Lesson 1: Soil Tests

Grassland soils are important in meeting production goals on any given plot of land. To best manage the area, analyses to evaluate the fertility status of the soil must be performed. A soil test report, which provides information from such tests, is a valuable tool in grassland management.

The procedures used to collect a soil sample may influence the results of the test. A representative sample must be taken from within the grassland; for example, wet spots as well as dry spots should be represented. Ideally, about 15 to 20 subsamples should be taken to a depth of 6 to 7 inches and then combined in a composite sample. Once the sample is taken, it may be analyzed by the University Extension service or private soil testing labs.

Soil Test Information

Soil test reports should include the following information (see Figure 1.1).

Field information (A) – This section contains information provided by the producer to identify the field and summarize previous management. This information includes, for example, the field name or number, field size, and previous crop.

Soil test information (B) – This section provides the results of the soil tests performed on the sample. The regular soil tests include the soil salt pH; available phosphorus, potassium, calcium, and magnesium; organic matter; neutralizable acidity; and cation exchange capacity. Tests for other nutrients can be obtained at additional charge. The basic set of tests provides the necessary data to develop nitrogen, phosphate, potash, and agricultural lime recommendations for the intended cropping plan.

Rating (C) – This section provides a rating for the salt pH and nutrients tested. The rating system helps interpret the soil test information in Section B.

Nutrient requirements (D) – This section contains three parts: cropping options, yield goal, and fertilizer recommendations.

Cropping options (E) – This section lists cropping plans or crops for which fertilizer recommendations were requested. Recommendations can be given for up to four different cropping scenarios. Additional scenarios can be done at the local University Extension center if plans change after the lab report comes back.

Yield goal (F) – The yield goal section shows the level of production selected for the crops listed in Section E, "Cropping Options." The yield goal chosen should be based on soil type, yield history, fertility level, presence of irrigation, and economic considerations.

Pounds per acre (G) – This section lists the fertilizer recommendations for the crops and yield goals listed. The recommendations are reported as pounds of N (nitrogen), P_2O_5, (phosphate), and K_2O (potash) per acre. The fertilizer recommendation is designed to provide an agronomic recommendation of the nutrients needed to meet the yield goal in Section F and improve soil fertility over time. Following these soil test recommendations will increase or maintain the levels of phosphorus and potassium needed for the high rating category if the recommended fertilizer rate is applied annually for 8 years Micronutrient recommendations, such as zinc, should be applied once and the soil resampled in 3 to 5 years to determine the need for additional applications.

Limestone suggestions (H) – This section gives the suggested amount of limestone to raise soil salt pH to an optimal level for the cropping options listed. Desired soil salt pH ranges for Missouri crops are given in Figure 1.2.

The limestone recommendation is given for the cropping option requiring the highest salt pH range. For example, if a cool-season grass and alfalfa were both listed in Section E, the limestone recommendation would be for alfalfa since it requires a higher soil salt pH level. The recommendation is reported as pounds of effective neutralizing material (ENM) per acre.

Special Notes (I) – Many times notes appear at the bottom of the soil test report to help the producer interpret and use the results and recommendations.

Figure 1.1 – Soil Test Report

University Extension
UNIVERSITY OF MISSOURI COLUMBIA

Soil Test Report

Soil Testing Laboratory
23 Mumford Hall, MU
Columbia, MO 65211
Phone: (573) 882-0623

or

Soil Testing Laboratory
P.O. Box 160
Portageville, MO 63873
Phone: (573) 379-5431

Serial no. M9999	Lab no. 9969999	
Area 015	County 010	Region 3
Submitted 06/10/96	Processed 06/12/96	

A

FIELD INFORMATION			
Field ID	Hill top field	Sample no.	1
Acres	40	Last Limed Not known	Irrigated No
Last crop	019 Cool-Season Grass Pasture		

Soil sample submitted by:

This report is for:

Example Report
University of Missouri
Columbia, MO 65211

B SOIL TEST INFORMATION — **C** RATING

Soil test		Value	Very low	Low	Medium	High	Very High	Excess
pH$_s$	(salt pH)	4.9	*******					
Phosphorus	(P)	22	********************					
Potassium	(K)	lbs/acre	********************************					
Calcium	(Ca)	303	*************************					
Magnesium	(Mg)	lbs/acre	**************					
Sulfur	(SO_4-S)	ppm						
Zinc	(Zn)	ppm						
Manganese	(Mn)	ppm						
Iron	(Fe)	ppm						
Copper	(Cu)	ppm						

