is dark grayish brown to dark brown when moist. In some places the Cca horizon is hard and compact and almost weakly cemented. Depth to the Cca horizon is 30 to 60 inches. The deeper soils are in gently sloping areas and on north-facing slopes.

This soil is moderately permeable. It holds 10 to 12 inches of water that plants can use. Roots penetrate to a depth of 60 inches or more. Runoff is slow, and the hazard of erosion is slight. About 3 percent of the acreage has been severely eroded. In a few places, bedrock is at a depth of 40 to 60 inches.

This soil is used for wheat, barley, and grasses and for grazing. Capability unit IIIe-1; Loamy range site

Ritzville silt loam, 8 to 30 percent slopes (ReD).-This strongly sloping and moderately steep soil is on hilly uplands. Most slopes are long. Runoff is medium, and the hazard of erosion is moderate. Included with this soil in mapping are small areas that are severely eroded. This soil is used for wheat and barley and for grazing. Capability unit IIIe-3 ; Loamy range site (L-2) .

Ritzville silt loam, 30 to 40 percent slopes (ReE).-This steep soil is on uplands. Runoff is rapid, and the hazard of erosion is severe. About 10 to 15 percent of the acreage is severely eroded. This soil is used for wheat, barley, and grasses and for grazing. Capability unit IVe-4; Loamy range site (L-2).

Ritzville silt loam, 40 to 65 percent slopes (ReF).-This very steep soil is on north-facing slopes. Runoff is very rapid, and the hazard of erosion is very severe. This soil is used for grazing. Capability unit VIIe-2; North Exposure range site (N-1) .

Riverwash

Riverwash (Rn) consists of nearly level or gently sloping areas of unsorted sand, gravel, and cobblestones along streams. It is frequently flooded and is unsuited to farming. Capability unit VIIIw-1.

Rock Land

Rock land (Ro) consists of areas that have rock outcrops and areas of very shallow soils less than 10 inches thick. Rock land is mainly in steep and very steep, mountainous areas. It is unsuited to farming and is used mostly as wildlife habitat. Capability unit VIIIs-1.

Roloff Series

The Roloff series consists of well-drained silt loams that are underlain by basalt bedrock at a depth of 20 to 40 inches. These soils formed in wind-laid silts and glacial outwash. They are on basalt plateaus, rolling or hilly uplands, and old terraces. Slopes are 0 to 65 percent. Elevation ranges from 800 to 1,400 feet. Annual precipitation is 10 to 12 inches. The mean annual temperature is about 53° F., and the frost-free season is 140 to 160 days. The vegetation was largely bluebunch wheatgrass and Sandberg bluegrass. Roloff soils are associated mainly with Ritzville, Farrell, Ellisforde, and Kuhl soils.

In a representative profile, the surface layer is very dark grayish-brown silt loam about 8 inches thick. The subsoil is dark-brown silt loam about 8 inches thick. The substratum is brown silt loam that contains many fragments of basalt. It rests on bedrock at a depth of about 28 inches.

Roloff soils are used for wheat and grasses and for grazing.

Roloff silt loam, 0 to 30 percent slopes (RsD).-This nearly level to moderately steep soil is on uplands.

Representative profile of Roloff silt loam, 0 to 30 percent slopes, in grassland, junction of Field Gulch Road and Sand Road, 540 feet north-northwest of the gate and 110 feet west of the road, SE1/4SE1/4 sec. 9, T. 12 N., R. 37 E.:

A11-0 to 3 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, medium, platy structure; soft, very friable, slightly sticky, slightly plastic; many fine and very fine roots; neutral; clear, smooth boundary. 3 to 5 inches thick.

A12-3 to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, medium, blocky structure; slightly hard, very friable, slightly sticky, slightly plastic; many roots; mildly alkaline; gradual, wavy boundary. 3 to 5 inches thick.

B1-8 to 16 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/) dry; weak subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; common roots; mildly alkaline; gradual, wavy boundary. 4 to 8 inches thick.

C-16 to 28 inches, brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; massive; slightly hard, friable, slightly sticky, slightly plastic; common roots; 5 to 10 percent is sharp basaltic fragments 1/16 to 1/2 inch in diameter; moderately alkaline; abrupt, wavy boundary. 10 to 22 inches thick.

IIR-28 inches, basalt bedrock.

The A1 horizon ranges from silt loam to very fine sandy loam in texture. The B horizon ranges in moist value from 3 to 4 and in chroma from 2 to 3. Depth to basalt ranges from 20 to 40 inches. In some deeper profiles, the soil material below a depth of 30 inches and basalt contain lime. In some profiles the C horizon contains up to 40 percent coarse basaltic sand and fine gravel mixed with the loess.

This soil is moderately permeable. It holds 4 to 7 inches of water that plants can use. Roots penetrate to the bedrock. Runoff is slow to medium, and the hazard of erosion is slight to moderate.

This soil is used for wheat and grasses and for grazing. Capability unit IVe-1; Loamy range site (L-2).

Roloff silt loam, 30 to 45 percent slopes (RsE).-This steep soil is on uplands. Runoff is rapid, and the hazard of erosion is severe. A few rock outcrops are included in some areas. This soil is used for grazing. Capability unit VIe-2; Loamy range site (II-2).

Roloff silt loam, 45 to 65 percent slopes (RsF).-This very steep soil is on uplands. Runoff is very rapid, and the hazard of erosion is very severe. Many rock outcrops are included in some areas. This soil is used for grazing. Capability unit VIIe-1; Loamy range site (L-2).

Roloff rocky very fine sandy loam, 15 to 40 percent slopes (RrE).-This moderately steep to steep soil is on old terraces, plateaus, and slopes that extend into canyons. Areas of rock outcrops and very shallow soils, mostly about 10 to 15 feet in diameter, make up 5 to 10 percent of the acreage. This soil is very fine sandy loam in all

parts above bedrock. Runoff is medium to rapid, and the hazard of erosion is moderate to severe. Some areas of this loam contain 15 to 25 percent gravel and cobblestones. This soil is used for grazing. Capability unit VIe-2 ; Loamy range site (L-2) .

Roloff-Kuhl complex, 8 to 30 percent slopes (RuD).-This complex is made up of about 50 percent Roloff silt loam and about 40 percent Kuhl silt loam. Rock outcrops make up about 10 percent of the acreage. Areas of the Roloff soil are mostly 0.1 to 0.5 acre in size. This complex is used for grazing. Capability unit VIe-2; Roloff soil in Loamy range site (L-2), Kuhl soil in Shallow range site (S-2) .

Roloff-Kuhl complex, 30 to 65 percent slopes (RuF).-This complex is about 50 percent Roloff silt loam and about 30 percent Kuhl silt loam. Rock outcrops occupy about 20 percent of the acreage. Areas of the Roloff soil are mostly 0.1 to 0.5 acre. in size. Runoff is rapid, and the hazard of erosion is very severe. This complex is used for grazing. Capability unit VIIe-1; Roloff soil in Loamy range site (L-2), Kuhl soil in Shallow range site (S-2).

Spofford Series

The Spofford series consists of moderately well drained silt loams that are underlain by basalt bedrock at a depth of 20 to 40 inches. These soils formed in wind-laid silts. They are in small areas north of the Tucannon River. Slopes are 8 to 15 percent. Elevation ranges from 500 to 2,000 feet. Annual precipitation is 12 to 19 inches. The mean annual temperature is about 53° F., and the frost-free season is 150 to 180 days. The original vegetation was largely bluebunch wheatgrass and Sandberg bluegrass. Spofford soils are associated mainly with Asotin, Athena, Oliphant, Tucannon, and Walla Walla soils.

In a representative profile, the surface layer is very dark grayish-brown to very dark brown silt loam about 6 inches thick. The upper part of the subsoil, about 7 inches thick, is very dark grayish-brown heavy silt loam that is strongly alkaline and has a strong columnar structure. The lower part of the subsoil is dark-brown, strongly calcareous heavy silt loam about 7 inches thick. The substratum is dark grayish-brown, strongly calcareous
silt loam that is underlain by basalt bedrock at a depth of 32 inches. In this survey area the Spofford soils have basalt bedrock at a depth of 20 to 40 inches. This is outside the defined range for the series, but this difference does not significantly alter the usefulness or behavior of the soils.

Spofford soils are used mainly for grazing. Many small areas are used for the same crops as the larger areas of surrounding soils.

Spofford silt loam, 8 to 15 percent slopes (SpC).-This strongly sloping soil is mostly in areas less than 3 acres in size. Many areas of this soil are too small to map separately and are included in large tracts of Asotin, Athena, Oliphant, Tucannon, and Walla Walla soils.

Representative profile of Spofford silt loam, 8 to 15 percent slopes, in grassland, about 530 feet west of the south quarter corner, SE1/4SW1/4 sec. 13, T. 12 N., R. 39 E.:

A11-0 to 4 inches, very dark grayish-brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; massive; soft, very friable, nonsticky, nonplastic ; many medium roots; neutral; abrupt, smooth boundary. 2 to 4 inches thick.

A12-4 to 6 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, medium, prismatic and weak. medium, blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many fine and medium roots; neutral; abrupt, smooth boundary. 2 to 6 inches thick.

B2t-6 to 13 inches, very dark grayish-brown (10YR 3/2) heavy silt loam., grayish brown (10YR 5/2) dry; strong, coarse, columnar structure; Ys-inch coating of light-gray material on rounded top of columns; very hard, very firm, sticky, plastic; few fine roots in vertical fractures only; thick clay films on vertical surfaces; strongly alkaline; clear, wavy boundary. 4 to 10 inches thick.

B3-13 to 20 inches, dark-brown (10YR 3/3) heavy silt loam, brown (10YR 5/3) dry; moderate, medium, prismatic and strong, fine, angular blocky structure; hard, friable, sticky, plastic; very few fine roots; white film of lime on vertical surfaces; violently effervescent; very strongly alkaline; clear, wavy boundary. 7 to 12 inches thick.

C-20 to 32 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak, coarse, prismatic structure; hard, friable, slightly sticky, slightly plastic; very few roots; 3 percent is coarse basaltic gravel; violently effervescent; very strongly alkaline; abrupt, wavy boundary. 6 to 15 inches thick.

R-32 inches, basalt bedrock with lime in fractures.

Depth to basalt bedrock ranges from 20 to 40 inches. Depth to the B2t horizon ranges from 4 to 10 inches. Only the thicker A horizon is above the weaker B2t horizon.

This soil is slowly permeable. It holds about 3 to 5 inches of water that plants can use. Roots penetrate the subsoil mainly through cracks and along surfaces of peds. Runoff is medium, and the hazard of erosion is moderate to severe.

This soil has the same uses as the larger areas of surrounding soils. Capability unit VIe 2; Loamy range site (L-2) .

Stratford Series

The Stratford series consists of well-drained, very stony silt loams that are underlain by sand, gravel, cobblestone, and boulders at a depth of 20 to 40 inches. These soils formed in glacial outwash that contains wind-laid silts and volcanic ash in places. They are on terraces along the Snake River Canyon. Slopes are 0 to 30 percent. Elevation ranges from 500 to 1,000 feet. The largest areas are along the Snake River between the county line and the mouth of the Tucannon River. Annual precipitation is 10 to 12 inches. The mean annual temperature is about 54° F., and the frost-free season is 160 to 190 days. The vegetation is largely bluebunch wheatgrass and Sandberg bluegrass. Stratford soils are associated with Kuhl, Ellisforde, and Farrell soils.

In a representative profile, the surface layer is very dark grayish-brown very stony silt loam 6 inches thick. The underlying layer, to a depth of 13 inches, is dark-brown very stony silt loam. Below this is dark grayish-brown gravelly silt loam that is strongly calcareous in the lower part. It is underlain by coarse sand, gravel, cobblestones, and boulders at a depth of about 30 inches.

Stratford soils are used as range and wildlife habitat. A few areas near streams are irrigated.

Stratford very stony silt loam, 0 to 30 percent slopes (SrD).-This nearly level to steep soil is on terraces along the Snake River Canyon.

Representative profile of Stratford very stony silt loam, 0 to 30 percent slopes, in grassland, 1.5 miles southeast of Lyon Ferry and 500 feet northeast of the road, NW1/4NW1/4 sec. 32, T. 13 N., R. 37 E.:

A11-0 to 3 inches, very dark grayish-brown (10YR 3/2) very stony silt loam, grayish brown (10YR 5/2) dry; weak, thin, platy structure; soft, very friable; nonsticky, nonplastic ; many roots; 4 percent stones and boulders, and 2 percent gravel; neutral; abrupt, smooth boundary. 2 to 3 inches thick.

A12-3 to 6 inches, very dark grayish-brown (10YR 3/2) very stony silt loam, grayish brown (10YR 5/2) dry; weak, medium, blocky structure; slightly hard, friable, nonsticky, nonplastic ; common roots; 4 percent stones and boulders, and 5 percent gravel; neutral; gradual, wavy, boundary. 3 to 8 inches thick.

AC-6 to 13 inches, dark-brown (10YR 3/3) stony silt loam, brown (10YR 5/3) dry; massive; slightly hard, friable, slightly sticky, slightly plastic; common roots; 4 percent stones and boulders, and 10 percent gravel; mildly alkaline; clear, wavy boundary, 5 to 10 inches thick.

C1-13 to 24 inches, dark grayish-brown (10YR 4/2) gravelly silt loam, light brownish gray (10YR 6/2) dry; massive; slightly hard, friable, slightly sticky, slightly plastic; common roots; 30 percent gravel, and 4 percent stones and boulders; moderately alkaline; clear, wavy boundary. 10 to 14 inches thick.

C2ca-24 to 30 inches, dark grayish-brown (10YR 4/2) gravelly silt loam, light brownish gray (10YR 6/2) dry; massive; slightly hard, friable, slightly sticky, slightly plastic; common roots; 30 percent gravel, and 4 percent stones and boulders; strongly effervescent with hydrochloric acid; strongly alkaline. 2 to 6 inches thick.

IIC3-30 to 60 inches, unassorted coarse sands, gravel, cobblestones, and boulders.

Depth to the underlying IIC horizon ranges from 20 to 40 inches. A Cca horizon is not present in some areas.

This soil has moderate permeability above the layer of sand, gravel; cobblestones, and boulders. Root penetration is restricted by that layer. The soil holds about 4 to 6 inches of water that plants can use. Runoff is slow to medium, and the hazard of erosion is slight to moderate.

This soil is used mainly for grazing. A few areas near streams are irrigated. Capability unit VIIs-1; Loamy range site (L-2).

Terrace Escarpments

Terrace escarpments (Tc) are on very steep, eroded fronts of terraces. They consist of sandy, cobbly, and bouldery alluvium that has a shallow surface layer in some places. These areas are used mainly as wildlife habitat. Capability unit VIIIs-1.

Tolo Series

The Tolo series consists of well-drained silt loams that are underlain by an older buried soil. These soils formed in volcanic ash mixed with wind-laid silts. They are on wide ridgetops and north-facing areas in the Blue Mountains. Slopes are 3 to 65 percent. Elevation ranges from 3,600 to 5,000 feet. Annual precipitation is *30* to 40 inches. The mean annual temperature is 44° F., and the frost-free season is 90 to 100 days. The vegetation is mainly Douglas-fir and grand. fir and a few scattered spruce and western larch. Tolo soils are associated mainly with Couse soils and the Tolo wet subsoil variant.

In a representative profile, there is a forest litter *3* inches thick that consists of partially decomposed fir needles, twigs; and cones. The surface layer is brown silt loam *2* inches thick that is underlain by a brown silt loam subsoil. The subsoil is underlain at a depth of 22 inches by an older, buried, brown and dark-brown silt loam subsoil. Basalt bedrock is at a depth of about 66 inches (fig. 7).

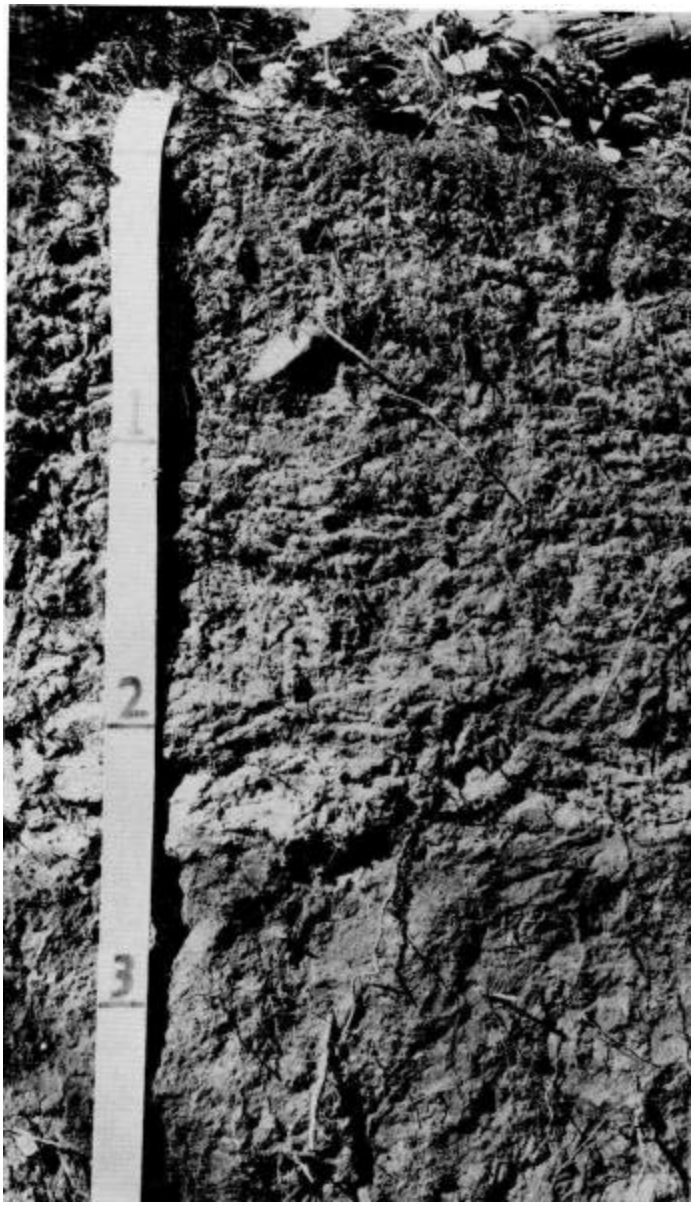

Figure 7-Profile of Tolo silt loam. The upper part of this soil formed in volcanic ash mixed with wind-laid silts. The lower part is an older, buried soil.

Tolo soils are used by mainly for timber, recreation, and wildlife habitat. Some areas are used for wheat and for grazing.

Tolo silt loam, 3 to 15 percent slopes (ToC).-This gently sloping to strongly sloping soil is on north-facing and northeast-facing areas.

Representative profile of Tolo silt loam, 3 to 15 percent slopes, in woodland that has very little understory, about 400 feet west of Skyline Road at the National Forest boundary, in the south quarter of sec. 23, T. 9 N., R. 40 E.:

0-3 inches to 0, litter of fir needles, small twigs, and cones in varying stages of decomposition.

A1-0 to 2 inches, brown (10YR 4/3) coarse silt loam, pale brown (10YR 6/3) dry; very fine granular structure; soft, very friable, nonsticky and nonplastic ; many very fine and common fine roots; medium acid; abrupt, smooth boundary. 0 to 2 inches thick.

B21-2 to 7 inches, brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; massive; soft, very friable, nonsticky and nonplastic ; many fine, medium, and coarse roots; slightly acid; gradual, wavy boundary. 5 to 10 inches thick.

B22-7 to 18 inches, brown (10YR 4/3) coarse silt loam, pale brown (10YR 6/3) dry; massive; soft, very friable, nonsticky and nonplastic ; many medium and coarse roots; slightly acid; clear, irregular boundary. 10 to 20 inches thick.

B23-18 to 22 inches, dark yellowish-brown (10YR 4/4) coarse silt loam, light yellowish brown (10YR 6/4) dry; massive; soft, very friable, nonsticky and nonplastic; made up largely of slightly altered volcanic ash; abundant coarse roots; slightly acid; abrupt, wavy boundary. 2 to 4 inches thick.

Alb-22 to 30 inches, brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; massive; slightly hard, friable, slightly sticky and nonplastic ; common coarse roots; black concretions 0.25 to 1.0 millimeter in diameter; gray streaks in the lower part; neutral; gradual, wavy boundary. 4 to 12 inches thick.

A2B21b-30 to 37 inches. brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; massive, to weak, medium, prismatic structure; slightly hard, friable, slightly sticky and nonplastic ; common coarse roots; neutral; gradual, wavy boundary. 6 to 11 inches thick.

B22tb-37 to 49 inches, brown (10YR 4/3) heavy silt loam, pale brown (10YR 6/3) dry; weak, fine, subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common coarse roots; few thin patchy clay films; 1 to 2 percent is basalt sand; slightly acid; clear, wavy boundary. 8 to 12 inches thick.

B23tb-49 to 66 inches, dark-brown (7.5YR 4/4) heavy silt loam, yellowish brown (10YR 5/4) dry; weak, fine, subangular blocky structure; hard, firm, slightly sticky and slightly plastic; few coarse roots; thin clay films; 2 to 5 percent is basalt sand; neutral; abrupt, extremely irregular boundary. 2 to 20 inches thick.

