Lesson 12: Interpretations and Management of Soil

The first steps in evaluating soils involve learning how to identify horizons and site characteristics, and how to describe their important properties. The next steps examine the use and management of the soil. Management practices discussed in this lesson include the feasibility of artificial drainage, the suitability for irrigation, water erosion, evaluating the erosion hazard, conservation practices for erosion control, and hazards or limitations for cropping systems.

Management choices are sometimes difficult to make, because they depend on interactions among several soil factors: the specific crops being grown, the effects of climatic conditions, and site characteristics. Constraints of complying with a farm plan are complicated when winter-kill or chemical carryover limit choices of crops. Also, farmers must avoid growing some crops on a particular tract of land for more than 2 years in a row for control of disease and allelopathy (the suppression of growth of one plant species by another due to the release of toxic substances).

The materials in this manual have been generalized considerably for statewide use. The guidelines given in the sections that follow should be adequate for soil judging contests, but it should be recognized that there may be exceptions to these guidelines. Missouri has such as diversity of soils, climate, types of agriculture, and management practices that a general manual simply cannot account for every possibility.

Suitability of Artificial Drainage

The growth of most agricultural and forest plant species is seriously affected by prolonged periods of free water on the land surface where oxygen is excluded from the root zone. Only aquatic plants or a few special plants, such as rice or cypress trees, can tolerate such conditions. Soils that are less than well-drained often can be improved by artificial drainage. The two major soil properties to consider for the need for **surface drainage** are the internal drainage class and slope (both shape and steepness). Since evaluating the soils for underground tile drains is very difficult, only artificial surface drainage is considered. **Artificial surface drainage** can be provided by leveling or filling depressions, by land grading, and by digging shallow surface ditches to remove water.

The decision as to whether or not surface drainage is needed can be made from a study of the site. If surface water stands on a site for continuous periods of 8 hours or more during the growing season, surface drainage is needed.

Somewhat poorly drained, poorly drained, and very poorly drained soils (high water table <2 feet) that are nearly level, with no depressional areas, may not need surface drainage. However, many nearly level soils will have depressional areas or a concave slope that restricts the natural flow of surface water. Good judgment should be used to decide if surface drainage is needed. See Figure 12.1.

Figure 12.1 – Guide for Determining Artificial Surface Drainage

Drainage is needed for:

1. Soils that are somewhat poorly drained, poorly drained, or very poorly drained, and are nearly level with depressional spots.
2. Sloping soils below seepy areas.

It should be noted that before any artificial drainage is started, areas should be checked by the appropriate government agency for wetland regulations.

Suitability for Irrigation

The best soils for irrigation are deep, nearly level, well-drained soils with high available water capacity. Any departure from these conditions will lower the irrigation suitability.

Primary Soil Properties Affecting Irrigation

The primary soil characteristics that affect the suitability for irrigation are surface texture, slope, available water capacity, depth to high water table, permeability, percent of rock fragments, and depth to bedrock. To evaluate the soil for irrigation suitability, these characteristics are considered assets or liabilities. Irrigation guidelines are summarized in Table 12.1.

Surface texture affects the intake of water into the surface layer. Soils high in sand content have a fast intake rate; silty and loamy soils have a moderate intake rate; and clayey soils have a slow intake rate. Although silty and loamy soils have a moderate intake rate, their property of high available water capacity gives them the best overall suitability for irrigation.

Slope affects the amounts and rates of water applied. This is most critical with furrow irrigation. Length of run is determined by the rate of water movement into the soil and the time it takes applied water to reach the lower end of the run. Sloping soil areas or depressional spots in soil areas will interfere with the desired surface run. A desirable grade enables the irrigation water to soak into the soil and move down the grade to the end of the run. Too much slope will move the water down the slope faster than it should. This may result in too little water soaking in at the upper end of the slope and too much water accumulating at the lower end of the run. This may cause erosion. Generally, slopes of less than 3 percent have the greatest potential for furrow irrigation. Where sprinkler and center-pivot systems are used, slope gradient is not as critical, but still has a great effect on water intake and runoff. Slopes less than 3 percent are considered an **asset**, those over 3 percent are considered a liability.

Many nearly level fields have depressional spots that need filling or smoothing for successful irrigation. The cost of grading and preparing the field may not be feasible. If the field has depressional areas and grading is needed, this would be considered a **liability**.

Available water capacity is important to the frequency and amounts of water that can be applied to the soil. Those soils with low or very low available water are considered a **liability**.