Organic matter 2.2 %	Neutralizable acidity 6.0 meq/100g	Cation Exch. Capacity 12.8 meq/100g	
pH in water	Electrical Conductivity mmho/cm	Sodium (Na) lbs/a	
Nitrate (NO_3-N) Topsoil ppm	Subsoil ppm	Sampling Depth Top inches	Subsoil inches

D NUTRIENT REQUIREMENTS

E Cropping options	**F** Yield goal	N	P_2O_5	K_2O	Zn **G**	S
Alfalfa/Grass	0	20	55	0		
Establishment	0	20	45	0		
Clover/Grass Establishment	6	0	80	235		
Alfalfa/Grass Hay	150 CD/A	90	30	20		

(Pounds per acre: N, P_2O_5, K_2O, Zn, S)

LIMESTONE SUGGESTIONS **H**	
Effective neutralizing material (ENM)	1,395
Effective magnesium (EMg)	

I

To determine limestone need in tons/acre, divide ENM requirements by the guarantee of your limestone dealer.

When N requirement for cool-season grass exceeds 90 lbs/acre, apply 2/3 of it during the period from December through February, and the remainder in August.

Do not use nitrogen on spring seedlings of legumes after May 1st because of potential weed competition.

Area Agronomy Specialist Agronomy Specialist Phone (573) 882-1000 ____________ Signature

White - Farmer, Yellow - ASCS, Blue - Firm, Pink - Extension MP 189 Revised 1/96

University of Missouri, Lincoln University, U.S. Department of Agriculture & Local University Extension Councils Cooperating
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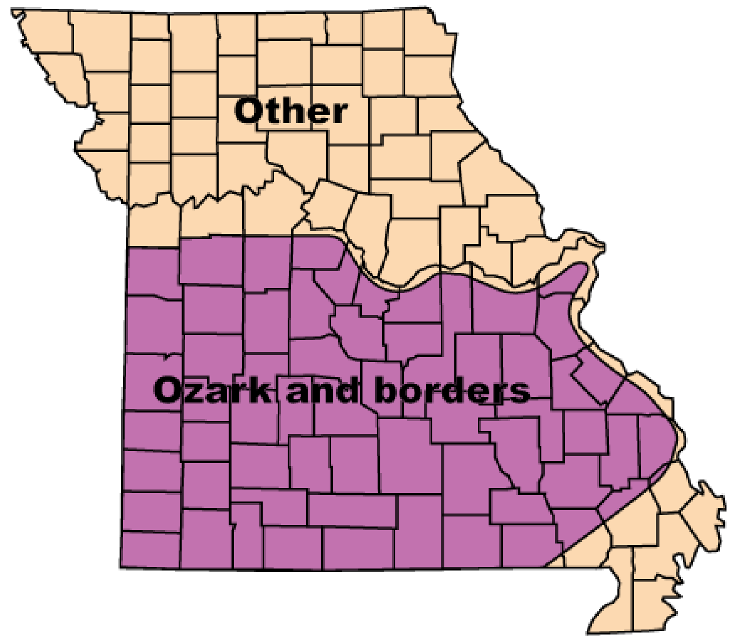
Figure 1.2 – Desired Soil Salt pH Ranges for Missouri Crops

	Soil region	
Crop	Ozark and border	Other
Alfalfa and alfalfa-grass establishment	6.6-7.0	6.1-6.5
Birdsfoot trefoil and birdsfoot trefoil-grass establishment	6.1-6.5	5.6-6.0
Clover and clover-grass establishment	6.1-6.5	5.6-6.0
Cool-season grass establishment and production	5.6-6.0	5.6-6.0
Lespedeza and lesbedeza-grass establishment	6.1-6.5	5.6-6.0
Overseeding legumes	6.1-6.5	5.6-6.0
Warm-season grass establishment and production	5.6-6.0	5.6-6.0
Sudan grass and sudan/sorghum crosses	5.6-6.0	5.6-6.0
All row crops	6.1-6.5	6.1-6.5



Interpreting the Soil Analysis

The basic soil test in Missouri provides results for the salt pH, phosphorus, potassium, calcium, magnesium, organic matter, neutralizable acidity, and cation exchange capacity of the soil sample.