IIR-60 inches, fine-grained, dark-colored basalt bedrock.

Depth to bedrock is 40 to 66 inches. The 0 horizon ranges from 1 to 3.5 inches in thickness. A thin 0 horizon has an A1 horizon 1 to 3 inches thick, and a thick 0 horizon has an A1 horizon 1 inch thick or a thin sporadic A2 horizon. The B2 horizon ranges in value from 3 to 5 moist and 4 to 6 dry; chroma is 3 or 4, and hue ranges from 10YR to 7.5YR. The lower values and chroma are associated with the redder hue. The C horizon, where present, ranges from sporadic lenses of only slightly altered volcanic ash to a continuous layer about 4 inches thick.

This soil has moderate permeability above the buried subsoil and moderately slow permeability in the buried subsoil. Roots penetrate to the bedrock. The soil holds about 10 to 12 inches of water that plants can use. Runoff is medium, and the hazard of erosion is moderate.

This soil is used far growing timber and as wildlife habitat. Capability unit IVe-12; woodland group 2o.

Tolo silt loam, 15 to 40 percent slopes (ToE).-This moderately steep to steep soil is on uplands in areas that face north and northeast. Runoff is medium to rapid, and the hazard of erosion is severe. Included in mapping are many areas that are grayer than the typical Tolo soil. This soil is used mainly for growing timber. Capability unit VIe-6; woodland group 2o.

Tolo silt loam, 40 to 65 percent slopes (ToF).-This very steep soil is on uplands. Rock outcrops, mostly 30 to 40 feet in diameter, are on V-shaped ridges. Bedrock is at a depth of 40 to 60 inches. The soil holds about 6 to 10 inches of water that plants can use. Runoff is very rapid, and the hazard of erosion is very severe. Included in mapping are a few areas where the soil is grayer than typical Tolo soils and a few areas of rock outcrops. All of the acreage is in woodland. Capability unit VIIe-4; woodland group 1r.

Tolo Series, Wet Subsoil Variant

This variant of the Tolo series consists of moderately well drained silt loams that are underlain by an older buried soil. These soils formed in volcanic ash mixed with wind-laid silts. They are on broad ridgetops. The largest acreage is east of Skyline Road and north of Maloney Mountain. Other areas are on Robinette Mountain and on Cahill Mountain. Slopes are 3 to 15 percent. Elevation ranges from 3,200 to 4,000 feet. Annual precipitation is 30 to 40 inches. The mean annual temperature is approximately 45° F., and the frost-free season is 100 to 115 days. The vegetation is grand fir, Douglas-fir, western larch, and lodgepole pine. The Tolo wet subsoil variant is associated mainly with Couse, Tolo, and Klicker soils.

In a representative profile, there is a forest litter of partially decomposed organic material. The surface layer is very dark grayish-brown silt loam 2 inches thick. The subsoil, about 16 inches thick, is dark-brown coarse silt loam. This is underlain by an older soil that is dark-brown to brown silty clay loam. It extends to a depth of 60 inches or more. Basalt bedrock is at a depth of about 77 inches.

Tolo wet subsoil variant is used mainly for timber, recreation, and wildlife.

Tolo silt loam, wet subsoil variant, 3 to 15 percent slopes (TsC).-This gently sloping to strongly sloping soil is on north-facing ridgetops and plateaus.

Representative profile of Tolo silt loam, wet subsoil variant, 3 to 15 percent slopes, in woodland and brush, 300 feet southeast of the entrance to Boy Scout Camp and 40 feet northeast of Maloney Mountain Road, NW1/4SW1/4 sec. 12, T. 9 N., R. 40 E.:

O-1.5 inches to 0, litter of pine and fir needles, leaves, grasses, and twigs in all stages of decomposition.

A1-0 to 2 inches, very dark grayish-brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, very fine, granular structure; soft, very friable, nonsticky, nonplastic ; many fine roots; neutral; abrupt, smooth boundary. 0 to 4 inches thick.

B21ir-2 to 7 inches, dark-brown (7.5YR 4/4) coarse silt loam, brown (7.5YR 5/4) dry; massive; soft, non-

sticky, nonplastic; many fine and medium roots; neutral; gradual, wavy boundary. 3 to 8 inches thick.

B22ir-7 to 18 inches, dark-brown (7.5YR 4/4) coarse silt loam, brown (7.5YR 5/4) dry, slightly lighter in color than the B21ir horizon; soft, nonsticky, nonplastic; many fine roots; apparently lower in alluvial iron and organic-matter content than the B21ir horizon; neutral; abrupt, wavy boundary. 10 to 20 inches thick.

IIA1b-18 to 36 inches, dark-brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; fine subangular blocky structure; slightly hard, very friable, sticky, plastic; common coarse and fine roots; neutral; clear, wavy boundary. 10 to 22 inches thick.

IIA2b-36 to 42 inches, grayish-brown (10YR 5/2) silt loam, light gray (10YR 7/2) dry; weak, medium, prismatic and moderate, fine and medium, blocky structure; hard, friable, slightly sticky, slightly plastic; common medium and coarse roots; common, fine, brown mottles; slightly acid; clear, wavy boundary. 4 to 9 inches thick.

IIA2b-B2b-42 to 52 inches, grayish-brown (10YR 5/2) silty clay loam, light gray (10YR 7/1) dry; moderate, medium, prismatic structure; very hard, very firm, sticky, plastic; few or very fine roots; A2 horizon material has light brownish-gray (10YR 6/2) tongues from the horizon above; moderately thick, patchy, yellowish-brown (10YR 5/4) clay films; neutral; clear, wavy boundary. 6 to 12 inches thick.

IIB2tb-52 to 77 inches, brown (10YR 4/3) light silty clay loam, pale brown (10YR 6/3) dry; moderate, medium, prismatic and strong, fine, blocky structure; very hard, very firm, sticky, plastic; very few roots; moderately thick continuous clay films; gray silt in vertical fractures; 1 to 2 percent basaltic sand; neutral; abrupt, irregular boundary. 12 to 28 inches thick,

III-77 inches, hard basalt bedrock.

The A1 horizon is thickest in open or brushy areas and absent under a dense canopy of grand fir. A thin A2 horizon is present in places. Hue in the B2ir horizon ranges from 10YR to 7.5YR ; 10YR is the most common dry hue, and 7.5YR is the dominant moist hue. Value is dominantly 5 or 6 when dry and 3 or 4 when moist; chroma is 3 and 4. In the lower sequum the IIA1b horizon is absent in places. The IIA2b horizon extends to a depth of 50 inches in some places. The IIB2tb horizon ranges from heavy silt loam to light silty clay in texture.

The subsoil of this Tolo wet subsoil variant is saturated in winter and spring. Permeability is moderate above the buried subsoil and slow within it. Roots penetrate the silty clay loam layer mainly through cracks and along ped faces. The soil holds about 8 to 10 inches of water that plants can use. Runoff is medium, and the hazard of erosion is moderate. Included in mapping are cleared areas that are moderately eroded.

This soil is used mainly for timber and as wildlife habitat. Capability unit IVe-12; woodland group 2d.

Tucannon Series

The Tucannon series is made up of well-drained silt loams that are underlain by basalt bedrock at a depth of 20 to 40 inches. These soils formed in wind-laid silts on uplands. The largest areas are southeast of Dayton in the Touchet Canyon and south and east of Marengo. Slopes are 0 to 65 percent. Elevation ranges from 1,500 to 2,500 feet. Annual precipitation is 16 to 18 inches. The mean annual temperature is about 50° F., and the frost-free season is 155 to 165 days. The original vegetation was largely Idaho fescue and bluebunch wheatgrass. Tucannon soils are associated with Athena soils.

In a representative profile, the surface layer is very dark brown silt loam about 11 inches thick. The subsoil is very dark grayish-brown, dark-brown, and brown silt loam. It is underlain by basalt at a depth of about 28 inches.

Tucannon soils are used for wheat, barley, grasses, and legumes and for grazing.

Tucannon silt loam, 15 to 25 percent slopes (TuD).-This moderately steep soil is on hilly uplands.

Representative profile of Tucannon silt loam, 15 to 25 percent slopes, in grassland, 0.5 mile northeast of a gravel pile near Highway No. 126, and 175 feet southeast of the road, NE1/4NE1/4 sec. 26, T. 11 N., R. 40 E.:

A11-0 to 3 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, fine and medium granular structure; slightly hard, friable, slightly sticky, nonplastic ; many fine roots; slightly acid; abrupt, wavy boundary. 2 to 5 inches thick.

A12-3 to 11 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine and medium, granular structure; slightly hard, friable, sticky, slightly plastic; common fine and very fine roots; slightly acid; clear, wavy boundary. 4 to 8 inches thick.

B21-11 to 17 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, grayish brown (10YR 5/2) dry; weak, medium, prismatic and moderate, fine, blocky structure; hard, friable, sticky, plastic; common fine roots; few very thin coatings that may be clay films on some ped surfaces; neutral; gradual, wavy boundary. 4 to 8 inches thick.

B22-17 to 23 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; weak, medium, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; neutral; clear, wavy boundary. 4 to 6 inches thick.

B23-23 to 28 inches, brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; neutral; abrupt, wavy boundary. 2 to 15 inches thick.

IIR-28 inches, basalt bedrock.

Depth to bedrock is 20 to 40 inches. In places the horizon above the bedrock contains as much as 20 percent basalt fragments a fourth of an inch to an inch in size.

This soil is moderately permeable. It holds about 3.5 to 7 inches of water that plants can use. Roots penetrate to the bedrock. Runoff is medium, and the hazard of erosion is moderate to severe.

This soil is used for wheat, barley, grasses, and legumes and for grazing. Capability unit IVe-10; Loamy range site (L-3) .

Tucannon silt loam, 0 to 15 percent slopes (TuC).-This nearly level to strongly sloping soil is on ridgetops. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The soil is used for wheat, barley, grasses, and legumes and for grazing. Capability unit IIIe-7; Loamy range site (L-3).

Tucannon silt loam, 25 to 40 percent slopes (TuE).-This steep soil is on canyon walls. Runoff is rapid, and the hazard of erosion is severe to very severe. This soil is used for wheat, barley, grasses, and legumes and for grazing. Capability unit VIe-4; Loamy range site (L-3).

Tucannon silt loam, 40 to 65 percent slopes (TuF).-This very steep soil is on canyon walls, mostly on north-facing slopes. Runoff is very rapid, and the hazard of erosion is very severe. Small areas of rock outcrops are

included in mapping. This soil is used for grazing. Capability unit VIIe-3; North Exposure range site (N-2).

Tucannon silt loam, 15 to 40 percent slopes, severely eroded (TuE3).-This moderately steep to steep soil is on uplands. Nearly all of the original surface layer has been removed by erosion, and the subsoil is exposed by tillage. Runoff is medium to very rapid, and the hazard of erosion is severe to very severe. This soil is used for wheat, barley, and grasses and for grazing. Capability unit VIe-4; Loamy range site (L-3).

Waha Series

The Waha series consists of well-drained soils that are underlain by basalt bedrock at a depth of 20 to 40 inches. These soils formed in wind-laid silts and weathered basalt. They are in the foothills of the Blue Mountains. Slopes are 0 to 65 percent. Elevation ranges from 2,000 to 3,500 feet. Annual precipitation is 19 to 23 inches. The mean annual temperature is about 48° F., and the frost-free season is 120 to 140 days. The. original vegetation was largely Idaho fescue, bluebunch wheatgrass, and Sandberg bluegrass. Waha soils are associated mainly with Palouse and Gwin soils.

In a representative profile, the surface layer is very dark brown silt loam about 13 inches thick. The subsoil, about 15 inches thick, is dark-brown silty clay loam that is very gravelly in the lower part. It is underlain by basalt bedrock at a depth of about 28 inches.

Waha soils are used for wheat, barley, grasses, and legumes and for grazing.

Waha silt loam, 15 to 25 percent slopes (WhD).-This moderately steep soil is on hilly uplands.

Representative profile of Waha silt loam, 15 to 25 percent slopes, in grassland, 160 feet east of the section line and 90 feet south of the road, SW1/4SW1/4 sec. 35, T. 9 N., R. 38 E.:

A11-0 to 5 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; slightly hard, friable, slightly sticky, slightly plastic; many fine roots; slightly acid; abrupt, wavy boundary. 2 to 5 inches thick.

A12-5 to 13 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine, subangular blocky structure; hard, friable, sticky, plastic; common fine roots; slightly acid; clear, wavy boundary. 4 to 10 inches thick.

B21t-13 to 17 inches, dark-brown (10YR 3/3) silty clay loam, brown (10YR 4/3) dry; moderate, fine, subangular blocky structure; very hard, firm, sticky, plastic; common roots; thin continuous clay films on vertical surfaces; neutral; clear, wavy boundary. 2 to 8 inches thick.

B22t-17 to 23 inches, dark-brown (10YR 3/3) silty clay loam, brown (10YR 4/3) dry; moderate, fine, blocky structure; very hard, firm, sticky, plastic; few roots; thin, continuous, very dark grayish-brown clay films on all surfaces; neutral; clear, wavy boundary. 2 to 6 inches thick.

IIB23t-23 to 28 inches, dark-brown (10YR 3/2) very gravelly silty clay loam, brown (10YR 4/3) dry; moderate, fine, blocky structure; very hard, firm, sticky, plastic; 60 to 70 percent by volume is basalt; clay films on basalt, neutral; abrupt, wavy boundary. 5 to 12 inches thick.

IIR-28 inches, basalt bedrock.

Depth to bedrock ranges from 20 to 40 inches. The moist color of the A horizon ranges from very dark brown to black. Texture of the B2t horizon ranges from heavy silt loam to silty clay loam. The heavy silt loam is dominant where the soil is thickest.

This soil has moderately slow permeability. It holds about 3.5 to 7 inches of water that plants can use. Roots penetrate to the bedrock. Runoff is medium, and the hazard of erosion is moderate to severe.

This soil is used for wheat, barley, peas, and grasses and for grazing. Capability unit IVe-10; Loamy range site (L-3) .

Waha silt loam, 0 to 15 percent slopes (WhC).-This nearly level to strongly sloping soil is on ridgetops. Runoff is slow to medium, and the hazard of erosion is slight to moderate. This soil is used for wheat, barley, peas, and grasses and for grazing. Capability unit IIIe-7; Loamy range site (L-3) .

Waha silt loam, 25 to 40 percent slopes (WhE).-This steep soil is on canyon walls. Runoff is rapid, and the hazard of erosion is severe to very severe. Included in some areas are numerous rock outcrops. This soil is used for wheat and barley and for grazing. Capability unit VIe-4; Loamy range site (L-3).

Waha silt loam, 40 to 65 percent slopes (WhF).-This very steep soil is on canyon walls. Runoff is very rapid, and the hazard of erosion is very severe. About 15 percent of the acreage of some areas is rock outcrops. This soil is used for grazing. Capability unit VIIe-3; North Exposure range site (N-3).

Waha silt loam, 8 to 40 percent slopes, severely eroded (WhE3).-This sloping to steep soil is on uplands. Nearly all of the original surface layer has been removed by erosion, and the subsoil is exposed by tillage. Runoff is medium to very rapid, and the hazard of further erosion is severe to very severe. Included in mapping in some areas are numerous rock outcrops. This soil is used for wheat, barley, and grasses and for grazing. Capability unit VIe-4;Loamy range site (L-3) .

Waha-Rock land complex (Wr).-This steed complex is on canyon walls. It is about 50 percent Waha silt loam and 50 percent basalt Rock land. The Waha soil is in irregularly shaped mounds that are no larger than about 0.1 acre in size. They are surrounded by strips or channels of Rock land. This complex is used for grazing. Capability unit VIIs-2; Waha soil in Loamy range site (L-3).

Walla Walla Series

The Walla Walla series consists of well-drained silt loams that formed in wind-laid silts. These soils are on uplands. The largest acreage is in the western part of Columbia County between Whetstone Hollow and the Walla Walla County line. Slopes are 0 to 65 percent. Elevation ranges from 900 to 2,000 feet. Annual precipitation is 12 to 16 inches. The mean annual temperature is about 54° F., and the frost-free season is 180 to 190 days. The original vegetation was largely bluebunch wheatgrass, Idaho fescue, and Sandberg bluegrass. Walla Walla soils are associated with Kuhl, Asotin, Chard, Oliphant, Ritzville, Hermiston, Onyx, Walvan, and Ritzcal soils.

In a representative profile, the surface layer is very dark brown silt loam about 13 inches thick. The subsoil, about 24 inches thick, is very dark grayish-brown to dark-brown silt loam. The substratum is silt loam that extends to a depth of 60 inches or more. It is brown and

noncalcareous to a depth of 51 inches and is grayish brown and strongly calcareous below that depth (fig. 8).

Walla Walla soils are used for wheat, barley, peas, grasses, and legumes and for grazing.

Walla Walla silt loam, 0 to 8 percent slopes (WwB).-This nearly level to gently sloping soil is on ridgetops.

Representative profile of Walla Walla silt loam, 0 to 8 percent slopes, in grassland, in a roadbank at the top of the hill between Fields Gulch and Smith Hollow, NW1/4SW1/4 sec. 17, T. 11 N., R. 37 E.:

A11-0 to 7 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; soft, very friable, slightly sticky, slightly plastic; many fine toots; neutral; abrupt, wavy boundary. 5 to 8 inches thick.

A12-7 to 13 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, medium, blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many fine roots; neutral; clear, wavy boundary. 5 to 6 inches thick.

B1-13 to 19 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak prismatic structure; slightly hard, friable, sticky, plastic; common fine roots; neutral; clear, wavy boundary. 5 to 10 inches thick.

B2-19 to 37 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; weak, medium, prismatic structure; slightly hard, very friable, slightly sticky, slightly plastic; common fine roots; neutral; gradual, wavy boundary. 12 to 20 inches thick.

C1-37 to 51 inches, brown (10YR 4/3) silt loam, pale brown (10YR 6/3) dry; massive; soft, very friable, slightly sticky, slightly plastic; common fine roots; mildly alkaline; clear, wavy boundary. 10 to 16 inches thick.

C2ca-51 to 60 inches, grayish-brown (10YR 5/2) silt loam, light gray (10YR 7/2) dry; massive; soft, very friable, slightly sticky, slightly plastic; few fine roots; violently effervescent ; moderately alkaline.

The color of the A horizon ranges from very dark grayish brown to very dark brown. Depth to the Cca horizon is generally more than 50 inches.

This soil is moderately permeable. It holds 10 to 12 inches of water that plants can use. Roots penetrate to a depth of 60 inches or more. Runoff is slow, and the hazard of erosion is slight.

This soil is used for wheat, barley, peas, grasses, and legumes. Capability unit IIe-1; Loamy range site (L-2).

Walla Walla silt loam, 8 to 30 percent slopes (WwD).-This strongly sloping to moderately steep soil is in large areas. Runoff is medium, and the hazard of erosion is moderate. Included in mapping are small areas of Spofford soils and areas where bedrock is at a depth of 40 to 60 inches. This soil is used for wheat, barley, peas, grasses, and legumes. Capability unit IIIe-4; Loamy range site (L-2).

Walla Walla silt loam, 30 to 40 percent slopes (WwE).-This steep soil in most places has a very dark brown surface layer that is less than 10 inches thick. Runoff is rapid, and the hazard of erosion is severe. This soil is used for wheat, barley, grasses, and legumes and for grazing. Capability unit IVe-5; Loamy range site (L-2) .

Walla Walla silt loam, 40 to 65 percent slopes (WwF).-This very steep soil is mostly on north-facing slopes. Runoff is very rapid, and the hazard of erosion is very severe. Included in some places are areas that are

Figure 8.-Profile of Walla Walla silt loam. The dark-colored surface layer is more than a foot thick and is underlain by a lighter colored subsoil similar in texture. The soil is calcareous below a depth of about 4 feet.

severely eroded, areas that are underlain by bedrock at a depth of 20 to 40 inches, and many rock outcrops. This soil is used for grazing. Capability Unit VIIe-2; North Exposure range site (N-1).

Walla Walla silt loam, 8 to 30 percent slopes, severely eroded (WwD3).-This strongly sloping to moderately steep soil is on uplands. Most of the original surface layer of this soil has been removed by erosion. The plow layer

is now dark-brown silt loam. Runoff is medium to rapid, and the hazard of further erosion is severe. This soil is used for wheat, barley, grasses, and legumes and for grazing. Capability unit IVe-6; Loamy range site (L-2).

Walla Walla silt loam, 30 to 40 percent slopes, severely eroded (WwE3).-This steep. soil is on uplands. Most of the original surface layer has been removed by erosion and the plow layer is now dark-brown silt loam. Runoff is rapid, and the hazard of further erosion is severe to very severe. This soil is used for wheat, barley, grasses, and legumes and for grazing. Capability unit IVe-6; Loamy range site (L-2).

Walvan Series

The Walvan series consists of well-drained very fine sandy loams that formed in volcanic ash and wind-laid silt. These soils are mostly in small areas. Slopes are 15 to 40 percent. Elevation ranges from 900 to 2,500 feet. Annual precipitation is 12 to, 16 inches. The mean annual temperature is about 53° F., and the frost-free season is 150 to 180 days. The original vegetation was largely bluebunch wheatgrass and some needle-and-thread. Walvan soils are associated with Walla Walla, Athena, and Ritzville soils.

