United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

National Range and Pasture Handbook

Chapter 3 Ecological Sites and Forage Suitability Groups

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Landscapes are divided into basic units for study, evaluation, and management. On rangelands and forest lands, these units are called ecological sites; while on forage croplands and pasturelands, they are forage suitability groups. This chapter provides an explanation and understanding of these basic units, as well as instructions on how to develop an ecological site description and a forage suitability group description.

Chapter 3 is divided into two basic sections. Section 1 deals with ecological sites for native grazing lands. Ecological site descriptions contain information about soils, physical features, climatic features, associated hydrologic features, plant communities possible on the site, plant community dynamics, annual production estimates and distribution of production throughout the year, associated animal communities, associated and similar sites, and interpretations for management.

Section 2 of this chapter deals with forage suitability groups for agronomically managed grazing lands. Forage suitability groups (FSG) condense and simplify soils information. They provide the soil and plant science information for planning. The forage suitability groups description contains the soil map units that make up the FSG, adapted forage species and planting mixtures, limitations of the FSG, conservation problems associated with the various limitations, annual forage production estimates, and distribution of production during the growing season.

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600.0300 Rangeland ecological sites

(a) Definition

Rangeland landscapes are divided into ecological sites for the purposes of inventory, evaluation, and management. An ecological site, as defined for rangeland, is a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation.

An ecological site is the product of all the environmental factors responsible for its development, and it has a set of key characteristics that are included in the ecological site description. Ecological sites have characteristic soils that have developed over time throughout the soil development process. The factors of soil development are parent material, climate, living organisms, topography or landscape position, and time. These factors lead to soil development or degradation through the processes of loss, addition, translocation, and transformation.

An ecological site has a characteristic hydrology, particularly infiltration and runoff, that has developed over time. The development of the hydrology is influenced by development of the soil and plant community.

An ecological site has evolved a characteristic plant community (kind [cool season, warm season, grassland, shrub-grass, sedge meadow] and amount of vegetation). The development of the vegetation, the soil, and the hydrology are all interrelated. Each is influenced by the others and influences the development of the others. The plant community on an ecological site is typified by an association of species that differs from that of other ecological sites in the kind and/or proportion of species, or in total production.

Most ecological sites evolved with a characteristic kind of herbivory (kinds and numbers of herbivores, seasons of use, intensity of use). Herbivory directly influences the vegetation and soil, both of which influence the hydrology.

An ecological site evolved with a characteristic fire regime. Fire frequency and intensity contributed to the characteristic plant community of the site.

Soils with like properties that produce and support a characteristic native plant community are grouped into the same ecological site.

An ecological site is recognized and described on the basis of the characteristics that differentiate it from other sites in its ability to produce and support a characteristic plant community.

600.0301 Plant community development and dynamics

(a) Succession and retrogression

Succession is the process of soil and plant community development on an ecological site. Retrogression is the change in species composition away from the historic climax plant community because of management or severe natural climatic events.

Succession occurs over time and is a result of interactions of climate, soil development, plant growth, and natural disturbances. Plant succession is defined as the progressive replacement of plant communities on an ecological site that leads to development of the historic climax plant community.

Primary succession is the formation process that begins on substrates having never previously supported any vegetation (lava flows, volcanic ash deposits, etc.). Secondary succession occurs on previously formed soil from which the vegetation has been partially or completely removed.

In some locations, primary succession was never completed before the site was disturbed by human intervention. An example is the historic lakebed of Lake Bonneville in the Great Basin area of Utah, Nevada, and Idaho.

Ecological site development, along with associated climatic conditions and normal disturbances (occurrence of fire, grazing, flooding) remaining within normal ranges, produces a plant community in dynamic equilibrium with these conditions. This plant community is referred to as the historic climax plant community. Vegetation dynamics on an ecological site includes succession and retrogression. The pathway of secondary succession is often not simply a reversal of disturbances responsible for retrogression and may not follow the same pathway as primary succession.

(b) Historic climax plant communities

The historic climax plant community for a site in North America is the plant community that existed at the time of European immigration and settlement. It is the plant community that was best adapted to the unique combination of environmental factors associated with the site. The historic climax plant community was in dynamic equilibrium with its environment. It is the plant community that was able to avoid displacement by the suite of disturbances and disturbance patterns (magnitude and frequency) that naturally occurred within the area occupied by the site. Natural disturbances, such as drought, fire, grazing of native fauna, and insects, were inherent in the development and maintenance of these plant communities. The effects of these disturbances are part of the range of characteristics of the site that contribute to that dynamic equilibrium. Fluctuations in plant community structure and function caused by the effects of these natural disturbances establish the boundaries of dynamic equilibrium. They are accounted for as part of the range of characteristics for an ecological site. Some sites may have a small range of variation, while others have a large range. Plant communities that are subjected to abnormal disturbances and physical site deterioration or that are protected from natural influences, such as fire and grazing, for long periods seldom typify the historic climax plant community.

The historic climax plant community of an ecological site is not a precise assemblage of species for which the proportions are the same from place to place or from year to year. In all plant communities, variability is apparent in productivity and occurrence of individual species. Spatial boundaries of the communities; however, can be recognized by characteristic patterns of species composition, association, and community structure.

(c) State and transition models

A state and transition model will be used to describe vegetation dynamics and management interactions associated with each ecological site. The model provides a method to organize and communicate complex information about vegetation response to disturbances (fire, lack of fire, drought, insects, disease, etc.) and management.

A state is a recognizable, relatively resistant and resilient complex with attributes that include a characteristic climate, the soil resource including soil biota, and the associated aboveground plant communities. The soil and vegetative components are inseparably connected through ecological processes that interact to produce a sustained equilibrium that is expressed by a specific suite of plant communities. The primary ecological processes are water cycle, nutrient cycle, and the process of energy capture. Each state has distinctive characteristics, benefits, and values depending upon the intended use, products, and environmental effects desired from the site.

Two important attributes of a state are resistance and resilience. Resistance refers to the capability of the state to absorb disturbance and stresses and retain its ecological structure. Resilience refers to the amount of disturbance or stress a state can endure and still regain its original function after the disturbances and stresses are removed.

States are relatively stable and resistant to change caused by disturbances up to a threshold point. A threshold is the boundary between two states such that one or more of the ecological processes has been irreversibly changed. Irreversible implies that restoration cannot be accomplished through natural events or a simple change in management. Active restoration (brush management, range planting, prescribed burning, etc.) must be accomplished before a return to a previous state is possible. Additional thresholds may occur along the irreversible portion of a transition causing a change in the trajectory toward another state as illustrated in figure 3–1. Once a threshold is crossed, a disequilibrium among one or more of the primary ecological processes exists and will be expressed through changes in the vegetative community and eventually the soil resource. A new stable state is formed when the system reestablishes equilibrium among its primary ecological processes.

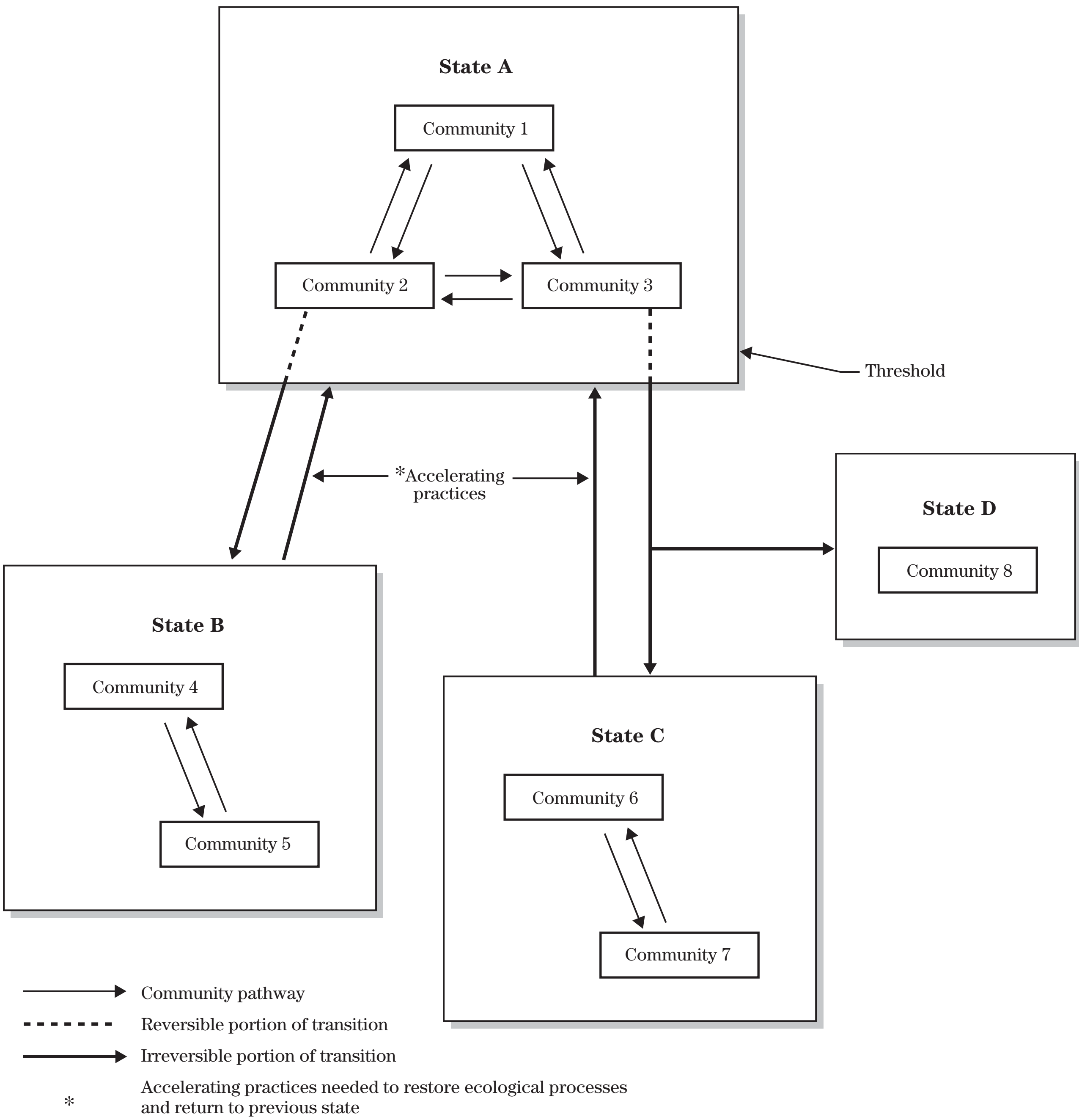
Transition is the trajectory of system change between states that will not cease before the establishment of a new state. A transition can be triggered by natural events, management actions, or both. Some transitions may occur very quickly and others over a long period. Two phases of a transition are recognized: reversible and irreversible. Prior to crossing a threshold, a transition is reversible and represents an opportunity to reverse or arrest the change. Vegetation management practices and, if needed, facilitating practices are used to reverse the transition. Once a threshold is crossed, the transition is irreversible without significant inputs of management resources and energy. Significant inputs are associated with accelerating practices, such as brush management and range planting.

States are not static, as they encompass a certain amount of variation because of climatic events, management actions, or both. Dynamics within a state do not represent a state change since a threshold is not crossed. To organize information for management decisionmaking purposes, these different expressions of dynamics within the states may need to be described. These different vegetative assemblages within states will be referred to as plant communities and the change between these communities as community pathways.

Figure 3–1 illustrates the different components of a state and transition model diagram for an ecological site. States are represented by the large boxes and are bordered by thresholds. The small boxes represent plant communities with community pathways representing the cause of change between communities. The entire trajectory from one state to another state is considered a transition (i.e., from State A to State B). The portion of the transition contained within the boundary of a state is considered reversible with a minimum of input from management. Once the transition has crossed the threshold, it is not reversible without substantial input (accelerating practices). The arrow returning to a previous state (State B to State A) is used to designate types of accelerating practices needed. Additional thresholds occurring along a transition may change the trajectory of a transition (from State C to State D).

The first state described in an ecological site description is the historic climax plant community or naturalized plant community. From this state, a "road map" to other states can be developed. Each transition is to be identified separately and described, incorporating as much information as is known concerning the causes of change, changes in ecological processes, and any known probabilities associated with the transitions. Plant communities and community pathways within states may be described as needed.

Figure 3–1 Example of state and transition model diagram for an ecological site



(d) Naturalized plant communities

Ecological site descriptions are to be developed for all identified ecological sites. In some parts of the country, however, the historic climax plant community has been destroyed, and it is impossible to reconstruct that plant community with any degree of reliability. In these regions, site descriptions will be developed using the naturalized plant communities for the site. The use of this option for ecological site descriptions is limited to those sites where the historic climax plant community has been destroyed and cannot be reconstructed with any degree of reliability. Examples of the areas in the United States where this may be used are the State of Hawaii, the Caribbean Area, and the annual grasslands of California. Approval to describe additional rangeland ecological regions in this way must be obtained from the national program leader for range and pasture.

(e) Permanence and change of ecological site potential on rangeland

Retrogression can occur on a given ecological site resulting in a number of different states depending on the type of disturbance(s), the sequence of disturbances, climatic variations, and other variables. Many states that are considered vegetative expressions of degraded historic climax plant communities are stable and can persist for many years without evidence of secondary succession. This persistence certainly extends beyond practical timeframes for use and management planning. As long as the physical environment supporting these states remains similar to that unique mix of conditions required by the historic climax plant community, change to another ecological site is not recognized. The ecological potential for the site is not considered to have been altered merely because the present state is stable and can persist for many years.

Severe physical deterioration can permanently alter the potential of an ecological site to support the original plant community. Examples include permanently lowering the water table, severe surface drainage caused by gullying, and severe soil erosion by water or wind. When the ecological site's potential has significantly changed, it is no longer considered the same site. A change to another ecological site is then recognized, and a new site description may need to be developed based on its altered potential.

Some ecological sites have been invaded by or planted to introduced species. The introduced species may become well established or naturalized to the site. They may dominate the site, or they may continue to occupy part of the site even when secondary succession has restored the plant community to near historic climax conditions. In these cases of invasion or introduction of introduced species, a change in ecological site is not recognized because the edaphic and climatic potential for the site has not been altered.

600.0302 Determining the characteristic vegetation states of an ecological site

Where possible, the historic climax plant community for each ecological site is to be determined. Where it is not possible to determine the historic climax plant community, the naturalized plant community will be described. In addition to the historic climax plant community or naturalized plant community, other known states occurring on the site are to be included in the ecological site description.

The description of each state should be considered as an approximation and subject to modification as additional knowledge is gained. Every effort should be made to examine plant communities within the ecological site's area of occurrence during different seasons and in different years. This is necessary to adequately describe the vegetation dynamics within a site.

Characteristics of a state obtained from a single source or site are not conclusive for describing the state. In evaluating plant information, consideration must be given to many factors including:

- Effects of fire or lack of fire
- Impacts of grazing or lack of grazing
- Impacts of rodent concentrations
- Impacts of insects
- Soil erosion or deposition by wind and/or water
- Drought or unusually wet years
- Variations in hydrology and storm events
- Plant disease
- Introduced plant species

The following methods are used in determining the characteristic states of an ecological site:

- Identification and evaluation of reference sites with similar plant communities and associated soils. When describing the historic climax plant community, the reference sites should not have been subjected to abnormal disturbances (or the lack of normal disturbance). The productivity and the species composition of the plant community should be evaluated.
- Interpolation and extrapolation of plant, soil, and climatic data from existing historic reference areas along a continuum to other points on that continuum for which no suitable reference community is available.
- Evaluation and comparison of the same ecological sites occurring in different areas, but that have experienced different levels of disturbance and management. Further comparison should be made with areas that are not disturbed. Projecting the response of plant species to given disturbances and relating the present day occurrence of species on a site to past disturbances (type and extent of disturbance, frequency, and magnitude) provides a basis for approximating certain vegetative characteristics of the plant community.
- Evaluation and interpretation of research data dealing with the ecology, management, and soils of plant communities.
- Review of historical accounts, survey and military records, and botanical literature of the area.

The NRCS Ecological Site Inventory Information System (ESIS)-Ecological Site Inventory (ESI) database can provide useful data in identifying plant communities. This database can be accessed on the Internet at

http://plants.usda.gov/esis

(a) Differentiation between ecological sites

When writing an ecological site description, the following criteria are used to differentiate one ecological site from another:

- Significant differences in the species or species groups that are in the historic climax plant community.
- Significant differences in the relative proportion of species or species groups in the historic climax plant community.
- Significant differences in the total annual production of the historic climax plant community.
- Soil factor differences that determine plant production and composition, the hydrology of the site, and the functioning of the ecological processes of the water cycle, nutrient cycles, and energy flow.

Initial guidelines for determining significant differences follow:

- Presence (or absence) of one or more species that make up 10 percent or more of the historic climax plant community by air-dry weight.
- A 20 percent (absolute) change in composition, by air-dry weight, between any two species in the historic climax plant community.
- A difference in average annual herbaceous production of
  - — 50% @ 200–500 lb/ac
  - — 30% @ 500–1,000 lb/ac
  - — 20% @ 1,000 lb/ac or greater
- Any differences in guidelines above, either singly or in combination, great enough to indicate a different use potential or to require different management are basis for establishing or differentiating a site.

The above guidelines for initial comparisons are not definitive for site differentiation or combination. The differences between sites may be finer or broader than these guidelines. Rationale and the site features listed in the respective ecological site descriptions should readily and consistently distinguish the differences.

Differences in kind, proportion, and/or production of species are the result of differences in soil, topography, climate, and other environmental factors. Slight variations in these factors are not criteria for site differentiation; however, individual environmental factors are frequently associated with significant differences in historic climax plant communities. The presence or absence of a water table within the root zone of highly saline soil in contrast to a nonsaline soil is dramatically reflected in plant communities that such soils support. Marked changes in soil texture, depth, and topographic position usually result in pronounced differences in plant communities, total production, or both. Therefore, such contrasting conditions in the soil characteristics, climate, topography, and other environmental factors known to be associated with a specific ecological site can be used as a means of identifying the site when the historic climax plant community is absent.

Generally, one species or a group of species dominates a site. Dominant status does not vary from place to place or from year to year. Because of their stability in the historic climax plant community, dominant species can often be used to distinguish sites and to differentiate one site from another. When dominant species are in equal proportion, species in minor proportions can be used to distinguish sites.

In evaluating the significance of kinds, proportion, and production of species or species groups that are dominant in a historic climax plant community, and given different soil characteristics, the relative proportion of species may indicate whether one or more ecological sites are involved. For example, in one area the historic climax plant community may consist of 60 percent big bluestem and 10 percent little bluestem, and in another area it may consist of 60 percent little bluestem and 10 percent big bluestem. Thus, two ecological sites are recognized. Although the production and species are similar, the proportion's difference distinguishes them as separate sites.