Salt pH (pHs) is a numerical measure of the relative level of soil acidity. Salt pH refers to the salt solution used in the laboratory to measure the pH of the soil sample. Some laboratories used water instead of a salt solution for pH measurements and these results are simply reported as pH. Crops require different pH levels for optimum growth and yield. Proper pH levels help to improve root development and provide a good environment for soil microorganisms. Soil pHs for some crops differs among regions of the state.

Phosphorus (P) is the second line of the table. The test for phosphorus measures the relative availability of phosphorus to the plant for growth, not the total amount in the soil. The ratings range from very low to very high.

Potassium (K) is measured by the amount available for plant growth (also referred to as exchangeable potassium) and not by total potassium in the soil. The cation exchange capacity (CEC) of the soil and the current level of exchangeable potassium are used to determine the need for additional potassium. Generally, as the CEC increases, so does the desired level of exchangeable potassium.

Calcium (Ca) is measured to help calculate the CEC of the soil. The rating for calcium levels is based on the soil pH. Soils with very low to low soil pH will rate medium for calcium, and soils with pH of medium to high will rank high for calcium. Missouri soils are rarely in need of calcium.

Magnesium (Mg) is only added when levels are very low to medium. For soils that are rated very low to low, crop yields will be improved with applications of magnesium. When lime and magnesium are both needed, dolomitic limestone may be applied because it contains calcium and magnesium.

Organic Matter (O.M.) is the decayed plant material, or humus, in the soil. The level of organic matter is used to determine the potential nitrogen available to a crop during the growing season.

Neutralizable acidity (N.A.) measures the exchangeable hydrogen. It is a measure of the reserve acidity in soil, or its ability to remain acid. Higher N.A. indicates more reserve acidity. This figure aids in the calculation of liming requirements for the soil.

Cation exchange capacity (CEC) measures the soil's ability to hold positively charged nutrients called cations—calcium, magnesium, potassium, and hydrogen.

Routine fertilizer recommendations are made for the major nutrients used by plants. Nitrogen, phosphorus, and potassium are the major nutrients applied in fertilizer for forage production. In some cases, sulfur or micronutrients like zinc (Zn), manganese (Mn), iron (Fe), and copper (Cu) may be added when they become deficient in the soil.

The amount of nitrogen (N) that needs to be added to the soil is determined by the cropping option, soil texture, and organic matter. The figure is expressed in pounds of nitrogen needed per acre.

Phosphorus and potassium are added in the fertilizer mix based upon the soil test and the desired yield of a particular crop. Phosphorus is added in fertilizer to build up or maintain the current level of phosphorus in the soil. Potassium levels needed for alfalfa hay, row crops, and small grains are calculated by the following formula:
220 + 5(CEC) = lbs. K/acre.

Fertilizer Application and Yield Response

The soil test rating in Section C indicates the relative level of each nutrient tested and provides information on the probability that the application of a particular fertilizer will increase crop yield. Table 1.1. can be used to determine the probability of a yield increase from fertilizer applications for each soil test rating. The probability of an increase in yields from fertilizer drops as the soil test rating rises. For example, soil with a rating of very low for a particular nutrient is much more likely to respond to fertilizer than soil with a rating of medium for that nutrient.

Liming to Increase pH

Agricultural limestone is tested based on purity and fineness of grind. These results determine the limestone's effective neutralizing material, or ability to reduce soil acidity. A producer can call an agricultural lime dealer at a quarry to find out the local ENM. This figure and the ENM required by the soil (provided on the soil test report) are all that is necessary to calculate the tons of limestone needed per acre, as shown in the formula below.

$$\frac{\text{ENM required by the soil test}}{\text{ENM of agricultural limestone}} = \text{tons of limestone/acre}$$

To determine the amount of lime needed in tons per acre, divide the ENM value from the soil test by the ENM of the limestone. For example, if the soil test ENM requirement is 1,395 pounds per acre and the quarry guarantees 400 pounds of ENM per ton of limestone, then 3.48 tons of limestone per acre (1,395 ÷ 400 = 3.48) are needed.