In a representative profile, the surface layer is very dark brown silt loam about 9 inches thick. The .subsurface layer is dark grayish-brown very fine sandy loam that extends to a depth of 14 inches. The underlying layer, to a depth of 29 inches, is brown very fine sandy loam. Below this to a depth of 60 inches or more is light brownish-gray sandy loam.

Walvan soils are used for the same crops as the surrounding soils. Many areas of Walvan soils are idle.

Walvan silt loam, 15 to 40 percent slopes (WyE).-This soil is mostly in small areas within larger areas of Walla Walla, Ritzville, and Athena soils. Many areas are too small to map separately and are included in mapping units of the surrounding soils.

Representative profile of Walvan silt loam, 15 to 40 percent slopes, in a cultivated area, 140 feet north of the road at the north-south centerline of the section, SE1/4NW1/4 sec. 32, T.11 N., R. 38 E.:

Ap-0 to 9 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; soft, very friable nonsticky, nonplastic; common fine very fine, and coarse roots
slightly acid; abrupt, smooth boundary. 8 to 10 inches thick.

A11-9 to 14 inches, -very dark grayish-brown (10YR 3/2) very fine sandy loam, dark grayish brown (10YR 4/ 2) dry; massive; soft, very friable, nonsticky, nonplastic; common fine and coarse roots; neutral; abrupt, wavy boundary. 2 to 8 inches thick.

C1-14 to 29 inches, brown (10YR 5/3) very fine sandy loam, light brownish gray (10YR 6/2) dry; massive; soft, very friable, nonsticky, nonplastic ; common fine roots and few coarse roots; mildly alkaline; clear, wavy boundary. 12 to 20 inches thick.

C2-29 to 66 inches, light brownish-gray (10YR 6/2) sandy loam, white (10YR 8/1 or 8/2) dry; massive; soft, very friable, nonsticky, nonplastic ; few fine roots; mildly alkaline.

The A horizon, when moist, ranges from very dark brown to gray. The color is largely the result of different proportions of wind-laid silt and volcanic ash in which the soils formed.

In some cultivated areas additional mixing of ash and silt by tillage implements has occurred. Depth to the ash layer ranges from 8 to 29 inches. The ash is in layers that approximate the dip of the soil surface, in nonconforming dikelike masses, or in thick rounded lenses.

This soil has moderate permeability in the upper part of the profile and moderately rapid permeability below. It holds 6 to 9 inches of water that plants can use. Roots penetrate to a depth of 60 inches or more. Runoff is medium to rapid, and the hazard of water erosion is moderate to severe. The hazard of soil blowing is very severe.

A large part of the acreage is used for the same crops as the surrounding soils. Many areas of this soil are idle. Capability unit VIe-3; Loamy range site (L-2).

Yakima Series

The Yakima series consists of well-drained silt loams that are underlain by very gravelly sand at a depth of 20 to 40 inches. These soils formed in alluvium. They are in areas along streams and on fans. Slopes are 0 to 8 percent. Elevation ranges from 600 to 1,200 feet. The largest areas are along the Tucannon River below State Highway No. 410. Annual precipitation is 7.0 to 16 inches. The mean annual temperature is about 54° F., and the frost-free season is 150 to 190 days. The vegetation was largely bluebunch wheatgrass and. giant wildrye. Cottonwoods and willows grew near the streams. Yakima soils are associated with Onyx and Esquatzel soils on the bottom lands and with Farrell, Ellisforde, Kuhl, and Ritzville soils on the uplands.

In a representative profile, the surface layer is very dark grayish-brown silt loam 8 inches thick. The underlying layer, to a depth of 30 inches, is very dark grayish-brown gravelly silt loam. Below this is very gravelly sand. In many areas the surface layer is gravelly silt loam.

Yakima soils are used mainly for wheat and grazing in nonirrigated areas and for alfalfa, sweet corn, and asparagus in irrigated areas.

Yakima silt loam, 0 to 3 percent slopes (YmA).-This nearly level soil is in small areas on wide valley bottoms.

Representative profile of Yakima silt loam, 0 to 3 percent slopes, in a cultivated area, 256 feet west of railroad mile post number 1.29 and 20 feet south of the fence, NE1/48W1/4 sec. 3, T.12. N., R. 37 E.:

Ap-0 to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; slightly hard, friable, nonsticky, nonplastic ; common fine and medium roots; 10 percent is coarse basalt pebbles; slightly acid; abrupt, smooth boundary. 6 to 10 inches thick.

C1-8 to 22 inches very dark grayish-brown (10YR 3/2) gravelly silt loam grayish brown (10YR 5/2) dry; massive; slightly hard, friable, nonsticky, nonplastic ; common fine and medium root; 20 percent is coarse basalt pebbles; neutral; gradual, wavy boundary. 10 to 20 inches thick.

C2-22 to 30 inches, very dark grayish-brown (10YR 3/2) gravelly silt loam. grayish brown (10YR 5/2) dry; massive; slightly hard, friable, nonsticky, nonplastic ; common medium roots; 30 percent is coarse basalt pebbles; neutral; clear, wavy boundary. 4 to 14 inches thick.

IIC3-30 to 60 inches, very gravelly sand, 50 percent is pebbles larger than 1 inch in diameter and 35 percent is pebbles 2 millimeters to 1 inch in diameter; neutral.

The A horizon is very fine sandy loam, loam, or silt loam. The C1 and C2 horizons are 20 to 30 percent gravel. Depth to the very gravelly sand IIC3 horizon is 20 to 40 inches. Reaction is slightly acid to mildly alkaline.

This soil has moderate permeability above the very gravelly sand layer and very rapid permeability in that layer. Root penetration is restricted by the very gravelly layer. The soil holds about 4 to 8 inches of water that plants can use. Runoff is very slow, and the hazard of erosion is none to slight.

This soil is used mainly for irrigated alfalfa, sweet corn, and asparagus. Capability unit IVs-1.

Yakima gravelly silt loam 0 to 3 percent slopes (YvA).-The surface layer of this soil contains 10 to 30 percent gravel by volume. The soil holds about 3 to 6 inches of water that plants can use. It is used mainly for irrigated alfalfa and grasses. Capability unit IVs-2.

Yakima gravelly silt loam, 3 to 8 percent slopes (YvB).-This soil is on small alluvial fans at the mouth of streams in canyons. Runoff is slow, and the hazard of erosion is slight. Most of the acreage is idle or is used for grazing. Some areas are irrigated. Capability unit IVs-2.

Use and Management of the Soils

This section describes the general management of the soils for crops and pasture, range, woodland, and wildlife and gives information about soil characteristics significant in engineering. It explains the system of capability classification used by the Soil Conservation Service and groups the soils by capability units. It also gives estimated yields of crops and pasture plants commonly grown in the survey area.

Crops and Pasture

Differences in relief, precipitation, and soil in the Columbia County Area cause diverse limitations in the use and management of soils for crops.

Erosion control is the major concern on most cultivated soils. In about 70 percent of the cultivated acreage, the soils have slopes ranging from 15 to 45 percent, and rain and melting snow often cause excessive runoff and severe erosion, particularly when the surface layer is frozen. On the steepest soils, material is moved downslope during each cultivation through tillage erosion.

Shortage of moisture during the growing season is a limitation on many cultivated soils and is most severe in areas of lowest precipitation. Management practices that conserve moisture are therefore important.

About 4 percent of the cultivated area, mostly in the Tucannon Valley, is affected by excess water all or part of the year. About 3 percent is subject to occasional overflow and siltation, and 1 percent needs drainage.

Most of the soils in the Area are high in content of organic matter and have good tilth. However, eroded soils and soils that have been cultivated for many years have less organic matter in the surface layer, absorb water more slowly, store less moisture, and are more susceptible to erosion. Crop residue, fertilizer, and green-manure crops are needed to maintain organic-matter content, fertility, and good tilth of these soils.

Salts and alkali adversely affect the suitability of the soils for cultivated crops in only a very small acreage.

In about 25 percent of the Area the soils are too steep, too shallow, or too rocky for cultivation. These soils should be kept in permanent cover vegetation and should be managed for grazing domestic livestock, for wildlife habitat, woodland, or watershed, or for recreation and esthetic value.

Important practices in managing the soils for crops are described in the following paragraphs.

Crop rotation.-Two cropping systems are in general use in the Area: (1) alternate grain and summer fallow, and (2) alternate grain and field peas. Combinations and variations of these systems are practiced, including rotations with grasses and legumes and continuous grain crops.

Farmers throughout the Area use a grain-summer fallow rotation. This is not a desirable rotation where annual precipitation is sufficient to make annual cropping practical, as on Palouse soils and most Athena soils. Annual cropping provides better protection against runoff and erosion, makes more efficient use of available moisture, and produces more organic matter than the grain-summer fallow system.

Where annual rainfall is less than about 14 inches, as on Ritzville and some areas of Walla Walla soils, annual cropping is not consistently practical. In these dry areas, summer fallow is included in the rotation system to store moisture from two seasons for use by a single crop.

On steep, shallow, or eroded soils, grasses and legumes are needed in rotation with grain, peas, or summer fallow. The time that the soil is in grasses and legumes should be increased where the erosion hazard is most severe.

Crop residue.-Many farmers burn the residue of grain and pea crops. This practice destroys organic matter needed to maintain fertility and tilth and leaves the soil. exposed to runoff and erosion. Tillage equipment has been improved in recent years to make residue easier to use. Also, shorter strawed varieties of grain have been developed, and commercial fertilizers are now available that make it possible to use large amounts of residue and still obtain economic yields.

Where annual cropping of grain is practical, the residue should be mixed throughout the tillage layer of the soil. Plowing residue under in a layer or leaving too much residue on the surface impedes water intake, root. penetration, and plant growth. Pea vines are utilized best when left on the surface.

Where the summer fallow system is used, crop residue should be left on the surface where it provides maximum protection against soil blowing and water erosion and helps to conserve moisture. If a stubble-mulch fallow system is properly managed, the weight of the surface mulch after seeding the grain in fall should be about half the weight of the residue produced by the preceding crop.

Proper tillage.-Tillage operations should be kept to the minimum necessary to control weeds and prepare a suitable seedbed for the crop. Careful operation of imple-

By VERLE G. KAISER, agronomist, Soil Conservation Service.

ments and tilling only when the soil is not too wet or too dry are also important.

Fertilizers.-Fertilizer should be applied in the optimum amounts determined by soil tests and field trials.

Erosion control.-Field diversions and terraces are designed to intercept surface runoff and either hold the water in place until it infiltrates the soil or carry it off the slope at a slow rate to a place where it can be disposed of safely. Level terraces are suitable on deep loams and silt loams and on soils that slope less than about 5 percent. Gradient terraces or diversions are used on soils that slope from 5 to 12 percent and on shallow soils. All such diversions must have protected outlets, and emergency outlets are advisable for level terraces. Drop structures and debris basins or sediment traps should be included in most terrace and diversion systems. Careful design and construction are necessary.

Grassed waterways are needed in field draws to prevent gullying caused by runoff. They also can serve as outlets for gradient terraces and diversions.

Contour farming is an effective. method of reducing runoff and controlling water erosion. On long slopes, planting crops in transverse strips prevents exposing the entire slope to runoff at any one time. Stripcropping, in which cover vegetation and crops are planted in alternate bands, reduces soil loss on long slopes.

Where the slope and topography do not permit cropping in multiple strips, the upper half of the slope can be planted to protective cover vegetation and the lower half to a crop. This method is called "divided slope farming." For best results, strips should be as nearly on the contour as practical.

Where soil blowing is a hazard, effective control can be provided by stripcropping and tilling as nearly at right angles to the prevailing wind direction as practical. Mulching "blow spots" with straw and planting trees and shrubs for windbreaks also are helpful.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or engineering.

In the capability system, all kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These levels are described in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows

Class I soils have few limitations that restrict their use. (None in this Area.)

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife. (None in this Area.)

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife habitat or water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated 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 close-growing plant cover is maintained; *w* shows that water in or on the soil interferes 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* used in the Columbia County Area but not in all parts of the United States, shows 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 limitations. Class V can contain, at the most, only the subclasses indicated by *w, s,* and *c,* because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture or range, woodland, wildlife habitat, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are 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 designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1 or IIIe-4. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined. in the foregoing paragraph; and the Arabic

numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in the Columbia County Area are described, and suggestions for the use and management of the soils are given. The soil series represented in each unit are named, but this does not mean that all the soils of the series are in the unit. To find the unit in which a given soil has been placed, refer to the "Guide to Mapping Units" at the back of this survey.

CAPABILITY UNIT IIe-1

This unit consists of well-drained soils of the Chard and Walla Walla series. Slopes range from 0 to 8 percent. These soils hold 9 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is slow, and the hazard of erosion is slight. Annual precipitation ranges from 12 to 16 inches, and the frost-free season is 170 to 190 days.

These. soils are suited to winter wheat, spring wheat, and barley. Green peas are grown on the Walla Walla soils, where they mature 7 to 10 days earlier than on Palouse and Athena soils, the principal soils used for peas in the Area.

Winter wheat and summer fallow is the most common rotation. In some years the moisture supply is too low for annual cropping. Alfalfa and grass are grown occasionally in a long-term rotation.

In a winter wheat-summer fallow rotation, the management practices needed to control erosion consist of mixing all crop residue into the tillage layer, leaving soils cloddy when fallow, shaping waterways and seeding them to grass, and seeding early in fall. Contour tillage may be necessary where slopes are more than about 5 percent. Diversions and stripcropping are needed where runoff from higher areas crosses these soils. Diversions may also be needed on long slopes. Growing grasses and legumes in the rotation helps to maintain or improve tilth and to control erosion.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to sulfur and phosphorus.

CAPABILITY UNIT IIe-2

This unit consists of well-drained soils of the Athena and Palouse series. Slopes range from 0 to 8 percent. These soils hold 10 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is slow, and the hazard of erosion is slight. Annual precipitation is 16 to 23 inches, and the frost-free season is 140 to 165 days.

These soils are well suited to winter wheat, green peas for canning and freezing, dry peas, barley, and spring wheat. They are also well suited to legumes and grasses for hay and pasture, but these crops are not generally grown.

There is sufficient moisture for annual cropping. A winter wheat-green pea rotation is most common. Recropping of grain sometimes is successful if large quantities of nitrogen are applied (fig. 9).

Practices that reduce erosion include mixing all crop residue into the tillage layer, keeping the surface rough during winter, shaping waterways and seeding them to grass, and seeding fall grain early after a fallow year. Contour tillage may be necessary where slopes are steeper than about 5 percent. Diversions and stripcropping are needed on long slopes. Diversions may also be needed where runoff from higher areas crosses these soils. Growing grasses and legumes in rotation also helps to maintain or improve soil tilth and control erosion.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to sulfur and phosphorus.

CAPABILITY UNIT IIs-1

Only Patit Creek silt loam, 0 to 3 percent slopes, is in this unit. This soil is well drained and has very gravelly sandy loam material at a depth of 20 to 40 inches. It is on bottom lands along streams. Slopes range from 0 to 3 percent. This soil holds about 5 to 8 inches of water that plants can use. Root penetration is somewhat restricted by the very gravelly layer. Permeability above the very gravelly layer is moderate. Runoff is very slow, and there is little or no hazard of erosion. Annual precipitation is 16 to 24 inches, and the frost-free season is 155 to 165 days.

Without irrigation this soil is suited to wheat, barley, grasses, and legumes. Alfalfa, asparagus, apples, wheat, grasses, and legumes are suitable crops under irrigation.

Management practices needed consist of mixing all crop residue into the tillage layer and seeding fall grain early after a fallow year. Protection of streambanks is needed in some places. Diversions may be necessary where runoff from higher areas crosses this soil. Reverse plowing should be practiced if the moldboard plow is used. Growing grasses and legumes in the rotation helps to maintain or improve tilth.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to sulphur and phosphorus.

CAPABILITY UNIT IIc-1

This unit consists of well-drained soils of the Hermiston and Onyx series. Slopes range from 0 to 3 percent. These soils hold 10 to 12 inches of water that plants can use. Root penetration is very deep. Near Waitsburg, about 500 acres of the Onyx soil is underlain by gravel between depths of 40 and 60 inches, and a water table is within 3 feet of the surface in spring. Permeability is moderate. Runoff is very slow, and there is little or no hazard of erosion. Annual precipitation is 12 to 18 inches, and the frost-free season is 160 to 180 days.

These soils are used for winter wheat, spring wheat, and barley. Green peas are grown mainly on the Hermiston soils, where they mature a week to 10 days earlier than on the principal soils used for peas in the survey area. In some years the moisture supply is insufficient for annual cropping. Winter wheat-summer fallow is the most common rotation. Alfalfa and grass are grown occasionally in long-term rotations.

Management practices needed to control erosion consist of mixing all crop residue into the tillage layer and seeding fall grain early after a fallow year. Diversions may be necessary where runoff from higher areas crosses these soils. Waterways should be shaped and seeded to grass. Reverse plowing should be practiced if the moldboard plow is used. Growing grasses and legumes in the rotation helps maintain or improve tilth.

Figure 9.-A good stand of winter wheat, in spring, on Athena silt loam, 0 to 8 percent slopes. Wheat was seeded in a cloddy seedbed after green peas were harvested.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to sulfur and phosphorus.

CAPABILITY UNIT IIc-2

This unit consists of well-drained soils of the Covello and Mondovi series. Slopes range from 0 to 3 percent. These soils hold 10 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is very slow, and there is little or no hazard of erosion. Annual precipitation is 16 to 23 inches, and the frost-free season is 150 to 165 days.

These soils are used for winter wheat, spring wheat, green peas, dry peas, barley, alfalfa, and grasses. There is sufficient moisture for annual cropping. A winter wheat-green pea rotation is most common. Pasture grasses and asparagus are suited if water is available for irrigation.

Management practices needed consist of mixing all crop residue into the tillage layer and seeding fall grain early after a fallow year. Protection of streambanks is needed in some places, and waterways should be shaped and seeded to grass. Diversions may be necessary where runoff from higher areas crosses these soils. Growing grasses and legumes in the rotation helps to maintain or improve tilth. Chiseling may be needed occasionally to break tillage pans. Reverse plowing should be practiced if the moldboard plow is used.

Grain, grass, and other nonlegume crops respond to nitrogen fertilizer, and legumes may respond to sulfur and phosphorus.

CAPABILITY UNIT IIIe-1

This unit consists of well-drained soils of the Ellisforde and Ritzville series. Slopes range from 0 to 8 per-

cent. These soils hold from 6 to 12 inches of water that plants can use. Root penetration is very deep. Permeability ranges from moderate to moderately slow. Runoff is slow, and the hazard of erosion is slight. Annual precipitation is 10 to 12 inches, and the frost-free season is 140 to 180 days.

These soils are used mainly for winter wheat in a wheat-summer fallow rotation. Precipitation is too low for annual cropping.

Management practices needed to control erosion consist of using stubble-mulch tillage, seeding fall grain early, and shaping waterways and seeding them to grass. Contour, cross slope, or crosswind tillage may be needed in some places. Diversions may be needed where runoff from higher areas crosses these soils. Growing grasses in a long-term rotation helps to maintain or improve tilth and control erosion.

Grain and grass respond to nitrogen fertilizer.

CAPABILITY UNIT IIIe-2

This unit consists of well-drained soils of the Ellisforde, Esquatzel, and Farrell series. Slopes range from 0 to 8 percent. These soils hold from 5 to 11 inches of water that plants can use. Root penetration is very deep. Permeability ranges from moderate to moderately slow. Runoff is very slow or slow, and the hazard of water erosion is none to, slight. The hazard of soil blowing is moderate. Annul precipitation is 10 to 12 inches, and the frost-free season is 150 to 190 days.

Low rainfall restricts the choice of crops on these soils to winter wheat and drought-tolerant grasses unless water is available for irrigation. A winter wheat-summer fallow rotation is most commonly used on nonirrigated cropland. The costs per acre for labor and machinery are less than those for soils in areas of higher rainfall.

Management practices needed to control erosion consist of using stubble-mulch tillage, crosswind tillage, and seeding fall grain early. In some places, stripcropping at right angles to the prevailing winds is necessary. Growing grasses in a long-term rotation helps to maintain or improve tilth and control erosion.

Grain and grass respond to nitrogen fertilizer.

CAPABILITY UNIT IIIe-3

This unit consists of well-drained soils of the Farrell and Ritzville series. Slopes range from 8 to 30 percent. These soils hold 9 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is medium, and the hazard of erosion is moderate. Annual precipitation is 10 to 12 inches, and the frost-free season is 140 to 190 days.

Low rainfall restricts the choice of crops on these soils mainly to winter wheat and drought-tolerant grasses. Generally these soils are too far from a water source to be irrigated. Winter wheat and summer fallow is the most common rotation.

Management practices needed to control erosion consist of using stubble-mulch tillage and contour tillage, seeding fall grain early, and shaping waterways and seeding them to grass. Diversions and stripcropping are needed on long slopes. In some places, wind stripcropping may be more beneficial in controlling erosion than contour tillage. Growing grasses in a long-term rotation helps to maintain or improve tilth and control erosion.

Grain and grass respond to nitrogen fertilizer.