The effect of any single environmental factor can vary, depending on the influence of other factors. For example, soil depth is more significant on a site that receives extra water from runoff or in a high precipitation zone, than on an upland site in a low precipitation area. An additional 2 inches of annual rainfall may be highly important in a section of the country that has an arid climate, but of minor significance in a humid climate. A difference in average annual production of 100 pounds per acre, dry weight, is of minor importance on ecological sites capable of producing 2,000 pounds per acre. This difference, however, is highly significant on sites capable of producing only 200 to 300 pounds per acre. Similar variations in degree of significance apply to most factors of the environment. Consequently, in identifying an ecological site, consideration must be given to its environment as a whole as well as to the individual components.

Where changes in soils, aspect, topography, or moisture conditions are abrupt, ecological site boundaries are distinct. Boundaries are broader and less distinct where plant communities change gradually along broad environmental gradients of relatively uniform soils and topography. Making distinctions between ecological sites along a continuum is difficult. Thus, the need for site differentiation may not be readily apparent until the cumulative impact of soil and climatic differences on vegetation is examined over a broad area. Although some plant communities may appear to be along a continuum, distinctive plant communities can be identified and described.

At times, normally less frequently occurring plants may increase on a site, or the site may be invaded by plants not formerly found in the historic climax plant community. The presence or absence of these plants may fluctuate greatly because of differences in microenvironment, weather conditions, or human actions. Consequently, using them for site identification can be misleading, so they should not be used to differentiate sites. Site differentiation, characterization, and determination are based on the plant community that develops along with the soils. A study of several locations over several years is needed to differentiate and characterize a site.

Availability and accessibility to domestic livestock grazing are not factors in ecological site determination and differentiation. Site differentiation is based on those soil characteristics, response to disturbance, and environmental factors that directly affect the nature of the historic climax plant community composition and production.

(b) Assembly of ecological site data

To evaluate plant communities and to make meaningful distinctions between ecological sites, the data collected at each location must be recorded in an orderly manner. Complete data on species, composition, production, soils, topography, climate, and other pertinent factors should be recorded carefully. Using plant association tables to assemble data makes it possible to readily identify the important similarities and differences. Exhibit 3.1–1 is a recording of production and composition data from sample locations that includes four identified soils on which the plant community was assumed to be climax. Exhibit 3.1–2 illustrates the means by which these data are used to group similar plant communities into ecological sites. It also illustrates that composition and production of the historic climax plant community on one soil is consistently comparable and that different soils can be grouped into a single ecological site. The occurrence in three plant communities of Idaho fescue, a significant difference in forb and shrub components, and a significant difference in production indicate two different sites.

The Ecological Site Inventory database contains information about species composition and production that has been collected on specific ecological sites. The Ecological Site Inventory database should be used in conjunction with other supporting data for the documentation, modification, and creation of ecological site descriptions.

A documentation file containing all supportive information used for the development and modification of ecological site descriptions will be established and maintained in the state office.

600.0303 Name, number, and correlation of ecological sites

The demand for broader interpretation of rangeland resources, the increasing uses to which ecological site information is being applied, the Ecological Site Information System, and computerized programs for soil classification have created a need for a standardized system of naming or numbering ecological sites.

(a) Naming ecological sites on rangeland

Ecological sites are named to help users recognize the different sites in their locality. Names of ecological sites should be brief and should be based on such readily recognized permanent physical features as the kinds of soil, climate, topography, or a combination of these features. Some examples of ecological site names based on these criteria are Deep Sand, Sandy, Sandy Plains, Limestone Hills, Clay Upland, Saline Lowland, Gravelly Outwash, Level Winding Riparian, Pumice Hills, Sub-irrigated, Wet Meadows, Fresh Marsh, and Sandy Savanna.

Names depicting landforms and using physiographic features that are complexes of ecological sites generally should not be used. Because of vegetation changes or absence in some places, plant names alone are unsuitable ecological site names.

Ecological sites having similar soils and topography may exhibit significant differences in their historic climax plant communities because of climatic differences. For example, the average annual precipitation of the sandy plains of the Oklahoma Panhandle ranges from 16 to 23 inches. Quantitative evaluation indicates that the amount of vegetation produced in areas where precipitation is 16 to 19 inches is significantly less than that produced in areas where precipitation is 20 to 23 inches. Thus two ecological sites are recognized and can be distinguished by the inclusion of the precipitation zone (PZ) in the name of the sites; e.g., Sandy Plains Ecological Site 16-19 PZ and Sandy Plains Ecological Site 20-23 PZ.

The limited number of permanent physiographic features or other features that can be used in naming ecological sites makes repeated use of these terms inevitable. Deep sands, for example, occur in areas of widely divergent climate and support different historic climax plant communities. The name Deep Sand is appropriate for each of these areas, but obviously, it is used throughout the country to designate several ecological sites. Where this occurs within a major land resource area, the applicable precipitation zone or other differentiating factors are to be included as part of the name. Sites that have the same name, but are in different major land resource areas are different sites.

(b) Numbering ecological sites

Ecological sites are numbered for use in the Ecological Site Information System. The ecological site number for rangelands consists of five parts:

1. The letter **R** identifies the type of ecological site as rangeland. This designation precedes the 10-character site number, but is not actually a part of the number.
2. A three-digit number and a one-digit letter Major Land Resource Area (MLRA).
3. A single letter Land Resource Unit (LRU), where applicable.
4. A three-digit site number, assigned by the state.
5. A two-digit letter state postal code.

If the MLRA is only two numbers and no letters, insert a zero in the first space followed by the two numbers. The letters A, B, C, etc., following the MLRA, represent the MLRA subdivisions. Where no MLRA subdivision exists, put an **X** in the fourth space to denote that there is no MLRA subdivision. For states using LRU's, enter appropriate letter in the space provided. Insert a **Y** when LRU's are not used. The next three digits represent the individual ecological site number and are assigned by the state. The first and second digits should be filled with 0's rather than left blank. The final two letters are the state's two-letter postal code. An example ecological site number for rangeland is:

R070CY123NM

(c) Correlating ecological sites

Soil-ecological site correlation establishes the relationship between soil components and ecological sites. Ecological sites are correlated on the basis of soils and the resulting differences in species composition, proportion of species, and total production of the historic climax plant community. Sometimes it is necessary to extrapolate data on the composition and production of a plant community on one soil to describe the plant community on a similar soil for which no data are available. The separation of two distinct soil taxonomic units does not necessarily delineate two ecological sites. Likewise, some soil taxonomic units occur over broad environmental gradients and may support more than one distinctive historic climax plant community. Changes may be brought about by other influences, such as an increase or decrease in average annual precipitation.

Ecological sites are to be correlated between states. Only one name should be given to a single site that occurs in adjacent states within the same MLRA.

The following procedures for soil-ecological site correlation are compatible with procedures in National Soil Survey Handbook, Part 627.

(1) Responsibilities of state conservationists

- Maintain all ecological site descriptions within their state.
- Propose and develop new sites.
- Consult with administrators of cooperating agencies for correlating all sites within their states.
- Designate which state is responsible for maintaining and updating ecological site descriptions when a site occurs in more than one state.

(2) Responsibilities of field personnel

- Collect the necessary documentation for each site.
- Propose draft descriptions for consideration and approval by the appropriate state technical specialist.

(3) Guidelines for internal consistency of soil-ecological site correlation

These guidelines ensure that site characteristics are compatible within each feature and between individual features.

- Portray each individual feature with the narrowest feasible range of characteristics that accurately describes the site.
- Check that all combinations of features are compatible with the range of characteristics that are described for each individual feature. Coordinate the soil moisture and temperature with the climatic features described. Review the compatibility of listed plant species and the soil properties listed under soil features. Check for other apparent inconsistencies.

(4) Guidelines for correlation between ecological sites

- Make comparisons with existing site descriptions when proposing new sites, reviewing existing sites, or correlating between soil survey areas, major land resource areas, or states.
- Compare all sites that have two or more major species in common and all sites that have the same soil family, groups of similar families, or other taxa.

Soil-ecological site correlation normally takes place in conjunction with progressive soil surveys. However, ecological site correlation may also be necessary because of updates or revisions of ecological site descriptions.

600.0304 Ecological site descriptions on rangeland

An ecological site description is prepared for each ecological site that is identified (exhibit 3.1–3). Descriptions should clearly present the features that characterize the site. They are to address all the resources of the site that are important for identifying, evaluating, planning, developing, managing, and monitoring rangeland resources. Descriptions are developed as part of Ecological Site Information System (ESIS) using the ecological site description format for rangelands. ESIS – Ecological Site Description database is the official repository for all data associated with rangeland ecological site descriptions. The state office is responsible for entry and maintenance of site descriptions in this database. A Technical Support Reference (appendix B) and User's Guide (appendix C) for the Ecological Site Description database are in the appendix of this handbook. This database can be accessed at the following Internet site:

http://plants.usda.gov/esis

The description includes the information that follows, as appropriate, along with other pertinent information:

(a) Heading

All ecological site descriptions will identify USDA and Natural Resources Conservation Service.

(b) Ecological site type

All ecological site descriptions will identify whether it is rangeland or forest land.

(c) Ecological site name

The full name of the site should be placed on each page of the description. Refer to section 600.0303(a) for guidance on naming ecological sites on rangeland.

(d) Ecological site ID

The site number begins with an R followed by the site 10-digit number. This number is placed on each page of the description. Refer to section 600.0303(b) for guidance on numbering ecological sites.

(e) Major land resource area

List the major land resource area code and common name.

(f) Physiographic features

Describe the position of the site on the landscape. In reference to the historic climax plant community, does the site typically generate runoff, receive runoff from other sites, or receive and generate runoff. Most of the information for this section can be obtained from the National Soils Information System (NASIS). Physiographic features include:

- Landform (refer to NASIS for list of possible landform types)
- Aspect
- Site elevation
- Slope
- Water table
- Flooding
- Ponding
- Runoff class

(g) Climatic features

Climatic information will be developed and included in the description of the site. Climatic features that typify the site, relate to its potential, and characterize the dynamics of the site, such as storm intensity, frequency of catastrophic storm events, drought cycles, should be included. Climatic features include:

- Frost-free period
- Freeze-free period
- Mean annual precipitation
- Monthly moisture and temperature distribution
- Location of climate stations

(h) Influencing water features

Include information regarding water features where the plant community is influenced by water or water table from a wetland or stream associated with the site. Water features include the Cowardin wetland classification system and Rosgen stream classification system. Enter the system(s), associated subsystem(s), and class(es). If a riverine system is influencing the site, then enter the Rosgen stream code. More than one stream type may be associated with the site.

(i) Representative soil features

Briefly describe the main properties of the soils associated with the site. Give special attention to properties that significantly affect plant, soil, and water relationships and the site hydrology. Describe the extent of rills and gullies found in historic climax plant community. Rills and gullies are inherent to some geologic formations. Describe extent of waterflow patterns across the soil surface during overland flow. Soils with inherently high erodibility and low vegetation cover may have a large number of natural flow patterns. Describe amount and patterns of pedestalling and terracettes caused by wind or water inherent to the historic climax plant community. Describe size and frequency of wind scoured areas. Describe how susceptible the site is to compaction. Describe expected nature of surface organic layer of historic climax plant community. Describe the expected physical and chemical crusts that might be present. Most of the information for this section can be obtained from the National Soils Information System (NASIS). Representative soil features include:

- Parent materials
- Surface texture
- Subsurface Texture
- Surface fragments
- Subsurface fragments
- Drainage class
- Permeability Class
- Depth
- Electrical conductivity
- Sodium adsorption ratio
- Calcium Carbonate Equivalent
- Soil reaction (pH)
- Available waterholding capacity

(j) Plant communities

Include in this section:

- Description of the vegetation dynamics of the site
- State and Transition Model diagram
- Description of the common states that occur on the site and the transitions between the states. If needed, describe the plant communities and community pathways within the state.
- Plant community composition
- Ground cover and structure
- Annual production
- Growth curves
- Photos of each state or community

(1) Ecological dynamics of the site

Describe the general ecological dynamics of the site. States could be described at the level of growth form, lifeform, or functional group. Describe the changes that are expected to occur because of variation in the weather, and what effects this might have on the dynamics of the site. Include the assumptions made of how the site developed (fire frequency, native herbivory). Other information regarding the dynamics of the site in general should be included.

(2) Plant communities

The first plant community entered into site description should be the interpretative community. This plant community will be either the historic climax plant community or, where applicable, the naturalized plant community for the site. **The first sentence in this section will clearly state whether the interpretative plant community is the historic climax or naturalized plant community.**

Describe other states and plant communities that may exist on the site. One or more plant communities for each state can be described. If only one plant community is described for a state, the community narrative can be used to describe the dynamics of that state. If more than one plant community is described for each state, the amount of detail entered into site description is determined by site description authors. As a minimum, information should be entered into the community narrative describing dynamics of the plant community and causes of community pathway changes. Identify and describe the thresholds between states. Provide information that will aid in the identification and evaluation of how the ecological processes of the site are functioning. These processes include the water cycle, nutrient cycle, and energy flow. Explain what causes shifts or changes, and what effect these changes will have on these ecological functions. Describe changes in hydrologic and erosion characteristics of the site resulting from changes in states. Describe amount and distribution of litter expected. Describe the patterns of plant mortality. Some plants have been found to be cyclic, going through cycles of large-scale mortality followed by recruitment.

Information in regards to transitions between states should be described in the plant community narrative. Incorporate as much information as is known concerning the causes of change and any know probabilities associated with the transitions.

(i) Plant community composition—A detailed species composition list will be entered for the historic climax plant community or naturalized plant community. A detailed species composition list needs to be developed for any other states or plant communities that are considered desired plant communities, and a similarity index calculation is made. List the major plant species and their normal relative production, expressed in pounds air-dry weight (pounds per acre per year), in the total plant community. Species should be listed by group, common name, scientific name, pounds per acre allowable for group, and pounds per acre by species.

If plant groups are used, plant groupings must identify whether individual species within the group will have a production limitation or whether a single species can account for the entire group allowable. Numerous items must be considered when placing plant species into groups for the purpose of ecological site description development. Some of these items are kind of plant, structure, size, rooting structure, life cycle, production, niche occupied, and photosynthetic pathways. Plant groups include cool-season tall grasses, cool-season midgrasses, warm-season tall grasses, warm-season midgrasses, warm-season short grasses, annual grasses, perennial forbs, biennial forbs, annual forbs, shrubs, half-shrubs, deciduous trees, evergreen trees, cacti, yucca and yucca-like plants, succulent forbs, and leafy forbs. This list is not exhaustive, and the professionals describing the site may identify other items or situations and, therefore, identify other groups.

Professional judgment must be used when grouping plants in ecological site descriptions. Group plants in the manner that best describes the site. For instance, two or three groups of warm-season midgrasses may be described because of different niches occupied and differences in production, structure, elevation, and climatic adaptations in the area of the site.

(ii) Ground cover and structure—Soil surface cover is the percentage of the soil surface actually occupied by vegetative basal cover, biological crusts, litter, surface fragments, water, and bare ground.

Ground cover (vertical view) is the percentage of material, other than bare ground, that protects the soil surface from being hit directly by a raindrop. This would include first contact with plant canopy cover, biological crust, litter, surface fragments, bedrock, and water.

Structure of canopy cover – Canopy cover is the percentage of ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of plants. List the average height and canopy cover for each level of vegetative stratification.

Refer to figure 3–2 for information needed in ground cover and structure section of the site description.

Figure 3–2 Ground cover and structure

Soil Surface Cover

Basal cover				Non-vascular plants	Biological crust	Litter	Surface fragments >1/4 & 3"	Surface fragments >3"	Bedrock	Water	Bare ground
Grass/ grasslike	Forb	Shrub/ vine	Tree								
___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___

Ground Cover

Vegetative cover						Non-Vegetative cover					
Grass/ grasslike	Forb	Shrub/ vine	Tree	Non-vascular plants	Biological crust	Litter	Surface fragments >1/4 & 3"	Surface fragments >3"	Bedrock	Water	Bare ground
___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___	___ to ___

Structure of Canopy Cover

	Grasses/Grasslike	Forbs	Shrubs/Vines/Liana	Trees
0.5 feet	________ to ________	________ to ________	________ to ________	________ to ________
>0.5 – 1 feet	________ to ________	________ to ________	________ to ________	________ to ________
>1 – 2 feet	________ to ________	________ to ________	________ to ________	________ to ________
>2 – 4.5 feet	________ to ________	________ to ________	________ to ________	________ to ________
>4.5 – 13 feet	________ to ________	________ to ________	________ to ________	________ to ________
>13 – 40 feet	________ to ________	________ to ________	________ to ________	________ to ________
>40 – 80 feet	________ to ________	________ to ________	________ to ________	________ to ________
>80 – 120 feet	________ to ________	________ to ________	________ to ________	________ to ________
>120 feet	________ to ________	________ to ________	________ to ________	________ to ________

(iii) Total annual production—Show total annual production as median air-dry production and the fluctuations to be expected during favorable, normal, and unfavorable years. In areas where examples of the historic climax plant community are not available, cite the highest production in plant communities for which examples are available.

(iv) Plant community growth curves—Describe a growth curve for the state or plant community that you are describing, in percent growth by month (fig. 3–3). This includes the curve name and number.

Name—Enter a brief descriptive name for each curve.

Number—The number is to be used only one time in each state. The first two digits are for the state postal code, and the last four digits enter numbers from 0001 to 9999.

(k) Site interpretations

This section includes the site interpretations for the use and management of the site. The information includes animal community, hydrologic functions, recreational uses, wood products, other products, and other information.

Animal community—Includes information regarding wildlife and livestock interpretations.

(1) Wildlife interpretations

An introductory paragraph will be developed that provides general information about the ecological site. The information should relate to the entire site. Information in this paragraph is not specific to any particular plant community. The following information will be described:

- Landscape descriptions
- Area sensitive species
- Transitory/migratory animals
- Invasive species (plants and animals)
- Thresholds by animal species
- Species guilds, keystone species
- Aquatic elements/inclusions; e.g., mineral springs/seeps, riparian areas
- Essential habitat elements across plant communities/sites
- Potential species, e.g., extirpated, historical, incidental

The following information will be shown in the order listing lowest trophic level to highest trophic level. Specific species related to the plant community should be described along with any known interactions.

- Invertebrates (includes edaphic if known)
- Fish
- Reptiles/amphibians—according to scale
- Birds—migrant and resident, also guilds
- Mammals—nongame/game, species of interest
- Essential habitat elements; e.g., lek sites
- Variations impacting wildlife

(2) Livestock Interpretations

General descriptions for use of this site by livestock, domesticated wildlife, wild horses, and burros should be included. Suitability of this site for grazing by kind and class of livestock and potential management problems that exist (poisonous plants, topography, and physical barriers) should be described. Describe wildlife-livestock interactions and competition. Include forage preferences for livestock and wildlife by plant species and/or various parts of a plant species for each month of the year.

Figure 3–3 Plant community growth curves

Name:
Number:
Description:

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.

Hydrologic functions—Indicate changes in hydrology functions that may occur with the shift to different plant communities that can occur on the site. For each plant community, describe the changes in infiltration and runoff characteristics expected because of changes in plant species composition and soil surface characteristics. For example, with plant community composition shifts from blue grama to buffalograss, runoff is typically accelerated because of a shift in plant growth form and root morphology characteristics. Information about water budgets for each plant community can be included.