Limestone is applied to neutralize soil acidity and increase salt pH. It does contain calcium, but its main use is to neutralize acidity. Dolomitic limestone contains appreciable amounts of magnesium and is often used on magnesium-deficient soils. Some liming materials have a higher ENM rating than calcitric limestone.

Table 1.1 – Probability of Yield Increase from Fertilizer Application

RATING						Probability of response to fertilizer
Very low	Low	Medium	High	Very High	Excess	
* * * *						very high
* * * * * *	* * * *					high
* * * * * *	* * * * * *	* * * *				medium
* * * * * *	* * * * * *	* * * * * *	* * * *			low
* * * * * *	* * * * * *	* * * * * *	* * * * * *	* * * *		none

Summary

Soil tests provide important information that can affect a grassland's production. To use the data correctly, an understanding of the soil test results and the suggested treatments is required.

Credits

Dent, David, and Anthony Young. *Soil Survey and Land Evaluation.* London: Allen & Unwin, 1981.

Donahue, Roy L., Raymond W. Miller, and John C. Shickluna. *Soils: An introduction to Soils and Plant Growth.* 5th ed. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1983.

University Extension agricultural publications, University of Missouri-Columbia.

G9102: *Liming Missouri Soils*
G9111: *Using Your Soil Test Results*
G9112: *Interpreting Missouri Soil Test Reports*

Lesson 2: Using Soil Survey Manuals

Soil survey manuals provide useful information for grassland management. Soil scientists evaluate the soil for chemical and physical properties, make maps, and interpret the information for agricultural, engineering, recreational, and urban uses.

The characteristics of soils are very important when selecting plants for a grassland. Because soils provide so many vital components required by plants, it is imperative that the soil and plants of a grassland are suitable for each other and can meet the production goals and wildlife needs of the area.

Soil Surveys and Grasslands

The soil survey manual begins with a section on how to use the soil survey that provides an introduction to or review of the manual. A large map called the general soils map, which is used for land use planning, is also included. The general soils map shows the phases, or borders, of the different soil series (groups of similar soils) by means of lines that outline irregularly shaped areas and often follow contour lines.

When more detailed planning is necessary to manage a particular grassland, aerial photographs on which the phases of the soil series are drawn can be used to aid in making land use decisions. Information on the use and management of the soils is provided next, describing the land use potential and management for all areas of interest. The series are also covered in descriptions of the soils, which discusses the soil characteristics, limitations on use, land capability (uses), and suggested management practices. Finally, a section on the formation and classification of the soil is also included. It provides information on uniform systems of soil classification.

Locating Property

When trying to locate a plot of land in the manual, first find the property in the "Index to Map Sheets." Then turn to the page number of the map sheet indicated by the index and use landmarks and features and/or the U.S. standard land survey system to locate the plot. The U.S. standard land survey system is the method used for locating specific areas of land. The basis of this system is the base line (x-axis) and the principal meridians (y-axis). These two lines act as the reference points from which townships are established. Each township is a six-mile square divided into 36 sections, making each section one square mile. Most sections contain 640 acres, but the sections on the north and west sides may be larger or smaller if correlations need to be made. Sections are broken down into further subdivisions called quarters, which are identified by direction (NW, NE, SW, SE) and contain 160 acres. Each quarter can be divided into smaller components. Townships are numbered from the base line both north (N) and south (S), and the ranges from the principal meridian are numbered east (E) and west (W). See Figure 2.1 for a diagram of the system. Figure 2.2 shows divisions of a section.

