Manual 6 • Reprinted September 2007
$12.50

MANUAL FOR JUDGING OREGON SOILS



Oregon State University | Extension Service

Contents

Foreword

Soil judging has been part of the vocational agriculture curriculum in Oregon high schools for more than 40 years. Since 1956, the OSU Extension Service and the Oregon Association of Conservation Districts have worked together to organize and operate the State Soil Judging Contest.

The Extension Service also has provided educational materials for the students and conducted training sessions for the instructors. For many years, Extension Bulletin 769, *Soil Judging from the Ground Up*, was used as the primary text for the program.

As we learned more about Oregon soils, however, and as soil management alternatives became more complicated, we realized that just revising EB 769 would not do the job. Instead a completely new manual was needed.

We began writing a new soil judging manual, and developing a new format for judging soils, in 1978, when we introduced several new ideas to a group of about 20 Vo-Ag instructors. They liked the new format, and their comments were very helpful as we wrote a draft of a new manual. We used this draft for 4 years while we tested new ideas and revised the text.

Publication of this manual would not have been possible without numerous suggestions from many soil scientists and Vo-Ag instructors who have been very closely associated with the soil judging program for a number of years. To each of them, we express our sincere appreciation.

There are several major changes in this new *Manual.*

1. We encourage students to study the whole soil profile and evaluate each of the natural soil horizons present.
2. We stress gathering primary data on just a few important properties that students can determine in the field—color, texture, and structure.
3. We show students how to use these basic properties to discover some important aspects of soil behavior, such as effective depth, water-holding capacity, susceptibility to erosion, and internal drainage class.
4. We explain why soil properties and soil behavior are important to soil management.
5. We develop keys for students to use to relate soil properties to important decisions about irrigation suitability, crop choices, erosion control, and other questions.

We don't expect students to memorize all the factors and interactions that enter into a management decision. We do hope, however, that they will learn how to use the keys to translate their evaluations of profile data into solutions to real problems facing modern agriculturalists and environmental scientists.

Above all, we view soil judging primarily as an educational program. Contests certainly add a dimension of challenge and fun, but they are not the primary objective of the program. Instead, the main objective is to encourage students to investigate this fascinating resource we call soil, to discover how soils are organized into horizons, to learn both how to describe a few key properties of soil horizons and to interpret them in terms of management practices—and to develop a sense of stewardship for the soils that support them.

Nothing would make us happier than for a student to challenge some of the generalized management interpretations we describe in this manual in terms of their relevance to his or her own soil conditions—and for the instructor to seize that opportunity to do some real teaching about the kinds of interactions one must consider when deciding how best to use the soil resources available on a given farm. When this happens, the *Manual for Judging Oregon Soils* will have accomplished its real purpose.

Why Study Soil?

Soil is an essential natural resource. Without a doubt, that is the most important reason for studying the soil. Nathaniel Shaler put it this way: "Soil, ever slipping away in streams to the sea, is a kind of *placenta* that enables living things to feed upon the earth."

The sketch in Figure 1 illustrates our dependence on the soil. Unlike plant life, we human beings can't manufacture our own food from the four primary resources of soil, air, water, and sunlight. Instead, we depend completely on green plants, which take nutrients and water from the soil and combine them with air and sunlight to provide our food supply.

Some of those plants, such as wheat and corn, we eat directly. Others, such as alfalfa hay and range grasses, we process through livestock first. Even the fish we eat depend on plants that grow in the sea using nutrients that have been washed out of the soil and carried to the sea in rivers and streams.

We study the soil, then, to increase our understanding of this resource that supports us.

Another important reason for studying soil is that soils are different. Oregon alone has nearly 2,000 different kinds of soils, ranging from deep to shallow, clayey to sandy, wet to dry, nearly level to steeply sloping. These differences are important, because different soils require different kinds of management practices.

Wet soils, for example, are essential components of wetland ecosystems. Proper management of wet soils depends on recognizing the imprint of saturated

[1]Shaler, N.S., *Man and the Earth* (Chautauqua, NY: The Chautauqua Press, 1915).