Depth to high water table (internal drainage) is a factor that affects the rate at which internal free water leaves the soil to allow aeration. The gravitational water needs to move out of the profile quickly so the roots can obtain adequate aeration. This can be a problem if over-irrigation is followed by a rain. Soils that are moderately well drained or better (water table >2 feet) are considered an **asset**; those that are somewhat poorly drained or wetter (water table <2 feet) are considered a **liability**.

Permeability affects the rate at which water moves down through the profile to reach field capacity (see Lesson 10). Good permeability is effective only if the seasonal water table is below the rooting zone at the time of irrigation.

Rock fragments and **depth to bedrock** affect the available water capacity of the soil. This limits the amount of irrigation water that can be absorbed.

Types of Water Erosion

Water erosion is the detachment and transportation of soil particles. There are three main types of water erosion: sheet, rill, and gully.

Table 12.1 – Irrigation Guidelines

Soil Characteristic	Asset	Liability
Surface soil texture	Loam, silt loam, silty clay loam, clay loam	All other textures
Slope	0–3%	>3%
Available water capacity	>6 inches	0–6 inches
Depth to high water table	>2 feet	0–2 ft
Permeability	>0.2 inches/hour	<0.2 inches/hour
Rock fragments >3 inches (surface layer)	<15%	>15%
Depth of soft or hard bedrock	>40 inches	0–40 inches

Detachment is caused by raindrop impact. See Figure 12.2. This is the major cause of sheet erosion. Some detachment of soil particles is caused by flowing water. Soil loss from sheet erosion is more or less uniform over a field. It may be barely detectable on a year-to-year basis. After soil particles are detached, they can be floated into rills and gullies and transported into low places or off the field.

Figure 12.2 – Raindrop Impact

Soil particles and globules of mud are hurled in all directions when a water drop strikes wet soil.

Rills are small channels where runoff water concentrates. The channels are shallow enough (generally less than 4 inches) that they are easily smoothed and filled in by ordinary tillage. After a field is tilled, it is not possible to tell whether soil losses resulted from sheet or rill erosion.

Gullies form in natural drainageways, plow furrows, animal trails, between crop rows, and below overtopped terraces. Gullies generally cannot be easily smoothed and filled by ordinary tillage.

Topsoil loss on cropland in Missouri averages about 10 tons (about 1/16 inch) per acre per year. If this amount of erosion (soil loss) is allowed to continue unchecked year after year, it can cause great losses of topsoil and crop productivity.

Erosion Control

It is standard procedure to evaluate the hazard of erosion under the worst possible conditions. These conditions include bare soil without vegetation and without any kind of soil conservation practice to slow down water running over the surface. Most soils are not managed so poorly. But the erosion hazard is always present, and it is essential that erodible soils are protected.

The need for erosion control depends on a soil's erosion hazard and the kind of crop that can be grown. Hay and pasture crops provide much of the erosion protection needed. Others, such as row crops and winter wheat, need specific management to minimize soil erosion.

Regardless of the size of the erosion problem, farmers should be aware of and practice conservation. A sloping soil, if managed improperly, is subject to erosion that reduces the quality of the soil resource for future generations. The USDA uses the Revised Universal Soil Loss Equation (RUSLE) to determine the soil loss under various vegetative cover and crops. This is the most accurate method and is used to estimate soil loss by sheet and rill erosion for the USDA. Steepness and length of slope, soil erodibility, rainfall energy and intensity, vegetative cover (both residue and growing crop), and type of mechanical erosion control practice are the key factors in the RUSLE.

The right kind of erosion control practice for any particular field, farm, or forest can be determined only by an on-site inspection. There are no magic formulas or prescriptions that fit every situation. Sometimes adequate erosion control can be achieved by the simple application of one of the general practices described below. In other cases, two or three different practices may be needed. In still other cases, there may be appropriate measures that are not included below. It is important to recognize the problem, know the various kinds of erosion control practices available, and use a healthy dose of common sense in managing soils to minimize erosion.

Management Practices to Control Erosion

There are several management practices to control erosion. These include types of tillage, cropping sequences, and constructing terraces.

No-Till

No-till means exactly what it says. A crop is planted directly into the stubble from a previous crop, or into a sod or cover crop, without tilling the soil first. The soil is not cultivated during the growth of the crop. Instead, weeds are controlled with chemicals. Without a doubt, no-till planting of crops is the most effective erosion control system.