Figure 2.1 – U.S. Standard Land Survey System

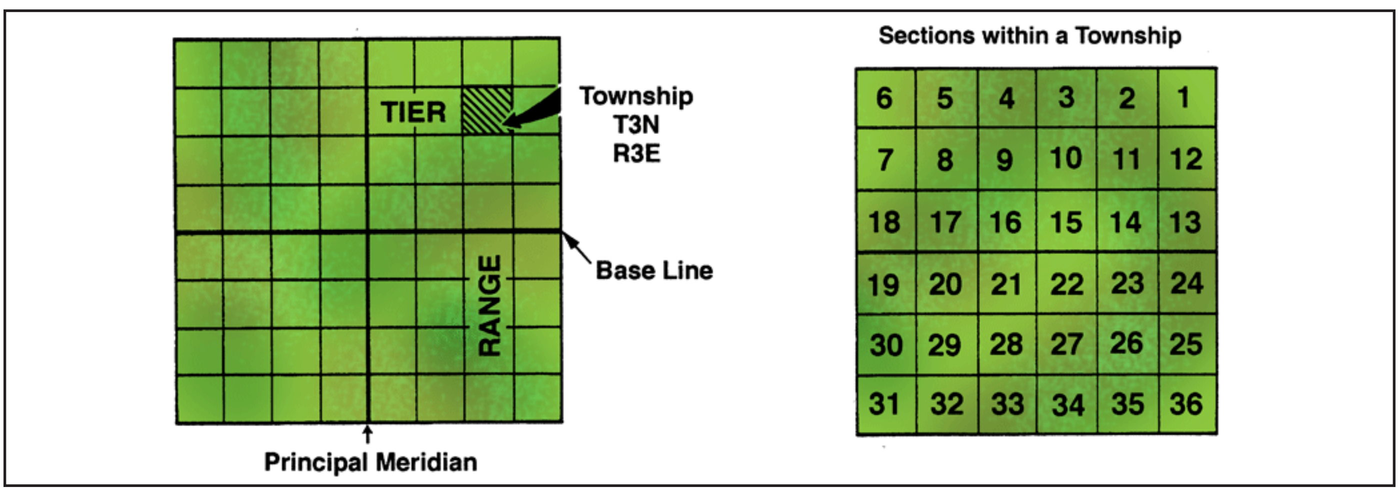
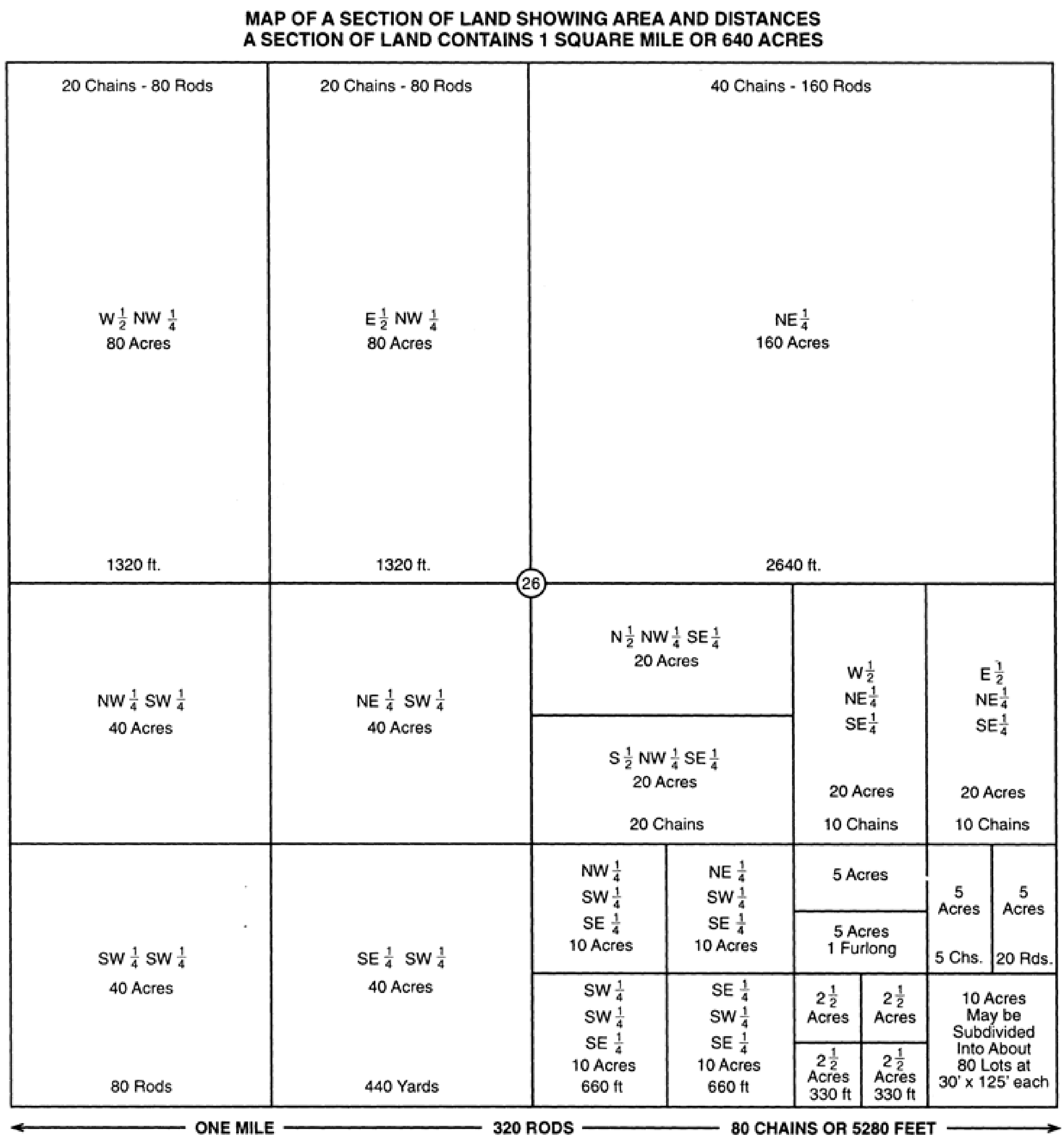