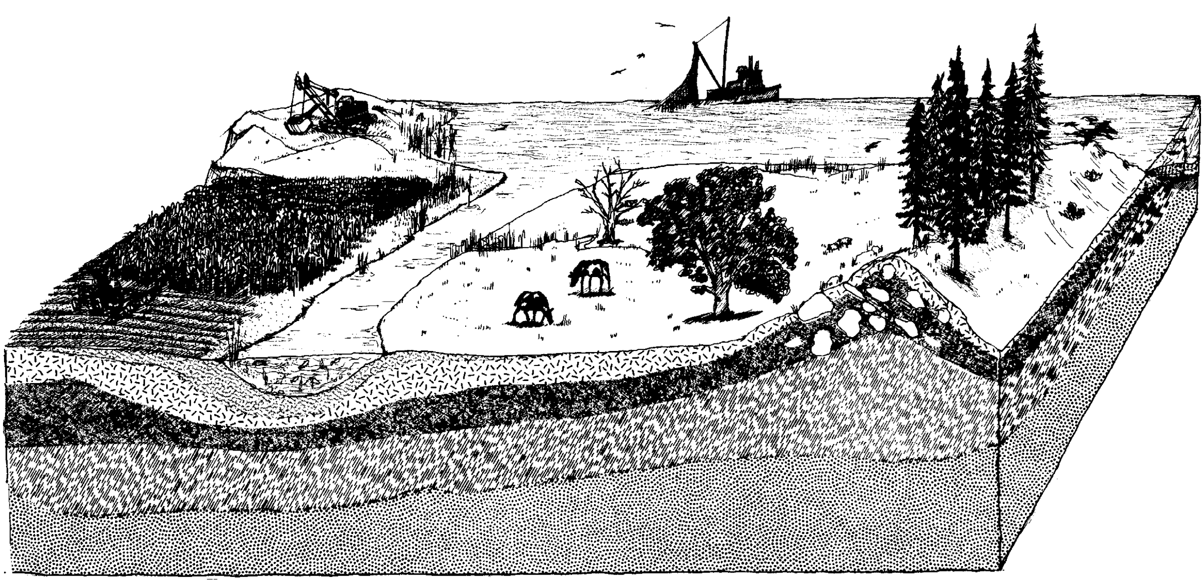

Figure 1.—All of our food resources can be traced directly back to the soil.

conditions on soils and maintaining water tables at desired levels.

Many soils require irrigation for maximum productivity. Both the amount of irrigation water needed and the proper method of applying it depend on a soil's permeability rate and water-holding capacity.

Still other soils have a very serious erosion hazard. The proper choice of conservation practices depends in part on the texture of the surface horizon and the steepness of the slope.

Only by studying soils can we learn how to tailor management practices to the specific needs of each of the many different kinds of soils we depend on.

Some of us study soil because we're just plain curious about this unique and fascinating natural resource. When you dig a hole or scrape off a road cut, you discover right away that there's a whole lot more to the soil than just the top 8 or 10 inches.

Soil scientists, in fact, study the soil to a depth of about 5 feet. They see several different layers, or *horizons,* in the soil. Together, these horizons make a soil *profile*.

We describe the horizons in a soil profile in terms of their properties, or *morphology*. Some properties, such as color and root abundance, can be determined by eye. Others, such as texture and structure, require a keen sense of touch.

You, too, can learn how to determine the important properties of soil horizons. Then you will be able to make a number of important decisions about drainage, irrigation, crop selection, erosion control—and much, much more.

At the beginning of this chapter, we talked about how all human life depends on our soil resources. Knowing that, we must study the soil so that we can learn how to protect it for others to use. There's plenty of good soil on this planet—as long as we take care of it properly. But if we let it erode, or compact it, or mine it, it will fail to support us.

Farmers are the primary stewards of the soil, for they are the tillers of the land. All of us, however, share the responsibility to protect this valuable resource. If we manage our soil properly, it will continue to nourish us for generations to come. If we don't, our very civilization is threatened.

So study the soil, learn about its properties and behavior, manage it wisely, and do your part as a steward of the land.

The Soil We Study

Soil has been defined by lots of different people in lots of different ways. Here's a very basic definition:

> **SOIL—**the natural medium in which plants grow.

This definition, however, may be a little too simple. Here's a better one:

> **SOIL—**a natural body that develops in profile form from a mixture of minerals and organic matter. It covers the earth in a very thin layer and supplies plants with air, water, nutrients, and mechanical support.

Our definition is, of course, the one we prefer:

> **SOIL—**a *living, dynamic system* at the *interface* between air and rock. Soil forms in response to forces of *climate* and *organisms* that act on *parent material* in a specific *landscape* over a long period of *time.*

We like this definition because each key word says something important about the soil. Why *living?* Because the soil is full of living organisms: roots large and small, animals and insects, millions of microscopic fungi and bacteria.

Equally important are the decaying remains of plants and animals after they die. They form soil organic matter, or *humus,* which is vitally important for good soil tilth and productivity.

Dynamic says that the soil changes all the time. Oregon soils change from very wet in the winter to very dry in the summer. Even under irrigation, the amount of water in the soil can vary widely.

Soil organic matter increases when crop residues are worked in, and decreases as fresh plant materials decay. Soil nutrients increase as soil minerals break down. They decrease as water moving through the soil carries them away. Even soil acidity, or pH, changes seasonally.

The word *system* says that all parts of the soil work together to make up the dynamic whole. A change in one part may cause changes in many other parts.

Suppose, for example, we add water until the soil is very wet. That reduces the amount of air available to plant roots. It makes the soil colder, and the activity of roots and soil microbes (very small plants and animals) slows down. The wet soil is stickier and cannot bear as much weight.