No-till is very effective for erosion control because bare soil is never exposed at the surface. In addition, roots from the previous crop help to keep the soil anchored in place. No-till helps to maintain high organic matter levels, and it eliminates the possibility of forming a tillage pan (hard layer caused by years of tillage at the same depth). All these factors combine to maximize water absorption into the soil.

No-till is difficult in some situations, and it does require special equipment and different kinds of fertilization and weed control practices. But in many areas, it can be the most effective erosion control method as well as an effective soil management practice to improve yields.

Conservation Tillage

This system allows some cultivation of the crops to prevent weed growth. Conservation tillage ranges from no-till to a minimum of 30-percent residue cover on the surface after planting. Chisel or disc tillage equipment is used to prepare the seedbed. The best conservation tillage system uses as little tillage as possible and utilizes chemicals to control weed growth.

Contour Planting

This is a way of planting on the contour of the land following established grades for terraces and diversions.

Contour Strip Cropping

Contour crops are planted in a systematic arrangement of strips or bands that provide vegetative barriers to control erosion. Width of strips may vary, but usually are the same for each crop and can be interchanged from year to year.

Contour buffer strips are somewhat similar to contour strip-cropping. However, the buffer strips are much narrower than the cultivated or cropped strips (20–30 percent of the slope) and are planted to grass. To be most effective, buffer strips should have tall vegetation in spring and early summer.

Grassed Waterways

Grassed waterways are areas planted to grass where water usually concentrates as it runs off of a field. They slow the runoff water and guide it off of the field, thereby reducing gully erosion.

Grassed waterways can be used to collect excess runoff water from contours, buffer strips, and can serve as outlets for terraces.

Conservation Cropping Sequence

An adapted sequence of crops is designed to provide adequate organic residue for maintenance or improvement of soil tilth. For example, a conservation cropping sequence used in conjunction with any of the tillage practices listed will enhance the effectiveness of the tillage system.

Terraces

Constructing terraces is the most expensive way to control erosion on crop land. However, with very productive soils, terraces could be the choice of some farmers. There are three basic types of terraces: broad-base, narrow-base, and steep backslope. All three of these can either be **gradient** and/or **parallel**. Gradient terraces have a definite grade to the channel (low area for holding or draining water) ranging from level to 2 inches per 100 running feet. Parallel terraces run parallel to each other.

Although the erosion hazard is greatly reduced by shortening the length of the slope, the actual percentage of the slope is increased by both broad-base and narrow-base terraces. The slope is decreased by steep backslope terraces.

Broad-base terraces generally are constructed on slopes of 8 percent or less. The terrace channels and berms (ridges or embankments) are constructed broadly enough that large machinery can operate easily and crops can be planted, although the slop is increased. Construction cuts are made on the uphill side of the berm. See Figure 12.3.

Narrow-base terraces generally are constructed on slopes over 8 percent and have grass planted on both sides of the berm. Construction cuts are made on the uphill side of the berm.

Steep backslope terraces generally are constructed on slopes over 8 percent. They have grass on the back side of the berm. Berms are constructed by pushing up the soil only from the lower side. The big advantage of steep backslope terraces is the reduction of the slope of the land farmed. See Figure 12.4. The differences between effective slopes of broad-base and steep backslope terraces are shown in Figure 12.5.

Cost-effective methods for controlling erosion vary. No-till or the following methods used together may be the best options for land owners to choose among: a good cropping sequence, a good conservation tillage system, and contour planting.