CAPABILITY UNIT IIIe-4

This unit consists of well-drained soils of the Chard and Walla Walla series. Slopes range from .S to, 30 percent. These soils hold 9 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is medium, and the hazard of erosion is moderate. Annual precipitation is 12 to 16 inches, and the frost-free season is 170 to 190 days.

These soils are well suited to wheat, barley, and perennial grasses and are moderately well suited to sweet clover or alfalfa for green-manure crops. Most farmers use a winter wheat-summer fallow rotation. Wheat and green peas are grown alternately in a few places. Alfalfa or sweet clover is grown with grass as a soil-improving crop.

Management practices needed to control erosion consist of using stubble-mulch tillage (fig. 10) and contour tillage, shaping waterways and seeding them to grass, and seeding fall grain early after a fallow year. Diversions and stripcropping are necessary on long slopes. Diversions may be necessary, where runoff from higher areas crosses these soils. Growing grasses and legumes in the rotation helps to maintain or improve tilth and control erosion.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to sulfur and phosphorus.

CAPABILITY UNIT IIIe-5

This unit consists of well-drained soils of the Asotin and Oliphant series. These soils are underlain by bedrock at a depth of 20 to 60 inches. Slopes range from 0 to 15 percent. These soils hold from 3.5 to 9 inches of water that plants can use. Roots penetrate to the bedrock. Permeability is moderate. Runoff is slow to medium, and the hazard of erosion is moderate. Annual precipitation is 12 to 16 inches, and the frost-free season is 135 to 160 days.

These soils are used for wheat, barley, grasses, and legumes, and for grazing. Most of the acreage is farmed in a wheat-summer fallow rotation.

In a wheat-summer fallow rotation, management practices needed to control erosion consist of using stubble-mulch tillage and contour tillage, seeding fall grain early, and shaping waterways and seeding them to grass. Diversions and stripcropping are needed on long slopes. Diversions may be necessary where runoff from higher areas crosses these soils. Growing grasses and legumes in the rotation helps to maintain or improve tilth and control erosion.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to sulfur and phosphorus.

CAPABILITY UNIT IIIe-6

This unit consists of well-drained soils of the Athena and Palouse series. Slopes range from 8 to 25 percent. These soils hold 10 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is medium, and the hazard of erosion is moderate. Annual precipitation is 16 to 23 inches, and the frost-free season is about 140 to 165 days.

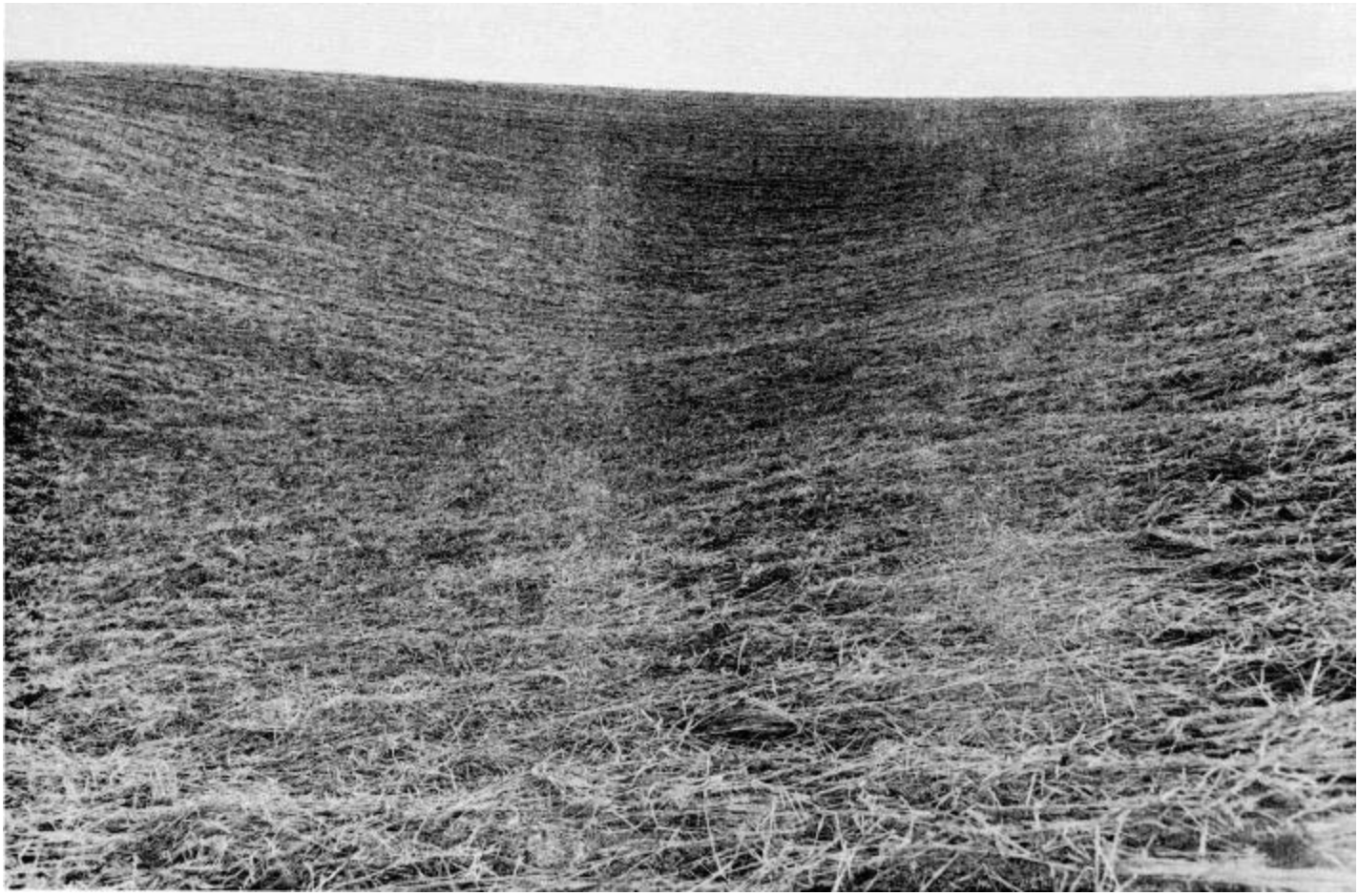

Figure 10.-Stubble mulch on Walla Walla silt loam, 8 to 30 percent slopes. This is a good erosion control practice.

These soils can be cropped every year. Winter wheat, spring wheat, green peas, and barley are grown. Intermediate wheatgrass and alfalfa are suitable for hay and pasture and are good soil-improving crops. A cropping system commonly used is winter wheat and green peas.

In a wheat-fallow rotation, management practices needed to control erosion consist of mixing all crop residues into the tillage layer, using cloddy fallow, tilling on the contour, shaping waterways and seeding them to grass, and seeding fall grain early. In a wheat-pea rotation, and when wheat is grown every year, all crop residue should be mixed into the tillage layer and the soils should be tilled no more than is necessary to control weeds and prepare a seedbed. Chiseling is needed occasionally to break tillage pans. Chiseling results in deeper penetration of moisture in the winter and slows runoff in spring. Diversions and stripcropping are necessary in either cropping system to control erosion on long slopes. Diversions on slopes that are steeper than about 15 percent should not be cultivated; they should be seeded to grass, and a filter strip should be established at the upper edge to control siltation. Diversions may be necessary where runoff from higher areas crosses these soils. Growing grasses and legumes in the rotation helps to maintain or improve tilth and control erosion. The plow furrow should be turned uphill if the moldboard plow is used in annual cropping.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to sulfur and phosphorus. Grain, particularly if grown 2 years or more in succession, may respond to sulfur.

CAPABILITY UNIT IIIe-7

This unit consists of well-drained soils of the Athena, Palouse, Tucannon, and Waha series. Bedrock is at a depth of 20 to 60 inches. Slopes range from 0 to 15 percent. These soils hold about 3.5 to 10 inches of water that plants can use. Roots penetrate to the bedrock. Permeability is moderately slow in the Waha soils and moderate in the other soils. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Annual precipitation is 16 to 23 inches, and the frost-free season is 120 to 165 days.

These soils are used mainly for growing wheat in a wheat-fallow rotation. Part of the acreage is used for barley, grasses, and legumes. There is sufficient precipitation for annual cropping.

In a winter wheat-fallow rotation, the management practices needed to control erosion consist of using stubble-mulch tillage and contour tillage, shaping waterways

and seeding them to grass, and seeding fall grain early. Chiseling may be needed occasionally to break tillage pans. Diversions and stripcropping are needed on long slopes. Diversions may be necessary where runoff from higher areas crosses these soils. Where wheat is grown every year, all crop residue should be mixed into the tillage layer, and the soils should be tilled no more than is necessary to control weeds and prepare a seedbed. The furrow should be turned uphill if a moldboard plow is used. Growing grasses and legumes in the rotation helps to maintain or improve tilth and control erosion.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to sulfur and phosphorus.

CAPABILITY UNIT IIIe-8

Only Couse silt loam, 0 to 15 percent slopes, is in this unit. This soil is moderately well drained and has slopes of 0 to 15 percent. It holds about 8 to 10 inches of water that plants can use. Root penetration is restricted by the very slowly permeable substratum. The subsoil is saturated until early in summer. Runoff is slow to medium, and the hazard of erosion is moderate. Annual precipitation is 24 to 30 inches, and the frost-free season is 100 to 120 days.

This soil produces forage for livestock and wild game and trees for lumber and pulp. It is well suited to the production of forest products. If cleared, it is suited to green peas and winter wheat provided erosion control is adequate. Erosion is very difficult to control in a summer fallow system. Timely tillage is sometimes difficult because the soil is wet until late in spring. A suitable rotation system should include orchardgrass and red clover for 2 years and alternate wheat and peas for 4 years. Alfalfa may be used, but the high water table in spring impairs the growth of alfalfa.

Management practices for erosion control on short slopes consist of mixing all crop residue into the tillage layer, tilling on the contour, tilling no more than is necessary to control weeds and prepare a seedbed, chiseling occasionally to break tillage pans, and shaping waterways and seeding them to grass. Diversions and stripcropping are needed on long slopes. Diversions may be necessary where runoff from higher areas crosses this soil.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to sulfur and phosphorus.

CAPABILITY UNIT IIIw-1

Only Covello silt loam, 0 to 3 percent slopes, is in this unit. This soil is somewhat poorly drained. Slopes range from 0 to 3 percent. A water table is within 24 to 48 inches of the surface most of the time. Root penetration is restricted by the water table. Permeability is moderate. Runoff is very slow, and there is little or no hazard of erosion. The annual precipitation is 16 to 23 inches, and the frost-free season is 150 to 165 days.

Most of the acreage of this soil is used for grazing. Part is used for wheat, barley, grasses, and legumes. Excellent stands of grasses and legumes are grown. Because of wetness, tillage in spring is delayed and weeds that tolerate wetness encroach in stands of grain. The soil can be cropped annually to grain.

Management practices needed consist of mixing all crop residue into the tillage layer and tilling no more than is necessary to control weeds and prepare a seedbed. Chiseling may be needed occasionally to break tillage pans. In some places it is necessary to divert runoff from higher areas to prevent siltation on this soil. If drainage is provided, most crops are suitable. Drainage can be accomplished by tile drains or open drains.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to sulfur and phosphorus.

CAPABILITY UNIT IIIs-1

Only Patit Creek gravelly silt loam, 0 to 3 percent slopes, is in this unit. This soil is well drained and is underlain by very gravelly sandy loam at a depth of 20 to 40 inches. Slopes range from 0 to 3 percent. The soil holds 4 to 7 inches of water that plants can use. Permeability is moderate above the very gravelly layer and rapid within that layer. Root penetration is restricted by the very gravelly layer. Runoff is very slow, and there is little or no hazard of erosion. Annual precipitation is 16 to 24 inches, and the frost-free season is 155 to 165 days.

Without irrigation, barley, grasses, and legumes are suitable crops. Grasses and legumes, apples, and asparagus are suitable crops under irrigation.

Management practices needed consist of mixing all crop residue into the tillage layer and seeding early in fall after a fallow year. Protection of streambanks is needed in some places. Diversions may be necessary where runoff from higher areas crosses this soil. Reverse plowing should be practiced if a moldboard plow is used. Growing grasses and legumes in the rotation helps to maintain or improve tilth.

Nonlegumes respond to nitrogen fertilizer, and legumes may respond to phosphorus and sulfur.

CAPABILITY UNIT IIIc-1

Only Esquatzel silt loam, 0 to 3 percent slopes, is in this unit. This soil is well drained. Slopes range from 0 to 3 percent. The soil holds about 9 to 11 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is very slow, and there is little or no hazard of erosion. Annual precipitation is 10 to 12 inches, and the frost-free season is 150 to 180 days.

This soil is used for wheat, barley, grasses, and legumes. Precipitation is too low for annual cropping. Barley frequently is not suited in years of low rainfall.

In a wheat-fallow rotation, management practices needed consist of using stubble-mulch tillage and seeding fall grain early. Growing grasses and legumes in rotation helps maintain or improve tilth. Diversions may be necessary where runoff from higher areas crosses this soil.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to sulfur and phosphorus.

CAPABILITY UNIT IVe-1

Only Roloff silt loam, 0 to 30 percent slopes, is in this unit. This soil is well drained. Bedrock is at a depth of 20 to 40 inches. Slopes range from 0 to 30 percent. The soil holds about 4 to 7 inches of water that plants can use. Roots penetrate to the bedrock. Permeability is moderate. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Annual precipitation is 10 to 12 inches, and the frost-free season is 140 to 160 days.

This soil is used mainly for wheat and grasses. Precipitation is too low for annual cropping.

Management practices needed to control erosion in a wheat-fallow rotation consist of using stubble-mulch tillage, contour tillage on slopes of more than 5 percent, shaping waterways and seeding them to grass, seeding fall grain early, and cultivating no more than is necessary to control weeds and prepare a seedbed. Diversions and stripcropping are needed on long slopes. Diversions may be necessary where. runoff from higher areas crosses this soil. Growing grasses in a long-term rotation helps to maintain or improve tilth and control erosion. The soil is well suited to perennial grasses. Rotation grazing and properly placed watering and salting facilities are necessary for maximum use of grasslands.

Grain and grass respond to nitrogen fertilizer.

CAPABILITY UNIT IVe-2

This unit consists of well-drained soils of the Farrell series. Slopes range from 0 to 15 percent. These soils hold 8 to 10 inches of water that plants can use. Root penetration is very deep. Permeability is moderately rapid. Runoff ranges from very slow to slow, and the hazard of water erosion from none to slight. There is a moderate hazard of soil blowing. Annual precipitation is 10 to 12 inches, and the frost-free season is 160 to 190 days.

These soils are used mainly for wheat and grasses. Part of the acreage of these soils is irrigated. Alfalfa, asparagus, sweet corn, and improved pasture grasses are grown in irrigated areas: Precipitation is too low for annual cropping.

In a wheat-fallow rotation, management practices needed to control erosion consist of using stubble-mulch tillage, tilling no more than is necessary to control weeds and prepare a seedbed, seeding early in fall, crosswind tillage, and in places, stripcropping at right angles to the prevailing wind. Growing grasses in a long-term rotation maintains or improves tilth and controls erosion.

Grain and grass respond to nitrogen fertilizer.

CAPABILITY UNIT IVe-3

Only Ritual silt loam, 15 to 40 percent slopes, is in this unit. This soil is well drained and limy. Slopes range from 15 to 40 percent. The soil holds 5 to 7 inches of water that plants can use. Root penetration is restricted because of the high content of lime in the subsoil. Permeability is moderate. Runoff is medium to rapid, and the hazard of erosion is severe. Annual precipitation is 10 to 16 inches, and the frost-free season is 140 to 160 days.

This soil is used mainly for wheat and grass. Precipitation is too low for annual cropping.

Management practices needed to control erosion consist of growing grass about half the time in a long-term rotation of grass and grain and summer fallow, using stubble-mulch tillage and contour tillage, tilling no more than is necessary to control weeds and prepare a seedbed, seeding fall grain early, and shaping waterways and seeding them to grass. Diversions may be necessary where runoff from higher areas crosses this soil.

Grain and grass respond to nitrogen and phosphorous fertilizer.

CAPABILITY UNIT IVe-4

This unit consists of well-drained soils of the Farrell and Ritzville series. Slopes range from 30 to 45 percent. The soils hold 9 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is rapid, and the hazard of erosion is severe. Annual precipitation is 10 to 12 inches, and the frost-free season is 140 to 190 days.

These soils are used mainly for winter wheat and grass. Precipitation is too low for annual cropping.

Management practices needed to control erosion consist of growing grass about half the time in a long-term grass-grain-fallow rotation, using stubble-mulch tillage and contour tillage, tilling no more than is necessary to control weeds and prepare a seedbed, and seeding fall grain early. A suitable rotation is 5 to 7 years of grass followed by 5 to 7 years of grain and fallow. Diversions and contour stripcropping are needed on long slopes. Diversions may be necessary where runoff from higher areas crosses these soils.

Grain and grass respond to nitrogen fertilizer.

CAPABILITY UNIT IVe-5

This unit consists of well-drained soils of the Chard and Walla Walla series. Slopes range from 30 to 40 percent. These soils hold 9 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is rapid, and the hazard of erosion is severe. The annual precipitation is 12 to 16 inches, and the frost-free season is 170 to 190 days.

These soils are used mainly for wheat, barley, grass, and alfalfa. Precipitation is marginal for annual cropping. Most of the acreage is cultivated in a wheat and fallow rotation.

Management practices needed to control erosion consist of growing grasses or grasses and legumes about half the time, in a long-term grass-grain-fallow rotation, using stubble-mulch tillage and contour tillage, tilling no more than is necessary to control weeds and prepare a seedbed, and seeding fall grain early. A suitable rotation is 5 to 7 years of grasses or grasses and legumes followed by. 5 to 7 years of grain and fallow. Contour stripcropping is needed on long slopes. Diversions may be. necessary where runoff from higher areas crosses these soils.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to sulfur and phosphorus.

CAPABILITY UNIT IVe-6

This unit consists of well-drained, severely eroded soils of the Walla Walla series. Sloes range from 8 to 40 percent. These soils hold 10 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is medium to rapid, and the hazard of erosion is severe to very severe. Annual precipitation is 12 to 16 inches, and the frost-free season is 180 to 190 days.

Few areas of these soils are managed separately. Management in most areas is the same as that for adjacent, uneroded soils. Alternate winter wheat and summer fallow is the main cropping system used.

To control further erosion, grasses or grasses and legumes should be planted about half the time in a long-term rotation. A suitable rotation is 5 to 7 years of grass or grass and alfalfa followed by 5 to 7 years of grain and fallow. When grain is grown, practices needed to control erosion are using stubble-mulch tillage and contour tillage, tilling no more than is necessary to control weeds and prepare a seedbed, and seeding fall grain early. Contour stripcropping is needed on long slopes. Diversions may be

necessary where runoff from higher areas crosses these soils.

Grain and grass respond to nitrogen and phosphorous fertilizer, and legumes may respond to phosphorus and sulfur.

CAPABILITY UNIT IVe-7

This unit consists of well-drained soils of the Asotin and Oliphant series. Bedrock is at a depth of 20 to 60 inches. Slopes range from 15 to 30 percent. These soils hold 3.5 to 9 inches of water that plants can use. Roots penetrate to the bedrock. Permeability is moderate. Runoff is medium, and the hazard of erosion is moderate to severe. Annual precipitation is 12 to 16 inches, and the frost-free season is 135 to 160 days.

These soils are used mainly for wheat, barley, grasses, and legumes and for grazing. Most of the acreage used for grain is in a wheat-fallow rotation.

Management practices needed to control erosion in a grain-fallow rotation consist of growing grass or grass and alfalfa for .about half the time in a long-term rotation, using stubble-mulch tillage and contour tillage, seeding fall grain early, and shaping waterways and seeding them to grass. A suitable rotation is 5 to 7 years of grass or grass and alfalfa followed by 5 to 7 years of grain and fallow. Diversions and stripcropping are needed on long slopes. Diversions on these soils should be seeded to grass, and a filter strip should be established at the upper edge to control siltation. Diversions may be necessary where runoff from higher areas crosses these soils.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to phosphorus and sulfur.

CAPABILITY UNIT IVe-8

This unit consists of well-drained soils of the Athena and Palouse series. Slopes range from 25 to 40 percent. These soils hold 10 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is rapid, and the hazard of erosion is severe. Annual precipitation is 16 to 23 inches, and the frost-free season is 140 to 165 days.

Grain, grass, and alfalfa are suitable crops.

Satisfactory erosion control cannot be achieved through the use of a winter wheat and fallow rotation. A suitable rotation is 3 to 5 years of grass or grass and alfalfa followed by 1 to 2 years of annual grain.

Management practices needed to control erosion in this rotation system consist of mixing all crop residue into the tillage layer, contour tillage, keeping the surface rough over winter, and tilling no more than is necessary to control weeds. Stripcropping is needed on long slopes. Diversions may be necessary where runoff from higher areas crosses these soils.

In years of heavy snowfall, these soils are often covered by drifts that smother fall-seeded grain, permit weed invasion, and cause severe rill erosion or deep soil slips. These hazards can be reduced by leaving stubble or by planting windbreaks of trees and shrubs on the hilltops.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to phosphorus and sulfur.