Recreational uses—Indicate the potential uses that the site can support or that may influence the management of the site. List special concerns that will maintain the recreational potentials or site conditions that may limit its potential. Also list plant species that have special aesthetic values, uses, and landscape value.

Wood products—Indicate use or potential uses of significant species that may influence the management of the site.

Other products—Indicate the use or potential uses of other products produced on the site. These may include such things as landscape plants, nuts and berries, mushrooms, and biomass for energy potentials.

Other information—Other pertinent, interpretive, and descriptive information may be included.

(l) Supporting information

Record information about the relationship of this site to other ecological sites and the documentation and references used to develop the ecological site description.

Associated sites—Identify and describe the sites that are commonly located in conjunction with the site.

Similar sites—Identify and describe sites that resemble or can be confused with this site.

Inventory data references—Enter a listing of inventory plots supporting the site description. Record the data source and sample identification of each inventory plot used in the development of the site description.

State correlation—Enter the states with which this site has been correlated.

Type locality—Enter location of a typical example of the site. Indicate township, range, section, or longitude, latitude, and specific location.

Relationship to other established classification systems—Enter a description of how this ecological site description may relate to other established classification systems.

Other references—Record other reference information used in site development or in understanding ecological dynamics of the site.

(m) Site description approval

Authorship—Original authors' names and date. Revision authors' names and revision date.

Site approval—Indicate site approval by the state technical specialist. The state specialist responsible for Field Office Technical Guide rangeland information must review and approve all site descriptions before they are distributed.

(n) Revising ecological site descriptions

Analysis and interpretation of new information about the soil, vegetation, and other onsite environmental factors may reveal a need to revise or update ecological site descriptions. Because the collection of such information through resource inventories and monitoring is a continuous process, site descriptions should be periodically reviewed for needed revision. It is especially important that site descriptions be reviewed when new data on composition, production, or response to disturbance become available. Documented production and composition data, along with related soil, climate, and physiographic data, will be the basis of the site description revisions or new site descriptions.

(o) Developing new site descriptions

A new site description should be prepared when data analysis or new information reveals that a different or new ecological site exists. Generally, enough land area must be identified to be of importance in the management or study of the site before a new site will be developed and described. A new ecological site may be differentiated from an existing site when sufficient erosion or other action has occurred to significantly alter the site's potential.

600.0305 Rangeland ecological sites and soil surveys

NRCS policy dictates mapping of soils and the publication of soil surveys that contain essential information for use in conservation and resource planning activities. These surveys must meet the requirements of the National Cooperative Soil Survey program (see National Soil Survey Handbook, part 606).

The National Soil Survey Handbook, parts 622 and 627, establishes responsibility for planning soil surveys on rangeland. Soil scientists and rangeland management specialists work together to map soils and ecological sites in rangeland areas. Essential activities include development of soil survey work plans, determination of composition of soil mapping units, preparation of map legends, determination of mapping intensity, and necessary field reviews.

(a) Using soil surveys to identify ecological sites

Where Order II soil surveys are completed and ecological site interpretations have been made, boundaries of ecological sites can generally be determined directly from the soil map.

Order III mapping describes individual soil and plant components at association or complex levels. This requires that mapping unit descriptions be developed that describe each association component and assign locations and percentages to each. Individual ecological sites must be described at a level equivalent to the individual components of the Order III soils map.

(b) Soil interpretations for rangeland use in published soil surveys

The National Soil Survey Handbook establishes NRCS policy and procedures for preparing soil interpretations for rangeland. The criteria for developing interpretations are the responsibility of grazing lands discipline leaders. Part 644 outlines policy and procedure for publishing soil surveys, and part 651 outlines policy for preparing advanced soil reports.

Each ecological site will be assigned a unique number that distinguishes it from all other ecological sites. Refer to section 600.0303(b) of this chapter for guidance. This 10-character number will be correlated to each soil series or taxonomic unit that occurs within the ecological site. This number and site name will be input into NASIS or other applicable soils database.

600.0306 Forest land ecological sites

(a) General

The guidance for preparing forest land ecological site descriptions is in the National Forestry Manual, part 537.3. The NRCS state grazing lands specialist will work with the state forester to develop understory plant community descriptions, forage preference ratings, and other appropriate information for each forest site that is suited to grazing. This information will be included in the Field Office Technical Guide.

Forest land ecological site descriptions normally characterize the mature forest plant community that historically occupied the site as well as the other states that commonly occupy the site. An example forest land ecological site description is in the National Forestry Manual, part 537.4, exhibit 537-14.

(b) Separating forest lands from rangelands in areas where they interface

Guides will be developed, as necessary, to separate rangelands from forest lands in areas where they interface. In North America, they are separated based on the historic kind of vegetation that occupied the site. Forest land ecological sites are assigned and described where the historic vegetation was dominated by trees. Rangeland ecological sites are assigned where overstory tree production was not dominant in the climax vegetation.

An example of this type guide is Inventorying, Classifying, and Correlating Juniper and Pinyon Plant Communities to Soils in Western United States (GLTI 1997).

600.0307 Native and naturalized pasture

The historic climax plant community for land managed as native and naturalized pasture was forest land or naturally open land other than rangeland. Many native and naturalized pasture plant communities closely resemble the understory of grazed forest land that has an open or sparse canopy occurring on similar soils. Therefore, ecological site descriptions for forest land will be used as interpretive units for native and naturalized pasture occurring on forest soils.

If forest land ecological site descriptions have not been developed, or if they do not adequately serve the purpose, forage suitability groups will be developed as the basic interpretive or suitability grouping for native and naturalized pasture. Forage suitability groups consist of one or more soils capable of producing similar kinds and amounts of herbaceous vegetation. These soils are also capable of producing similar kinds and amounts of overstory trees.

If forest land ecological site descriptions are to be used for native and naturalized pastures, they must have details about the herbaceous native and naturalized plant community, its production potential, and other pertinent features. Development of forest land ecological sites will follow guidance in the National Forestry Manual. The natural tree overstory part of the description will be omitted only if not known. The state forester and state grazing lands specialist, working as a team, have the responsibility of identifying and describing forest land ecological sites with native and naturalized pasture. Assistance from soil scientists and biologists will be requested as needed.

A forest land ecological site description will be prepared for each native and naturalized pasture site that is identified and named. Descriptions should clearly describe the important features of the site. All significant resources of the site will be described and characterized in sufficient detail to provide guidance for expert planning, managing, and monitoring of the native and naturalized pasture communities.

United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

National Range and Pasture Handbook

Chapter 3 Ecological Sites and Forage Suitability Groups

Section 1 Ecological Sites for Rangeland and Forest Land

Exhibits

Plant Association Table (First Assemblage)

(T means trace; dashes mean did not occur)

Species	Production at location number 1	2	3	4	5	6	7
	Pounds per acre (air-dry)						
bluebunch wheatgrass	910	1,190	1,690	960	1,380	1,260	1,620
Sandberg bluegrass	110	120	260	95	185	70	375
Thurber needlegrass	15	T	—	15	—	10	—
needleandthread	10	—	—	10	—	T	—
cheatgrass	10	—	T	—	—	T	T
Pacific fescue	—	15	T	—	T	—	T
squireltail	—	—	T	—	—	T	—
Idaho fescue	—	—	400	—	460	—	250
lineleaf fleabane	15	15	—	20	—	15	25
snow eriogonum	15	15	50	15	50	T	25
cluster phlox	15	25	—	30	—	15	—
longleaf phlox	10	—	50	25	50	T	25
yarrow	20	15	50	20	50	15	30
pussytoes	T	15	—	—	—	T	—
arrowleaf balsamroot	—	—	50	—	25	—	50
hangingpod milkvetch	—	—	25	—	25	—	25
silky lupine	—	—	25	—	25	—	25
specklepod loco	—	—	T	—	25	—	25
indianwheat	—	10	—	—	—	—	—
tarweed	—	—	—	T	—	T	—
tapertip hawksbeard	—	—	50	—	50	—	25
filaree	—	—	—	—	—	T	—
gray rabbitbrush	10	T	T	5	T	15	T
gray horsebrush	—	—	T	—	T	—	T
Total	**1,140**	**1,420**	**2,650**	**1,195**	**2,325**	**1,400**	**2,500**
Soil Taxonomic Unit No.	1	2	3	1	4	1	3

Exhibit 3.1–2 Plant association table (final assemblage)

Plant Association Table (Final Assemblage)

(T means trace; dashes mean did not occur)

Species	1	2	3	4	5	6	7
	Production at location number						
	Pounds per acre (air-dry)						
bluebunch wheatgrass	910	1,190	960	1,260	1,690	1,380	1,620
Sandberg bluegrass	110	120	95	70	260	185	375
Thurber needlegrass	15	T	15	10	—	—	—
needleandthread	10	—	10	T	—	—	—
cheatgrass	10	—	—	T	T	—	T
Pacific fescue	—	15	—	—	T	T	T
squireltail	—	—	—	T	T	—	—
Idaho fescue	—	—	—	—	400	460	250
lineleaf fleabane	15	15	20	15	—	—	25
snow eriogonum	15	15	15	T	50	50	25
cluster phlox	15	25	30	15	—	—	—
longleaf phlox	10	—	25	T	50	50	25
yarrow	20	15	20	15	50	50	30
pussytoes	T	15	—	T	—	—	—
arrowleaf balsamroot	—	10	—	—	—	—	—
hangingpod milkvetch	—	—	T	T	—	—	—
silky lupine	—	—	—	T	—	—	—
specklepod loco	—	—	—	—	50	25	50
indianwheat	—	—	—	—	25	25	25
tarweed	—	—	—	—	25	25	25
tapertip hawksbeard	—	—	—	—	50	50	25
filaree	—	—	—	—	50	50	25
gray rabbitbrush	10	T	5	15	T	T	T
gray horsebrush	—	—	—	—	T	T	T
Total	**1,140**	**1,420**	**1,195**	**1,400**	**2,650**	**2,325**	**2,500**
	Site No. 1				Site No. 2		
Soil Taxonomic Unit No.	1	2	1	1	3	4	3

Exhibit 3.1–3 Rangeland Ecological Site Description Example

(Data presented in this rangeland ecological site description are examples for content and format only.)

United States Department of Agriculture
Natural Resources Conservation Service

ECOLOGICAL SITE DESCRIPTION

ECOLOGICAL SITE CHARACTERISTICS

Site Type: Rangeland

Site Name: Loamy Upland 12 – 16 PZ

Site ID: R041XC313AZ

Major Land Resource Area: 041 — Southeastern Arizona Basin and Range

Physiographic Features

This site occurs on old fan and stream terraces.

Land Form: (1) Fan terrace
(2) Stream terrace

	Minimum	Maximum
Elevation (feet):	3300	5000
Slope (percent):	1	8
Water Table Depth (inches):	0	0
Flooding:		
Frequency:	none	none
Duration:	none	none
Ponding:		
Depth (inches):	0	0
Frequency:	none	none
Duration:	none	none
Runoff Class:	slow	slow
Aspect:	No influence on this site	

Climatic Features

Precipitation in the subresource area ranges from 12 to 16 inches yearly in the eastern part with elevations from 3,600 to 5,000 feet. Precipitation in the western part ranges from 13 to 17 inches yearly with elevations from 3,300 to 4,500 feet. Winter-summer rainfall ratios are 40:60 in the west side of the resource area to 30:70 in the eastern part of the area. Summer rains originate in the Gulf of Mexico and are convective, usually brief, intense thunderstorms and occur between July and September. Cool-season moisture tends to be frontal, originates in the Pacific and Gulf of California, and falls in widespread storms with long duration and low intensity. Snow rarely lasts more than 1 day. May and June are the driest months of the year. Humidity is generally very low. Temperatures are mild. Freezing temperatures are common at night from December through April; however, temperatures during the day are frequently above 50 degrees Fahrenheit. Occasionally in December to February, brief periods of 0 degrees Fahrenheit temperatures may be experienced some nights. During June and rarely during July and August, some days may exceed 100 degrees Fahrenheit. The cool-season plants start growing early in spring and mature in early summer. The warm-season plants take advantage of the summer rains and are growing and nutritious from July through August. Warm-season grasses may remain green throughout the year.

	Minimum	Maximum
Frost-free period (days):	170	220
Freeze-free period (days):	180	225
Mean annual precipitation (inches):	12	17

Monthly precipitation (inches) and temperature (°F)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Min.	0.30	0.20	0.24	0.07	0.06	0.12	2.71	1.59	0.54	0.12	0.27	0.24
Precip. Max.	1.26	1.08	1.02	0.60	0.49	1.00	4.94	4.79	2.56	2.07	1.25	1.97
Temp. Min.	29	31	36	42	50	58	65	63	57	46	35	29
Temp. Max.	62	67	72	79	86	95	94	91	88	80	70	63

Climate Stations: (1) 29334, Willcox, Arizona. Period of record 1961–2000.
(2) 28619, Tombstone, Arizona. Period of record 1961–2000.
(3) 22659, Douglas, Arizona. Period of record 1961–2000.

Influencing Water Features

No water features influence this site.

Wetland Description:	System	Subsystem	Class
(Cowardin System)	none		

Stream Types:
(Rosgen System) none

Representative Soil Features

Soils all have argillic horizons 4 inches below the surface. Plant-soil moisture relationships are good. Soil surface is dark colored and has a crumbly structure. Rills, gullies, wind-scoured areas, pedestals, and soil compaction layers are not present on the site. An argillic (clay) horizon at shallow depths is a strong textural contrast to the surface and should not be confused with a compacted layer. Bulk density of the surface soil should be no more than 1 gram per cubic centimeter. Terracettes are common on moderate slopes, especially where long-lived halfshrubs (false mesquite and ratany species) intercept waterflow patterns. Because this site occurs on older surfaces and can have slopes up to 14 percent, natural flow patterns can occur, but at very low densities, and they are not actively eroding. Bare ground should be no more that 30 percent. Gravel and rock cover can range from 10 to 50 percent.

Predominant Parent Materials:
Kind: alluvium
Origin: mixed

Surface Texture: (1) sandy loam
(2) loam
Surface Texture Modifier: none
Subsurface Texture Group: sandy
Surface Fragments - 3 inches (% cover): 5
Surface Fragments >3 inches (% cover): 5
Subsurface Fragments < = 3 inches (% Volume): 0
Subsurface Fragments > 3 inches (% Volume): 0
Drainage Class: somewhat poorly drained
Permeability Class: moderate

	Minimum	Maximum
Depth (inches):	60	60
Electrical Conductivity (mmhos/cm):	0	0
Sodium Adsorption Ratio:	10	20
Calcium Carbonate Equivalent (percent):	1	2
Soil Reaction (1:1 Water):	6.0	7.0
Soil Reaction (0.1M $CaCl_2$):	NA	NA
Available Water Capacity (inches):	1.5	3.0

PLANT COMMUNITIES

Ecological Dynamics of the Site

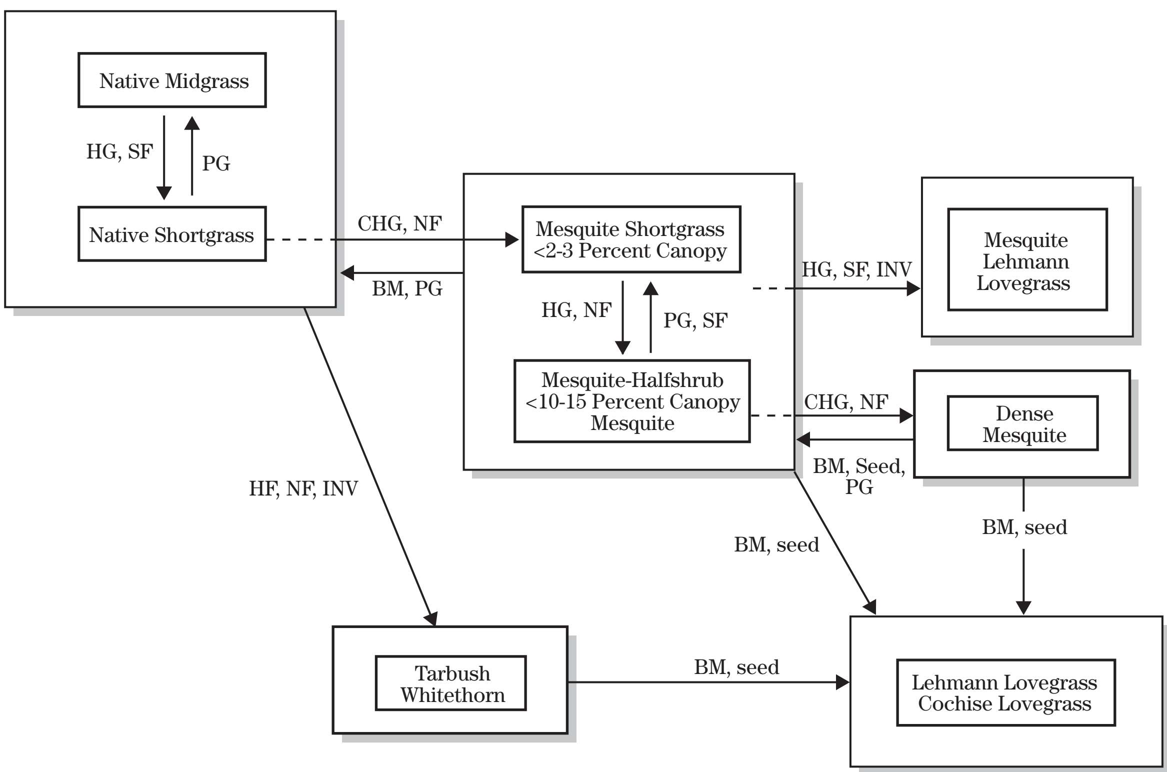
The historic climax plant community is an even mixture of perennial mid and short grasses well dispersed throughout the site. Natural fire was important in the development of the historic climax plant community. The amount of basal cover of grasses and half shrubs is uniform across the site. Warm-season perennials in both a mid- and short-grass group can dominate the plant community. A cool-season group of low-growing, sprouting shrubs is also important on the site. Annuals are uncommon except in mild, wet winters. Cacti and succulents occur in minor amounts. Cryptogams occur in trace amounts.

Natural plant mortality is very low. Major species produce seeds and vegetative structures each year in normal years. Periodic severe drought occurs once each decade and can impede reproduction. The plant community on this site can lose considerable perennial grass cover in severe drought.

The standing crop of herbaceous vegetation from the previous year decomposes quickly in a wet July and August because of intense biological activity. Standing crop of previous year vegetation can persist through a dry summer, slowly oxidizing. Litter is mainly herbaceous material and should provide from 20 to 40 percent soil cover from winter through early summer. Peak amounts of litter are in May or June. The previous year's litter decomposes rapidly in a wet July and August, and no litter is on the ground in September during these years. Litter amounts increase from fall through winter and spring as the peak standing crop of grasses weathers during the year. No noxious or invasive species occur in the historic climax plant community.