Figure 12.3 – Broad-base Terrace

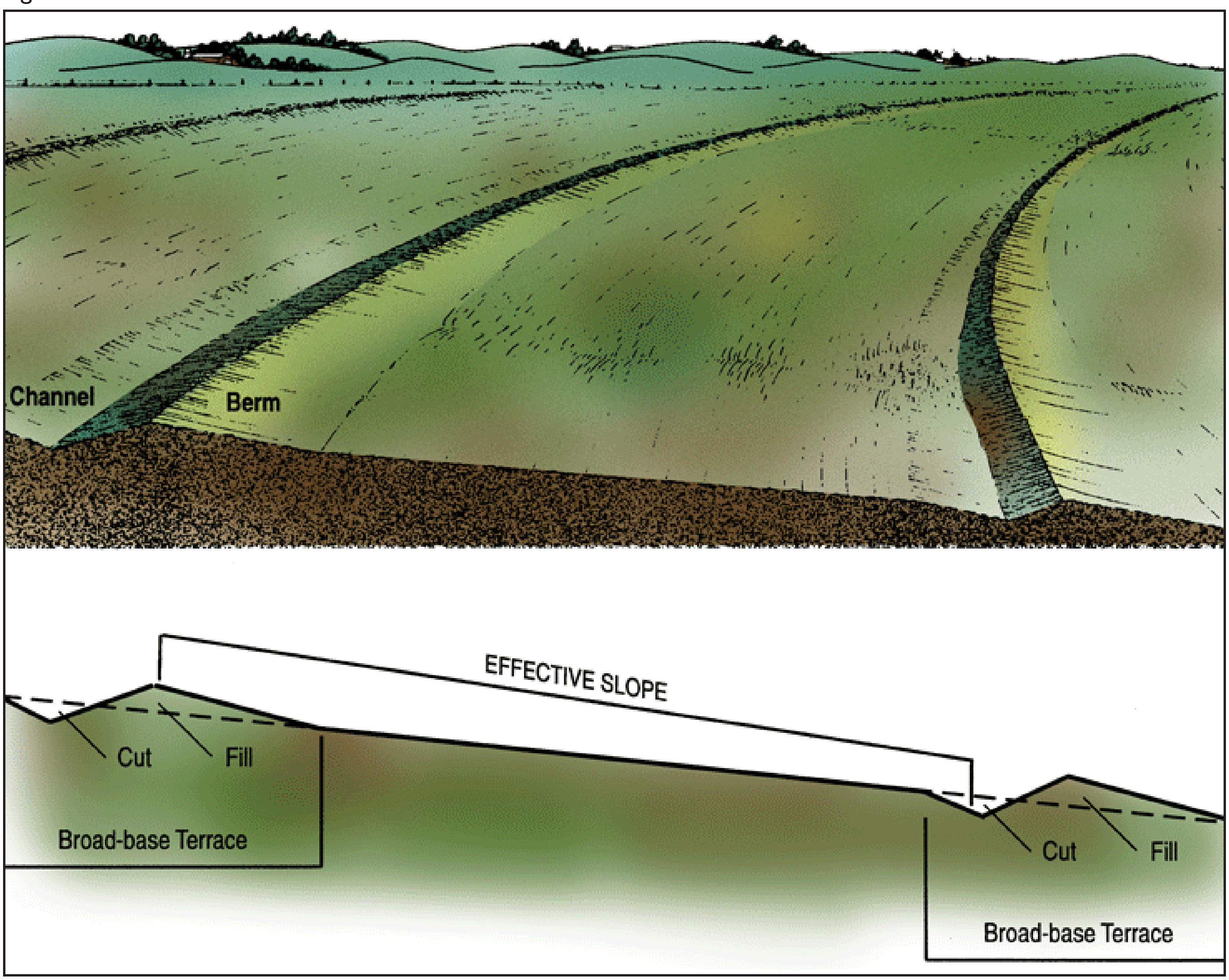


Figure 12.4 – Steep