CAPABILITY UNIT IVe-9

This unit consists of well-drained, severely eroded soils of the Athena and Palouse series. Slopes range from 8 to 25 percent. These soils hold 8 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is medium to rapid, and the hazard of erosion is severe. Annual precipitation is 16 to 23 inches, and the frost-free season is about 140 to 165 days.

These soils are used mainly for wheat and barley. Farmers avoid growing peas on these soils because the peas would mature before peas on adjacent, uneroded soils, thereby lowering the quality of the crop pack.

To control further erosion, the soils should be planted to grasses or legumes for several years before grain is grown, and then grasses or grasses and legumes should be grown for at least half the time in rotation with grain. A suitable rotation consists of 3 to 5 years of grass or alfalfa and grass followed by 3 to 5 years of annual grain.

Management practices needed consist of mixing all crop residue into the tillage layer, tilling on the contour, turning the furrow slice uphill, chiseling in years when grain is grown, tilling no more than is necessary to control weeds and prepare a seedbed, and shaping waterways and seeding them to grass. Diversions and stripcropping are needed on long slopes. Diversions may be needed where runoff from higher areas crosses these soils.

Mulching and spreading manure and crop residue are beneficial.

Grain and grass respond to nitrogen and phosphorus fertilizers, and legumes may respond to phosphorus and sulfur.

CAPABILITY UNIT IVe-10

This unit consists of well-drained soils of the Athena, Palouse, Tucannon, and Waha series. Bedrock is at a depth of 20 to 60 inches. Slopes range from 15 to 25 percent. These soils hold 3.5 to 8 inches of water that plants can use. Roots penetrate to the bedrock. Permeability is moderate in the Athena, Palouse, and Tucannon soils and moderately slow in the Waha soils. Runoff ranges from medium to rapid, and the hazard of erosion from moderate to severe. Annual precipitation is 16 to 23 inches, and the frost-free season is about 120 to 165 days.

These soils are used for wheat, barley, grasses, and legumes. There is sufficient precipitation for annual cropping. Erosion is very difficult to control if a wheat-fallow rotation is used.

Where grain is grown annually, the management practices needed to control erosion consist of mixing all crop residue into the tillage layer, tilling no more than is necessary to control weeds and prepare a seedbed, tilling on the contour, and shaping waterways and seeding them to grass. Diversions and stripcropping are needed on long slopes. Diversions should be seeded to grass and a filter strip should be established at the upper edge to control siltation. Diversions may be necessary where runoff from higher areas crosses these soils. Growing grasses and legumes in the rotation helps to maintain or improve tilth and control erosion.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to phosphorus and sulfur.

CAPABILITY UNIT IVe-11

This unit consists of well-drained and moderately well drained soils of the Couse and Larkin series. Basalt

bedrock or a very slowly permeable substratum is at a depth of 30 to 55 inches. Slopes range from 0 to 25 percent. These soils hold 5 to 10 inches of water that plants can use. Runoff ranges from slow to medium, and the hazard of erosion from moderate to severe. Annual precipitation is 18 to 30 inches, and the frost-free season is 100 to 140 days.

These soils are well suited to grass and trees. They can be cropped to annual grain in rotation with grasses and legumes. A suitable rotation is 3 to 5 years of alfalfa and grass followed by 1 or 2 years of grain.

Management practices needed to control erosion consist of mixing all crop residue into the tillage layer, tilling on the contour, turning the furrow slice uphill, leaving the surface rough over winter, and shaping waterways and seeding them to grass. Diversions and stripcropping are needed on long slopes. On slopes steeper than about 15 percent, diversions should be seeded to grass and a filter strip should be established at the upper edge to prevent siltation. Diversions may be necessary where runoff from higher areas crosses these soils.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to phosphorus and sulfur.

CAPABILITY UNIT IVe-12

This unit consists of well drained and moderately well drained soils of the Tolo series and a variant of the Tolo series. Slopes range from 3 to 15 percent. These soils hold 8 to 12 inches of water that plants can use. Permeability is moderate in the subsoil and moderately slow or slow in the buried subsoil. In spring, the soils are saturated above the buried subsoil. Runoff is medium, and the erosion hazard is moderate. Annual precipitation is 30 to 40 inches, and the frost-free season is 90 to 115 days.

These soils are used mainly for trees. Some areas are used for grain and for grasses and legumes. Trees tend to encroach in stands of grass, and the stands of grass must be reestablished frequently. These soils should be under a year-round cover.

When grain is grown, management practices needed to control erosion consist of mixing all crop residue into the tillage layer, tilling on the contour, turning the furrow slice uphill, leaving the surface rough over winter, and shaping waterways and seeding them to grass. Diversions and stripcropping are needed on long slopes. Diversions may be necessary where runoff from higher areas crosses these soils. In places drainage is necessary for maximum crop production.

Grain and grass respond to nitrogen fertilizer, and legumes may respond to phosphorus and sulfur.

CAPABILITY UNIT IVs-1

Only Yakima silt loam, 0 to 3 percent slopes, is in this unit. This soil is well drained and is underlain by very gravelly sand at a depth of 20 to 40 inches. Slopes range from 0 to 3 percent. The soil holds about 4 to 8 inches of water that plants can use. Permeability is moderate above the very gravelly layer and very rapid within that layer. Root penetration is restricted by the very gravelly layer. Runoff is very slow, and there is little or no hazard of erosion. Annual precipitation ranges from 10 to 18 inches, and the frost-free season is 150 to 190 days.

A large part of the acreage is used for irrigated alfalfa, sweet corn, and asparagus.

When growing dryfarmed grain, management practices needed consist of mixing all crop residue into the tillage layer and seeding fall grain early after a fallow year. Reverse plowing should be practiced if a moldboard plow is used. In some places protection of streambanks is necessary.

Nonlegumes respond to nitrogen fertilizer, and legumes respond to phosphorus and sulfur.

CAPABILITY UNIT IVs-2

This unit consists of well-drained gravelly soils of the Yakima series. These soils are underlain by very gravelly sand at a depth of 20 to 40 inches. Slopes range from 0 to 8 percent. These soils hold about 3 to 6 inches of water that plants can use. Permeability is moderate above the very gravelly layer and very rapid within that layer. Root penetration is restricted by the very gravelly layer. Runoff is very slow or slow, and the hazard of erosion is none to slight. Annual precipitation is 10 to 18 inches, and the frost-free season is 150 to 190 days.

Most of the acreage of these soils is irrigated to alfalfa and grass. Small acreages are in dryfarmed grain. Some areas are idle or used for grazing the native vegetation.

Protection of streambanks is needed in some places. The soils require light, frequent irrigation when irrigated crops are grown, and nitrogen fertilizer is most effective when applied in several light applications annually.

CAPABILITY UNIT VIe-1

This unit consists of well-drained soils of the Farrell series. Slopes range from 15 to 45 percent. These soils hold 8 to 10 inches of water that plants can use. Root penetration is very deep. Permeability is moderately rapid. Runoff ranges from medium to rapid, and the hazard of erosion is moderate to severe. Annual precipitation is 10 to 12 inches, and the frost-free season is about 160 to 190 days.

These soils are well suited to grazing and use as wildlife habitat. They can be reseeded by ordinary farm machinery.

CAPABILITY UNIT VIe-2

This unit consists of well drained and moderately well drained soils of the Asotin, Kuhl, Roloff, and Spofford series. Slopes range from 8 to 45 percent. These soils hold 3 to 8 inches of water that plants can use. Roots penetrate dominantly to a depth of 20 to 40 inches. Permeability is moderate. Runoff ranges from medium to rapid, and the hazard of erosion is moderate to severe. Annual precipitation is 10 to 19 inches, and the frost-free season is 140 to 180 days.

These soils are well suited to grazing and use as wildlife habitat. All but the rocky soils can be reseeded by ordinary farm machinery.

CAPABILITY UNIT VIe-3

This unit consists of well-drained soils of the Oliphant and Walvan series. Slopes range from 15 to 40 percent. These soils hold 6 to 9 inches of water that plants can use. Root penetration ranges from a depth of about 40 inches to more than 60 inches. Permeability is moderate to moderately rapid. Runoff ranges from medium to rapid, and

the hazard of erosion is moderate to very severe. Annual precipitation is 12 to 16 inches, and the frost-free season is 135 to 180 days.

These soils are well suited to grazing and use as wildlife habitat. They can be reseeded by ordinary farm machinery.

CAPABILITY UNIT VIe-4

This unit consists of well-drained soils of the Athena, Palouse, Tucannon, and Waha series. Slopes range from 8 to 40 percent. These soils hold about 3.5 to 12 inches of water that plants can use. Root penetration ranges from a depth of about 20 inches to more than 60 inches. Permeability is moderate to moderately slow. Runoff ranges from medium to very rapid, and the hazard of erosion is severe to very severe. Annual precipitation is 16 to 23 inches, and the frost-free season is 120 to 165 days.

These soils are well suited to grazing and use as wildlife habitat. They can be reseeded by ordinary farm machinery.

CAPABILITY UNIT VIe-5

This unit consists of well drained and moderately well drained soils of the Couse and Larkin series. slopes range from 3 to 40 percent. These soils hold about 4 to 9 inches of water that plants can use. Permeability is moderate to very slow. Runoff ranges from medium to rapid, and the hazard of erosion is moderate to severe. Annual precipitation is 18 to 30 inches, and the frost-free season is 100 to 140 days.

These soils are well suited to woodland, grazing, and use as wildlife habitat. They can be reseeded by ordinary farm machinery.

CAPABILITY UNIT VIe-6

Only Tolo silt loam, 15 to 40 percent slopes, is in this unit. This soil is well drained. It holds about 10 to 12 inches of water that plants can use. Roots penetrate to bedrock, which is at a depth of 40 to 66 inches. Permeability is moderate above the buried subsoil and moderately slow in the buried subsoil. Runoff is medium to rapid, and the hazard of erosion is severe. Annual precipitation is 30 to 40 inches, and the frost-free season is 90 to 100 days.

This soil is well suited to woodland and use as wildlife habitat.

CAPABILITY UNIT VIe-7

This unit consists of well-drained soils of the Athena and Palouse series. Slopes range from 40 to 55 percent. These soils hold 8 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is very rapid, and the hazard of erosion is very severe. Annual precipitation is 16 to 23 inches, and the frost-free season is 140 to 165 days.

These soils are well suited to grazing and use as wildlife habitat. In some places they can be reseeded by ordinary farm machinery but only with difficulty.

CAPABILITY UNIT VIs-1

Only Patit Creek cobbly silt loam, 0 to 3 percent slopes, is in this unit. This soil is well drained. It holds about 3 to 6 inches of water that plants can use. Root penetration is restricted by a very gravelly layer at a depth of 20 to 40 inches. Permeability is moderate above the very gravelly layer and rapid within that layer. Runoff is very slow, and there is little or no hazard of erosion. Annual precipitation is 16 to 24 inches, and the frost-free season is 155 to 165 days.

This soil is well suited to grazing and use as wildlife habitat. It can be reseeded, but the cobblestones make this difficult.

CAPABILITY UNIT VIIe-1

This unit consists of well-drained soils of the Asotin, Kuhl, and Roloff series. Slopes range from 30 to 65 percent. These soils hold 1.5 to 8 inches of water that plants can use. Roots penetrate to depths of 20 to 40 inches. Permeability is moderate. Runoff is rapid to very rapid, and the hazard of erosion is very severe. Annual precipitation is 10 to 16 inches, and the frost-free season is 140 to 160 days.

These soils are well suited to grazing and use as wildlife habitat. Except in a few areas, they cannot be reseeded by ordinary farm machinery.

CAPABILITY UNIT VIIe-2

This unit consists of well-drained soils of the Ritzville and Walla Walla series. Slopes range from 40 to 65 percent. These soils hold 10 to 12 inches of water that plants can use. Root penetration is very deep. Permeability is moderate. Runoff is very rapid, and the hazard of erosion is very severe. Annual precipitation is 10 to 16 inches, and the frost-free season is 140 to 190 days.

These soils are well suited to grazing and use as wildlife habitat. Except in a few areas, they cannot be reseeded by ordinary farm machinery.

CAPABILITY UNIT VIIe-3

This unit consists of well-drained soils of the Linville, Tucannon, and Waha series. Slopes range from 40 to 65 percent. These soils hold 3.5 to more than 12 inches of water that plants can use. Roots penetrate to depths of 20 to more than 60 inches. Permeability is moderately slow. Runoff is very rapid, and the hazard of erosion is very severe. Annual precipitation is 16 to 23 inches, and the frost-free season is 120 to 165 days.

These soils are well suited to grazing and use as wildlife habitat. Except in a few places, they cannot be reseeded by ordinary farm machinery.

CAPABILITY UNIT VIIe-4

This unit consists of well-drained soils of the Tolo and Larkin series. Slopes range from 40 to 65 percent. These soils hold 6 to 12 inches of water that plants can use. Roots penetrate to a depth of 2.5 to 6 feet. Permeability ranges from moderate to moderately slow. Runoff is very rapid, and the hazard of erosion is very severe. Annual precipitation is 18 to 40 inches, and the frost-free season is 90 to 140 days.

These soils are well suited to woodland and use as wildlife habitat.

CAPABILITY UNIT VIIs-1

Only Stratford very stony silt loam, 0 to 30 percent slopes, is in this unit. This soil is well drained and very stony. It holds 3 to 5 inches of water that plants can use. Root penetration is restricted by a layer of sand, gravel, cobblestones, and boulders at a depth of 20 to 40 inches. Permeability above that layer is moderate. Runoff is slow to medium, and the hazard of erosion is slight to moder-

ate. Annual precipitation is 10 to 12 inches, and the frost-free season is 160 to 190 days.

In nonirrigated areas, this soil is well suited to grazing and use as wildlife habitat. In some irrigated areas near streams it is suited to pasture grass. Reseeding is not practical in most nonirrigated areas.

CAPABILITY UNIT VIIs-2

This unit consists of well-drained soils of the Anatone. Gwin, Klicker, and Kuhl series. Slopes range from 0 to 65 percent. These soils hold about 1.5 to 3 inches of water that plants can use. Roots penetrate to a depth of 10 to 40 inches. Permeability is moderate to moderately slow. Runoff ranges from slow to rapid, and the hazard of erosion is slight to very severe. The annual precipitation is 10 to 40 inches, and the frost-free season is 90 to 160 days.

These soils are well suited to grazing and use as wildlife habitat. Reseeding is not practical.

CAPABILITY UNIT VIIIe-1

This unit consists only of Dune land. Areas of Dune land are used for recreation, watershed, wildlife, and other nonfarm uses. They are too sandy and unstable for crops.

CAPABILITY UNIT VIIIw-1

This unit consists only of Riverwash. This material is unsuitable for crops because it is subject to flooding and is too gravelly and cobbly for tillage.

CAPABILITY UNIT VIIIs-1

This unit consists of land types and soils that are too rocky, gravelly, cobbly, or stony for crops. All are used for wildlife habitat, watershed, recreation, and other nonfarm uses.

Estimated yields

Soil, climate, and management are the main factors that affect crop yields in the Columbia County Area. The wide variety of soils and the wide range in annual precipitation cause significant differences in management. in the Area.

Table 2 gives the estimated average acre yields of the crops commonly grown on the arable soils of the Area. The data are based on the experience of farmers and ranchers and on the knowledge of people in the Soil Conservation Service and the Agricultural Extension Service.

Yields in columns A are obtained by those who use relatively small amounts of fertilizer, plant common varieties of wheat and barley, and till frequently to control weeds. Plant residue is burned or otherwise reduced until it is of little value for erosion control. The soil is finely pulverized and is highly susceptible to erosion by wind or water.

Yields in columns B are obtained by the majority of the farmers. Relatively large amounts of fertilizer are applied. The amount is based on soil tests. For example, the Washington Agricultural Experiment Station found that after allowing 4 inches of moisture for roots and straw, each additional inch of moisture would produce 6 or 7 bushels of wheat and that 2.7 to 3 pounds of nitrogen per acre would be required for each bushel. Yields in columns B are for new varieties of wheat and other crops. The new varieties of wheat, such as Gaines and Nugaines, increase production over the old varieties by approximately 15 bushels per acre where annual precipitation is 16 to 23 inches, 10 bushels where 12 to 16 inches, and as much as 5 bushels where 10 to 12 inches. To obtain the yields in columns B, tillage operations are carefully timed and kept to a minimum.

A few farmers found that by using perennial or biennial legumes and grasses in the rotation, they were able to obtain higher yields of winter wheat with significantly smaller applications of nitrogen. Those yields are given in columns C for soils on which that practice is applicable.

It is important to keep in mind that the figures given in table 2 are estimates of average yields that can be expected over a period of years. Yields in any one year may be much higher or lower than the average. For example, there are wide differences in precipitation from year to year in the Area, and these differences affect crop yields.

Range

More than a third of the Columbia County Area is range. Range designates areas on which the potential plant community consists of grasses, forbs, and shrubs that are valuable for forage. Approximately 95,000 acres is in the Snake River and Tucannon River Valleys in the northern part of the county, and 35,000 acres is in the foothills of the Blue Mountains. An additional 43,000 acres of woodland provides limited grazing following logging operations.

Most ranchers must provide pasture or feed during the off seasons. Ranchers who have large holdings generally raise calves for sale. Those who own small areas of productive range generally buy calves and graze them while pasture is available and then fatten them in feedlots on locally produced barley, peavine silage, cannery byproducts, and corn silage.

In the Snake River and Tucannon River area, the principal forage plants are bluebunch wheatgrass and Idaho fescue. This range is grazed in winter and early in spring. In summer and fall, the cattle and sheep are moved to irrigated pastures or are taken to the mountains. Idaho fescue and bluebunch wheatgrass are the important forage grasses in the foothills. They provide forage late in spring and in summer. In wooded areas, forbs and shrubs make up a large part of the forage.

Overgrazing and selective grazing have reduced the stand of desirable forage plants on nearly all of the range. In many areas the desirable plants have been replaced by such undesirable plants as rabbitbrush, lupine, medusahead wildrye, and yellow starthistle. A large part of the range now produces about half the forage it is capable of producing. Future forage production depends upon range management.

Range sites and condition classes

In order to manage range properly, the rancher should know the different kinds of soil on his range and the

By DEWAYNE BECK, range conservationist, Soil Conservation Service.

plants each is capable of supporting. The soils in the Columbia County Area have been grouped into range sites. These sites differ from each other in their ability to produce a significantly different kind or amount of climax vegetation and require different grazing use or management.

The climax or potential vegetation on rangeland in the Area consists of a combination of plants that originally grew on the sites. A rancher can determine the condition of his range by comparing the present vegetation with the climax vegetation for the site. Four classes of range condition are recognized. A range that has 75 to 100 percent of its climax vegetation is in excellent condition. One with 50 to 75 percent is in good condition. One with 25 to 50 percent is in fair condition, and one with less than 25 percent is in poor condition. Range in excellent condition produces the highest yields of forage and has good cover for soil and water conservation.

All soils in the Area but those that are entirely under cultivation or that are unsuitable for grazing have been grouped into range sites. Some. sites are. identified not only by name, but also by symbol. The three North Exposure range sites, for example, are identified as N-1, N-2, and N-3. The letter N denotes the name of the site. The numerals denote differences in vegetation within the site, depending on the location, the amount of annual precipitation, and the length of the growing season. The description of each range site gives the important soil characteristics, names the principal plants, and gives information about use and management of the site. Additional information is available at the office of the Soil Conservation Service in Dayton, Wash.

The soil series represented in each site are named, but this does not mean that all the soils of the series are in the site. To determine the range site in which a given soil has been placed, refer to the "Guide to Mapping Units" at the back of this survey.

SANDY LOAM RANGE SITE

This site is made up of well-drained soils of the Farrell series. They have moderate permeability. Slopes range from 0 to 45 percent. Elevation is 700 to 1,700 feet. Annual precipitation is 10 to 12 inches. The soils are on terrace remnants and terrace fronts in the canyons tributary to the Snake River and Tucannon River Valleys. Approximately 2,000 acres is grazed. Small areas near streams where irrigation water is available are being converted to cropland.

When this site is in excellent condition, the vegetation is dominantly bluebunch wheatgrass and needle-and-thread. Bluebunch wheatgrass decreases under excessive grazing or burning and is replaced by the less productive needle-and-thread, Sandberg bluegrass, balsamroot, milkvetch, and rabbitbrush. Undesirable plants, such as mustard, thistle, and cheatgrass, invade the site as the more desirable grasses are grazed out. The soils are highly susceptible to trampling by livestock and are subject to soil blowing where the vegetative cover has been destroyed.

In favorable years total annual yield from this site is about 700 pounds per acre. In unfavorable years the yield is about 530 pounds. About 90 percent of the yield is from plants that provide forage for cattle or sheep. Most areas of this site are near watering places or feedlots and are heavily grazed.

LOAMY RANGE SITE (L-2)

This site consists of well-drained soils of the Asotin, Chard, Ellisforde, Farrell, Oliphant, Ritzcal, Ritzville, Roloff, Stratford, Walla Walla, and Walvan series, and small areas of moderately well drained soils of the Spofford series. These soils have dominantly moderate permeability. Slopes range from 0 to 65 percent. Elevation ranges from 500 to 2,500 feet. Annual precipitation is 10 to 16 inches.