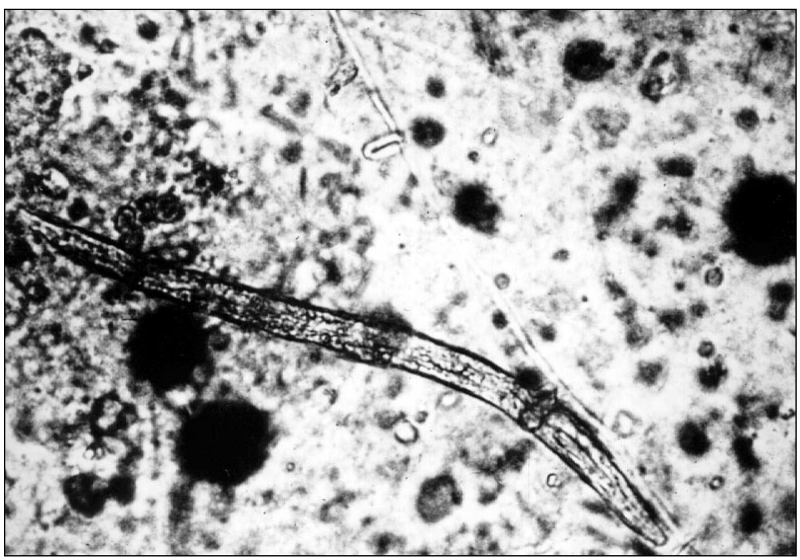

Figure 2.—Living, dynamic soil. The microscopic worm shown is called a nematode. The lower part of the nematode is being attacked and invaded by a fungus.

Now let's remove the excess water. The whole system changes to a warmer and drier soil that is better for plants to grow in and easier for farmers to manage.

The word *interface* stresses the idea that soil is indeed a very thin rind at the earth's surface. When air meets rock, especially if the air is warm and the rock is moist, the rock begins to change. Some changes are physical. They break rocks down into smaller pieces. Other changes are chemical. They destroy some of the original minerals and create new ones.

These physical and chemical changes are called *weathering.* Weathering occurs only within the first few feet of the earth's surface. Plate 5 illustrates a strongly weathered soil. The light-colored parts of the BC horizon are highly weathered bedrock remnants not yet fully changed into soil.

Now consider the size of the earth. The distance from the surface to the center of the earth is about 4,000 miles. Thus, 10 feet of weathered rock out of 4,000 miles is something less than .00005 percent. Soil does indeed occur at the point of contact between earth and atmosphere!

Factors of Soil Formation

The rest of the key words in our definition of soil tell us something about how soil forms. We think in terms of five *soil-forming factors.* Two of them, climate and organisms, are called *active* factors. They provide the forces that cause soil to form. The other three, parent material, topography, and time, are called *passive* factors. They respond to the forces exerted by climate and organisms.

Together, the interactions between the force factors and the response factors result in a new product, a unique natural resource, which we call soil.

Five Soil-forming Factors
Climate
Organisms
Parent Material
Topography
Time

Climate

Climate affects soil most directly through temperature and rainfall. In warm, moist climates, rocks and minerals weather very quickly. The soil that forms often has a reddish color. Most of the red soils in western Oregon are red because they formed when the climate was warmer than it is now.

High rainfall also causes *leaching*—the removal of soil materials by water flowing through the soil. Free lime is completely leached from western Oregon soils. These soils are acid. Free lime is still present in many eastern Oregon soils because there isn't enough rain to leach the soil completely.

Warm, moist climates encourage lots of plant growth, and that means lots of soil organic matter. The opposite is true in hot, dry climates. Soils in the Willamette Valley are dark-colored because they have plenty of organic matter. Soils in the Ontario area are light-colored because they have very little organic matter.

Organisms

Organisms are of three general types: large plants, tiny plants (microbes), and animals. Roots of large plants help break rocks apart and mix soil particles. Root channels provide pathways for water and air movement through the soil. Aboveground plant parts die and decay, thereby building up the organic matter in the soil.

Microscopic organisms, or microbes, are an extremely important part of the soil. They are the primary decomposers. They change raw plant material into a complex black substance called humus. At the same time they release soil nitrogen, an essential nutrient that plants need in large quantities. Thus, rich, fertile topsoils are rich and fertile because they are well supplied with humus (see Plates 3, 4, and 8). Even the earthy smell of moist, rich, topsoil is caused by a microorganism.

Microbes and the humus they produce also act as a kind of glue to hold soil particles together in aggregates. Well-aggregated soil is ideal for providing the right combination of air and water to plant roots.

Without microbes, therefore, soil would be a virtually inert (lifeless) body. With them, soil is truly a living, dynamic system.

Soil animals include large burrowing animals, small earthworms and insects, and microscopic worms called nematodes. All are important because they help mix soil. Animal mixing carries raw plant debris that lies on the soil surface down into the topsoil. Only then can the microbes do their job of changing plant material to humus.