Backslope Terrace

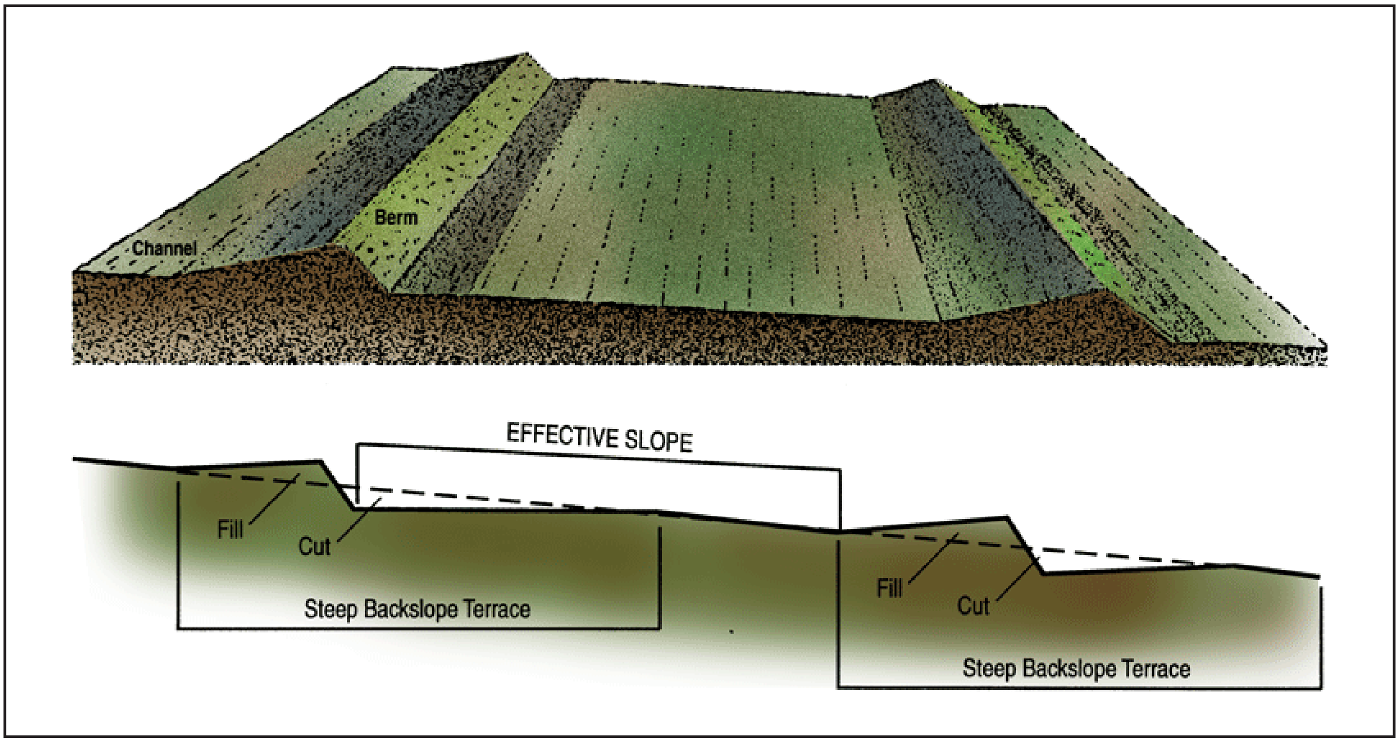
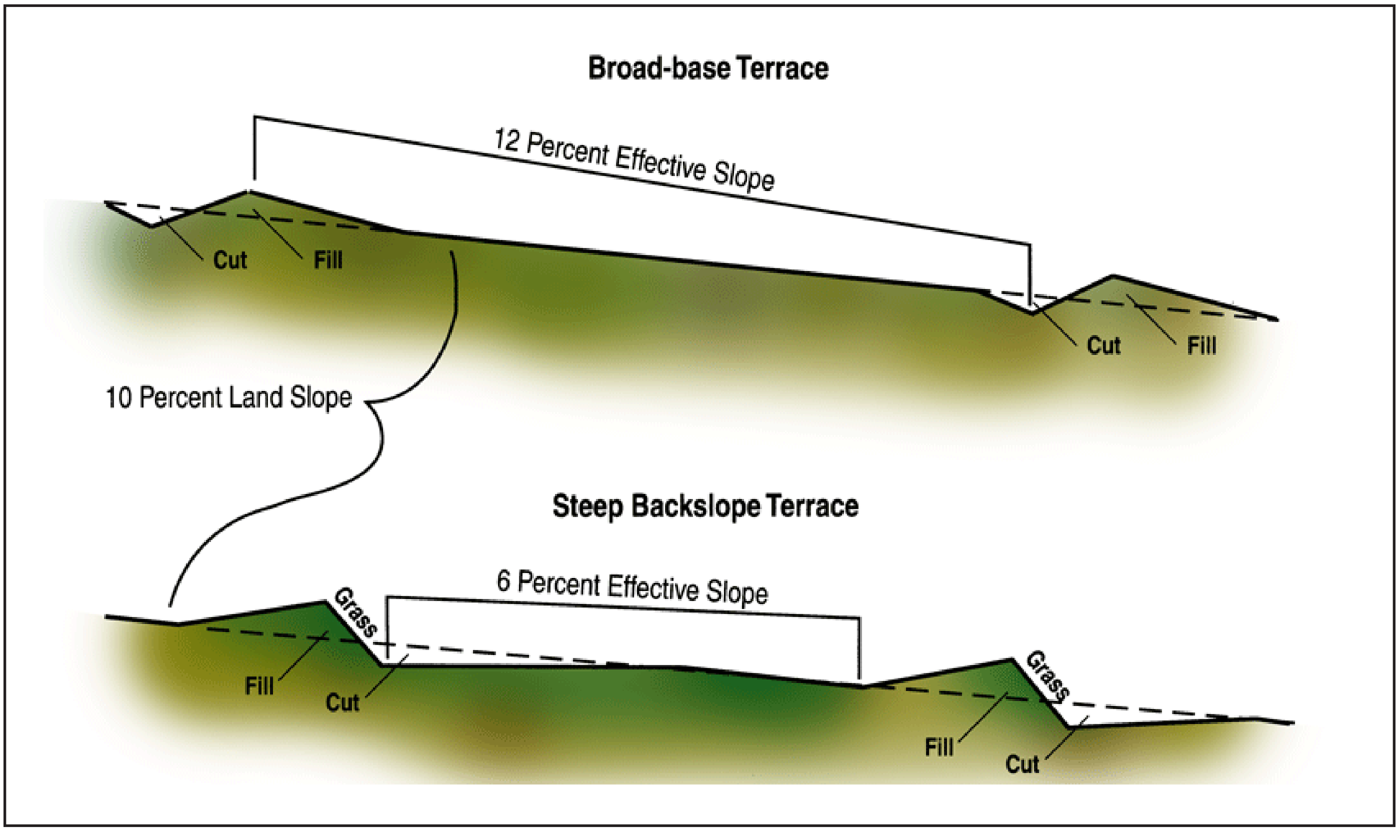