Most of the acreage of Chard, Ritzville, and Walla Walla soils is cultivated. An estimated 38,000 acres remains in range in the area near the Tucannon River and Snake River in the northern part of Columbia County. Small areas are scattered throughout the cropland in the western part of Columbia County.

The most productive forage plants are bluebunch wheatgrass and Idaho fescue. Idaho fescue is preferred by cattle and is the first to disappear when overgrazed. Sandberg bluegrass, lupine, yarrow, and rabbitbrush increase on overgrazed rangeland. Cheatgrass brome, annual fescue, and thistles invade severely overgrazed and eroded areas. When the site is in excellent condition, plants should cover 40 percent of the area and litter, 35 percent.

Moderate yields of forage are obtained when this site is in excellent condition. In favorable years total annual air-dry yield from this site is about 1,100 pounds per acre. In unfavorable years the yield is about 800 pounds. About 95 percent of the yield is from plants that furnish forage for cattle and sheep.

LOAMY RANGE SITE (L-3)

This site consists of well-drained soils of the Athena, Palouse, Tucannon, and Waha series. These soils are moderately permeable. Slopes range from 0 to 40 percent. Elevation ranges from 1,300 to 3,500 feet. Annual precipitation is 16 to 23 inches. This rangeland is in small areas associated with cropland in the central part of the county. Only about 20,000 acres of these soils is grazed.

The potential plant community includes a wide variety of high-producing forage grasses. Idaho fescue and bluebunch wheatgrass are dominant. Plants that increase when the site is overgrazed are Canada bluegrass, lupine, milkvetch, hawthorn, bitter cherry, and wild rose. Severely overgrazed areas become too brushy for cattle.

Although the areas of this range site are small, they are highly productive and respond to a high level of range management. Total annual air-dry yield is estimated to be about 1,000 pounds per acre in unfavorable years and about 2,400 pounds in favorable years. About 90 percent of the yield is from plants that furnish forage for cattle or sheep.

SHALLOW RANGE SITE (S-2)

This site consists of well-drained soils of the Kuhl series. Permeability is moderate. Slopes range from 0 to 65 percent. Elevation ranges from 500 to 2,400 feet. Annual precipitation ranges from 10 to 19 inches, but is mostly 10 to 15 inches. This site occupies about 20,000 acres, mainly in the lower part of the Tucannon Valley.

The principal forage grass on this site is bluebunch wheatgrass. mall amounts of Idaho fescue grow on the more favorable areas. Low forage plants, such as Sandberg bluegrass, needle-and-thread, yarrow, and rabbitbrush, increase as the more palatable bunchgrasses are weakened by overgrazing. Undesirable weedy plants that invade this site include cheatgrass brome, tumbling mustard, and salsify.

These soils do not store enough moisture to produce high yields of forage. In favorable years total annual airdry yield is about 650 pounds per acre. In unfavorable years the yield is about 360 pounds. About 90 percent of the yield is from plants that furnish forage for cattle or sheep. This site is generally the first to be grazed each spring. The poor condition of a large part of this site probably is due to the heavy grazing each spring.

SHALLOW RANGE SITE (S-3)

This site consists of well-drained soils of the Anatone and Gwin series. Anatone soils have moderate permeability. Gwin soils have moderately slow permeability. Slopes are 30 to 65 percent. Elevation ranges from 1,500 to 4,500 feet. Annual precipitation ranges from 16 to 35 inches but is mostly 16 to 23 inches. This site occupies about 27,000 acres in the eastern part of the cropland area and on open ridgetops and south-facing slopes of the Blue Mountains. On this site the rainy season starts about 2 weeks earlier in fall and ends 2 or 3 weeks later in spring than at lower elevations in the northern and western parts of the survey area. Where unprotected by plant cover, the soils are highly susceptible to water erosion.

Bluebunch wheatgrass and Idaho fescue are the most important forage plants on this site. When this site is in excellent condition, plants should cover more than 25 percent of the soil surface, and litter more than 25 percent. An increase in Canada bluegrass, Sandberg bluegrass, balsamroot, and lupine is a sign of overgrazing.

This site furnishes most of the grazing in the Blue Mountain area. The south-facing slopes are the first areas of the foothill and mountain rangeland that are ready for grazing in spring. Deer, elk, and cattle are usually on them before the soil is dry enough to resist trampling. Grazing early in spring has severely damaged the desirable forage grasses.

When this site is in excellent condition, the total annual air-dry yield is about 1,100 pounds per acre in favorable years and 650 pounds per acre in unfavorable years. About 90 percent of the yield is from plants that furnish forage for cattle or sheep.

NORTH EXPOSURE RANGE SITE (N-1)

This site consists of well-drained soils of the Ritzville and Walla Walla series. These soils have moderate permeability. Slopes range from 40 to 65 percent. Elevation ranges from 800 to 2,000 feet. Annual precipitation is 10 to 16 inches. These soils are on north-facing and northeast-facing slopes. They are readily damaged by trampling. This site occupies about 8,000 acres, widely distributed in the western and northern parts of the survey area. A large percentage of the acreage is in relatively small areas of rough, broken land and in the steep coves associated with large areas of cropland.

This site is most productive when Idaho fescue and bluebunch wheatgrass are dominant. Idaho fescue is readily grazed by cattle and is the first grass to disappear when the site is overgrazed. Low forage plants that increase when the site is overgrazed are Sandberg bluegrass, threadleaf sedge, aster, and lupine. Weedy plants that invade areas in poor condition and eroded areas are annual fescue, cheatgrass brome, bullthistle, and plantain.

The total annual air-dry yield ranges from about 1,500 pounds per acre in favorable years to about 1,000 pounds in unfavorable years. About 90 percent of the yield is from plants that furnish forage for cattle or sheep.

NORTH EXPOSURE RANGE SITE (N-2)

This site consists of well-drained soils of the Athena, Linville, and Tucannon series. These soils have moderate permeability. Slopes range from 40 to 65 percent. Elevation ranges from 1,300 to 2,800 feet. Annual precipitation is 16 to 20 inches. This site occupies about 6,500 acres in the Whetstone and Touchet Valleys in the central part of the county. It is mainly on rough, broken slopes that are too steep for cultivation. Plants and soils are easily damaged by trampling.

Idaho fescue is the major forage plant. Bluebunch wheatgrass and prairie junegrass grow in small amounts. Large patches of wild rose, hawthorn, snowberry, and other shrubs grow in coves or on moist spots. As the plant community begins to deteriorate, shrubs, lupine, balsamroot, and yarrow increase. Annual brome, medusahead wildrye, yellow starthistle, and salsify invade severely overgrazed and eroded areas.

Snow blown from adjacent ridgetops and south-facing slopes substantially increases the amount of moisture available for growth of plants so forage production is high. The estimated total annual yield ranges from 2,000 pounds of air-dry forage per acre in favorable years to 1,500 pounds in unfavorable years. About 80 percent of the yield is from plants that furnish forage for cattle or sheep. This site is usually grazed in alternate years with wheat or barley cropland in stubble.

NORTH EXPOSURE RANGE SITE (N-3)

This site consists of well-drained soils of the Palouse and Waha series. Palouse soils have moderate permeability. Waha soils have moderately slow permeability. Slopes range from 40 to 65 percent. Elevation ranges from 2,000 to 3,500 feet. Annual precipitation is 19 to 23 inches. These soils are highly susceptible to erosion when the plant cover is destroyed, and they are easily damaged by trampling when wet. This site occupies about 4,000 acres in the survey area. It is transitional between grassland and forest. Brush invades when the grass is overgrazed.

This site produces green forage later in summer than nearby sites. When it is in excellent condition, Idaho fescue and bluebunch wheatgrass produce large amounts of forage. Canada bluegrass, lupine,, geranium, snowberry, and wild rose increase if the site is overgrazed. Hawthorn, serviceberry, and spirea are also active invaders. St.-Johns-wort, mullein, dock, salsify, and other weeds invade severely overgrazed and eroded areas.

The estimated total annual air-dry yield in unfavorable years is 2,000 pounds per acre. In favorable years it is about 2,600 pounds per acre. About 90 percent of the yield is from plants that furnish forage for cattle or sheep.

BOTTOMLAND RANGE SITE

This site consists of well-drained soils of the Patit Creek series and a somewhat poorly drained soil of the Covello series. The Patit Creek soils have moderate permeability above the very gravelly layers. The Covello soil has moderate permeability. Slopes are 0 to 3 percent. Elevation ranges from 1,200 to 2,500 feet. Annual precipitation is 16 to 24 inches. About 6,000 acres of these soils is nearly level bottoms along all major streams on the Touchet River above Huntsville and on the Tucannon River above Pataha Creek. Range areas are interspersed with small cultivated fields, some of which are irrigated.

The small areas on bottom lands are grazed along with large areas on uplands. Cattle congregate on bottom lands. Most of these areas are severely overgrazed, and present productivity is low. The vegetation is largely mullein, dock, shrubs, and cheatgrass brome.

When in excellent condition, this site produces very high yields of basin wildrye and bluebunch wheatgrass. Estimated total annual air-dry yield ranges from 10,000 pounds per acre in favorable years to 6,000 pounds in less favorable years. About 90 percent of the yield is from plants that furnish forage for cattle or sheep.

Woodland

Forest covers about 43,000 acres, or about 11 percent of the total privately owned land in the Columbia County Area.

The forests, or woodlands, are in the southeastern part of the survey area, primarily on north, northeast, and northwest exposures in the Blue Mountains.

The principal woodland product is sawlogs for lumber. The important lumber trees are ponderosa pine, Douglas-fir, western larch, and grand fir. Most of the wood products are now processed outside the Area. There is a small demand for corral posts and poles of western larch and lodgepole pine.

Some of the forest land at lower elevations has been cleared for farming. About 4,600 acres of the Couse soils, 600 acres of the Larkin soils, and 200 acres of the Tolo soils have been used for farmland. These soils, however, are highly erodible and are not productive for cropping. A large part of this former forest land is now seeded to grass or is reverting to trees.

The woodland is also important for use as recreation areas and wildlife habitat. Boy Scout and Girl Scout camps and community camps attract campers and hikers from all of southeastern Washington. Large herds of deer and elk provide good hunting.

Woodland suitability grouping

In the Columbia County Area, soils, climate, topography, aspect, and elevation are the principal factors that affect tree growth. The seasonal . availability of soil moisture chiefly determines the kinds of trees that can grow and their rate of growth. Annual growth rate is highest on those soils that hold enough available moisture to maintain tree growth during the dry season in summer. The annual growth rate is lowest on those soils that have bedrock or other materials that restrict water and root penetration at a depth of less than 40 inches. Production is greatest on the very deep, moderately permeable soils on north, northeast, or northwest exposures.

Growth rate is reflected by the site index, which is determined by measuring the total height attained by dominant and codominant trees at 100 years of age (3). The indexes obtained are grouped into site classes as follows:
Index of more than 112, site class I; 99 to 112, site class II; 85 to 98, site class III; 71 to 84, site class IV; 57 to 70, site class V. Site class I is excellent and has high productivity, whereas site class V is poor and has low productivity.

Each woodland group is identified by a symbol, for example, 4r1. The first element of the symbol is a number that indicates the productivity by site class.

The second element of the symbol is a letter that denotes the subclass or the kind of soil limitation to be expected in woodland use and management. The letter d denotes restricted rooting depth; the letter *r* denotes slope; and the letter *x* denotes stones or rocks. The letter *o* denotes no limitation.

The third element of the symbol is a numeral that sequentially differentiates two specified groups that have the same first and second elements.

Table 3 gives yields of board feet per acre from unmanaged, even-aged, fully stocked stands of ponderosa pine by age of trees and site index. Only trees 11.6 inches or more in diameter were rated.

WOODLAND GROUP 1r

This group consists of deep and very deep, well-drained, medium-textured and moderately fine textured soils of the Tolo and Larkin series. These soils formed in thick deposits of wind-laid silts and volcanic ash on very steep north-facing and northeast-facing slopes. They occur above 2,500 feet elevation. The annual rainfall is about 30 inches. Snow accumulates in large drifts that do not melt until late in spring. The melting snow provides adequate moisture for plant growth late in summer.

Douglas-fir, ponderosa pine, and grand fir are the important commercial trees. The site class is I. Logging practices have gradually changed the timber stands from predominantly ponderosa pine to stands in which Douglas-fir is most common.

Use of equipment is severely limited by steep slopes and the heavy snow accumulation in winter.

Regeneration after logging varies with the size of the openings in the tree canopy and the available seed source. Ponderosa pine needs larger openings for regeneration than either Douglas-fir or grand fir. Reproduction generally is not limited by brush encroachment. If brush does become established, regeneration of the stand will be retarded and grand fir, which can develop under the shade of the undergrowth, is favored.

These soils have a low grazing value where the forest canopy is dense. There is a heavy duff layer under these conditions. Only limited forage and browse are available after logging. The principal understory plants are bracken, snowberry, and ocean-spray.

These soils are very well suited to timber production and water retention in watersheds. They also furnish food, cover, and water for wildlife.

By CLARK RINKER, formerly woodland conservationist, Soil Conservation Service.

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

WOODLAND GROUP 2o

This group consists of well-drained, medium-textured soils of the Tolo series. These soils formed in volcanic ash and wind-laid silts. They overlie a compact, medium-textured substratum of weathered silts and have basalt bedrock at a depth of 40 to 66 inches. These soils are on hilly uplands and north-facing and northeast-facing slopes between elevations of 3,600 to 5,000 feet. The annual precipitation generally is more than 30 inches.

Douglas-fir, grand fir, and western larch are the important commercial species. Occasionally, Engelmann spruce and ponderosa pine are in the stands. Lodgepole pine is present in scattered patches. The average site class is II. Logging practices and fires in succession have interrupted the growth of stands and have had a marked effect on their composition.

Use of equipment is moderately limited as a result of heavy snows and by steep slopes in part of the acreage.

Regeneration after logging varies with the size of the openings in the tree canopy, the available seed source, and the direction of soil slope. Grand fir, a shade-tolerant tree, generally grows in the understory and in small openings (fig. 11).

Douglas-fir grows in the larger open areas. Some open areas seed to western larch and lodgepole pine. Reproduction generally is not limited by brush encroachment. If brush does become established, regeneration of the stand will be retarded and grand fir, which can develop under the shade of the undergrowth, is favored.

Where the forest canopy is full, the grazing value of these soils is negligible. The principal understory plants are strawberry, swordfern, snowberry, ocean-spray, and huckleberry. After fires or harvest cuts, substantial amounts of forage may be produced if the exposed areas are seeded to grass.

Group 2o soils rate high for timber production and water retention in watersheds. They also furnish food, cover, and water for wildlife.

WOODLAND GROUP 2d

Only Tolo silt loam, wet subsoil variant, 3 to 15 percent slopes, is in this group. This soil formed in mixed, coarse volcanic ash and wind-laid silts over a dense, slowly permeable buried subsoil. It is on uplands between elevations of 3,200 and 4,000 feet. The annual precipitation is about 30 inches.

The stands of trees on this soil are mainly Douglas-fir, western larch, and grand fir. Scattered Engelmann spruce grow on the more moist sites, and ponderosa pine grows on some drier sites. The average site class is II. Logging practices and fires in succession have interrupted the growth of stands and have had a marked effect on their composition.

Use of equipment is severely limited as a result of heavy winter snows and wet soils.

Regeneration after logging varies with the size of the opening in the tree canopy, tile available seed source, and plant competition. Plant competition is severe on sites where willows are present.

There is some browse potential. The principal understory plants are willow, shinyleaf spirea, ocean-spray, snowberry, and wild rose.

This soil rates high for timber production and water retention in watersheds. It also furnishes food, cover, and water for wildlife.

WOODLAND GROUP 3d

This group consists of moderately well drained, medium-textured soils of the Couse series. These soils are nearly level to moderately steep. They are on uplands at elevations of 3,200 to 3,800 feet. The annual precipitation ranges from 24 to 30 inches.

Trees common to these soils are ponderosa pine and Douglas-fir. Scattered grand fir and western larch may be present. For the most important tree, ponderosa pine, the site class is II or III. Logging practices, grazing, and fires have changed most of these woodlands from all-aged to even-aged stands of ponderosa pine.

Use of equipment is severely limited by heavy snows in winter and unstable roads early in spring and late in fall. Natural regeneration after logging varies with the size of the area harvested, the seed source, and the condition of the seedbed. Ponderosa pine requires more sunlight than

Figure 11.-Stand of grand fir on Tolo silt loam, 10 miles east-southeast of Dayton. Grand fir grows rapidly on Tolo soils.

either Douglas-fir or grand fir for successful regeneration. Douglas-fir and grand fir may become established where moisture is adequate. Reproduction usually is satisfactory if a seed source is available. Shrubs that hinder reproduction are snowberry, shinyleaf spirea, ocean-spray, and a few willows.

The grazing value of these soils varies with the density of the stand. Small openings within the stand are common where the subsoil, which restricts the growth of roots, is near the surface.

The principal understory plants are pinegrass, elksedge, snowberry, and ocean-spray. Forage grasses are more abundant in the open areas.

Because of heavy snows and the good water-holding capacity of the soils, this group is important in the Area for use as watershed. The varied vegetation produces a good habitat for wildlife.

WOODLAND GROUP 4d

This group consists of soils of the Couse and Larkin series. These soils are similar to those in Group 3d, except that a large part of the dark-colored surface layer has been lost through water erosion. The soils have been cleared and used for the production of wheat and peas. A dense, compact subsoil is at or near the surface in some areas.

Erosion of the surface layer arid the resulting low fertility have lowered the timber-producing capacity of these soils. The site class is IV. Ponderosa pine is reestablishing itself on abandoned cropland where an adequate seed source is present. Some of the cropland is being planted to ponderosa pine. Abandoned cropland provides good forage for cattle until trees become dominant. The common grasses are Kentucky bluegrass, bulbous bluegrass, and timothy.

The soils in this group are most suitable for the production of ponderosa pine, forage plants, and wildlife habitat.

WOODLAND GROUPS 4o AND 4r

These groups consist of well-drained, medium-textured and moderately fine textured soils that formed in wind-laid silts. They are dominantly on slopes that face northwest, west, and southwest, at elevations between 3,000 and 4,500 feet. Annual precipitation ranges from 18 to 30 inches. The hazard of erosion is severe on burned-over or overgrazed soils that slope more than 25 percent.

Ponderosa pine and Douglas-fir are common to the soil: of this group. The site class is IV.

Use of equipment is limited by steep slopes and rock outcrop.

Tree reproduction is limited by plant competition for moisture on steep soils at higher elevations. Steep, dry, erodible areas should not be cleared of trees because of the difficulty in getting the stand to regenerate. Normally brush does not hinder tree reproduction, but if brush does become established, reproduction will be retarded.

About 25 percent of the understory vegetation is forage plants. These include bluebunch wheatgrass, Idaho fescue, mountain brome, elksedge, and pinegrass. The main shrubs are shinyleaf spirea, snowberry, wild rose, and ninebark.

The soils in these groups are important for woodland, grazing, watershed, and wildlife habitat.

WOODLAND GROUP 4x

Only Klicker very rocky silt loam, 40 to 65 percent slopes, is in this group. This well-drained, very rocky soil formed in weathered basalt and wind-laid silts and is 20 to 40 inches deep. It occurs at elevations above 3,000 feet. The annual rainfall generally is more than 30 inches.

The stands are mostly Ponderosa pine at lower elevations and ponderosa pine and Douglas-fir at higher elevations. The site class is commonly III for ponderosa pine and IV for Douglas-fir. Brush encroachment is moderate following logging operations, but reproduction occurs eventually. The soil is difficult to replant. Survival of seedlings is low on shallow soils on exposed slopes.

Use of equipment is severely limited because of steep slopes and rock outcrops.

Common forage plants are Idaho fescue, bluebunch wheatgrass, big bluegrass, Sandberg bluegrass, and pinegrass. The main shrubs are ninebark, wild rose, ocean-spray, and snowberry.

This soil is chiefly valuable for timber production, wildlife habitat, and for use as watershed.

Woodland protection

The timberland in Columbia County is protected by the U.S. Forest Service and local fire districts. Fire is a major hazard in summer because of lightning storms, low precipitation, and low humidity.

The principal disease of Douglas-fir, western larch, and grand fir is caused by dwarf mistletoe. No means has yet been found for combating dwarf mistletoe. The Oregon pine engraver beetle causes considerable damage to young pine trees. Several gall rusts, needle scales, bark insects, stem borers, and foliage moths are native to each part of the survey area. The damage to plants varies with climate and the number of insects present.

Feedlot and farmstead windbreaks

Most feedlots and farmsteads in the county need protection from strong winds. Well planned and well cared for windbreaks of trees and shrubs reduce snow drifting and erosion, provide protection for livestock and buildings, and furnish food and cover for wildlife.

Trees and shrubs planted in windbreaks should be adapted to the soils and the climate. A windbreak is generally three or more rows of woody plants; a windward row of dense, fast-growing shrubs; one or more rows of tall evergreen or deciduous trees; and a leeward row or rows of evergreens.

Caragana and Russian-olive are the best adapted for windbreaks on most of the soils in this county. Other shrubs are also adapted, but those mentioned are the most commonly used. Black locust is generally the preferred tree in the center row of the windbreak where height is needed. Austrian pine is commonly the preferred evergreen tree for windbreaks. Scotch pine, ponderosa pine, Douglas-fir, Norway spruce, blue spruce, and Rocky Mountain juniper are all well-adapted evergreens where there is sufficient soil moisture.