Figure 2.2 – Divisions of a Section



Soil Limitations

A soil's capability class, which indicates its uses, is determined by the limitations of an area. Limitations can be permanent or temporary. Knowledge of these limitations is of great value to the grassland manager, since it allows the management practices to be customized to the individual needs of the area.

Permanent limitations are not easy to change with conservation practices or management. Examples of permanent limitations include severe slope, soil depth, flooding, and large rocks. Some of these may be changed, although to do so would take great effort and expense, while others cannot be controlled.

Temporary limitations are problems that decrease land use potential but can be improved or removed with the implementation of conservation practices and better management. Examples of temporary limitations would include soil nutrient content, moderate slope, and minor drainage problems.

Soil Classifications

All soils are classified according to their uses and limitations. These soils are either cultivatable (able to produce crops) or noncultivatable (not able to produce crops). Each of these divisions is broken down into four different levels of cultivation, making eight soil classifications. A piece of property may have land that falls into several different soil classifications.

The cultivatable soils are Class I through Class IV.

Class I (1) – These soils have very few limitations to restrict use. No special treatment is needed for prevention of surface runoff even if the land is cultivated year after year. The land is nearly level with little risk of wind or water erosion. It has deep, well-drained soils that are easy to maintain.

Class II (2) – These soils have a few limitations that reduce the plant choices or that require moderate conservation practices to increase yields.

Class III (3) – Special conservation practices are needed for these soils because of the severe limitations that reduce the choice of plants. These conservation practices are less practical than Class II and require extra effort and costs.

Class IV (4) – Very sever limitations require careful management and/or special conservation practices on these soils to decrease the limitations that restrict the choice of plants.

Class V through Class VIII are the noncultivatable soils.

Class V (5) – This land is suitable for pasture and wildlife food and cover. It has few erosion hazards and is nearly level or gently sloping. The limitations are difficult to remove and prevent the use of standard farm equipment. The land may be wet, stony, and/or flooded by streams that may decrease the growing season.

Class VI (6) – These soils have severe limitations that reduce the uses of the area to grassland, range (if not overgrazed), and wildlife food and cover.

Class VII (7) – These soils have very severe limitations. An example would be a steep, rocky, eroded hillside.

Class VIII (8) – These areas are mountainous and suitable for wildlife, recreation, and/or water supply.

Classes II through VIII may have an additional label of E for erosion, W for wet, or S for stoniness, shallowness, or droughtiness. These labels indicate special conditions affecting the soil.

Factors Influencing Plant Selection

For plants to perform well, their needs for certain basic requirements must be met. Areas of interest when evaluating a grassland for plant selection are soil texture, soil depth, slope, erosion, surface runoff, permeability, and drainage.