Parent material

Parent material is the original geologic material that has been changed into the soil we see today. Parent material is passive because it simply responds to the changes brought about by weathering and biological activity.

Many parent materials are some kind of bedrock, like sandstone or basalt. Others are deposits of sediments carried by water, wind, or ice. Volcanic ash, lake-laid silts, dune sand, and glacial gravels all are examples of transported parent materials.

Time

Time is the great equalizer. Young soils inherit the properties of their parent materials. They tend to have the same color, texture, and chemical composition as their parent materials. Later on, the influence of parent material is not as evident.

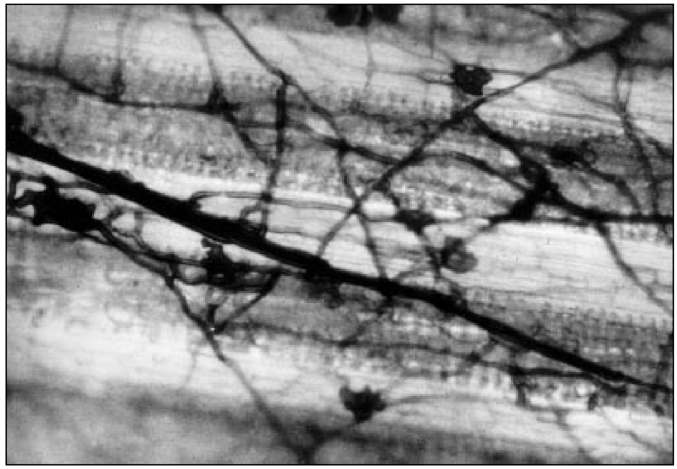

Figure 3.—Humus formation. Strands of fungus surround a freshly clipped blade of grass. Decomposition is beginning and will soon convert the clipping to soil organic matter.

As soils age, many original minerals are destroyed. Many new ones are formed. Soils become more leached, more acid, and more clayey. In short, the soil becomes more strongly developed with the passage of time.

Topography

Topography, or landscape position, causes localized changes in moisture, temperature, and parent material. When rain falls on a hillslope, for example, water runs away from the top of the hill. Excess water collects at the bottom of the hill. Soils at the top of the hill are relatively dry and often show the effects of erosion on the soil profile. Soils at the bottom of the hill not only are wetter but often are formed in materials transported down slope and deposited in lower landscape positions.

Another effect of topography is due to the direction that a slope faces. Soils on north-facing slopes, for example, tend to be cooler and wetter than soils on south-facing slopes.

Processes of Soil Formation

Our definition of soil has identified *five factors* of soil formation. We also can think in terms of four major *processes* that change parent material into life-sustaining soil. They are additions, losses, translocations, and transformations.

Processes of Soil Formation
Additions
Losses
Translocations
Transformations

Additions

The most obvious addition is organic matter. As soon as plant life begins to grow in fresh parent material, organic matter begins to accumulate. Organic matter gives a black or dark brown color to surface soils. This is why even very young soils usually have a dark-colored surface layer.

Other additions come with rainfall. On the average, rainfall adds about five pounds of nitrogen each year to every acre of soil. Rainfall also can be acid, especially downwind from industrial areas. Acid rain may change the rate of some soil processes. Rainfall, by causing rivers to flood, is indirectly responsible for the addition of new sediments to the soil on a river's floodplain.

Losses

Most losses occur by leaching. Water moving through the soil dissolves certain minerals and carries them out of the soil. Some minerals, especially salt and lime, are readily soluble. They are removed very early in the history of a soil's formation. That's why soils in humid regions don't contain free lime.

Many fertilizers, especially nitrogen fertilizers, also are quite soluble. They, too, are readily lost by leaching, either by natural rainfall or by irrigation water.

Other minerals, such as iron oxides and sand grains, dissolve very slowly. They remain in the soil until it is very old and highly weathered.

Losses also occur as gases or solids. Oxygen and water vapor are lost from soil as fresh organic matter decays. And when soils are very wet, nitrogen can be changed to a gas and lost to the atmosphere. Solids are lost by erosion, which removes both mineral and organic soil particles. Such losses are very serious, for the soil lost by erosion usually is the most productive part of the soil profile.

Translocations

Translocation means movement from one place to another. Usually we think of movement out of a horizon near the soil surface and into another horizon that is deeper in the soil.

In low rainfall areas, leaching often is incomplete. Water starts moving down through the soil, dissolving soluble minerals as it goes. But there isn't enough water to move all the way through the soil. When the water stops moving, then evaporates, the salts are left behind. That's how subsoil accumulations of free lime are formed (Plate 9). Many hardpans in soils of dry areas form this way, too (Plate 10).

Upward translocation also is possible. Even in the dry areas of eastern Oregon, there are some wet soils that have high water tables. Evaporation at the surface causes water to move upward continuously. Salts are dissolved on the way, and left behind as the water evaporates (Figure 4). Salty soils are difficult to manage, and they are not very productive.