Soils to be planted to windbreaks should be plowed in fall and weeded prior to planting. On these soils trees and shrubs cannot compete with weeds and grass. Clean cultivation is necessary to assure good survival.

Windbreaks should be protected from livestock, poultry, and fire.

Wildlife

Before 1858, wildlife lived throughout the survey area. Bear, cougar, coyote, deer, elk, mink, muskrat, and wolves were present in large numbers. Ducks, geese, grouse, sagehens, and songbirds were abundant before the prairie sod was plowed. Marmot, rabbits, and rattlesnakes were present in the more rocky and drier parts of the survey area. McKay Creek, Patit Creek, Pataha Creek, Whetstone Creek, and other streams were fully perennial, clear, and well stocked with fish. The grasslands, wooded bottom lands, timbered mountain slopes, and clear streams together formed an excellent habitat for a large wildlife population.

Since 1858, more than half the acreage in the survey area has been plowed. Most of the remaining acreage has been intensively grazed, and part has been severely overgrazed by livestock. About 45,000 acres of woodland is being cut over for the second time. Deer and elk have lost their winter range. The elk disappeared, and the deer retreated into the canyons of the Blue Mountains.

Elk herds from the Yellowstone herd in Montana were released in the Blue Mountains in the spring of 1913. This herd is now well established. During summer it ranges 12 to 20 miles southeast of the survey area in the deep canyon tributaries of the Wenaha River on the border between Washington and Oregon. Late in autumn or early in winter, part of the herd moves to the upper part of the Tucannon River Valley and to areas near Maloney

Mountain. Another band moves to the upper part of the Touchet River Valley and to areas near Cahill Mountain.

There is no longer food and cover for the sagehen and prairie chicken. Many of the streams are no longer perennial. They flow for a few weeks each spring and are generally silt laden. Trout, beaver, and waterfowl have left these streams. Most of the fur-bearing animals have disappeared.

Ring-necked pheasant, California quail, Hungarian partridge, and chukar partridge have been introduced to replace the native birds of the uplands. These game birds have become established and furnish considerable hunting. Turkeys and bighorn sheep have recently been introduced.

Each year an increasing number of hunters come to the Area for game birds, deer, and elk. If this trend continues, landowners, individually or in groups, may find it profitable to use some of their soils for the production of game birds and animals.

Each soil in the Area has some potential for providing food, cover, or water for some. species of wildlife. Rarely does a single soil provide all that is needed for a single species. Grouse nest in the grasslands, then move their broods into wooded areas. Elk graze on one soil early in spring and on another in fall. Some soils support grass, others woody shrubs, and still others are more suitable for trees. Where these soils are associated on the landscape, they complement each other in supplying food and shelter for wildlife.

Each of the eight soil associations shown on the General Soil Map at the back of this publication has a combination of topographic features, soils, and plants that is suitable for one or more species of wildlife. The important species of wildlife and some general suggestions for wildlife management for each of the eight associations are discussed in the paragraphs that follow.

1. Ritzville association.-This is a relatively poor association for most wildlife species. There are a few ring-necked pheasants, meadow larks, Hungarian partridges, rabbits, and coyotes early in spring. During the dry season they congregate around a few stock watering facilities, or migrate into the valleys along the major streams.

Watering facilities placed near wheatfields on range in good or excellent condition materially aid in establishing new colonies of ring-necked pheasant. The best sites should be accessible to wheatfields each summer.

2. Kuhl-Farrell-Roloff association.-The brushy areas, weed patches, fence rows, and asparagus patches in this association make good cover for ring-necked pheasant. The yield of birds is high, but many are killed by hunters. Close cooperation between landowners and the State Game Commission has improved conditions, but farmers are still reluctant to establish bird habitats.

In the uncultivated areas, food and cover for wildlife are poor late in summer and winter. Chukar partridge has been successfully introduced on the steep rocky slopes. Their chief food is cheatgrass that invaded as a result of overgrazing. The rough rocky areas offer some measure of protection and escape. A few deer and coyote are in this association. Marmot and rattlesnakes are in the rocky areas.

3. Walla Walla-Asotin-Chard association.-Many farmed fields in this association are irregular in shape and have unusually large grassed borders that provide a favorable habitat for ring-necked pheasant and Hungarian partridge (fig. 12).

These game birds now congregate near a few springs or stock watering facilities. Additional watering stations, winterfeed areas, and better control of overgrazing by livestock are needed to build up the bird population.

Chukar partridge are in the rocky areas, and a few mule deer graze some of the steep, north-facing slopes. Coyotes are fairly common, but their number is kept low by the predator control program.

4. Walla Walla association.-There is little suitable cover for any species of wildlife in this association. The potential for upland game birds is high. If protected from fire and grazing, the few small patches of native vegetation in rocky areas and on steep, north-facing slopes have potential for good brooding and wintering sites. These areas are scattered, and any significant increase in bird population would require the seeding of nesting, brooding, and wintering areas on soils now under cultivation.

5. Patit Creek-Hermiston-Onyx association.-California quail and ring-necked pheasant nest in the thickets and fence rows in this association. Orchards, pasture, and abandoned farmsteads also furnish shelter and cover. There are good wintering and nesting areas for ringnecked pheasant and California quail. Even though many birds are destroyed in farming operations and by roving cats and dogs, hunting is good in this association. Many of the birds in the wheatfields migrated from the bottom lands. Deer use the brushy areas for crossing the stream valley. They have damaged the apple orchards at some of these crossings.

6. *Athena-Palouse association.*-Deer are plentiful in the uncultivated areas of this association, especially the brushy areas. Quail and ring-necked pheasant are also plentiful where the grasslands have not been overgrazed. They nest and start their broods in these areas, then move to borders of the cultivated fields when the wheat matures.

Blue grouse are in the wooded areas. Coyote are plentiful, and there are a few bobcat and black bear. Elk may move into this association when winter is severe.

A suitable range management program is necessary to maintain the present deer herd. A significant increase in either deer or livestock will bring about overgrazing. This will adversely affect wildlife. The establishment of brush in the steep, north-facing coves of drier areas would encourage deer to move into them. This practice and additional watering stations would favor an increase in the deer population.

7. Couse-Larkin association.-The combination of pine thickets, open brushy slopes, and grassland provides good deer habitat in this association. A shortage of water late in summer is common, and deer may move to areas that have more water. This is one of the important wintering areas for elk. There are a few bear, and blue grouse are plentiful in the association.

All species of wildlife make good use of the ponds built to store water for livestock. Deer are the principal users of the ponds during July and August. Because of the abundance of browse and forbs, these soils produce better deer habitat than livestock range. Cattle graze on

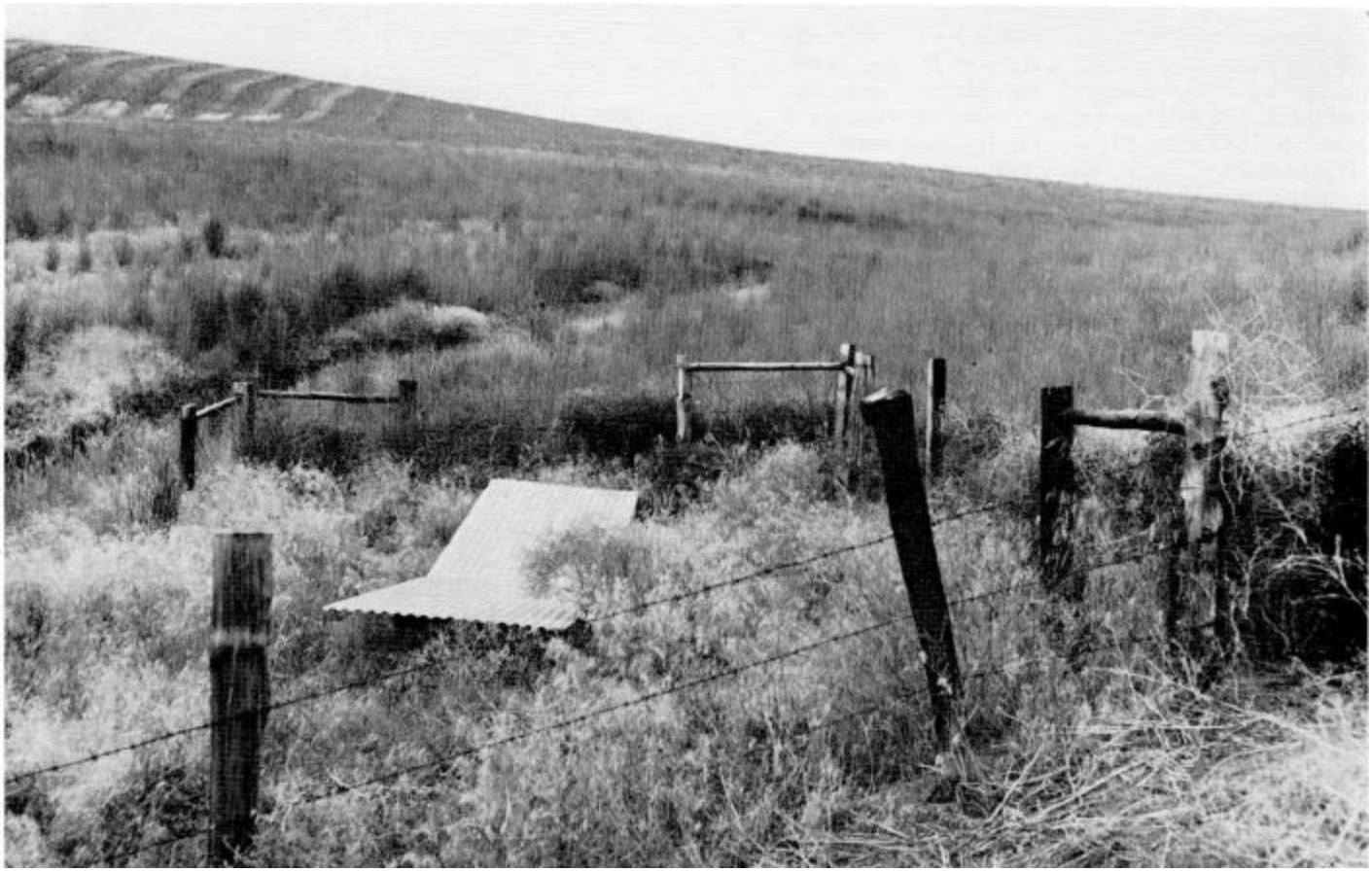

Figure 12.-A watering station for upland birds established by the State Game Commission. Tall wheatgrass and big bluegrass seeded in alternate bands on Walla Walla silt loam provide cover for ring-necked pheasant. If the grass is plowed under, few birds utilize the station.

abandoned farmland, in burned areas, and along log skidways. They do not utilize the browse thickets until after the grassy areas are grazed off. Good range and woodland practices are needed for maintaining the wildlife population.

8. Tolo-Gwin association.-Little grass, forbs, or browse grows in this association except in rocky, loggedoff, or burned areas. These areas furnish shelter and escape for deer and elk. The south-facing slopes are the first to be free of snow in spring. Elk and deer make good use of the grasses and sedges until the snow melts from slopes that face east or west, where browse plants and forbs are more plentiful.

The large elk herd appears to be approaching maximum size for the association. Its future depends on the preservation of the food supply. Burning and indiscriminate logging can ruin this wildlife resource, but protection from fire and harvesting only mature timber by approved methods will maintain a permanent cover and food supply.

Use of the Soils in Engineering

This section provides information about use of the soils as structural material or as a foundation upon which structures are built. Among those who can benefit from this section are town and city managers, planning commissions, land developers, engineers, contractors, and farmers.

Among properties of the soils that are highly important in engineering are permeability, strength, compaction characteristics, drainage condition, shrink-swell potential, grain size, plasticity, and reaction. Also important are depth to the water table, depth to bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage effluent and refuse.

Information in this section of the soil survey can be helpful to those who-

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they

are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.

6. Predict the trafficability of soils for cross-county movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 4 and 5, which give estimated soil properties significant to engineering and interpretations for various engineering uses.

This information, along with the soil map for identification and the text in other sections, permits many interpretations other than those given in tables 4 and 5. It also can be used to make other useful maps. The information does not eliminate need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths greater than 6 feet. Also, inspection of sites, especially small ones, is needed because many delineated areas of a given soil may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for engineering uses.

Some of the terms used in this soil survey have a special meaning in soil science. The "Glossary" defines some terms as they are commonly used in soil science.

Engineering classification systems

The two systems most commonly used in classifying soils for engineering are the AASHO system adopted by the American Association of State Highway Officials and the Unified system used by SCS engineers, the U.S. Department of Defense, and others.

The AASHO system (1) is used to classify soils according to those properties that affect use in highway construction. In this system all soil material is placed in one of seven basic groups. The groups range from A-1, which consists of soils that have the highest bearing strength and are the best soils for subgrade foundation, to A-7, which consists of clay soils that have low strength when wet and that are the poorest soils for subgrade.

In the Unified system (10) soils are classified according to their texture and plasticity and their performance as engineering construction material. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC: six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. GP and GW are clean gravels, and GM and GC are gravels that contain, respectively, an appreciable amount of nonplastic and plastic fines. SP and SW are clean sands. SM and SC are sands that include fines of silt and clay. ML and CL are silts and clays that have a low liquid limit, and MH and CH are silts and clays that have a high liquid limit. Soils on the borderline between two classes are designed by symbols for both classes, for example, ML-CL.

Soil scientists use the USDA textural classification (6). In this, the texture of the soil is determined according to the proportion of soil particles that are smaller than 2 millimeters in diameter, that is, the proportion of sand, silt, and clay. Textural modifiers, such as gravelly, stony, shaly, and cobbly, are used as needed.

Table 4 shows the estimated classification of all the soils in the Area according to all three systems of classification.

Soil properties significant in engineering

Estimated soil properties important in engineering are given in table 4. These estimates are based on field classification and descriptions, physical and chemical tests of selected representative samples, test data from comparable soils in nearby areas, and from experience in working with soils in the survey area. The following paragraphs explain some of the terms used in table 4.

Soil texture is described in the standard terms used by the U.S. Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2.0 millimeters in diameter. Loam, for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, gravelly loamy sand. Sand, silt, clay, and some of the other terms used in USDA textural classification are defined in the Glossary.

Permeability refers only to movement of water downward through undisturbed and uncompacted soil. It does not include lateral seepage. The estimates are based on texture, structure, density, and porosity of the soil. Plowpans, surface crusts, and other properties resulting from use of the soils are not considered.

Available water capacity is that amount of capillary water in the soil available for plant growth after all free water has drained away.

Reaction is the degree of acidity or alkalinity of a soil, expressed as a pH value. The pH value and relative terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is an indication of the volume change to be expected in soil material with a change in moisture content. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates hazards to the maintenance of structures constructed in, on, or with such materials.

Corrosivity, as used in table 4, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. Rate of corrosion of uncoated steel is related to soil properties such as drainage, texture, total acidity, and electrical conductivity of the soil material. Corrosivity for concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. A corrosivity rating of low means that there is a low probability of soil-induced corrosion damage. A rating of high means that there is a high probability of damage, so that protective measures for steel and a more resistant type of concrete should be used to avoid or minimize damage.

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

Engineering interpretations

The interpretations in table 5 are based on the estimated engineering properties of soils shown in table 4, on test data for soils in this survey area and areas nearby, and on the experience of engineers and soil scientists with the soils of the Columbia County Area. The table rates suitability of the soil as a source for topsoil, sand and gravel, and road fill; summarizes soil features that affect their use in highway location, farm ponds, irrigation, terraces and diversions, and grassed waterways; and rates the soils for use as septic tank filter fields and sewage lagoons. While the information applies only to soil depths indicated in table 4, it is reasonably reliable to depths of about 6 feet for most soils, and several more feet for some soils.

The following paragraphs explain terms used in table 5.

Soil suitability for topsoil, sand, and gravel is rated good, fair, and poor, or unsuitable. The chief limitations are given for ratings less than good.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by the ease of working and spreading the soil material and preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; content of substances toxic to plants; texture of the soil material; and the content of stone fragments.

Sand and gravel are used in great quantities in many kinds of construction. The ratings provide guidance about where to look for probable sources. A soil rated as a good or fair source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account the thickness of the overburden, depth to the water table, or other factors that affect mining of the materials, nor do they indicate the quality and extent of the deposit.

Road fill is soil material used in embankments for roads. The suitability ratings reflect the relative ease of excavating the material at borrow areas and the performance of the soil material after it has been placed in an embankment that has been properly compacted and adequately drained.

Soil features that affect use of the soil for highway location, farm ponds, irrigation, terraces and diversions, and for grassed waterways are given in the respective columns.

Soil properties that most affect highway location are the bearing capacity and stability of the subgrade and the workability and quantity of cut and fill material available. The AASHO and Unified classifications of the soil material, and also the shrink-swell potential, indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and the amount of cut and fill needed to reach an even grade. Susceptibility of the soil to frost action and the erodibility of roadbanks are important to the stability and ease of maintenance of the highway.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and the depth to fractured or permeable bedrock or other permeable material.

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

Embankments, dikes, and levees require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Presence of stones or organic material in a soil are among factors that are unfavorable.

Drainage of cropland and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layer that influences the rate of water movement; depth to the water table; slope; stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulation of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water; amount of water held available to plants; need for drainage; and depth to water table or bedrock.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or other unfavorable material; presence of stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures has outlets for runoff and is not so difficult to vegetate as grassed waterways.

Soil limitations for sewage disposal are rated slight; moderate, and severe. *Slight* means soil properties generally are favorable for the rated use or limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means that soil properties are so unfavorable and so difficult to correct or overcome as to require major soil reclamation, special design, or intense management.

Septic tank filter fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 18 inches to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, susceptibility to flooding, and organic-matter content. Slope affects the layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet for a time sufficient for bacteria to decompose the solids. A lagoon should have a nearly level floor. The material used to construct the embankment should be compacted to medium density and the pond should be protected from flooding. Soil properties that affect the pond floor are permeability, organic-matter content and slope. If the floor needs to be leveled, depth to bedrock is also important. Among the soil properties that affect the embankment are the compaction characteristics and the amount of stones, if any, that affect the ease of excavation and the compaction of the embankment material.

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

Formation and Classification of the Soils

This section explains the factors of soil formation and tells how these factors relate to the soils in the Columbia County Area. It also explains the current system of classification and classifies the soils of the county according to that system and also the 1938 system. The last part of the section lists laboratory data based on chemical and physical analyses of three soils.

Factors of Soil Formation

Soil is formed by the forces of climate and living matter acting, through a period of time, on parent material as conditioned by relief. The properties of a soil are determined by five factors: (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the topography, or relief ; (4) living organisms; and (5) the length of time the forces of soil formation have acted on the parent material.

Soils differ according to the relative degree of influence of each soil-forming factor. These factors and their influence on the soils of the Columbia County Area are explained in the following paragraphs.

Parent material

The geologic materials from which the soils in the Columbia County Area formed have been classified into three broad groups (1) periglacial nonmarine sediments, mostly of the early and middle Pleistocene; (2) Miocene volcanic rocks; and (3) alluvium.

The periglacial nonmarine deposits cover about 325 square miles in the central part of the survey area. They are deep (as much as 100 feet or more) deposits of unconsolidated loess, commonly known as the Palouse Formation. This formation consists of several layers of rather uniform silty material. The older layers conform to the original contours of the underlying Columbia River basalt. These deposits were eroded to form steep slopes and escarpments on which the various layers were exposed.

Later deposits 6 to more than 8 feet deep covered the landscape. These deposits were largely volcanic material, and the soil minerals show little evidence of weathering. The percentage of clay is highest in the eastern and southeastern parts of the Area and somewhat lower in the western part. The soils in the Ritzville, Walla Walla, Athena, Palouse, and Couse series formed from these materials.

In the northern and southeastern parts of the survey area, the soils formed from a mixture of loess and volcanic rocks. Basalt, tuft, and pumice were extruded in the middle and late Miocene. They have been exposed by the uplift and subsequent erosion of the Blue Mountains in the southeast and by the downward cutting of the Snake River and its tributaries in the north. In these areas, the soils formed from slightly weathered products of the volcanic rocks and loess. The Kuhl soils in the north and the Larkin, Gwin, Klicker, and Anatone soils in the south contain the highest percentage of volcanic materials. Roloff, Asotin, Tucannon, and Waha soils have

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

basaltic materials in the lower part of their profiles. The Tolo soils area mixture of pumice and loess.

Soils formed from alluvium are conveniently divided into two groups based on age. The older group is on old terraces that were formed by swift-flowing glacial streams or in the backwaters of glacial lakes. The Farrell, Ellisforde, and Chard soils are in this group. The latter two soils have been strongly influenced by loess. The younger group consists of Covello, Esquatzel, Hermiston, Mondovi, Onyx, and Patit Creek soils on stream bottoms.

Climate

Climate directly affects soil formation through its influence on weathering, erosion, and plant growth. It helps determine the kind and density of plants that grow in an area. Temperature and precipitation are the main climatic factors in soil formation.