Lehmann lovegrass can invade and dominate the plant community. Mesquite can invade and dominate the plant community. With continuous heavy grazing, perennial grasses, such as blue grama, hairy grama, sprucetop grama, sideoats grama, and plains lovegrass, decrease. Under such circumstances, curly mesquite, threeawn species, and in places, false mesquite increase. As woody species increase, mesquite forms the over story with snakeweed and burroweed in the understory. Cholla and pricklypear can also increase. Mesquite tends to be short because of the presence of clay horizons at shallow depths in the soils. Where halfshrubs dominate the understory, the potential production of perennial grasses is about 10 percent greater than the present production of halfshrubs once they are removed from the plant community by fire or other brush management.

State and transition diagram



Legend

PG = Prescribed Grazing	CHG = Continuous Heavy Grazing
NF = No Fire	HG =Heavy Grazing
SF = Some Fire	BM = Brush Management
INV = Invasion	Seed = Seeding

Native Midgrass Plant Community

The interpretive plant community for this site is the historic climax plant community. This is a mixture of native midgrasses. This community is dominated by warm-season perennial grasses. All the major perennial grass species on the site are well dispersed throughout the plant community. Perennial forbs and a few species of low shrubs are well represented on the site. The aspect of this site is that of open grassland. This plant community evolved through the Holocene in the absence of grazing by large herbivores and with fire frequency of every 10 to 20 years. It exists all across the upper end of this land resource unit (LRU) especially on moderate slopes with very gravelly surface.

Native Midgrass Plant Species Composition:

Group	Common Name	Scientific Name	Group Allowable Low	Group Allowable High	Annual Production (lb/ac) Low	Annual Production (lb/ac) High
	GRASSES /GRASSLIKE					
1	Cane beardgrass	*Bothriochloa barbinoides*	400	500	400	500
	Plains lovegrass	*Eragrostis intermedia*			400	500
	Sideoats grama	*Bouteloua curtipendula*			400	500
2	Blue grama	*Bouteloua gracilis*	150	250	150	250
	Black grama	*Bouteloua eriopoda*			150	250
	Hairy grama	*Bouteloua hirsuta*			150	250
	Sprucetop grama	*Bouteloua chondrosioides*			150	250
	Wolftail	*Lycurus phleoides*			150	250
3	Arizona muhly	*Muhlenbergia arizonica*	10	50	10	50
	Curly mesquite	*Hilaria mutica*			10	50
	Rothrock grama	*Bouteloua rothrockii*			10	50
	Sand dropseed	*Sporobolus cryptandrus*			10	50
	Slender grama	*Bouteloua repens*			10	50
4	Bottlebrush squirreltail	*Sitanion hystrix*	10	50	10	50
	Fall witchgrass	*Leptoloma cognatum*			10	50
	Fluffgrass	*Erioneuron pulchellum*			10	50
	Green sprangletop	*Leptochloa dubia*			10	50
	Hall's panic	*Panicum hallii*			10	50
	Pima pappusgrass	*Pappophorum vaginatum*			10	50
	Purple grama	*Bouteloua radicosa*			10	50
	Red grama	*Bouteloua trifida*			10	50
	Slim tridens	*Tridens muticus*			10	50
	Spike dropseed	*Sporobolus junceus*			10	50
	Spike pappusgrass	*Enneapogon desvauxii*			10	50
	Vine mesquite	*Panicum obtusum*			10	50
5	Harvard threeawn	*Aristida harvardii*	50	100	50	100
	Mesa threeawn	*Aristida gentilis*			50	100
	Poverty threeawn	*Aristida divaricata*			50	100
	Purple threeawn	*Aristida purpurea*			50	100
	Red threeawn	*Aristida longiseta*			50	100
	Spidergrass	*Aristida ternipes*			50	100
	Wooton threeawn	*Aristida pansa*			50	100
	Wright's threeawn	*Aristida wrightii*			50	100

Native Midgrass Plant Species Composition—Continued

Group	Common Name	Scientific Name	Group Allowable Low	Group Allowable High	Annual Production (lb/ac) Low	Annual Production (lb/ac) High
6	Arizona cottontop	*Digitaria californica*	50	100	50	100
	Bush muhly	*Muhlenbergia porteri*			50	100
	Crinkle awn	*Trachypogon secundus*			50	100
	Plains bristlegrass	*Setaria vulpiseta*			50	100
	Purple muhly	*Muhlenbergia rigida*			50	100
	Tanglehead	*Heteropogon contortus*			50	100
7	Arizona brome	*Bromus arizonicus*	10	50	10	50
	Arizona panic	*Brachiaria arizonica*			10	50
	Desert lovegrass	*Eragrostis pectinacea*			10	50
	Featherfinger grass	*Chloris virgata*			10	50
	Mexican sprangletop	*Leptochloa uninervia*			10	50
	Needle grama	*Bouteloua aristidoides*			10	50
	Prairie threeawn	*Aristida oligantha*			10	50
	Red sprangletop	*Leptochloa mucronata*			10	50
	Six weeks fescue	*Vulpia octoflora*			10	50
	Six weeks grama	*Bouteloua annua*			10	50
	Six weeks threeawn	*Aristida adscensionis*			10	50
	Spreading lovegrass	*Eragrostis pectinacea*			10	50
	FORBS					
8						
	Arizona cudweed	*Pseudognaphalium arizonicum*	10	50	10	50
	Dyschoriste	*Dyschoriste decumbens*			10	50
	Sida	*Sida stipularis*			10	50
	Spreading fleabane	*Erigeron divergens*			10	50
	Orange flame flower	*Talinum aurantiacum*			10	50
	Hairy evolvulus	*Evolvulus arizonicus*			10	50
9	American vetch	*Vicia americana*	100	150	100	150
	Anoda	*Anoda spp.*			100	150
	Arizona snakecotton	*Froelichia arizonica*			100	150
	Ayenia	*Ayenia* spp.			100	150
	Hairyseed bahia	*Bahia absinthifolia*			100	150
	Bluedicks	*Dichelostemma capitatum*			100	150
	Wire lettuce	*Stephanomeria pauciflora*			100	150
	Evening primrose	*Oenothera primiveris*			100	150
	Desert globemallow	*Sphaeralcea ambigua*			100	150
	Desert marigold	*Baileya multiradiata*			100	150
	Desert windflower	*Anemone tuberosa*			100	150
	Dogbane dyssodia	*Dyssodia papposa*			100	150
	Slender goldenweed	*Machaeranthera gracilis*			100	150
	Hog potato	*Hoffmannseggia glauca*			100	150
	Dutchman's pipe	*Aristolochia watsonii*			100	150
	Leatherweed croton	*Croton pottsii*			100	150
	New Mexico silverbush	*Argythamnia neomexicana*			100	150
	Pink perezia	*Acourtia wrightii*			100	150
	Rockcress	*Arabidopsis* spp.			100	150

Native Midgrass Plant Species Composition—Continued

Group	Common Name	Scientific Name	Group Allowable Low	Group Allowable High	Annual Production (lb/ac) Low	Annual Production (lb/ac) High
	Slender janusia	*Janusia gracilis*			100	150
	Slim vetch	*Vicia ludoviciana*			100	150
	Small matweed	*Guilleminea densa*			100	150
	Spiny goldenweed	*Machaeranthera pinnatifida*			100	150
	Texas dogweed	*Thymophylla acerosa*			100	150
	Trailing four o'clock	*Allionia incarnata*			100	150
	Twinleaf senna	*Senna bauhinioides*			100	150
	Ragweed	*Ambrosia confertiflora*			100	150
	Yerba-de-venado	*Porophyllum gracile*			100	150
10	Arizona gumweed	*Grindelia arizonica*	10	50	10	50
	Aster	*Aster* spp.			10	50
	Ball clover	*Gomphrena nitida*			10	50
	Blanketflower	*Gaillardia* spp.			10	50
	Breadroot	*Psoralidium* spp.			10	50
	Bull filaree	*Erodium texanum*			10	50
	Sage	*Salvia* spp.			10	50
	Cinchweed	*Pectis papposa*			10	50
	Cryptantha	*Cryptantha* spp.			10	50
	Desertpeony	*Acourtia* spp.			10	50
	Desert indianwheat	*Plantago ovata*			10	50
	Western fiddleneck	*Amsinckia tessellata*			10	50
	Buckwheat	*Eriogonum* spp.			10	50
	Gordon bladderpod	*Lesquerella gordonii*			10	50
	Goldeneye	*Heuchera longiflora*			10	50
	Ground cherry	*Physalis* spp.			10	50
	Greeneyes	*Berlandiera lyrata*			10	50
	Hairy bowlesia	*Bowlesia incana*			10	50
	Hairypod pepperweed	*Lepidospartum latisquamum*			10	50
	Honeymat	*Tidestromia lanuginosa*			10	50
	Lambsquarter	*Chenopodium* spp.			10	50
	Lewis blue flax	*Linum lewisii*			10	50
	Lipstick plant	*Plagiobothrys arizonicus*			10	50
	Loco weed	*Astragalus* spp.			10	50
	Arizona maresfat	*Lotus salsuginosus*			10	50
	Mojave lupine	*Lupinus sparsiflorus*			10	50
	Medium pepperweed	*Lepidium virginicum*			10	50
	New Mexico thistle	*Cirsium neomexicanum*			10	50
	Orange caltrop	*Kallstroemia grandiflora*			10	50
	Carelessweed	*Amaranthus palmeri*			10	50
	Patota	*Monolepis nuttalliana*			10	50
	Pectocarya	*Pectocarya* spp.			10	50
	Phlox	*Phlox* spp.			10	50
	Pinnate tansy mustard	*Descurainia pinnata*			10	50
	Purslane	*Portulaca* spp.			10	50
	Rattlesnake carrot	*Daucus pusillus*			10	50
	Ragged jatropha	*Jatropha macrorhiza*			10	50
	Red mariposa lily	*Calochortus kennedyi*			10	50

Native Midgrass Plant Species Composition—Continued

			Group Allowable		Annual Production (lb/ac)	
Group	Common Name	Scientific Name	Low	High	Low	High
	Scorpionweed	*Phacelia* spp.			10	50
	Sego lily	*Calochortus nuttallii*			10	50
	Silverleaf nightshade	*Solanum elaeagnifolium*			10	50
	Spiderling	*Boerhavia* spp.			10	50
	Spiderwort	*Tradescantia* spp.			10	50
	Tepary bean	*Phaseolus acutifolius*			10	50
	SHRUBS					
11	Desert zinnia	*Zinnia acerosa*	50	100	50	100
	False mesquite	*Calliandra eriophylla*			50	100
	Range ratany	*Krameria erecta*			50	100
	Spreading ratany	*Krameria lanceolata*			50	100
	Shrubby buckwheat	*Eriogonum wrightii*			50	100
	Slender janusia	*Janusia gracilis*			50	100
	Texas zinnia	*Zinnia grandiflora*			50	100
12	Broom snakeweed	*Gutierrezia sarothrae*	10	20	10	20
	Burroweed	*Isocoma tenuisecta*			10	20
	Threadleaf snakeweed	*Gutierrezia microcephala*			10	20
13	Banana yucca	*Yucca baccata*	10	20	10	20
	Arizona acacia	*Acacia greggii*			10	20
	Fourwing saltbush	*Atriplex canescens*			10	20
	Greythorn	*Ziziphus obtusifolia*			10	20
	Knifeleaf condalia	*Condalia spathulata*			10	20
	Longleaf Mormon tea	*Ephedra trifurca*			10	20
	Menodora	*Menodora scabra*			10	20
	Sacahuista	*Nolina microcarpa*			10	20
	Soaptree yucca	*Yucca elata*			10	20
	Tarbush	*Flourensia cernua*			10	20
	Velvetpod mimosa	*Mimosa dysocarpa*			10	20
	Whitethorn acacia	*Acacia constricta*			10	20
	Wait-a-bit	*Mimosa aculeaticarpa*			10	20
	Western honey mesquite	*Prosopis glandulosa* var. *torreyana*				10
20						
	Whitestem paperflower	*Psilostrope cooperi*			10	20
	Wolfberry	*Lycium* spp.			10	20
	Yerbe-de-pasmo	*Baccharis pteronioides*			10	20
	Velvet mesquite	*Prosopis velutina*			10	20
14	Christmas cholla	*Opuntia leptocaulis*	10	50	10	50
	Coryphantha	*Coryphantha* spp.			10	50
	Engelmann pricklypear	*Opuntia engelmannii*			10	50
	Fishhook barrel cactus	*Ferocactus wislizeni*			10	50
	Hedgehog cactus	*Echinocereus* spp.			10	50
	Jumping cholla	*Opuntia fulgida*			10	50
	Ocotillo	*Fouquieria splendens*			10	50
	Palmer agave	*Agave palmeri*			10	50

Native Midgrass Plant Species Composition—Continued

Group	Common Name	Scientific Name	Group Allowable Low	Group Allowable High	Annual Production (lb/ac) Low	Annual Production (lb/ac) High
	Pencil cholla	*Opuntia arbuscula*			10	50
	Pincushion cactus	*Mammillaria* spp.			10	50
	Staghorn cholla	*Opuntia versicolor*			10	50
	TREES					
15	Blue paloverde	*Cercidium floridum*	10	20	10	20
	Littleleaf paloverde	*Parkinsonia microphylla*			10	20
	Mexican paloverde	*Parkinsonia aculeata*			10	20
	Oneseed juniper	*Juniperus monosperma*			10	20

Structure and Cover

Soil Surface Cover

Basal cover				Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & ²3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
Grass/ Grasslike	Forb	Shrub/ Vine	Tree								
10 to 15	1 to 2	3 to 5	0 to 1	to	to	55 to 60	1 to 5	1 to 5	to	to	10 to 15

Ground Cover

Vegetative cover						Non-Vegetative cover					
Grass/ Grasslike	Forb	Shrub/ Vine	Tree	Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & ²3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
35 to 40	3 to 5	10 to 15	0 to 1	to	to	25 to 35	1 to 3	1 to 3	to	to	5 to 8

Structure of Canopy Cover

	Grasses/Grasslike	Forbs	Shrubs/Vines	Trees
²0.5 feet	to	to	to	to
>0.5 Ð ²1 feet	to	to	to	to
>1 Ð ² 2 feet	8 to 10	3 to 5	10 to 15	to
>2 Ð ² 4.5 feet	35 to 40	to	to	to
>4.5 Ð ² 13 feet	to	to	to	0 to 1
>13 Ð ² 40 feet	to	to	to	to

Annual Production by Plant Type:

Plant Type	Annual Production (lbs/ac) Low	RV	High
Grasses/Grasslike	700	800	1,000
Forb	100	125	200
Shrub/Vine	75	100	150
Tree	5	15	25
Total	880	1,040	1,375

Plant Growth Curve:

Growth Curve Number: AZ0001
Growth Curve Name: Native/midgrass
Growth Curve Description: Native plant community with high similarity index and average growing conditions

Percent Production by Month

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	5	5	3	2	2	20	20	18	10	5	5

Native Shortgrass Plant Community

This plant community exists in the upper end of the LRU. It is especially common on nearly level slopes with little or no gravel cover. It is characterized by a cover of short grama grasses (blue, black, sprucetop), curly mesquite, and shrubs like calliandra and krameria. It is stable unless basal cover falls below 5 to 6 percent on 2 to 3 percent slopes. Production is less than historic climax plant community as more shallow-rooted plants cannot fully exploit the soil, water, and nutrients in average or better growing seasons. This plant community is excellent for livestock grazing, but lacks midgrass cover needed by some wildlife species (antelope fawns). The grass cover is easily thinned by drought, but recovers rapidly. The transition includes heavy grazing with some occurrence of fire. The water cycle has been altered, as has the mineral cycle.

Native Shortgrass Plant Species Composition:

Group	Common name	Scientific name	Group allowable Low	Group allowable High	Annual production (lb/ac) Low	Annual production (lb/ac) High
	GRASSES /GRASSLIKE					
1	Cane beardgrass	*Bothriochloa barbinoides*	15	50	15	50
	Plains lovegrass	*Eragrostis intermedia*			15	50
	Sideoats grama	*Bouteloua curtipendula*			15	50
2	Blue grama	*Bouteloua gracilis*	300	400	300	400
	Black grama	*Bouteloua eriopoda*			150	250
	Hairy grama	*Bouteloua hirsuta*			150	250
	Sprucetop grama	*Bouteloua chondrosioides*			150	250
	Wolftail	*Lycurus phleoides*			150	250
3	Arizona muhly	*Muhlenbergia arizonica*	15	50	15	50
	Curly mesquite	*Hilaria mutica*			15	50
	Rothrock grama	*Bouteloua rothrockii*			15	50
	Sand dropseed	*Sporobolus cryptandrus*			15	50
	Slender grama	*Bouteloua repens*			15	50
4	Bottlebrush squirreltail	*Sitanion hystrix*	10	50	10	50
	Fall witchgrass	*Leptoloma cognatum*			10	50
	Fluffgrass	*Erioneuron pulchellum*			10	50
	Green sprangletop	*Leptochloa dubia*			10	50
	Hall's panic	*Panicum hallii*			10	50
	Pima pappusgrass	*Pappophorum vaginatum*			10	50

Native Shortgrass Plant Species Composition—Continued

Group	Common name	Scientific name	Group allowable Low	Group allowable High	Annual production (lb/ac) Low	Annual production (lb/ac) High
	Purple grama	*Bouteloua radicosa*			10	50
	Red grama	*Bouteloua trifida*			10	50
	Slim tridens	*Tridens muticus*			10	50
	Spike dropseed	*Sporobolus junceus*			10	50
	Spike pappusgrass	*Enneapogon desvauxii*			10	50
	Vine mesquite	*Panicum obtusum*			10	50
5	Harvard threeawn	*Aristida harvardii*	15	100	15	100
	Mesa threeawn	*Aristida gentilis*			15	100
	Poverty threeawn	*Aristida divaricata*			15	100
	Purple threeawn	*Aristida purpurea*			15	100
	Red threeawn	*Aristida longiseta*			15	100
	Spidergrass	*Aristida ternipes*			15	100
	Wooton threeawn	*Aristida pansa*			15	100
	Wright's threeawn	*Aristida wrightii*			15	100
	FORBS					
6	Arizona cudweed	*Pseudognaphalium arizonicum*	15	50	15	50
	Dyschoriste	*Dyschoriste decumbens*			15	50
	Sida	*Sida stipularis*			15	50
	Spreading fleabane	*Erigeron divergens*			15	50
	Orange flame flower	*Talinum aurantiacum*			15	50
	Hairy evolvulus	*Evolvulus arizonicus*			15	50
7	Arizona gumweed	*Grindelia arizonica*	10	50	10	50
	Aster	*Aster* spp.			10	50
	Ball clover	*Gomphrena nitida*			10	50
	Blanketflower	*Gaillardia* spp.			10	50
	Breadroot	*Psoralidium spp.*			10	50
	Bull filaree	*Erodium texanum*			10	50
	Sage	*Salvia* spp.			10	50
	Cinchweed	*Pectis papposa*			10	50
	Cryptantha	*Cryptantha* spp.			10	50
	Desertpeony	*Acourtia* spp.			10	50
	Desert indianwheat	*Plantago ovata*			10	50
	Western fiddleneck	*Amsinckia tessellata*			10	50
	Buckwheat	*Eriogonum* spp.			10	50
	Gordon bladderpod	*Lesquerella gordonii*			10	50
	Goldeneye	*Heuchera longiflora*			10	50
	Ground cherry	*Physalis* spp.			10	50
	Greeneyes	*Berlandiera lyrata*			10	50
	Hairy bowlesia	*Bowlesia incana*			10	50
	Hairypod pepperweed	*Lepidospartum latisquamum*			10	50
	Honeymat	*Tidestromia lanuginosa*			10	50
	Lambsquarter	*Chenopodium* spp.			10	50
	Lewis blue flax	*Linum lewisii*			10	50
	Lipstick plant	*Plagiobothrys arizonicus*			10	50