Another kind of translocation involves very thin clay particles. Water moving through the soil can carry these particles from one horizon to another, or from place to place within a horizon. When the water stops moving, clay particles are deposited on the surface of soil aggregates. We call these coatings *clay skins,* and they have a dark, waxy appearance (Plate 15).

Transformations

These are changes that take place in the soil. Microorganisms that live in the soil feed on fresh organic matter and change it into humus. Chemical weathering changes the original minerals of parent materials. Some minerals are destroyed completely. Others are changed into new minerals. Many of the clay particles in soils are actually new minerals that form during soil development.

Still other transformations change the form of certain elements. Iron oxide usually gives soils a yellowish-brown or reddish-brown color. In waterlogged soils, however, iron oxide changes to a different form that we call *reduced.* Reduced iron oxide is lost quite easily from the soil by leaching. After the iron is gone, the soil has a gray or white color.

Repeated cycles of wetting and drying create *mottled* soil (Plates 7 and 16). Part of the soil is gray because of loss of iron, and part is yellow-brown where the iron oxides have accumulated in localized areas.

From Rock to Soil

How do all these processes work together to form soil? Let's start with a fresh parent material. Climate starts acting on it immediately. Weathering begins to change minerals. Leaching removes salts, then free lime.

As soon as plants begin growing, they add organic matter to the soil. Biological activity increases, and humus forms. Soon a dark-colored surface horizon is present.

Weathering and leaching continue to change soil minerals and remove soluble components. More horizons develop beneath the surface. The soil becomes more acid. Clay minerals begin to form. Clay is translocated and clay skins become visible.

As the amount of clay in subsoil horizons increases, the rate of water movement through the soil decreases. Weathering continues, but leaching isn't as rapid. After a while, further change is very slow, and the whole soil-plant-landscape system is in a kind of steady state.

How do we know that all this has happened? First, we dug a hole to reveal a soil profile. Next, we studied the soil carefully, located the horizons, and determined their properties. Then we interpreted the information from the profile in terms of the factors and processes of soil formation.

You, too, can learn how to describe and interpret soil profiles. That's what the rest of this *Manual* is all about.

Figure 4.—Upward translocation. The white areas, called slick spots, are accumulations of salts left on the soil surface after water moving up through the soil evaporated at the surface.

Kinds of Soil Horizons

A soil horizon is a layer of soil parallel to the earth's surface. It has a unique set of physical, chemical, and biological properties. The properties of soil horizons are the results of soil-forming processes, and they distinguish each horizon from other horizons above and below.

Soil horizons are named using combinations of letters and numbers. Six general kinds of horizons may occur in soil profiles (Figure 5), and they are named with capital letters: O, A, E, B, C, R. These are called *master horizons*.

O Litter layer

A Mineral surface horizon, dark-colored, granular structure

E Strongly leached horizon, light-colored, platy structure

B Subsoil horizon of maximum development, "brown," blocky structure

C Weathered "parent material," "brown," massive structure

R Hard bedrock

Figure 5.—Generalized soil profile. Each master horizon is shown in the relative position in which it occurs in a soil profile. All six master horizons are shown, even though any one soil usually has only three or four.

Gradual changes from one master horizon to another give rise to *transition horizons*. These are named with two letters, for example, AB, BA, BC. Special kinds of master horizons are named by adding lower case letters—for example Ap, Bt, Cr. Thick horizons may be subdivided using Arabic numbers, as in Al, A2, or Bw1, Bw2, Bw3.

A single soil profile never has all the horizons that are possible. Most Oregon soils have A, B, C, and one or two transition horizons. Other Oregon soils may have an A horizon resting directly on a C horizon, or an A-E-B-C horizon sequence, or even an O-E-B-C sequence.

Because all six master horizons occur somewhere in Oregon, we need to know what each one is and how it differs from the others.

Master Horizons

Each master horizon has a distinct set of properties.

O horizon

The O stands for organic. O horizons don't have to be 100 percent organic material, but most are nearly so. Forest soils usually have thin organic horizons at the surface. They consist of leaves and twigs in various stages of decay (Plate 1).

Wet soils in bogs or drained swamps often have O horizons of peat or muck. Soils in Lake Labish, Waldo Lake, and Lower Klamath Lake all have O horizons of this kind. Other than these, very few agricultural or rangeland soils in Oregon have O horizons.

A horizon

The A horizon is the surface horizon of mineral soil. Its unique characteristic is a dark color formed by addition of humus (Plates 3, 4, 5, 6, 8, and 12). Granular or fine blocky structure (aggregate shape) and friable consistence (ease of crushing) also are typical.

The thickness of A horizons ranges from a few inches in dry, rangeland soils to over 20 inches (50 cm) in some Willamette Valley soils. Every cultivated agricultural soil has an A horizon.