The mean annual temperature in the survey area probably does not vary more than 10° F. Soils at elevations of more than 3,000 feet have generally formed under mean annual temperatures of less than 45 ° F. The mean temperature in January is in the low twenties. Soils that formed under these conditions are of the Anatone, Couse, Tolo, and Klicker series. Below an elevation of 3,000 feet, the mean annual temperature ranges from 45° to 55° F. During December, January, and February, the average daily temperature ranges from 25° to 40° F. The soils are generally frozen for periods in winter. Rapidly melting snow and rain cause excessive runoff and severe erosion on frozen soil. The average temperature during June, July, and August ranges from about 65° F. in the Blue Mountains to 75° F. at Starbuck. During these months the potential evaporation rate is approximately seven times the average rainfall for the same period.

The annual precipitation ranges from about 11 inches at Starbuck to 34 inches 25 miles southeast. It may approach 40 inches in areas along the upper part of the Touchet River. During July and August precipitation is generally less than 1 inch. It gradually increases during fall and reaches a peak about. midwinter. The decrease in precipitation is gradual during spring, but is abrupt in July. This precipitation pattern favors deeprooted plants that are able to draw water stored deep in the soil. Shallow-rooted plants mature and become dormant during the dry season. Soils less than 30 inches deep do not store enough water for maximum plant growth during the dry season. During the wet season, the shallow soils are saturated and a large amount of the annual precipitation is lost as runoff.

The part of the survey area that receives less than 23 inches of annual precipitation was originally grassland; parts that receive more than 23 inches were forested. In areas that receive 10 to 13 inches of precipitation, the soils have a very dark grayish-brown surface layer, 7 to 10 inches thick, and lime occurs at a depth of about 30 inches. Where annual precipitation is 12 to 16 inches, the surface layer is both darker and thicker and the lime layer is generally below a depth of 60 inches. In areas that receive 16 to 23 inches of precipitation, the soils are even darker and contain substantially more organic matter. There is some movement of clay into the subsoil, as evidenced by the accumulation of fine clay on the surface of some of. the soil aggregates in the B

horizon. The soils in wooded areas have a thin, grayish-brown surface layer and a zone of iron accumulation.

Relief

The relief, or topography, of the landscape indirectly influences the formation of soils. It greatly affects drainage, erosion, depth of the soil, penetration of water into the soil, microclimate of the soil, and the type of vegetation that grows on the soil. Elevation, slope, and aspect are the important elements of relief in the survey area.

Generally, precipitation increases and temperature decreases with an increase in elevation. The total plant growth is greater, and the breakdown of plant materials is slower on foothills of Blue Mountains than in the area around Starbuck.

Slopes range from 0 to 3 percent on the stream bottoms, 3 to 15 percent on plateaus and broad ridgetops, 8 to 30 percent on the rolling to hilly uplands, and 30 to 65 percent in the deep canyons and on steep mountains. Areas where slopes are 0 to 3 percent are somewhat poorly drained in places. Nearly all of these areas are subject to deposition of materials washed from adjacent uplands. Normal profiles have formed where slopes are 3 to 30 percent. Erosion is no concern in areas where the natural vegetation is intact, but it is a serious hazard on cultivated soils that have slopes of 8 to 30 percent. Thin soils have formed where slopes are 30 to 65 percent. Soils that are deeper than normal have formed on north-facing exposures, and shallow and rocky soils have formed on the south-facing exposures.

In the Columbia County Area, the slopes that face south and southwest receive the more direct rays of the sun and have higher temperatures than slopes that face north and northwest. Evaporation is less on the cooler, north-facing slopes so that more water is available for plant growth. North-facing slopes also receive additional moisture from the melting snow washed and blown from adjacent ridgetops. As a consequence, the soils on north-facing slopes are darker than soils elsewhere.

The Onyx, Yakima, Patit Creek, and Covello soils occur on stream bottoms and are subject to occasional overflow and silt deposition. The Covello soils are somewhat poorly drained.

About 60 percent of the Area is rolling uplands. The Athena, Palouse, Ritzville, and Walla Walla soils are characteristic of the rolling uplands. The soils on north-facing slopes have a thicker, darker colored A horizon than those on south-facing slopes.

Living organisms

To a large degree, soil formation begins when plants begin to grow and animals begin to utilize the plant products. Plants draw moisture and nutrients from the soils .and intercept runoff and reduce soil erosion. Their roots penetrate the earth's mantle and improve the aeration and permeability of the soil material. When their life cycles are complete, plant and animal remains are returned to the soil. The decomposition of plant and animal remains is one of the fundamental processes in soil formation. The decomposed materials enter into the chemical reactions with the mineral components of the soil mass. Under some conditions, organic and mineral materials combine and are fixed in the soil. This reaction is responsible for the dark-colored A horizon in the grassland soils. Under other conditions the mineral and organic materials become mobile and are carried downward by percolating water. This process takes place under forest cover.

About 85 percent of the Columbia County Area was once grassland. The vegetation was deep-rooted bunchgrasses capable of extracting soil moisture deep in the soil and of shallow-rooted grasses that matured, produced seed in a short season, and became dormant early in summer. The native plant cover varied in kind, composition, and density. Bluebunch wheatgrass grew under a wide range of soil and moisture conditions. Needle-and-thread, prairie junegrass, and other plants grew under a narrower range of conditions.

In those areas that receive less than 12 inches of annual precipitation, bluebunch wheatgrass and Sandberg bluegrass are the principal grasses. On coarser textured soils or eroded areas, needle-and-thread is dominant. Where the precipitation ranges from 12 to 16 inches, Idaho fescue grows in association with bluebunch wheatgrass and Sandberg bluegrass. Bluebunch wheatgrass, Idaho fescue, big bluegrass, and prairie junegrass grow in areas where precipitation is 16 to 23 inches.

Trees grow in this Area under a variety of conditions. Soils that are on stream bottoms and receive 16 to 19 inches or more of precipitation are timbered. Similarly the soils on mountains, broad ridgetops, and on slopes that face northwest, north, northeast, and some that face east are timbered. At higher elevations, the soils on these sites have a thin A1 horizon, a thin or intermittent A2 horizon, and a B horizon that has an iron accumulation. At slightly lower elevations the soils have characteristics that are between those of grassland and woodland.

Time

Soil formation begins as soon as a rock is exposed on the earth's surface, a sediment appears above the water, or a fresh mantle of loess is laid down. As soil formation progresses, characteristic layers called horizons are formed within the soil profile. Generally, the larger the number of horizons and the greater their thickness and distinctness, the more mature is the soil**.** Depending on the nature of the parent material and the vigor of the soil-forming process, it takes hundreds or even thousands of years to form pronounced genetic horizons.

The parent materials in the Columbia County Area are of relatively recent origin or deposition. The basalt is Miocene, the loess appears to have been deposited in the middle to late Pleistocene;, and the stream sediment is recent.

Many of the soils have not formed distinct horizons. The Chard, Ellisforde, Farrell, Ritzville, and Roloff soils have a distinct, dark-colored A horizon, but only a very weak B horizon. The A horizon is darker and thicker in the Walla Walla soils, but there is a weak structural B horizon. Athena soils have an A horizon. that is thicker and a moderate structural B horizon that contains a few thin clay films. There is a slight accumulation of clay in the B horizon of the Palouse soils.

In the mountain area, the soils have somewhat stronger profiles. The Waha and Gwin soils have a dark-colored surface horizon and a textural B horizon.

On the stream or valley bottoms, many of the soils do not have distinct genetic horizons. The horizons or layers in these soils are largely due to the stratification of the parent materials.

Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to learn and remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that soil characteristics can be applied to large geographic areas.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (2) and revised later (6). The system currently used by the National Cooperative Soil Survey was developed in the early sixties (5) and adopted in 1965 (9). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 6 gives the classification of each soil series of the Columbia County Area, by family, subgroup, and order, according to the current system. It also shows one category-the great soil group-of the 1938 system.

ORDER: Soils are grouped into orders according to properties that seem to have resulted from the same processes acting to about the same degree on the parent material. Ten soil orders are recognized in the current system: Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, Entisols and Histosols, occur in many

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

different climates. Two soil orders are recognized in the Columbia County Area: Inceptisols and Mollisols.

Inceptisols are soils that show only slight evidence of soil formation. There are two soil series in this order, Tolo and Walvan. On the Tolo soils the native vegetatation is mainly Douglas-fir and grand fir, and the annual precipitation is 30 to 40 inches. On the Walvan soils the native vegetation is mainly bluebunch wheatgrass, and the annual precipitation is 12 to 16 inches. The parent material of the soils of both series is high in content of volcanic ash. Walvan soils have a dark-colored surface layer as a result of their grass cover.

Mollisols are soils that have a thick, dark-colored surface layer that contains at least 1 percent organic matter. All the soil series in the Columbia County Area except the Tolo and Walvan are in this order. In most years the Mollisols are dry to a depth of 7 to 20 inches for 60 consecutive days after June 21.

SUBORDER: Each order is divided into suborders, primarily on the basis of the characteristics that seem to produce classes with the greatest genetic similarity. This grouping narrows the broad climatic range of the orders. The properties used to distinguish the suborders are mainly those that reflect either the presence or absence of waterlogging or the soil differences that are caused by climate or vegetation.

GREAT GROUP: Great groups are established on the basis of uniformity in kinds and sequence of major soil horizons and features. The horizons considered are those in which clay, iron, or humus have accumulated or those that have pans that interfere with root development or water movement. The features considered are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly content of calcium, magnesium, sodium, and potassium, and the like.

SUBGROUP: Great groups are divided into subgroups. A subgroup consists of the central (typic) segment or. intergrades that have properties of one great group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances when soil properties intergrade outside the range of any other great group, suborder, or order.

FAMILY: Families are established within a subgroup primarily on the basis of properties important to the growth of plants or the behavior of soils when used for engineering purposes. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

SERIES: The series consists of a group of soils that have major horizons that, except for texture of the surface layer, are similar in important characteristics and in arrangement in the profile.

Laboratory data

Selected chemical and physical properties of Couse, Kuhl, and Waha soils are given in table 7 and table 8. The profile of each soil is described in the section "Descriptions of the Soils."

The samples analyzed were taken from carefully selected pits. Prior to analysis the samples were air dried, ground to pass through a 2-millimeter round-hole screen, and stored in a closed container. Particle-size distribution was determined by the pipette method. To determine the pH factor, distilled water was added to 20 grams of soil

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

to a consistency of the saturation percentage and allowed to stand for 1 hour before reading with a glass electrode. The same sample was subsequently diluted with distilled water to a 1:10 soil-water ratio, and the pH was determined after 1 hour. The electrodes were placed deep in the suspension immediately after the final stirring. Organic carbon was determined by the heat of dilution method. Total nitrogen was determined by the Kjeldahl method. Moisture retention at 1/10, 1/3, and 15 atmospheres were determined by standard methods (8) .

Ten grams of soil were used to determine the cation-exchange capacity (8). Aliquots were evaporated, and the NH4OAc and organic matter were removed with HNO3 and HCL. Silica was dehydrated with 6N HCL. Residue was dissolved in 0.4N HCL and sodium and determined by a Beckman Model DU flame spectrophotometer.

Extractable calcium, magnesium, sodium, potassium, and hydrogen were determined according to standard methods (4,) Twenty-five grams of soil was extracted with 250 milliliters of one normal neutral solution of NH4OAc (pH 7) . Calcium was precipitated as the oxalate and titrated with permanganate; magnesium as ammonium magnesium phosphate was ignited and weighed as Mg2P2O7. Separate aliquots of the NH4OAc extracts for sodium and potassium were treated the same as NH4OAc extracts to determine cation-exchange capacity. Sodium and potassium were analyzed in a solution of 0.4N HCl by a Beckman flame spectrophotometer.

The extractable sodium and potassium was obtained by subtracting the soluble sodium and potassium, if present in the saturation extract, from the values of extractable NH4OAc.

Climate

The climate of the Columbia County Area is primarily a continental type, modified to some extent by the marine influence from the Pacific Ocean. The Rocky Mountains are very effective in protecting this area from the more severe winter storms that move southward across Canada, and the Cascade Range forms a barrier to the eastward movement of moist air from the Pacific Ocean. An increase in elevation from less than 2,000 feet in the northern and central agricultural areas to 6,000 feet in the Blue Mountains results in several climatic areas within the survey area.

Summers are dry and hot, and winters are comparatively mild for this latitude (tables 9 and 10). The average afternoon temperatures in the warmest summer months are in the upper 80's, and the nighttime readings are in the 50's. Maximum temperatures at the lower elevations of the county exceed 90° F. on 25 to 40 days and rise above 100° F. on one or more days during most summers. Maximum temperatures have reached 100° F. or higher on 8 to 15 days in a few of the hottest summers, and 114° F. was recorded at Dayton on August 5, 1961. Periods of exceptionally high temperatures seldom last more than a few days before the marine influence from the ocean is felt. Records of temperatures at higher elevations in the Blue Mountains are not available. However, temperatures can be expected to decrease at the rate of approximately 3 to 5 degrees for each increase of 1,000 feet in elevation.

By EARL L. PHILLIPS, climatologist for Washington, National Weather Service, U.S. Department of Commerce.

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

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

During winter, afternoon temperatures are in the midthirties and nighttime temperatures are in the midtwenties. Maximum temperatures are below freezing on 25 to 35 days, and minimum temperatures drop below zero on 3 to 5 days. During one of the colder winters, 1949-50, minimum temperatures at Dayton dropped to 0° F. on 18 days, to -10° F. on 8 days, and to -20° F. on 5 days. The lowest temperature recorded was -22° F. The average minimum temperature for the month of January has ranged from 1.7° F. in 1930 to 38.5 ° F. in 1953.

The annual precipitation ranges from 10 to 15 inches at the lower elevations and in drier areas near the Snake River to more than 40 inches at the higher elevations of the Blue Mountains. Precipitation is light in midsummer, increases in the fall, reaches a peak in winter, then gradually decreases in spring, increases again in June, and decreases sharply in July. The annual precipitation for the wettest year of record was 33.52 inches, and for the driest year, 12.07 inches. The average number of days per month that have 0.1 inch or more of precipitation increases from 1 in midsummer to 8 in midwinter. In winter, precipitation may occur as either rain or snow at the lower elevations but falls mainly as snow on the higher slopes. At the lower elevations and in farming areas, snow may be expected any time from the latter half of November through February. It seldom remains on the surface longer than 3 to 4 weeks or accumulates to a depth of more than 8 to 15 inches. The maximum depth on the surface at Dayton was 34 inches in 1916. Snow accumulates to a depth of several feet at the higher elevations and remains on the surface until late in spring. A snow cover is sometimes melted very rapidly by a rain or "chinook" wind, and the runoff may cause severe erosion in the hilly, cultivated areas.

An average of one to three thunderstorms can be expected each month from March through October. Hail and rainfall of high intensity sometimes occur during thunderstorms. Rainfall at a rate of an inch per hour for periods of 5 to 10 minutes and an accumulation of half an inch in one hour can be expected once in 2 years.

The number of clear or only partly cloudy days increases from less than 10 each month during winter to more than 25 in midsummer. The amount of sunshine received increases from about 25 percent of the daylight hours in winter to 60 percent in spring and 85 percent in summer. Moist air that crosses the Cascades in winter mixes with colder air and causes considerable fog and low clouds.

Records of average windspeed and evaporation near Walla Walla are generally representative, of conditions in the Columbia County Area

	April	May	June	July	August	September	October
Windspeed----------miles per hour----------	2. 9	2. 4	2. 0	1. 7	1. 6	1. 2	1. 5
Evaporation--------inches of water----------	5. 01	6. 56	7. 50	9. 64	8. 07	4. 92	2. 55

Estimates of potential evapotranspiration help to determine the amount of moisture available for use by plants. The potential evapotranspiration computed from temperature and precipitation data recorded at Dayton are given in table 9. The potential evapotranspiration during the 32° F. growing season of 163 days (average number of clays between the last 32° temperature in spring and the first in fall) is 20.8 inches, and the amount for the 28° F. growing season of 202 days is 22.8 inches.

The prevailing wind in this survey area is westerly or southwesterly most of the year. The average windspeed ranges from 5 to 10 miles per hour. The spring months are the windiest; however, strong winds often occur in fall and winter as storms move across the State. Windspeed can be expected to exceed 50 miles per hour once in 2 years.

Literature Cited

(1) AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS.
1961. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING. Ed. 8, 2 v., illus.

(2) BALDWIN, MARK, KELLOGG, CHARLES E., and THORP, JAMES.
1938. SOIL CLASSIFICATION. U.S. Dept. Agr. Ybk., pp. 979-1001, illus.
(3) MEYER, WALTER H.
1938. YIELD OF EVEN-AGED STANDS OF PONDEROSA PINE. U.S. Dept. Agr. Tech. Bul. 630, 66 pp., illus.
(4) PEECH, MICHAEL, ALEXANDER, L. T., DEAN, L. A., and REED, J. F.
1947. METHODS OF SOIL ANALYSIS FOR SOIL-FERTILITY INVESTIGATIONS. U.S .Dept. Agr. Circular 757, 25 pp.
(5) SIMONSON, ROY W.
1962. SOIL CLASSIFICATION IN THE UNITED STATES. Sci. 137: 1027-1034, illus.
(6) THORP, JAMES, and SMITH, GUY D.
1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUPS. 5011 Sci. 67: 117-126.
(7) UNITED STATES DEPARTMENT OF AGRICULTURE.
1951. SOIL SURVEY MANUAL. U.S. Dept. Agr. Handbook No. 18, 503 pp., illus.
(8)
1954. DIAGNOSIS AND IMPROVEMENT OF SALINE AND ALKALI SOILS. U.S. Dept. Agr. Handbook 60, 160 pp., illus.
(9)
1960. SOIL CLASSIFICATION. A COMPREHENSIVE SYSTEM, 7TH APPROXIMATION. 265 pp., illus. [Supplements issued in March 1967 and in September 19687
(10) UNITED STATES DEPARTMENT OF DEFENSE.
1968. UNIFIED SOIL CLASSIFICATION SYSTEM FOR ROADS, AIRFIELDS, EMBANKMENTS AND FOUNDATIONS. MILSTD-619B, 30 pp., illus.

Glossary

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

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. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

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 when dry or moist; does not hold together in a mass.

Friable.-When moist, crushes easily under gentle 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, and tends to stretch somewhat and pull apart, rather than to 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.

Diversion, or diversion terrace. A ridge of earth, generally a terrace, that is built to divert runoff from its natural course and, thus, to protect areas downslope from the effects of such runoff.

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 horizon and upper part of the B horizon and mottling in the lower part of the B horizon and C horizon.

Somewhat poorly 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.

Duff. Partly decayed organic matter on the forest floor.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Gravel. Loose or unconsolidated material consisting of rounded and subrounded fragments of rock ranging in size from 2 millimeters to 3 inches.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons

O horizon.-The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.-The mineral horizon at the surface or just below an 0 horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.-The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.-The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.-Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Loess. Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

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 (wind-laid silts) in eastern Washington and adjacent Idaho. Parent material of the Palouse, Athena, Walla Walla. and Ritzville soils and other soils in Columbia County.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *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. (An acid, or "sour," soil is one that gives acid reaction.) In words, the degrees of acidity or alkalinity are-expressed thus:

	pH		*pH*
Extremely acid---	Below 4.5	Neutral _____	6.2 to 7.3
Very strongly acid-	4.5 to 5.0	Mildly alkaline--	7.4 to 7.8
Strongly acid----	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid----	5.6 to 6.0	Strongly alkaline-	8.5 to 9.0
Slightly acid----	6.1 to 6.5	Very strongly Alka line _____	9.1 and higher

Rough fall tillage. An effective erosion control practice in part of Columbia County. 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.

Runoff. The rate that water is removed by flow over the surface of the soil. Rapidity of runoff and the amount .of water removed are affected by slope (both gradient and length); by texture, structure, and porosity of the surface layer; by vegetative cover; and by climate. The rate of runoff increases markedly if the surface layer is pulverized, frozen, or saturated during periods of rain or when snow melts. Terms used in this report are relative and it is assumed that the surface of the soils is bare. Terms are *very slow, slow, medium, rapid, very rapid.*

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. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Saline soil. A soil that contains soluble salts in amounts that impair growth of 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 strongly alkaline reaction; or contains harmful salts and exchangeable sodium and is strongly alkaline in reaction. The salts, exchangeable sodium, and strongly alkaline reaction occur in the soil in such amount that growth of most crops is less than normal.

Silt. Individual mineral particles of soil that range in diameter from the upper limit of clay (0.002 millimeter), to the lower limit of very fine sand, (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine." 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 11/2 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 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 clay, or (2) 50 to 80 percent silt and less than 12 percent clay.

Silt.-Soil material that is 80 percent or. more 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 contains 27 to 40 percent clay and 20 to 45 percent sand.

Silty clay loam.-Soil material that contains 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.

Uphill plowing. Tillage operations in which the furrow slice is turned up the slope instead of down. Effective on soils that have slopes of as much as 25 percent.

Volcanic ash. Small solid or porous fragments of pumice or obsidian, which look like coarse ashes ejected by volcanoes.

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 (1) single grain (each grain by itself, as in dune sand) or (2) massive (the particles adhering together without any regular cleavage as in some claypans and hardpans).

Stubble mulch. Stubble or other crop residue left on the surface of the soil or partly worked into 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.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in an uncultivated soil, about 5 to 8 inches thick. The plowed layer.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, that borders 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.