Native Shortgrass Plant Species Composition—Continued

Group	Common name	Scientific name	Group allowable Low	Group allowable High	Annual production (lb/ac) Low	Annual production (lb/ac) High
	Loco weed	*Astragalus* spp.			10	50
	Arizona maresfat	*Lotus salsuginosus*			10	50
	Mojave lupine	*Lupinus sparsiflorus*			10	50
	Medium pepperweed	*Lepidium virginicum*			10	50
	New Mexico thistle	*Cirsium neomexicanum*			10	50
	Orange caltrop	*Kallstroemia grandiflora*			10	50
	Carelessweed	*Amaranthus palmeri*			10	50
	Patota	*Monolepis nuttalliana*			10	50
	Pectocarya	*Pectocarya* spp.			10	50
	Phlox	*Phlox* spp.			10	50
	Pinnate tansy mustard	*Descurainia pinnata*			10	50
	Purslane	*Portulaca* spp.			10	50
	Rattlesnake carrot	*Daucus pusillus*			10	50
	Ragged jatropha	*Jatropha macrorhiza*			10	50
	Red mariposa lily	*Calochortus kennedyi*			10	50
	Scorpionweed	*Phacelia* spp.			10	50
	Sego lily	*Calochortus nuttallii*			10	50
	Silverleaf nightshade	*Solanum elaeagnifolium*			10	50
	Spiderling	*Boerhavia* spp.			10	50
	Spiderwort	*Tradescantia* spp.			10	50
	Tepary bean	*Phaseolus acutifolius*			10	50
	SHRUBS					
8	Desert zinnia	*Zinnia acerosa*	10	30	10	30
	False mesquite	*Calliandra eriophylla*			10	30
	Range ratany	*Krameria erecta*			10	30
	Spreading ratany	*Krameria lanceolata*			10	30
	Shrubby buckwheat	*Eriogonum wrightii*			10	30
	Slender janusia	*Janusia gracilis*			10	30
	Texas zinnia	*Zinnia grandiflora*			10	30
9	Broom snakeweed	*Gutierrezia sarothrae*	5	15	5	15
	Burroweed	*Isocoma tenuisecla*			5	15
	Threadleaf snakeweed	*Gutierrezia microcephala*			5	15
	TREES					
10	Blue paloverde	*Cercidium floridum*	1	5	1	5
	Littleleaf paloverde	*Parkinsonia microphylla*			1	5
	Mexican paloverde	*Parkinsonia aculeata*			1	5
	Oneseed juniper	*Juniperus monosperma*			1	5

Structure and Cover

Soil Surface Cover

Basal cover				Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
Grass/ Grasslike	Forb	Shrub/ Vine	Tree								
10 to 15	1 to 2	5 to 10	0 to 1	to	to	35 to 40	1 to 5	1 to 5	to	to	20 to 25

Ground Cover

Vegetative cover						Non-Vegetative cover					
Grass/ Grasslike	Forb	Shrub/ Vine	Tree	Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
35 to 40	3 to 5	10 to 15	0 to 1	to	to	15 to 25	1 to 2	1 to 2	to	to	5 to 8

Structure of Canopy Cover

	Grasses/Grasslike	Forbs	Shrubs/Vines	Trees
0.5 feet	to	to	to	to
>0.5 – 1 feet	35 to 40	to	to	to
>1 – 2 feet	5 to 10	3 to 5	to	to
>2 – 4.5 feet	to	to	10 to 15	to
>4.5 – 13 feet	to	to	to	0 to 1
>13 – 40 feet	to	to	to	to

Annual Production by Plant Type

Plant Type	Annual Production (lbs/ac) Low	RV	High
Grasses/Grasslike	345	572	650
Forb	15	30	50
Shrub/Vine	15	25	50
Tree	1	3	5
Total	376	630	755

Plant Growth Curve:

Growth Curve Number: AZ0002
Growth Curve Name: Native/Shortgrass
Growth Curve Description: Native plant community with low similarity index dominated by mesquite and cacti, and average growing conditions.

Percent Production by Month

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	5	5	10	15	25	10	5	5	5	5	5

Native Shortgrass

Mesquite Shortgrass Plant Community

This plant community exists all across the LRU. Mesquite canopy ranges from 1 to 10 percent. The understory is a continuous cover of short grama grasses and/or curly mesquite. It is stable unless basal cover falls below 5 to 6 percent on 2 to 3 percent slopes. Production is less than the historic climax plant community. Mesquite exploits the soil, water, and nutrients earlier in the spring and to a greater depth than shallow-rooted, warm-season grasses. Grass cover is easily thinned by drought and slow to recover because of the presence of mesquite. It is good for livestock grazing, but tree cover can interfere with livestock handling operations. The presence of mesquite allows species, such as mule deer and javelina, to use this site, but detracts from its value as antelope habitat. The transition includes heavy grazing, no fires, and proximity to mesquite in bottomlands. The ecological processes of water cycle, nutrient cycle, and energy flow are severely altered.

Mesquite Shortgrass Plant Species Composition:

Group	Common name	Scientific name	Group allowable Low	Group allowable High	Annual production (lb/ac) Low	Annual production (lb/ac) High
	GRASSES /GRASSLIKE					
1	Cane beardgrass	*Bothriochloa barbinoides*	15	50	15	50
	Plains lovegrass	*Eragrostis intermedia*			15	50
	Sideoats grama	*Bouteloua curtipendula*			15	50

Mesquite Shortgrass Plant Species Composition—Continued

Group	Common name	Scientific name	Group allowable Low	Group allowable High	Annual production (lb/ac) Low	Annual production (lb/ac) High
2	Blue grama	*Bouteloua gracilis*	300	400	300	400
	Black grama	*Bouteloua eriopoda*			150	250
	Hairy grama	*Bouteloua hirsuta*			150	250
	Sprucetop grama	*Bouteloua chondrosioides*			150	250
	Wolftail	*Lycurus phleoides*			150	250
3	Arizona muhly	*Muhlenbergia arizonica*	15	50	15	50
	Curly mesquite	*Hilaria mutica*			15	50
	Rothrock grama	*Bouteloua rothrockii*			15	50
	Sand dropseed	*Sporobolus cryptandrus*			15	50
	Slender grama	*Bouteloua repens*			15	50
4	Bottlebrush squirreltail	*Sitanion hystrix*	10	50	10	50
	Fall witchgrass	*Leptoloma cognatum*			10	50
	Fluffgrass	*Erioneuron pulchellum*			10	50
	Green sprangletop	*Leptochloa dubia*			10	50
	Hall's panic	*Panicum hallii*			10	50
	Pima pappusgrass	*Pappophorum vaginatum*			10	50
	Purple grama	*Bouteloua radicosa*			10	50
	Red grama	*Bouteloua trifida*			10	50
	Slim tridens	*Tridens muticus*			10	50
	Spike dropseed	*Sporobolus junceus*			10	50
	Spike pappusgrass	*Enneapogon desvauxii*			10	50
	Vine mesquite	*Panicum obtusum*			10	50
5	Harvard threeawn	*Aristida harvardii*	15	100	15	100
	Mesa threeawn	*Aristida gentilis*			15	100
	Poverty threeawn	*Aristida divaricata*			15	100
	Purple threeawn	*Aristida purpurea*			15	100
	Red threeawn	*Aristida longiseta*			15	100
	Spidergrass	*Aristida ternipes*			15	100
	Wooton threeawn	*Aristida pansa*			15	100
	Wright's threeawn	*Aristida wrightii*			15	100
	FORBS					
6	Arizona cudweed	*Pseudognaphalium arizonicum*	10	30	10	30
	Dyschoriste	*Dyschoriste decumbens*			10	30
	Sida	*Sida stipularis*			10	30
	Spreading fleabane	*Erigeron divergens*			10	30
	Orange flame flower	*Talinum aurantiacum*			10	30
	Hairy evolvulus	*Evolvulus arizonicus*			10	30
7	Arizona gumweed	*Grindelia arizonica*	10	20	10	20
	Aster	*Aster* spp.			10	20
	Ball clover	*Gomphrena nitida*			10	20

Mesquite Shortgrass Plant Species Composition—Continued

Group	Common name	Scientific name	Group allowable Low	Group allowable High	Annual production (lb/ac) Low	Annual production (lb/ac) High
	Blanketflower	*Gaillardia* spp.			10	20
	Breadroot	*Psoralidium* spp.			10	20
	Bull filaree	*Erodium texanum*			10	20
	Sage	*Salvia* spp.			10	20
	Cinchweed	*Pectis papposa*			10	20
	Cryptantha	*Cryptantha* spp.			10	20
	Desertpeony	*Acourtia* spp.			10	20
	Desert indianwheat	*Plantago ovata*			10	20
	Western fiddleneck	*Amsinckia tessellata*			10	20
	Buckwheat	*Eriogonum* spp.			10	20
	Gordon bladderpod	*Lesquerella gordonii*			10	20
	Goldeneye	*Heuchera longiflora*			10	20
	Ground cherry	*Physalis* spp.			10	20
	Greeneyes	*Berlandiera lyrata*			10	20
	Hairy bowlesia	*Bowlesia incana*			10	20
	Hairypod pepperweed	*Lepidospartum latisquamum*			10	20
	Honeymat	*Tidestromia lanuginosa*			10	20
	Lambsquarter	*Chenopodium* spp.			10	20
	Lewis blue flax	*Linum lewisii*			10	20
	Lipstick plant	*Plagiobothrys arizonicus*			10	20
	Loco weed	*Astragalus* spp.			10	20
	Arizona maresfat	*Lotus salsuginosus*			10	20
	Mojave lupine	*Lupinus sparsiflorus*			10	20
	Medium pepperweed	*Lepidium virginicum*			10	20
	New Mexico thistle	*Cirsium neomexicanum*			10	20
	Orange caltrop	*Kallstroemia grandiflora*			10	20
	Carelessweed	*Amaranthus palmeri*			10	20
	Patota	*Monolepis nuttalliana*			10	20
	Pectocarya	*Pectocarya* spp.			10	20
	Phlox	*Phlox* spp.			10	20
	Pinnate tansy mustard	*Descurainia pinnata*			10	20
	Purslane	*Portulaca* spp.			10	20
	Rattlesnake carrot	*Daucus pusillus*			10	20
	Ragged jatropha	*Jatropha macrorhiza*			10	20
	Red mariposa lily	*Calochortus kennedyi*			10	20
	Scorpionweed	*Phacelia* spp.			10	20
	Sego lily	*Calochortus nuttallii*			10	20
	Silverleaf nightshade	*Solanum elaeagnifolium*			10	20
	Spiderling	*Boerhavia* spp.			10	20
	Spiderwort	*Tradescantia* spp.			10	20
	Tepary bean	*Phaseolus acutifolius*			10	20
	SHRUBS					
8	Desert zinnia	*Zinnia acerosa*	15	50	15	50
	False mesquite	*Calliandra eriophylla*			15	50
	Range ratany	*Krameria erecta*			15	50
	Spreading ratany	*Krameria lanceolata*			15	50

Mesquite Shortgrass Plant Species Composition—Continued

Group	Common name	Scientific name	Group allowable Low	Group allowable High	Annual production (lb/ac) Low	Annual production (lb/ac) High
	Shrubby buckwheat	*Eriogonum wrightii*			15	50
	Slender janusia	*Janusia gracilis*			15	50
	Texas zinnia	*Zinnia grandiflora*			15	50
9	Broom snakeweed	*Gutierrezia sarothrae*	0	5	0	5
	Burroweed	*Isocoma tenuisecta*			0	5
	Threadleaf snakeweed	*Gutierrezia microcephala*			0	5
10	Banana yucca	*Yucca baccata*	15	150	15	150
	Arizona acacia	*Acacia greggii*			15	150
	Fourwing saltbush	*Atriplex canescens*			15	150
	Greythorn	*Ziziphus obtusifolia*			15	150
	Knifeleaf condalia	*Condalia spathulata*			15	150
	Longleaf Mormon tea	*Ephedra trifurca*			15	150
	Menodora	*Menodora scabra*			15	150
	Sacahuista	*Nolina microcarpa*			15	150
	Soaptree yucca	*Yucca elata*			15	150
	Tarbush	*Flourensia cernua*			15	150
	Velvetpod mimosa	*Mimosa dysocarpa*			15	150
	Whitethorn acacia	*Acacia constricta*			15	150
	Wait-a-bit	*Mimosa aculeaticarpa*			15	150
	Western honey mesquite	*Prosopis glandulosa* var. *torreyana*			15	150
11	Christmas cholla	*Opuntia leptocaulis*	10	20	10	20
	Coryphantha	*Coryphantha* spp.			10	20
	Engelmann pricklypear	*Opuntia engelmannii*			10	20
	Fishhook barrel cactus	*Ferocactus wislizeni*			10	20
	Hedgehog cactus	*Echinocereus* spp.			10	20
	Jumping cholla	*Opuntia fulgida*			10	20
	Ocotillo	*Fouquieria splendens*			10	20
	Palmer agave	*Agave palmeri*			10	20
	Pencil cholla	*Opuntia arbuscula*			10	20
	Pincushion cactus	*Mammillaria* spp.			10	20
	Staghorn cholla	*Opuntia versicolor*			10	20
	TREES					
12	Blue paloverde	*Cercidium floridum*	10	20	10	20
	Littleleaf paloverde	*Parkinsonia microphylla*			10	20
	Mexican paloverde	*Parkinsonia aculeata*			10	20
	Oneseed juniper	*Juniperus monosperma*			10	20

Structure and Cover

Soil Surface Cover

Basal cover				Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
Grass/ Grasslike	Forb	Shrub/ Vine	Tree								
5 to 10	1 to 2	3 to 5	0 to 1	to	to	35 to 40	1 to 5	1 to 5	to	to	30 to 35

Ground Cover

Vegetative cover						Non-Vegetative cover					
Grass/ Grasslike	Forb	Shrub/ Vine	Tree	Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
45 to 50	3 to 5	15 to 20	0 to 1	to	to	10 to 15	1 to 2	1 to 2	to	to	8 to 10

Structure of Canopy Cover

	Grasses/Grasslike	Forbs	Shrubs/Vines	Trees
0.5 feet	to	to	to	to
>0.5 – 1 feet	45 to 50	to	to	to
>1 – 2 feet	to	3 to 5	to	to
>2 – 4.5 feet	to	to	10 to 15	to
>4.5 – 13 feet	to	to	5 to 8	to
>13 – 40 feet	to	to	to	1 to 2

Annual Production by Plant Type

Plant Type	Annual Production (lbs/ac) Low	RV	High
Grasses/Grasslike	345	570	650
Forb	15	30	50
Shrub/Vine	40	150	225
Tree	10	15	20
Total	390	765	945

Plant Growth Curve

Growth curve number: AZ0003
Growth curve name: Mesquite/Shortgrass
Growth curve description: Native plant community with low similarity index dominated by mesquite and average growing conditions.

Percent Production by Month

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	5	5	5	10	10	25	10	10	5	5	5

Mesquite shortgrass

Mesquite-Halfshrub Plant Community

This plant community exists in the lower and mid parts of the LRU. Mesquite canopy is from 5 to 15 percent. Understory is a diverse mixture of cacti, burroweed, broom snakeweed, and other shrubs. Perennial grasses are in trace amounts. The community is poor for livestock grazing, poor for some wildlife species (pronghorn antelope and scaled quail), and good for other wildlife species, such as mule deer, javelina, and Gambel's quail. Transition is from mesquite shortgrass with continued heavy grazing and absence of fire. Ecological processes are severely altered, and site has lost recovery mechanisms.

Structure and Cover

Soil Surface Cover

Basal cover				Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
Grass/ grasslike	Forb	Shrub/ Vine	Tree								
1 to 2	1 to 2	5 to 8	0 to 1	to	1 to 2	20 to 25	5 to 8	1 to 5	to	to	45 to 50

Ground Cover

Vegetative cover						Non-Vegetative cover					
Grass/ Grasslike	Forb	Shrub/ Vine	Tree	Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
10 to 15	3 to 5	25 to 30	0 to 1	to	to	5 to 10	1 to 2	1 to 2	to	to	25 to 35

Structure of Canopy Cover

	Grasses/Grasslike	Forbs	Shrubs/Vines	Trees
0.5 feet	to	to	to	to
>0.5 – 1 feet	3 to 5	to	to	to
>1 – 2 feet	5 to 10	to	to	to
>2 – 4.5 feet	to	3 to 5	15 to 20	to
>4.5 – 13 feet	to	to	10 to 15	to
>13 – 40 feet	to	to	to	1 to 2

Annual Production by Plant Type

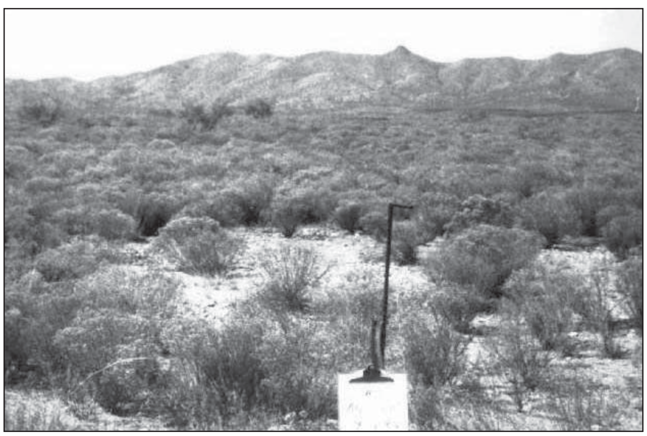
Plant Type	Annual Production (lbs/ac) Low	RV	High
Grasses/Grasslike	30	125	250
Forb	10	20	30
Shrub/Vine	500	590	695
Tree	10	15	25
Total	550	750	1,000

Plant Growth Curve

Growth curve number: AZ0004
Growth curve name: Mesquite/cacti
Growth curve description: Native plant community with low similarity index dominated by mesquite and cacti, and average growing conditions.