A horizons are extremely important in maintaining soil fertility and providing a favorable environment for root growth. They should be protected from damage by erosion or compaction.

E horizon

This horizon has a light gray or white color. It's not present in all Oregon soils, but when it is, it usually occurs immediately beneath an O or an A horizon (Plates 1, 5, 6, and 11).

E horizons are light-colored because nearly all the iron and organic matter has been removed. You can think of the E as meaning exit or leaching.

E horizons occur in several of the sandy soils along the Oregon coast. They also occur in some wet, silty soils that have dense, clayey subsoils. In the wet soils, the E horizon also has noticeably less clay than the B horizon beneath it.

B horizon

The B horizon is the subsoil layer that changes the most because of soil-forming processes. Several kinds of changes are possible.

In some soils, the B horizon has the brightest yellowish-brown or reddish-brown color (Plates 1, 2, 4, 5, 9, and 12). In others, it has the most evident blocky or prismatic structure (Plates 2 and 3). Many B horizons have more clay than any other horizon, and you may be able to see clay skins (Plates 3, 5, 6, and 9). Each of these major kinds of B horizons is discussed more fully in the next section, "Special Kinds of A, B, and C Horizons."

C horizon

The C horizon is weathered geologic material below the A or B horizon. Anything that you can dig with a spade but which has not been changed very much by soil-forming processes is considered C horizon (Plates 1, 2, 3, 4, 9, and 13).

R horizon

R stands for rock. It refers to hard bedrock that you can't easily dig with a spade. Depending on the depth to bedrock, the R horizon may occur directly beneath any of the other master horizons (Plate 12).

To judge an R horizon, mark its color, and check *none* for mottles and NA for texture. Bedrock essentially is 100 percent coarse fragments, so check *more than 60 percent*. The structure type is *massive* and the grade is *structureless*.

Special Kinds of A, B, and C Horizons

Many horizons are the result of unique processes that leave a distinct mark on the horizon. We identify these horizons with a lower-case letter immediately following the master horizon symbol. Over 25 letters and combinations of letters are possible. We'll discuss only nine that you are most likely to encounter in Oregon soils.

Ap horizon

The surface horizon of any soil that has been plowed or cultivated is called the plow layer (Plates 2, 6, 9, and 12). That's what the p stands for. Cultivation thoroughly mixes the upper 8 to 12 inches

(20 to 30 cm) of the soil and destroys any natural horizons that may have been present.

If the original A was very thick, plowing converts the upper part into an Ap, and the lower part remains simply as a second A horizon. If the original A was very thin, then the Ap could rest on a B, a C, or a transition horizon.

Even when a soil has been severely eroded, such that all the original A is gone, plowing an exposed B or C horizon would automatically make the surface horizon an Ap.

Bt horizon

The t stands for *texture.* Textural B horizons have distinctly more clay in them than the horizons above or below. You can feel the difference.

Some of the clay comes from the soil above the Bt. Water moving down through the soil carries very fine clay particles with it. When the downward movement stops, the clays are deposited, building up the waxy coatings we call *clay skins.* Some of the clay also comes from the weathering of original minerals in the Bt.

Bt horizons are quite common in Oregon soils. They usually have well-developed blocky or prismatic structure (Plates 3, 5, 6, and 9).

Bg horizon

This horizon is *gleyed.* That means it's very wet for long periods of time. Iron in the soil is chemically reduced, and much of it has been leached out of the soil. As a result, gleyed horizons usually are dark gray in color (Plates 7 and 8). They also may be mottled (see page 17), but not necessarily so.

Gleyed horizons almost always tell us that the soil is poorly or very poorly drained. Gleying is not restricted to the Bg; other gleyed horizons include Ag, BAg, BCg, Cg.

Bs horizon

We call this horizon a *spodic* horizon. It's common only in some of the sandy soils on marine terraces along the Oregon coast. A few soils at very high elevations in the Cascades and the Blue Mountains also have spodic horizons.

The color of a spodic horizon is quite distinctive. It's usually bright yellowish-brown or reddish-brown, and it fades with depth (Plate 1). Often there's a thin black layer at the top. The spodic horizon forms when iron, aluminum, and organic matter all are leached out of surface horizons, carried downward, and deposited in the subsoil.

Bw horizon

Think of the w as meaning *weathered.* Bw horizons have been changed by weathering, but not enough to form a Bt, Bg, or Bs. In Oregon soils, the Bw differs from the C by having weak or moderate blocky structure (see page 25). The Bw also may have a little brighter color (Plates 2, 4, 11, and 12), and it may be more leached than the C.

Bw horizons are common in soils of the Cascade and Coast Range Mountains, in young soils on river floodplains and low terraces, and in many soils of eastern Oregon.