Figure 12.5 – Comparison of a Broad-base Terrace and a Steep Backslope Terrace



Soil Characteristics as Hazards or Limitations for Cropping Systems

Many limitations or hazards may affect the cropping systems for a particular soil site. Six have been selected for evaluation here. They are: slope and erosion, available water capacity, surface drainage, internal drainage, rock fragment content (gravel, cobbles, channers, or flagstones), and surface stoniness. These are not the only important hazards or limitations that affect the choice of crops, but are probably the most significant and easiest to evaluate at a small site. See Table 12.2.

Summary

Management practices in this lesson include the suitability of artificial drainage and irrigation, water erosion, evaluating the erosion hazard, conservation practices for erosion control, and hazards or limitations for cropping systems. The two major soil properties considered for surface drainage are the internal drainage class and slope (shape and steepness). Surface drainage is needed on all soils that are somewhat poorly drained, poorly drained, or very poorly drained, and are nearly level in slope with depressional areas, and soils that are on sloping areas below seepy areas. The decision as to whether or not surface drainage is needed is determined after the site is studied.

The best soils for irrigation are deep, nearly level, well-drained soils with a high available water capacity. The primary soil characteristics affecting the suitability for irrigation are surface texture, slope, available water capacity, depth to high water table, permeability, rock fragments, and depth to bedrock. These characteristics are considered assets or liabilities.

The need for erosion control depends on the erosion hazard and the kind of crop that can be grown. The USDA uses the Revised Universal Soil Loss Equation to determine soil loss, and is based on steepness and length of slope, soil erodibility, rainfall energy and intensity, vegetative cover, and type of mechanical erosion control practice. Management practices for controlling erosion include no-till, conservation tillage, contour planting, terraces (broad-base, narrow-base, steep backslope), conservation cropping sequence, and contour strip cropping. Soil characteristics which may limit cropping systems include erosion, available water capacity, surface drainage, and rock fragment content.

Table 12.2 – Guide for Determining Hazards or Limitations for Cropping

Possible Hazard or Limitation	Soil Characteristics that Indicate a Hazard or Limitation Exists
Slope or erosion	1. All land slopes longer than 90 feet in excess of 2% slope. 2. Any eroded area where the upper 6–7 inches is either mixed topsoil and subsoil, mostly subsoil, or has gullies. See Plate 32, p. 50-H.
Available water capacity	Less than 10 inches of available water in the upper 60 inches of the profile.
Surface drainage	High water table <2 feet and nearly level with depressional spots. Also, sloping areas below seep spots.
Internal drainage	High water table <3.5 feet.
Rock fragments (volume upper 10 inches)	>15%
Stoniness (surface)	Stones <100 feet apart.
Rockiness	10 square feet of rock outcrop per 10,000 square feet of area.

Credits

Huddleston, J. Herbert, and Gerald F. Kling. *Manual for Judging Oregon Soils,* Corvallis: Oregon State University Extension Service, 1984.

Scrivner, C.L., James C. Baker, and Harold E. Grogger. *Evaluating Missouri Soils,* Columbia, MO: University Extension, 1972.

Soil Survey Division Staff. *Soil Survey Manual, Handbook #18,* rev. Washington, DC: U.S. Government Printing Office, U.S. Department of Agriculture, Soil Conservation Service, 1993.

Soils Interpretation Help Sheet. Missouri Department of Elementary and Secondary Education. Accessed May 8, 2008, from http://www.dese.mo.gov/divcareered/AG/CDE/SoilsInterpretation.pdf.