Percent Production by Month

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	5	5	3	5	10	25	15	13	8	3	3



Mesquite-halfshrub

Dense Mesquite Plant Community

This community occurs across the LRU, especially in historic heavy use areas, such as homesteads, horse pastures, along streams with perennial flow and watering locations, and archaeological sites. Mesquite canopy is from 15 to 30 percent. Understory consists of low shrubs, perennial grasses, and annual species. Community is poor for livestock grazing and poor habitat for most wildlife species. However, in southern Arizona, the oldest and largest mule deer bucks use mesquite thickets as hiding and escape cover. Frequently so much of the soil surface has been lost under this condition that the site will not respond to treatment. Transition is from mesquite shortgrass with excessive grazing and no fires.

Structure and Cover

Soil Surface Cover

Basal cover				Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
Grass/ Grasslike	Forb	Shrub/ Vine	Tree								
0 to 1	to	5 to 8	0 to 1	to	to	25 to 30	5 to 8	1 to 5	to	to	40 to 50

Ground Cover

Vegetative cover						Non-Vegetative cover					
Grass/ Grasslike	Forb	Shrub/ Vine	Tree	Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
3 to 5	0 to 1	25 to 30	3 to 5	to	to	10 to 15	3 to 5	1 to 2	to	to	30 to 40

Structure of Canopy Cover

	Grasses/Grasslike	Forbs	Shrubs/Vines	Trees
0.5 feet	to	to	to	to
>0.5 – 1 feet	to	to	to	to
>1 – 2 feet	1 to 3	0 to 1	to	to
>2 – 4.5 feet	1 to 2	to	3 to 5	to
>4.5 – 13 feet	to	to	20 to 30	to
>13 – 40 feet	to	to	to	3 to 5

Annual Production by Plant Type

Plant Type	Annual Production (lbs/ac) Low	RV	High
Grasses/Grasslike	30	70	100
Forb	5	10	15
Shrub/Vine	485	525	575
Tree	10	15	20
Total	530	620	700

Plant Growth Curve

Growth curve number: AZ0005
Growth curve name: Native 5
Growth curve description: Native plant community dominated by mesquite and average growing conditions.

Percent Production by Month

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	5	10	10	15	20	5	10	10	3	2	5

Dense mesquite

Tarbush/Whitethorn Plant Community

Community occurs in the eastern part of the LRU in areas where loamy upland is adjacent to limy sites and naturally support tarbush and whitethorn. Canopy cover exceeds 10 percent. The understory consists of shrubs and perennial grasses and annuals. This plant community is poor for livestock grazing and poor habitat for most wildlife species. The site is not stable. Surface soil has been lost, so the site will not respond to treatment. Transition is from native midgrass with heavy grazing, no fires, and a proximity to tarbush and whitethorn.

Structure and Cover

Soil Surface Cover

Basal cover				Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
Grass/ Grasslike	Forb	Shrub/ Vine	Tree								
0 to 1	0 to 1	3 to 5	0 to 1	to	1 to 2	25 to 30	5 to 8	1 to 5	to	to	50 to 60

Ground Cover

Vegetative cover						Non-Vegetative cover					
Grass/ Grasslike	Forb	Shrub/ Vine	Tree	Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
5 to 8	3 to 5	15 to 25	0 to 1	to	to	15 to 20	3 to 5	1 to 2	to	to	30 to 40

Structure of Canopy Cover

	Grasses/Grasslike	Forbs	Shrubs/Vines	Trees
0.5 feet	to	to	to	to
>0.5 – 1 feet	to	to	to	to
>1 – 2 feet	3 to 5	3 to 5	to	to
>2 – 4.5 feet	3 to 5	to	3 to 5	to
>4.5 – 13 feet	to	to	20 to 25	to
>13 – 40 feet	to	to	to	1 to 2

Annual Production by Plant Type

Plant Type	Annual Production (lbs/ac) Low	RV	High
Grasses/grasslike	60	150	200
Forb	15	40	50
Shrub/vine	500	580	630
Tree	15	20	30
Total	590	790	910

Plant Growth Curve

Growth curve number: AZ0006
Growth curve name: Native 6
Growth curve description: Plant community dominated by tarbush and whitethorn and average growing conditions.

Percent Production by Month

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	5	5	5	10	25	15	15	5	5	3	2

Tarbush/whitethorn

Mesquite/Lehmann Lovegrass Plant Community

Community has developed from mesquite native grasslands in the last 30 years. Livestock grazing, fire, and drought have enhanced invasion of Lehmann lovegrass. Mesquite canopy is less than 10 percent. Lehmann production equals or exceeds native grass production. Species diversity is reduced. Under mesquite/native grass conditions, it is common to find 40 to 50 perennial species. Under Lehmann dominance, that figure is 20 to 30 species. Community is good for livestock grazing and such wildlife as mule deer and Gambel's quail. Transition is from mesquite short grass with heavy grazing, some fires, and a Lehmann lovegrass seed source.

Structure and Cover

Soil Surface Cover

Basal Cover				Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
Grass/ Grasslike	Forb	Shrub/ Vine	Tree								
10 to 15	to	1 to 2	to	to	to	65 to 70	1 to 5	1 to 5	to	to	5 to 10

Ground Cover

Vegetative Cover						Non-Vegetative Cover					
Grass/ Grasslike	Forb	Shrub/ Vine	Tree	Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
55 to 60	0 to 1	10 to 15	0 to 1	to	to	10 to 15	1 to 2	1 to 2	to	to	5 to 8

Structure of Canopy Cover

	Grasses/Grasslike	Forbs	Shrubs/Vines	Trees
0.5 feet	to	to	to	to
>0.5 – 1 feet	to	to	to	to
>1 – 2 feet	to	0 to 1	to	to
>2 – 4.5 feet	55 to 60	to	5 to 10	to
>4.5 – 13 feet	to	to	5 to 7	to
>13 – 40 feet	to	to	to	1 to 2

Annual Production by Plant Type

Plant Type	Annual Production (lbs/ac) Low	RV	High
Grasses/Grasslike	1,215	1,330	1,450
Forb	15	25	50
Shrub/Vine	55	75	180
Tree	10	15	20
Total	1,295	1,445	1,700

Plant Growth Curve

Growth curve number: AZ0007
Growth curve name: Mesquite Lehmann lovegrass
Growth curve description: Plant community dominated by mesquite with an understory of Lehmann lovegrass, average growing conditions

Percent Production by Month

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	5	5	15	20	25	10	5	3	2	2	3

Mesquite/lehmann lovegrass

Lehmann, Boers, Wilmans, and/or Cochise Lovegrass Plant Community

Community exists where mechanical brush management was used to control mesquite, tarbush, whitethorn and cacti, and lovegrass species seeded. Community has a great deal of stability. Communities produce more than native grass communities by 20 to 50 percent. Plant species diversity is low. The transition is mesquite halfshrub/ cacti or dense mesquite with mechanical brush management and seeding of lovegrass species. The ecological processes are functioning similar to the historic climax plant community.

Structure and Cover

Soil Surface Cover

Basal cover				Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
Grass/ Grasslike	Forb	Shrub/ Vine	Tree								
15 to 20	to	1 to 2	to	to	to	65 to 70	1 to 5	1 to 5	to	to	5 to 10

Ground Cover

Vegetative cover						Non-Vegetative cover					
Grass/ Grasslike	Forb	Shrub/ Vine	Tree	Non-Vascular Plants	Biological Crust	Litter	Surface Fragments >1/4 & 3"	Surface Fragments >3"	Bedrock	Water	Bare Ground
65 to 70	1 to 2	3 to 5	0 to 1	to	to	10 to 15	1 to 2	1 to 2	to	to	5 to 8

Structure of Canopy Cover

	Grasses/Grasslike	Forbs	Shrubs/Vines	Trees
0.5 feet	to	to	to	to
>0.5 – 1 feet	to	to	to	to
>1 – 2 feet	to	1 to 2	3 to 5	to
>2 – 4.5 feet	65 to 70	to	to	to
>4.5 – 13 feet	to	to	to	0 to 1
>13 – 40 feet	to	to	to	to

Annual Production by Plant Type

Plant Type	Annual Production (lbs/ac) Low	RV	High
Grasses/Grasslike	1,265	1,415	1,550
Forb	15	30	50
Shrub/Vine	15	50	100
Total	1,295	1,495	1,700

Plant Growth Curve

Growth curve number: AZ0008
Growth curve name: Cochise and Lehmann lovegrass
Growth curve description: Plant community dominated by Lehmann and Cochise lovegrass, average growing conditions

Percent Production by Month

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	5	5	15	15	20	10	15	3	3	2	2

Lehmann, Boers, Wilmans, and/or Cochise lovegrass

ECOLOGICAL SITE INTERPRETATIONS

Animal Community

The plant community on this site is suitable for grazing by all classes of livestock at any season. With thin, coarse-textured surface over argillic horizons, these soils become less effective in catching summer rainfall if the grass cover is disturbed or depleted. With a good grass cover, the clayey subsoil releases moisture slowly to the plants over the summer. Lehmann lovegrass can invade this site slowly, but seldom forms a monotype. At the first sign of invasion, proper use of the native perennials must be practiced to avoid letting lovegrass spread. Herbaceous forage will be deficient in protein in winter. This site has no natural surface water associated with it; therefore, water development for livestock is necessary for utilization of this site.

Initial starting stocking rates will be determined with the landowner or decisionmaker. They will be based on past use histories and type and condition of the vegetation. Calculations used to determine an initial starting stocking rate will be based on forage preference ratings.

This site is important for many wildlife species. Major species include desert mule deer, pronghorn antelope, Gambel's quail, scaled quail, and blacktailed jackrabbit. This site has no natural surface water associated with it. Water developments are important to these and other wildlife on this site. Being an open grassland, this site is also home to a variety of small herbivores, birds, and their associated predators. With the exception of pronghorn antelope, this site is mainly a forage area for larger wildlife species. The value of this site for food or cover requirements for specific wildlife species changes with the changes in the vegetation that occur from one plant community to another. Each plant community and each animal species must be considered individually.

Plant Preferences by Animal Kind

Animal Kind: Cattle

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Sideoats grama	*Bouteloua curtipendula*	leaf	D	D	D	P	P	P	P	D	D	D	D	D
Plains lovegrass	*Eragrostis intermedia*	entire	D	D	D	P	P	P	P	D	D	D	D	D
Cane beardgrass	*Bothriochloa barbinoides*	leaf	P	P	P	P	D	D	D	D	U	U	U	U
Blue grama	*Bouteloua gracilis*	leaf	P	P	P	P	D	D	U	U	U	U	U	U
Sprucetop grama	*Bouteloua chondrosioides*	leaf	P	P	P	P	P	P	P	P	P	P	P	P
Curly-mesquite	*Hilaria mutica*	leaf	P	P	P	N	N	U	U	U	U	U	U	U
Hairy grama	*Bouteloua hirsuta*	leaf	D	D	D	D	D	D	D	U	U	U	U	U
Spider grass	*Aristida ternipes*	leaf	U	U	U	U	U	U	U	U	U	D	D	D
Red threeawn	*Aristida longiseta*	entire	N	N	N	N	N	N	D	D	D	D	D	N
False mesquite	*Calliandra eriophylla*	leaf	D	D	D	D	D	D	D	D	D	D	D	D
Range ratany	*Krameria erecta*	leaf	N	N	N	N	N	N	N	N	D	D	D	D

Animal Kind: Desert Mule Deer

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Sida	*Sida stipularis*	leaf	P	P	P	P	P	P	P	P	P	P	P	P
Hairy evolvulus	*Evolvulus arizonicus*	leaf	P	P	P	N	N	U	U	U	U	U	U	U
Dyschoriste	*Dyschoriste decumbens*	leaf	D	D	D	D	D	D	D	U	U	U	U	U
Spreading fleabane	*Erigeron divergens*	entire	N	N	N	N	N	N	D	D	D	D	D	N
Desert globemallow	*Sphaeralcea ambigua*	leaf	P	P	P	P	P	N	N	N	N	N	N	N
Hog potato	*Hoffmannseggia glauca*	leaf	N	N	N	N	N	N	N	N	D	D	D	D
False mesquite	*Calliandra eriophylla*	stem	D	D	D	D	D	D	D	D	D	D	D	D
Range ratany	*Krameria erecta*	stem	N	N	N	N	N	N	N	D	D	D	D	D
Yerbe-de-pasmo	*Baccharis pteronioides*	stem	D	D	D	D	D	N	N	N	N	N	N	N
Staghorn cholla	*Opuntia versicolor*	fruit	P	P	P	P	D	D	D	D	D	D	D	D
Engelmann pricklypear	*Opuntia engelmannii*	fruit	N	N	N	N	N	N	N	D	D	D	D	D
Ocotillo	*Fouquieria splendens*	flower	D	D	D	D	D	P	P	P	P	P	P	P
Fishhook barrel cactus	*Ferocactus wislizeni*	fruit	N	N	N	E	N	N	N	N	N	D	D	D
Palmer agave	*Agave palmeri*	flower	N	N	N	N	N	N	D	D	P	P	P	P

* Legend: P=Preferred D=Desirable U=Undesirable E=Emergency N=Nonconsumed T=Toxic

Plant Preferences by Animal Kind—Continued

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
			Forage preferences*											
Animal Kind: Pronghorn Antelope														
Sida	*Sida stipularis*	leaf	P	P	P	P	P	P	P	P	P	P	P	P
Hairy evolvulus	*Evolvulus arizonicus*	leaf	P	P	P	N	N	U	U	U	U	U	U	U
Dyschoriste	*Dyschoriste decumbens*	leaf	D	D	D	D	D	D	D	U	U	U	U	U
Spreading fleabane	*Erigeron divergens*	entire	N	N	N	N	N	N	D	D	D	D	D	N
Desert globemallow	*Sphaeralcea ambigua*	leaf	P	P	P	P	P	N	N	N	N	N	N	N
Hog potato	*Hoffmannseggia glauca*	leaf	N	N	N	N	N	N	N	N	D	D	D	D
False mesquite	*Calliandra eriophylla*	stem	D	D	D	D	D	D	D	D	D	D	D	D
Range ratany	*Krameria erecta*	stem	N	N	N	N	N	N	N	D	D	D	D	D
Yerbe-de-pasmo	*Baccharis pteronioides*	stem	D	D	D	D	D	N	N	N	N	N	N	N
Staghorn cholla	*Opuntia versicolor*	fruit	P	P	P	P	D	D	D	D	D	D	D	D
Engelmann pricklypear	*Opuntia engelmannii*	fruit	N	N	N	N	N	N	N	D	D	D	D	D
Ocotillo	*Fouquieria splendens*	flower	D	D	D	D	D	P	P	P	P	P	P	P
Fishhook barrel cactus	*Ferocactus wislizeni*	fruit	N	N	N	E	N	N	N	N	N	D	D	D
Palmer agave	*Agave palmeri*	flower	N	N	N	N	N	N	D	D	P	P	P	P
Animal Kind: Gambel and Scaled Quail														
Sida	*Sida stipularis*	leaf	P	P	P	P	P	P	P	P	P	P	P	P
Hairy evolvulus	*Evolvulus arizonicus*	leaf	P	P	P	N	N	U	U	U	U	U	U	U
Dyschoriste	*Dyschoriste decumbens*	leaf	D	D	D	D	D	D	D	U	U	U	U	U
Spreading fleabane	*Erigeron divergens*	entire	N	N	N	N	N	N	D	D	D	D	D	N
Desert globemallow	*Sphaeralcea ambigua*	leaf	P	P	P	P	P	N	N	N	N	N	N	N
Hog potato	*Hoffmannseggia glauca*	leaf	N	N	N	N	N	N	N	N	D	D	D	D
False mesquite	*Calliandra eriophylla*	stem	D	D	D	D	D	D	D	D	D	D	D	D
Range ratany	*Krameria erecta*	stem	N	N	N	N	N	N	N	D	D	D	D	D
Zinnia	*Zinnia* spp.	stem	P	P	P	P	P	P	P	P	P	P	P	P
Yerbe-de-pasmo	*Baccharis pteronioides*	stem	D	D	D	D	D	N	N	N	N	N	N	N
Staghorn cholla	*Opuntia versicolor*	fruit	P	P	P	P	D	D	D	D	D	D	D	D
Engelmann pricklypear	*Opuntia engelmannii*	fruit	N	N	N	N	N	N	N	D	D	D	DD	
Ocotillo	*Fouquieria splendens*	flower	D	D	D	D	D	P	P	P	P	P	P	P
Fishhook barrel cactus	*Ferocactus wislizeni*	fruit	N	N	E	N	N	N	N	N	N	D	D	D
Palmer agave	*Agave palmeri*	flower	N	N	N	N	N	N	D	D	P	P	P	P

* Legend: P=Preferred D=Desirable U=Undesirable E=Emergency N=Nonconsumed T=Toxic

Hydrology Functions
The hydrology of this site is characterized by high-intensity thunderstorms during summer months and, in winter, by low-intensity frontal storms. Sixty to 70 percent of the annual moisture occurs during the summer months. The site has a porous soil surface that is resistant to erosion when perennial vegetation cover is sufficient to protect the site from damage. As basal cover is reduced, the surface soil is exposed to accelerated erosion and can be quickly lost. The clayey subsoil is more resistant to erosion, but is not able to sustain the original plant community. Deteriorated sites are characterized by low infiltration and excessive runoff. This site naturally delivers water to adjacent sites downstream by overland flow. Concentrated flow patterns are common and can easily become rills and gullies if cover is lost.

Recreational Uses
This site is used for hunting, hiking, horseback riding, and off-road driving activities.

Wood Products
Considerable amounts of mesquite occupy several present-day plant communities. Wood products potential is low on this site as mesquites remain small and shrubby in stature because of the nature of the soils in this site.

Other Products
None

Other Information
None

SUPPORTING INFORMATION

Associated Sites

Site Name	Site ID	Site Narrative
Limy 12–16PZ	R041XC320AZ	This site is found in the field to be associated with the Limy Upland 12–16PZ and the Loamy Bottom sites.
Loamy Bottom	R041XC344AZ	

Similar sites

Site Name	Site ID	Site Narrative
Limy 12–16 PZ	R041XC320AZ	With the historic climax plant community, this site is not similar enough to any other site to cause a problem or concern. As this site deteriorates it may easily be confused with other deteriorated sites, such as Limy Upland. Many sites will deteriorate into similar plant communities.

State Correlation
This site has been correlated with the following states: NM, CA, UT.

Inventory Data References
The historic climax plant community has been determined by study of rangeland relict areas or areas protected from excessive grazing. Trends in plant communities going from heavily grazed areas to lightly grazed areas, seasonal use pastures, and historical accounts have also been used. The following transect and clipping data also document this site. There are 21 permanent transect locations on this site.