Bx horizon

This refers to a special feature called a *fragipan.* It is a massive, dense, but not cemented, soil horizon. The fragipan is often mottled and has streaks of gray silt scattered throughout (Plate 11). The fragipan is so dense that neither plant roots nor water can penetrate, except in the gray silt streaks. In Oregon, fragipans occur only in some of the upland soils of Columbia, Washington, Multnomah, and Clackamas counties.

Bk horizon

This horizon has an accumulation of calcium carbonate, or free lime. Carbonates leached from upper horizons have been redeposited in the Bk (Plate 9). You should be able to see white streaks or nodules of lime. These will bubble violently when a drop of hydrochloric acid (HCl) is placed on them.

Be careful though. Some soils in eastern Oregon have had free lime in them right from the beginning. They will react to the acid, too. We use the k only to indicate a horizon enriched in carbonates by translocation. A Bk horizon may very well have an ordinary C horizon beneath it that contains only its original amount of lime.

Bkqm horizon

This horizon is called a *duripan* (Plate 10). It is enriched with calcium carbonate (k) and silica (q), and it is strongly cemented (m).

Duripans are common in several soils of eastern Oregon. Limited rainfall has leached lime and silica from the upper 10 to 20 inches of soil and redeposited them in the Bkqm. Thin, pinkish coatings of opal may be present on the upper surfaces of duripan fragments. The duripan usually is only 6 to 10 inches thick, but it is so cemented that plant roots can't go through it.

A dense mat of roots spreading horizontally is a good indicator of a duripan. Sometimes, however, there are fractures in the duripan that will allow some plant roots to find a way down. And if the pan is only weakly cemented, you can break it up even more by ripping.

For soil judging contests, mark the most appropriate color. Check *none* for mottling, NA for texture, and *more than 60 percent* coarse fragments. The structure type is *massive* and the grade is *structureless.*

Cr horizon

Weathered bedrock, or rock that is soft enough to slice with a knife or a spade, is called Cr (Plate 13). It's rock material, and you often can see original rock structure, but it's not hard enough to be designated R.

When judging a Cr, first record its color, then check *none* for mottles, *NA* for texture, and *more than 60 percent* coarse fragments. The structure type is *massive* and the grade is *structureless*.

Transition Horizons

Master horizons rarely change abruptly from one to another. Instead, the changes occur gradually throughout a zone that may be 5 or 10 inches thick. These zones are called transition horizons. There are three common ones in Oregon soils.

AB horizon

This transition horizon occurs between the A and the B. It's dominated by properties of the A, but some of the properties of the B are evident. Dark colors associated with organic matter are fading because organic matter is decreasing (Plate 4). The structure often changes from granular to subangular blocky (see Chapter 4, "Soil Structure").

BA horizon

This horizon also occurs between the A and the B, but it has more of the characteristics of the B. Generally, the structure will be the same type as the B, but less strongly expressed. The color may be a little darker than the B (Plate 3), or the clay content may be less than the maximum in the B.

BC horizon

This is a transition from B to C. Properties of the B are dominant, but some influence of the C horizon is evident

(Plates 2 and 3). Often the clay content will be less than the maximum in the B, but more than in the C. Or the color will be fading. If the C is massive, the BC has structure, but it may have larger units and be more weakly expressed than in the B.

Subdivisions of Thick Horizons

Sometimes one or two of the horizons in a soil are so thick that they need to be subdivided. Small changes in texture, color, or structure commonly are used to make the subdivision.

Subdivisions, or vertical sequences within any single kind of horizon, always are indicated by a number immediately following the letter symbol(s). Here are a few examples of some thick soil horizons that could be subdivided:

Thick A horizon—Al, A2 (Plate 8)

Thick Bg horizon—Bg1, Bg2 (Plate 7)

Thick Bt horizon—Bt1, Bt2 (Plate 5)

Thick Bw horizon—Bw1, Bw2 (Plate 2)

Thick C horizon—C1, C2 (Plates 3 and 4)

More Than One Kind of Parent Material

Parent material is the geologic stuff from which soils form. It may be a river deposit, volcanic ash, clays weathered from rock in place, or one of many other kinds of materials. When all the horizons of a soil have formed in a single kind of parent material, we simply use the ordinary A, B, and C designations.

Some soils, however, have formed in more that one kind of parent material. A flooding river, for example, may deposit fresh silts on top of older sands and gravels. Or volcanic ash may be deposited on top of weathered bedrock.

If soil horizons are developed in more than one material, we place a number in front of the horizon name to indicate its position from the top down.

The geologic material at the surface is always assumed to be the first one, and the number 1 is never used.

The second geologic material is indicated by a 2, the third by a 3, and so on. Thus a soil developed in silt loam over gravel could have the following set of horizons: A-AB-B-2BC-2C.