Soil texture – The relative proportions of sand, silt, and clay particles in a soil determine its texture. It can vary from coarsely textured to finely textured with moderately coarse, medium, and moderately fine soils in between. Soil texture affects the amount of contact plant roots have with available water, air, and nutrients.

Soil depth – Soil depth refers to the area that plant roots have available to extend downward. Soil is divided into deep soils, which are more than 36 inches deep; moderately deep soils, which are 20-36 inches deep; shallow soils, which are 10-20 inches deep; and very shallow soils, which are less than 10 inches deep. Soil depth can limit the type of plants that can root in the soil. For example, if the soil depth is very shallow, the plant species that would prosper in that area are limited to short-rooting plans.

Slope – Slope refers to the steepness of the land's surface. It is measured as a percentage calculated by the difference in vertical elevation over a 100-foot horizontal distance. The severity of slope affects erosion and the ability to use farm machinery.

Erosion – The loss of soil by wind or water is erosion. Erosion can decrease the soil depth by removing the top-soil layer, which will decrease the quality of plant growth and limit the number of plants suitable to the area.

Surface runoff – Surface runoff refers to the rate at which water disappears from the soil surface by absorption or flowing over the soil. It can lead to erosion, the leaching of soil nutrients, and/or the washing away of seeds or nutrients.

Permeability –The movement of air and water through the soil is permeability. Root penetration, water movement in and on the soil, and nutrient leaching are all affected by the soil's permeability.

Drainage – Drainage refers to the speed at which water moves from the soil surface. Excessive or poor drainage limits plant growth. Drainage classes are discussed in greater detail in the next section.

Other factors also influence plant selection. Temperature range, rainfall, and length of season are climatic factors that affect plant growth and selection. Economic concerns also affect the selection of plants; one type of seed may cost less than another, making the first more economical, even though both may grow well in that soil.

Drainage Classes

Drainage classes are based on the frequency and duration of the periods during which the soil was saturated (voids between soil particles filled with liquid) or partially saturated when a particular soil was formed. The characteristics of the seven classes are based on the color and thickness of the subsurface soil layers.

Excessively drained soils – These soils are very porous and freely permeable for great depths.

Somewhat excessively drained soils –Water and air move freely but more slowly than excessively drained soils.

Well-drained soils – They are most often sandy or intermediately textured soils. The color is uniform except near the deep water table, where it becomes mottled or spotty.

Moderately well-drained soils – The soils have slower internal water movement. More mottling appears further up the profile (vertical section of the soil). Artificial drainage is suggested for an alfalfa crop.

Somewhat poorly drained soils – The surface is wet for many weeks throughout the year. Mottling is prominent just below the surface. Artificial drainage is almost always needed.

Poorly drained soils – These soils are wet for many months in the year. Mottling is prominent throughout the profile. Artificial drainage is required for crop growth.

Very poorly drained soils –The soils are wet almost every month of the year. They are usually gray in color with mottling on the surface. Artificial drainage may be difficult to install but is required for crop growth.

Obtaining Soil Manuals

Soil survey manuals for many Missouri counties can be obtained at no cost by Missouri residents and by all non-residents for a fee. Some counties do not have manuals. Contact a local Soil and Water Conservation district office or Natural Resources Conservation Service office to obtain copies if they are available.

Summary

Soil survey manuals are very useful for grassland managers. The maps and other information included in the manual help an individual to understand the potential uses of the soil and the conservation practices that could improve grassland production. Plant selection and growth depends a great deal on the characteristics of the soil. To select the best plants for a given area, these characteristics must be taken into account. Knowing the soil's limitations will improve management decisions made for the grassland.

Credits

Dent, David, and Anthony Young. *Soil Survey and Land Evaluation*. London: Allen & Unwin, 1981.

Donahue, Roy L., Raymond W. Miller, and John C. Shickluna. *Soils: An introduction to Soils and Plant Growth*. 5th ed. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1983.

Donahue, Roy L., Roy Hunter Follett, and Rodney W. Tulloch. *Our Soils and Their Management.* Danville, IL: Interstate Publishers, Inc., 1990.

Minor, Paul E. *Soil Science* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.