Data Source	Number of Records	Sample Period	State	County
Range 417	43	1972–1985	Arizona	Cochise
AZ Range 1	31	1970–1985	Arizona	Pima

Type Locality

State:	AZ	State:	AZ
County:	Pima	County:	Santa Cruz
Township:	21S	Township:	23S
Range:	8E	Range:	14E
Section:	19	Section:	13
General Description:	Buenos Aires NWR	General Description:	Santa Cruz
State:	AZ	State:	AZ
County:	Cochise	County:	Pinal
Township:	18S	Township:	10S
Range:	28E	Range:	13E
Section:	2	Section:	2
General Description:	Oak Ranch	General Description:	Tom Mix Hwy ROW
State:	AZ		
County:	Cochise		
Township:	21S		
Range:	19E		
Section:	17		
General Description:	Ft. Huachuca		

Relationship to Other Established Classifications

1. A.W. Küchler's Potential Natural Vegetation as unit number 58 Grama - Tobosa Shrubsteppe
2. Society for Range Management's Rangeland Cover Types as unit number 505 Grama - Tobosa Shrub

Other References

None

Site Description Approval

Author		Date	Approval	Date
Original WHN	SCS	1976	DGF Regional Range Conservationist	1976
Revised DGR	SCS	1987	KDW Regional Range Conservationist	1996

United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

National Range and Pasture Handbook

Chapter 3 Ecological Sites and Forage Suitability Groups

Section 2 Forage Suitability Groups

Chapter 3 — Ecological Sites and Forage Suitability Groups

Section 2 — Forage Suitablity Groups

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600.0308 Introduction

(a) Definition

Forage suitability groups (FSG's) are composed of one or more individual soil map unit components having similar potentials and limitations for forage production. Soils within a forage suitability group are sufficiently uniform to:

- Support the same adapted forage plants under the same management conditions
- Require similar conservation treatment and management to produce the forages selected in the quality and quantity desired
- Have comparable potential productivity

(b) Purpose

Forage suitability groups order, condense, and simplify soils information. They are interpretive reports providing the soil and plant science basis for planning individual tracts of grazing land where detailed soil mapping has been done. FSG's list the soil map unit components contained in them. They identify adapted forage species and seeding mixtures that will grow on those soils without corrective treatment. They may also identify other forages that could be grown after applying certain practices to correct limiting soil features found within a group.

FSG reports state which limitations are present and their severity, associated management problems, and conservation and management practices needed to overcome the limitations. They also should identify any over-riding limitation that precludes expansion of the list of adapted species. For instance, if the soil will frost heave, alfalfa will not be suitable for the soil even if it was fertilized, limed, and drained to support alfalfa.

FSG's also give total yearly forage production estimates for the forages commonly raised on the soils within the FSG. They display the distribution of production on pasture by forage species or commonly associated mixtures during the growing season, when reliable figures are available. This is useful for planning pasture availability throughout the grazing season.

600.0309 Indexing forage suitability groups

FSG's will be established for each Major Land Resource Area (MLRA) having significant forage production. Sort all soil map unit components in the MLRA by the pertinent soil factors described in this section into like groups. Adjacent MLRA's with similar FSG's are listed in the FSG documentation at the end of the report. Adjacent MLRA's with significant forage production that have many, if not all, of the same soil series and similar climatic conditions of an MLRA with developed FSG's may simply have FSG reports copied from the MLRA with developed FSG's and edited as needed. The new FSG reports are numbered to contain the proper MLRA identifier.

A state interested in developing FSG's shall assume leadership responsibility for MLRA's that are wholly contained within the state's boundaries or where the majority of the land area of the MLRA is in the state. Where an MLRA lies across state boundaries, state specialists are encouraged to form a multistate team to develop one set of FSG's per MLRA. All states where the MLRA occurs should be aware of the development of FSG's specific to the MLRA. Everyone with an interest should participate in the correlation and development of the FSG's to ensure they are comfortable with the final product. Where MLRA's lie across regional boundaries, develop a coordinated approach with approval of the involved regional conservationists.

Base FSG's on the best data available. Form a multidisciplinary FSG team of specialists. This team should review the soil factors and their rating criteria in this section of the handbook and determine which soil factors are critical to forage production and survival in the selected MLRA. They either use the nationally established breakpoints for limitation categories for each soil factor or adjust them to better fit and describe the data array for the region. Some data can come directly from the National Soil Survey Information System database. However, data specific to the area is best collected from land grant universities or Agricultural Research Service laboratories in or near the selected MLRA. The team should be knowledgeable personnel from those institutions, Extension forage specialists, NRCS grazing land specialists, NRCS plant material specialists, NRCS soil scientists, NRCS district conservationists working in high workload grazing land management regions, and, when available, forage researchers from private research facilities. Ascertain which forage species are best adapted to each FSG. Consult the NRPH Forage Suitability Group tables in this section on forage suitability and tolerance to soil conditions: drainage, pH, inundation period, salt, and available aluminum, or other references as needed.

Determine potential forage yield by FSG for each adapted species. Forage production data exists in published and unpublished forms. Conduct literature reviews to gather published data and ask research agronomists and grassland farmers and ranchers for unpublished production records. Hay production or stocking rate information often can be used to construct a productivity rating for a forage crop on a soil map unit component. Where no information is available for specific soil map unit components, forage species, or both, initiate clipping studies to provide production data. This, of course, creates a need for interim FSG's until data are collected and collated for publishing. Once information is assembled, designate a principal author. This person will write the FSG's in their entirety and send out a draft to all other team members for review and comment. Once consensus is reached, publish the FSG's.

The initial correlation and interpretive report of an FSG should be considered the best possible at the time of completion. When new data become known, revise the FSG accordingly. Notify team of proposed changes through a review and approval process to ensure the revised FSG is accepted by consensus.

FSG names are based primarily on soil features and limitations. Suggested naming convention hierarchy is depth, drainage class, texture, permeability, available water holding capacity, soil-forming materials, slope range, and any other significant soil feature that sets the FSG apart from others. An example is: *Deep, well drained, silty, acidic glacial till soils with moderate permeability and high AWC, level to undulating.* Include topographic characterization only if meaningful. If all the soil map unit components in the group lie on a flood plain, ridgetop, or other specific landscape position, a describing word or two can be included in the FSG name. MLRA's that have distinct precipitation zones because of orographic influences, or temperature zones due to elevation or latitude, should have FSG's developed for each distinct zone or Land Resource Unit (LRU). FSG names should then be modified to indicate the zone. For example, *Level to undulating, deep, well drained, medium textured, acidic soils with natural high fertility, 20-30" PZ (precipitation zone).*

MLRA's should be subdivided only when climatic differences are real. The differences are only real when they are greater than year-to-year variations within the MLRA, are consistent, and can be delineated on a map with certainty. If consensus is hard to reach on where to delineate zone boundaries, there may be no need to subdivide an MLRA.

In some cases adjacent MLRA's have many similarities in all environmental factors. Many MLRA's were split out only to show a difference in agricultural use or to delineate a major topographic feature. This is especially true of those MLRA designations made in the 1981 revision of Agricultural Handbook 296. In those instances forage adaptation and production may vary little from MLRA to MLRA.

Numbering of FSG's is done the same as for ecological sites. The number consists of five parts.

- The letter **G** identifies it as a forage suitability group. This designation precedes a 10-character forage suitability group number, but is not actually a part of the number.
- A 3-digit number coupled with one letter for MLRA. Code to an **X** if no MLRA letter is assigned. If a subdivision of MLRA is needed, procedures for establishing and revising MLRA's are in part 649.04 of the National Soil Survey Handbook.
- Use a single letter for the LRU where applicable. Insert a **Y** when no LRU is delineated.
- A 3-digit FSG number.
- A 2-digit letter state postal code.

If the MLRA number is only one or two digits, precede it with enough zeros to make a three-digit number. For states using LRU's, enter appropriate letter in the space provided. The next three digits representing the FSG should have three digits entered even if one or two zeros precede other numbers. This numbering convention must be strictly adhered to for automation purposes. A change in the length or alphanumeric convention of any of the above parts renders the code unreadable.

600.0310 Forage suitability group report content

Once the FSG groupings are completed, develop reports describing them and interpreting their value for forage and livestock production. Forage suitability group reports should be brief, but informative. See the example displayed as an exhibit. They should address the major factors that set one group apart from another. The report should make clear which soil map unit components are included in the FSG and the forages that are best adapted to the group for the soil survey area of interest. Forage yields should be given based on the level of management and the harvest method, cutting, and timing regime indicated. Level of management could be stated based on some level of nutrient availability or application rate. Examples are soil pH range and level of soil P and K availability (such as optimum or low for each nutrient). It might also give a rate of N application for all-grass stands based on production targets. It should include drainage or irrigation status for FSG's that ordinarily would benefit from such treatment and routinely receive it in the MLRA associated with the group. Harvest method indicates whether it is grazed or mechanically harvested. When the harvest method is grazing, harvest regime identifies the grazing methods commonly used and at some descriptive level of grazing pressure. When mechanically harvested, the regime might be given as the number of cuttings taken and when.

(a) FSG report

(1) Header
Identify USDA and NRCS to the left top. The forage suitability number and report name are on the right.

(2) Name
Enter the full report name of the FSG centered under the header.

(3) Number
Enter the code starting with alpha character **G** followed by the 10-digit alphanumeric code for the FSG.

(4) Major land resource area(s)
List the code and common name. If further broken down into LRU's, then indicate which LRU is represented.

(5) Physiographic features
Describe the landform(s) that the group of soils occupies. If there are any distinctive features that can impact treatment measures significantly, describe them to alert user of their presence. Examples of specific features are incised channels, seeps, slips, cliffs, and rock outcrops.

(6) Climatic features
Describe the climate for the MLRA or LRU being represented. This climatic information should relate to forage adaptation and production. Pertinent climatic data are:

- freeze-free period (28 °F) in days (9 years in 10 at least),
- last killing freeze in spring (28 °F) date,
- first killing freeze in fall (28 °F) date,
- last frost in spring (32 °F) date (1 year in 10 later than),
- first frost in fall (32 °F) date (1 year in 10 earlier than),
- length of growing season (32 °F) in days (9 years in 10 at least),
- growing degree-days (40 °F),
- growing degree-days (50 °F)
- average annual minimum temperature range (plant hardiness zone),
- average July temperature (°F),
- mean annual precipitation (inches),
- growing season mean precipitation (inches),
- monthly precipitation range (inches),
- monthly temperature range (°F),
- potential evapotranspiration,
- relative humidity (% actually held compared to potential),
- incidence of cloudiness (mean cloudy days per month),
- average number of days between 0.1 inch or greater rain events,
- days of snow cover of 1 inch or greater (where appropriate), and
- climate station(s) whose data are presented in FSG.

(7) Soil properties

This section expands upon the FSG name. More precise information on the following characteristics should be given. To be brief, much of this information is listed in bullet form. See exhibit section for a forage suitability group report (exhibit 3.2–1). The section should describe:

- surface soil textures,
- parent material,
- slope range covered,
- depth to first root-restrictive layers,
- type of restrictive layer (in nonprofessional's terms),
- drainage class,
- permeability class,
- depth to seasonal water table (if any),
- available water capacity range,
- natural pH range (root zone),
- salt content (when applicable),
- sodium adsorption ratio or exchangeable sodium percentage (when applicable),
- degree of stoniness (if present),
- frequency and duration of flooding or ponding (if any),
- cation exchange capacity (CEC) and organic matter content ranges,
- natural P and K reserves (if known),
- aluminum toxicity potential (if any),
- frost action class (where applicable), and
- trafficability issues.

(8) Soil map unit component list

List the **soil map unit components** in the group for the applicable soil survey area(s). Include soil map unit symbol and soil component names.

(9) Adapted forage species list

Indicate which forage species are best adapted to the soil and climatic conditions stated in the FSG report. Species should be listed by the common name used in the MLRA. To increase the usefulness of this list, consider listing commonly formulated forage mixtures as well. Forage mixtures listed should contain only those species adapted to the soil conditions stated in the report. If forage mixtures are not listed here, they should appear in the management section.

(10) Production estimates

Estimate total annual yields of the forages and forage mixtures listed. These estimates should be based on the soil conditions presented in the report and the various levels of management achievable under those conditions. Present these levels of management generically as low and high. Define these two levels of management in the management interpretations section for the FSG being presented. Table 3–1 defines low and high management from a broad national perspective. These definitions may be tailored to be more specific at the MLRA level. The planner must realize that producers may do a number of management factors at the high level and others at the low level. This allows a middle management to result and various shades of management style in between all three levels. If the specialist desires to list only the highest probable yield possible, this may be done and the low yield entry deleted. For MLRA's where irrigated pasture and forage crops are common, a second column for irrigated crop yields at both levels of management intensity is recorded. Again, the high management only or optimum yield can be a single entry for irrigated production.

Production estimates should be broken down by harvest method: forage crops or pasture. If a species is grazable or machine harvestable, give production estimates under each category. Others are only best harvested either by grazing or by machine harvest. For instance, the hay-type alfalfas do not persist well under most grazing regimes, but those developed for pasture use do.

State pasture forage production levels in animal unit months (AUM's). An AUM equals 790 pounds of dry matter consumed.

Forage crop production figures are entered in pounds per acre on an as fed basis. For instance, in the example, corn silage on a dry matter basis yields only 14,000 pounds per acre of dry matter under dryland high management, since it is about two-thirds water. List only the commonly grown forages unless a promising new forage needs promotion.

Example:

Forage crop	Dryland		Irrigated	
	management intensity			
	high (lb/ac)	low (lb/ac)	high (lb/ac)	low (lb/ac)
Alfalfa	8,000	4,000	12,000	9,000
Clover, red or Ladino	6,000	3,000	11,000	8,000
Corn silage	42,000	28,000	60,000	40,000
Legume-grass	8,000	4,000	13,000	10,000

Pasture	Dryland		Irrigated	
	management intensity			
	high (AUM/ac)	low (AUMs/ac)	high (AUM/ac)	low (AUMs/ac)
Tall fescue-K. blue-red clover	7.0	2.5	10.0	7.0
Orchard-K. blue-white clover	4.0	2.0	6.0	4.0
Tall fescue-Ladino clover	8.0	3.0	11.0	8.0
Switchgrass	11.0	6.0	- - -	- - -

1 AUM = 790 lb

Table 3–1 Impact of management on yields of forage crops and pasture [1/]

Management factor	Low management	High management
Nitrogen rates per year	None spread as manure or fertilizer.	Maximum annual rate applied [2/] for crop and area, split applied.
Available phosphorus	Soil tests low or deficient.	Soil tests optimum or higher.
Available potassium	Soil tests low or deficient.	Soil tests optimum or higher.
Soil pH	pH too low or high for crop.	pH optimum for crop.
Salinity (EC)	Yield 80% of normal or worse due to soil salt concentrations.	Salinity (EC) reduced to levels that do not reduce yield.
Sodium adsorption ratio (SAR)	Greater than 25.	Less than 13.
Irrigation water management	Often untimely, and inadequate for yield or salinity control.	Adequate and timely. Salinity of water compensated for.
Drainage	Inadequate.	Optimum for soil conditions.
Insect and disease control	Inadequate or often untimely.	Adequate and timely.
Plant desirability	Remaining forage species less productive than site permits.	Planted or desired forage species in proportions desired.
Plant cover	Open stand, bare ground or weedy patches between forage plants.	Complete canopy cover or optimum stem count for crop.

Table 3–1 Impact of management on yields of forage crops and pasture—Continued

Management factor	Low management	High management
Plant vigor	Off-color, spindly plants, slow recovery after harvest.	Good color, robust plants.
Soil compaction	Compaction restricts root growth and water infiltration.	Compaction is weakly present or destroyed as needed.
Sheet and rill erosion	Erosion rates exceed T.	Erosion rates below T.
Pasture only		
Percent legume	Less than 20% in WS [3/] grass; less than 30% in CS [3/] grass.	More than percentages at left, but less than 60% of dry wt. yield.
Livestock concentration areas areas	Denuded areas > 10%.	Minor bare spots or heavy use surfaced.
Severity of use	Grazed as low as livestock can at all times. Or, ungrazed or lightly grazed areas > 50%.	Grazing and clipping managed to keep forage in a vegetative, fast growth stage as is possible.
Noxious weed control	Inadequate or often untimely.	Adequate, few or none present.
Forage crops only		
Weed control	Inadequate; losing desirable species and forage quality.	Adequate and timely during establishment and production.
Planting and harvesting operations	Often untimely resulting in diminished stands and quality.	Timely and fitted to near ideal soil and crop conditions.

1/ Adapted from Fehrenbacher et al., 1978, Soil Productivity in Illinois, IL Coop. Ext. Cir. 1156.

2/ This must be in coordination with percent legume. Little N is needed when legumes meet minimum criteria set under low management, percent legume. Thus, N applications could be zero if legumes make up a significant portion of the stand. Alternatively, legume content could be low if N is applied instead.

3/ CS = cool-season. WS = warm-season.

(11) Growth curves

For pastured forages, display their growth curve or seasonal distribution of production or availability if reliable data are available for the MLRA or LRU being represented. See figure 3–4 for format. Combine species with similar seasonal distribution of growth data to cut down on redundancy and data display. If same growth curve is used for the one species, identify all species having this common growth curve.

(12) Soil limitations

Identify soil limitations that will adversely affect forage production or impact management flexibility. Examples of the first effect are:

- Acidic or alkaline soils will reduce most forage yields unless corrected with soil amendments that correct the pH to a range acceptable for the species desired.
- FSG's having low available water capacity (AWC) cannot be expected to yield as well as high AWC groups.

Examples of the second effect are:

- Low CEC FSG's require more frequent additions of K fertilizers at lower rates than high CEC FSG's.
- Slope steepness may require more involved fencing layouts and more frequent watering facilities to distribute grazing pressure evenly. Otherwise, pasture utilization rates suffer. Slope may also limit the ability to lime and fertilize fields that are extremely steep. As slopes steepen, the hazard of erosion increases for fields that may be tilled to introduce a new forage stand. To minimize the erosion hazard, tillage and planting options become narrower for steeper sloped FSG's.

If an easily corrected limitation makes the soil suited to other forage species, list those species in this section. Over-riding limitations should also be identified, if there are any. These limitations are so severe that few, if any, management or treatment measures can correct them for a particular forage species or a grazing land resource. Example situations include:

- Extremely steep land should be avoided for crop production for a number of reasons.
- Some land is in naturalized pasture rather than improved pasture because of extreme slope steepness, surface stoniness, droughtiness, topographic reasons, or any combination of these and other soil limitations.
- Northern soils prone to frost heave severely reduce over-wintering taprooted forages and small grain production.

For more guidance on writing this section of the FSG report, refer to the appropriate soil property in this chapter that is to be rated and managed in the MLRA.

Figure 3–4 Growth curve

Growth curve number: PA1208[1/]
Growth curve name: Tall fescue, 120-140 day growing season[2/]
Growth curve description: Tall fescue dominated pasture, <5% legume[3/]

Percent production by month[4/]

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0	0	0	5	32	27	12	5	16	3	0	0

1/ Use number only once in each state. The first 2 digits are for the state postal code, and for the last 4 digits, enter numbers from 0001 to 9999.

2/ Enter a brief descriptive name for each forage species or mixture for which data are available.

3/ Describe pasture type more fully by listing major botanical components.

4/ Include percent of growth or availability by month.