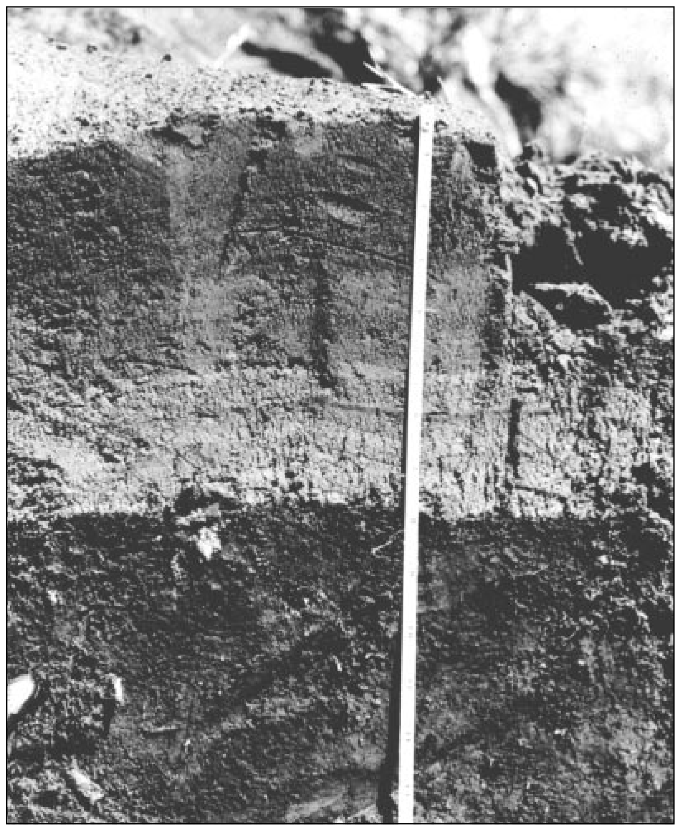

Figure 6.—Multiple parent materials. The gray material is recent volcanic ash resting on older, more weathered soil material. Notice the abrupt contact between the two contrasting materials.

Typical Horizon Sequences

Several common Oregon soils are listed below, followed by the names of the horizons in a typical profile. Nearly all geographic areas of Oregon are represented by the soils on this list.

Alicel	Ap-A-BA-Bw-2C
Bandon	O-E-Bs1-Bs2-Bs3-Bs4-C
Brenner	Ap-A-Bg1-Bg2-BCg-Cg
Carney	A1-A2-AB-C-2R
Cascade	A-Bw1-Bw2-2Bx1-2Bx2-2Bx3
Dayton	Ap-E-2Bt-2BCt-3C
Deschutes	A-BA-Bw-2C-3R
Fordney	Ap-C1-C2
Gem	Al-A2-BAt-Bt1-Bt2-BCt-BCtk-R
Hoopal	A1-A2-Bw-Bkqm-C
Josephine	O-A-BA-Bt1-Bt2-Bt3-C-Cr
Malabon	Ap-AB-Bt1-Bt2-BCt-2C
Nehalem	Ap-A-Bw-C
Nyssa	Ap-Bw-Bkq-Bkqm1-Bkqm2
Oakland	A1-A2-Bt1-Bt2-Bt3-BCt-Cr
Quincy	C1-C2
Ritzville	Ap-BA-Bw-Bk-C1-C2
Salem	Ap-Bt-BCt-2C
Simas	A-2Bt1-2Bt2-2BCk1-2BCk2
Walla Walla	Ap-A-BA-Bw-BCk1-BCk2

Locating Boundaries Between Horizons

The most useful thing you can do to help yourself find and name soil horizons is to prepare a good exposure of the soil profile. Either a good pit or a road cut will do, but in either case you should clean up the face of the vertical cut. Use your knife to pick off any soil that may have fallen down from the surface or that was smeared by a shovel or a backhoe. After you have a good, fresh surface, try each of the following techniques.

1. Look for color changes. Where there is an obvious color change there also is a horizon change. Color alone, however, is not sufficient to separate all horizons. Several soils in Oregon have nearly uniform colors extending all the way through the B and into the C.
2. Take a knife and gently poke the soil every few inches from the surface down to the lower part of the pit. Often you can "feel" the firmer consistence of subsoils and restrictive layers. You may even be able to locate a contact between B and C this way.
3. Starting at the top, check the soil texture with your fingers every 2 to 4 inches. If there is a marked increase in clay from A to B, you should detect it this way. A decrease in clay from B to C also should be evident.
4. With your knife, remove a handful of soil from the upper 4 inches of soil. Carefully break it apart and observe the size, shape, and strength of structural aggregates. Repeat this process every 4 to 6 inches down through the profile. Structural changes may be a good clue to boundaries between horizons and to the presence of transition horizons.
5. Each time you locate a tentative boundary, mark it with a nail, twig, or some other convenient marker. As you consider more and more characteristics, you may want to adjust some of the boundaries up or down.
6. When you have settled on an initial set of horizon boundaries, start looking more carefully at the color, texture, structure, pores, clay skins, etc. of each horizon. With a complete set of information, you may wish to make a final adjustment in your horizon boundaries.