(13) Management Interpretations

Information in this subsection is used to plan the use and management of soils for forage crops or pasture. This section conveys the importance of all the soil and climate data presented at first in a forage suitability group report. This section must make good interpretative use of that data for the forage suitability group report to convey much useful information to the end user. Management interpretations are based on the soil and climatic conditions described in the FSG's and whether the forage is grazed or mechanically harvested. These management interpretations will be primarily agronomic and grazing ones, but may include some agricultural engineering ones as well when appropriate. Examples of agronomic interpretations are

- seedbed preparation needs and planting depths and timing influenced by soil and climatic limitations;
- soil fertility recommendations based on soil CEC, native fertility, pH, salinity, and rainfall patterns; and
- forage crop harvest alternatives based on climatic constraints.

Grazing management interpretation examples are deferring grazing to avoid compacting wet soils, suggested modifications to rotational pasture layouts because of slope steepness or irregular terrain, and distance to drinking water based on terrain. Agricultural engineering interpretations could include fence design modifications required due to soil depth or terrain features, irrigation alternatives and modifications based on soil and climate requirements or topographic position, and drainage design alternatives of seasonally wet soils not considered to be protected wetlands. See table 3–2 for agronomic interpretations of common soil limitations that occur throughout the United States. Management intensities of low and high are used in the Production Estimates section, describe those levels of management now by land use. Refer to table 3–1 for general guidance as to what is meant by low and high management inputs on a broader national scale. When the management interpretations are not influenced by harvest method, write management recommendations in a general section. For instance, the need for lime is dependent on soil pH status and the forage species desired, not on whether the forages are harvested with machinery or by a grazing animal.

When management is influenced by harvest method, indicate in the subheading of this section whether it is pasture or forage crops. For example, nutrient management is different for pasture versus cropped land. In a pasture setting, nutrients are recycled on the same field. Depending on fencing and watering strategies, grazing method used, and the presence or absence of shady areas, nutrient distribution may vary considerably over the field. Yet, little phosphorus (P) and potassium (K) are removed from the system. In some cases more P and K may enter the field than leave it. This depends on the level of supplemental feeding while the animals are on pasture. Nitrogen (N) is generally the limiting nutrient unless legumes are present and make up at least 25 percent of the stand. Nitrogen is concentrated at urine spots and dung areas, so it takes years for even distribution of N to occur. Much excreted N is also lost to volatilization, runoff, and leaching in humid and subhumid areas because of its placement. On cropped land, the nutrients are removed completely with the harvest. They may or may not be returned to field. Depending on how efficiently the animal waste is collected, stored, and transferred back to the field, the amount of nutrients returned to that field from animal waste can range from overapplied to none at all. Stored forages fed to pastured cattle would create an animal waste source that is economically uncollectable and a net gain in nutrients to the pasture. For intensively managed cropland and hayland, therefore, a balanced fertilizer program is followed annually to maintain soil fertility levels.

Statements made in this section should be concise and accurate, but remain generic. For example, an FSG naturally low in a nutrient should state that it needs to be applied. If the FSG also has low CEC soils and high permeability, those nutrient applications may need to be split applied during the growing season. The FSG report should also indicate how that might differ for a legume versus a grass, or a warm-season grass versus a cool-season grass. It is impossible to state how much. First, it is field specific. It is forage species and species mixture specific. It is also dependent on the desired yield goal of different land managers and the amount of effort they are each willing to extend to other management practices that impact forage yield.

If a management measure needs to be qualified, cite an existing job sheet that goes into more detail. For instance, liming is generally a good practice for acidic soils. However, the forage being grown, yield goal desired, and the current soil pH of a particular field also dictate the level of liming or the need to lime at all. An FSG may contain acidic soils; however, the pH of the plow layer may differ due to different management histories of forage crop and pasture lands. On acid soils, different fields have received from one to several lime additions, while others may never have. Even the type of lime needs specifying if calcium and magnesium levels in the soil need balancing. Only a field specific soil test can indicate this. Reserve this amount of detail to an appropriate job sheet on liming.

Table 3–2 Agronomic interpretations of soil limitations

Soil limitation	Agronomic interpretations
Seasonal high water table >60 days in most years or permanent high water table	Denitrification frequently occurs in anaerobic subsoil. Tillage and harvest opera tions and forages with water intolerant roots affected by excess rain or elevated water table unless drainage is improved. Subirrigated forage crops need special fertilizer management to avoid soil nutrient losses and deferment from traffic when soils are saturated at surface.
Ustic, aridic, or xeric soil moisture regimes (subsoil dry >90 successive days each year within the 8- to 24-inch soil layer)	Irrigation required for optimum forage production. Fallow/crop production. Drought tolerant forage selection for dryland.
Low CEC (Plow layer CEC <4 meq/100g soil of effective CEC, or CEC <7 meq/100g soil by sum of cations at pH 7, or CEC <10 meq/100g soil of effective CEC at pH 8.2	Low ability to hold nutrients K, Ca, and Mg from leaching. Split apply K and N fertilizers when high application rates are recommended. Potential danger of overliming.
Aluminum (Al) toxicity, >60% Al saturation of the effective CEC, pH <5	Lime or apply gypsum to reduce exchangeable Al to a soil depth of at least 20 inches so that it no longer restricts root growth and nutrient uptake. Select Al tolerant species/varieties.
Acid soils, 10% to 60% Al saturation of the effective CEC within 20 inches of soil surface; pH 5–6	Lime to raise pH to the level needed to grow the forage crop desired. Acid soils over dolomitic limestone may be calcium deficient requiring calcitic lime applications. Select species adapted to acid soils.
High phosphorus (P) fixation	Requires high P application rates or band-applied superphosphate or ammonium phosphate. Can absorb large quantities of high P animal wastes without loss to runoff once incorporated. Most legumes difficult to establish and maintain.
Clays with high shrink-swell	Tillage difficult when too wet or too dry. Bunch grasses more adapted than sod formers. P deficiency common. Legume choices limited.

Table 3–2 Agronomic interpretations of soil limitations—Continued

Soil limitation	Agronomic interpretations
Low potassium (K) reserves, <2% of base saturation	Potential K-Mg-Ca soil imbalance. Need frequent applications of K, especially to retain legumes.
Calcareous soils, free $CaCO_3$ within 20 inches of soil surface, or pH >7.3	Potential micronutrient deficiency—Cu, Fe, Mn, Mo, Zn. P deficiency possible. Water soluble P fertilizers needed.
Sodic soils, > 15% Na-saturation of CEC or sodium adsorption ratio (SAR) > 13 within 20 inches of soil surface	Applications of acidifying soil amendments, lime, or gypsum depending on class of sodic soil, and applications of irrigation water and drainage.
Low AWC (available water capacity)	Irrigation where rainfall is insufficient and/or infrequent. Use of water efficient forages, such as warm-season species.
Slope, >25% land is	Machinery operations difficult impeding use of agronomic practices. Erosion hazard high if soil tilled or bared by animal traffic. Grazing may be uneven when flatter available and more accessible.
Flooding or ponding duration, > 7 days	Select species tolerant of prolonged flooding. Defer grazing until soil is firm and regrowth is well established. Once soil is firm, chop uniformly any silt-damaged standing forage back onto field. Ensile overmature standing forage with minimal silt damage. Mix this low quality forage with less mature forage from an unflooded field. Topdress fertilize fields harvested prior to flood if regrowth is short and yellow. Silt deposition greater than 2 to 3 inches may require reestablishment of forage stand in those areas. Restore damaged drainage facilities. Remove sand or gravel deposits or spread and mix with underlying soil.
Frost heave, high	Avoid planting taprooted forage crops or winter small grains where climate and soils cause frost heave to be almost an annual occurrence.

(14) Management dynamics

Describe the effect each management practice pertinent to the FSG has on forage species survival or vigor. How does each practice impact maintaining the forage species or mixture of species desired at the site? Describe patterns of community change symptomatic of a management input and the reasons change occurred. Include a description of how some plant species can invade or increase on the site because of a management decision. Also, describe the interactions of an established mixture of plant species and how to use them to maintain the desired mixture. This can be involved because of the management options available to producers on forage crop and pasture lands.

The main intent of this section is to show how forage plants respond to management stimuli. The most successfully applied management practices work with the ecosystem and support it. Management practices applied without regard to the ecosystem generally are economically ineffective, often lead to environmental degradation, and may fail to achieve the intended production goal as well. This section is optional. Develop only if it has instructional value for the FSG being described. This section gives the reasons for doing the management action.

(15) FSG documentation

Similar FSG's—Identify and describe FSG's, including similar FSG's in adjoining MLRA's, that resemble or can be confused with the current FSG. Note specific difference and contrasting management options to address difference. If from an adjoining MLRA, there may be no differences to point out.

Supporting data for FSG development—Include research references used, clipping study information, and farmer information, such as hay records or grazing information.

Site approval—Indicate FSG approval. Each FSG team will determine approval procedures for the MLRA.

(b) Revising forage suitability groups

Analysis and interpretation of new information about soil, plant adaptation, production, and management may indicate a need to revise or update FSG's. Because collection of such data is a continuing process, FSG's should be periodically reviewed for needed revision. When new data on plant adaptation, production, or management indicate a need for revision, it should be completed as soon as possible. Documentation of plant adaptation, production, and management will be the basis of the revision.

600.0311 Climatic factors that influence forage production

Climatic factors that influence forage production are numerous. Not only do they influence forage selection, growth, and yield in concert with the soil resource, they also influence how and when seedings and harvests can be made. In preparing the FSG report, the climate station(s) used to characterize the climatic data in the report need to be identified. List its station identification number and location and identify the 30-year period used to generate the climatic data.

To make good agronomic management recommendations in forage suitability group reports, the agronomist must be aware of how climate affects forage crop and pasture management. This subsection provides an overview of the important climatic factors nationwide. Table 3–3 lists the different agronomically significant climatic data elements and states the major reasons for their importance to forage production.

(a) Freeze-free period

Freeze-free period is the number of days where the air temperature does not fall below 28 degrees Fahrenheit at the 90 percent probability level. This is the growing season for cool-season perennial forage crops in temperate regions. As indicated by the National Water and Climate Center, three temperature indices are commonly used to define the growing season. This is the intermediate threshold temperature. It is labeled as the freeze-free period to avoid using the same terminology twice. See length of growing season in this section. A killing freeze (Am. Meteorological Soc. 1996) or moderate freeze (28 °F. or less) in the fall is widely destructive to most vegetation effectively ending the growing season for cool-season perennials. The last killing freeze in the spring marks the beginning of any significant cool-season grass growth. Some cold-tolerant grasses, such as tall fescue, may tiller and grow slowly before this date, but the forage mass produced is minimal.

The 90 percent probability level was selected based on the advice of Supplement number 1, Climatography of the U.S., Number 20, Freeze/Frost Data (1988). For agriculture interpretations, it is better to know that there is only a 10 percent chance that the freeze-free period will be shorter than the length given at the 90 percent probability than at an equal chance, 50 percent probability, used to determine the WETS growing season. Late spring freezes can cause severe injury or death to some perennial and annual forage crops that prematurely initiate growth because of warm weather before the killing freeze. Perennial ryegrass is a prime example. This growing season length combined with growing degree-day data sets the number of grazing or harvest cycles that are possible based on forage regrowth potential. However, cold-hardy brassicas and stockpiled fescue can extend the grazing season past the end of this growing season. Brassicas tend to keep growing past the killing freeze date in the fall.

Last killing freeze in spring and first killing freeze in fall at 28 degrees Fahrenheit at the 90 percent probability approximates times when cool-season forages can be planted. The last killing freeze in spring has only 1 chance in 10 of occurring later than the date indicated in the FSG report. Similarly, the first killing freeze in fall only has 1 chance in 10 of occurring earlier than the date indicated in the FSG report. Spring seeded cool-season forage crops can be planted slightly before the last killing freeze in spring if soil conditions permit and forage germination is delayed until past that date, or a companion crop canopy protects young seedlings. Summer-fall seeded cool-season perennial forage crops should be planted to emerge and grow for at least 6 weeks before the first killing freeze in the fall. Seedlings should be 3 to 4 inches tall before the first killing freeze in the fall. In Southern States where last killing freeze occurrence is early in the year (if at all), warm-season perennial forage crops are planted as early as the ground can be prepared.

(b) Frost-free period

Last frost in spring and first frost in fall at 32 degrees Fahrenheit at the 90 percent probability approximates when annual warm-season forage crops can be first planted and are most likely to be killed each year, respectively. Therefore, it is called a killing

Table 3–3 Climatic factors and their importance to forage production

Climatic factor	Primary importance
Freeze-free period (28 °F) in days	Approximate growing season for CS [1/] forages.
Last killing freeze in spring (28 °F) date	With soil temperature sets CS [1/] spring planting date.
First killing freeze in fall (28 °F) date	With ample timely rainfall sets CS [1/] summer planting date.
Last frost in spring (32 °F) date	With soil temperature sets WS [1/] spring planting date.
First frost in fall (32 °F) date	Most annual forages and weeds are killed on this date.
Length of growing season in days	Annual forage crop days to maturity selection.
Growing degree-days (40 °F)	CS [1/] forage first harvest date and number of harvests.
Growing degree-days (50 °F)	WS [1/] forage first harvest date and number of harvests.
Average annual min. temp. (plant hardiness zone)	Winterkill hazard for a specific species/cultivar.
Average July temperature	Heat-stress on a specific species/cultivar.
Mean annual precipitation (inches)	General guide to moisture abundance, species selection.
Growing season mean precipitation (inches)	Moisture guide for species selection and irrigation need.
Monthly precipitation range and average (inches)	Probability of having too little or too much.
Monthly temperature range and average (°F)	Indicates amount of heat for growth and curing.
Potential evapotranspiration (inches)	Need for irrigation water for optimum yields.
Relative humidity (%)	Influences foliar disease severity and cut forage drying rate.
Incidence of cloudiness (mean cloudy days per month)	Affects forage quality and drying rate.
Average number of days between ≥ 0.1 inch rain events	Affects forage quality and selection of harvest method.
Days of snow cover of 1 inch or greater (where appropriate)	With average minimum temperature affects winterkill hazard.

1/ CS = cool-season. WS = warm-season.

frost by the American Meteorological Society (1996). Here the risk of crop failure is critical so NOAA again recommends the 90 percent probability. Therefore, the last frost in spring has only 1 chance in 10 of occurring later than the date indicated in the FSG report. Similarly, the first frost in fall only has 1 chance in 10 of occurring earlier than the date indicated in the FSG report. The last frost in spring date is the earliest possible planting date to avoid a killing frost wiping out an emerged warm-season forage crop seeding. Warm-season forages need appropriately warm soil temperatures as well for good germination. Cold-tolerant forage crops can be planted before this date, especially if accompanied by a companion crop that canopies and thus protects them from frost. It is also important to know when the first killing frost occurs to ensure there is time for the annual warm-season forage crop to mature or to maximize harvestable yield prior to its being killed by frost. If a killing frost strikes prematurely, quality of the forage or grain is substantially lowered. This is especially critical for crop selection of late-planted annual forage crops often used as emergency or supplemental forage crops. Either the crop has to mature quickly, or it must withstand frosts and grow well during cool weather. The first frost in fall also effectively ends the growing season for warm-season perennial forage crops and most annual weeds. It often marks the beginning of cool-season forage production in climates where killing freezes seldom or never occur. Tropical areas are frost-free.

(c) Growing season length

The length of the agronomic growing season in days is set at 32 degrees Fahrenheit at the 90 percent probability. Growing season is the part of the year when the temperature of the vegetal microclimate remains high enough to allow aboveground plant growth. It is the interval between the last killing frost of spring and the first killing frost of fall, or the frost-free period. This killing frost can occur at aboveground air temperatures as high as 36 degrees Fahrenheit. Most thermometers used to monitor air temperature are 5 feet above the ground. Ground surface temperature at crop level is often 4 to 8 degrees Fahrenheit lower than that at the thermometer. Therefore, the data entry in the FSG report may, in fact, be shorter than that indicated by the last frost in spring and first frost in fall dates, respectively. This is the growing season length used by agronomists to determine crop maturity zones for such crops as corn and soybeans. Since corn and several other annuals are often forage crops, the frost-free period is the critical growing season length to record in the FSG report. To ensure the frost-free period is long enough for the annual forage crop to mature or be in a harvestable state before the killing frost occurs is a significant planning tool. It also reflects the effective growing season for warm-season perennial forages.

(d) Growing degree-days

Growing degree-days are recorded for forage crops at two base levels, base 40 degrees Fahrenheit and base 50 degrees Fahrenheit. The 40 degrees Fahrenheit base is used to calculate growing degree-days for cool-season forage crops. The 50 degrees Fahrenheit base is used to calculate growing degree-days for warm-season crops. Although for some warm-season forage crops, such as sorghum and sudangrass, a base temperature of 60 degrees Fahrenheit is more appropriate. Some crops, such as corn, have growing degree-days calculated using a minimum and a maximum apparent temperature limit for growth. The limits are 50 degrees Fahrenheit and 86 degrees Fahrenheit. Growth essentially ceases below 50 degrees Fahrenheit and above 86 degrees Fahrenheit. Any daily temperature extreme that does not fall within those limits is ignored, and the limit exceeded is put in its place in the equation. Growing degree-day units (GDU) per day for corn = $[T_{max} (\leq 86) - T_{min} (\geq 50)] / 2 - \text{base} (50)$.

Climatography of the United States No. 20 has GDU's published for 40, 50, 60, and 50/86 degrees Fahrenheit. Yearly GDU accumulations along with soil water availability govern the growth rate of plants. Cumulative GDU data can be used as a guide to select annual crop varieties that will mature before a killing frost, schedule crop harvest, and classify regional agricultural climatology. Yearly GDU accumulations for the United States begin on March 1 in the Climatography of the United States No. 20. National Water and Climate Center TAPS station data displays monthly growing degree-day data.

When dealing with an annual crop, GDU accumulation must begin at the planting date so the base GDU accumulation up to planting time is subtracted from the GDU accumulated after planting to monitor crop growth progress using GDU's. Growing degree-day accumulations have been used to schedule nitrogen fertilizer applications to cool-season grasses in Western Europe and the United Kingdom. It is called the T-sum 200 method. N fertilizer is spread when 200 heat units (GDU) of average daily temperatures in degrees Celsius base 0 degrees Celsius (32 °F) are reached from a start date of January 1. It works well for cool, humid regions. In more arid, warmer regions, fall and early spring applications on cool-season grasses are best since their growth ceases during the summer unless irrigated. Here T-sum 200 would recommend an incorrect timing of spring N applications and fail to suggest a fall application altogether. In humid, warm regions, late fall and late winter applications on cool-season grasses are best since their growth occurs during the winter months. Here, the T-sum 200 method could only work using a different starting date for the fall application and would need to be tested.

(e) Average annual minimum temperature

Average annual minimum temperature determines the plant hardiness zone designation for an area. This temperature is the average value of the lowest temperature recorded each year for the years of record, 1974 to 1986. Many MLRA's have more than one plant hardiness zone if they extend north to south very far, have significant elevational differences within them, or have large bodies of water that moderate near shore climates. The source for this information is in the USDA Plant Hardiness Zone Map, Miscellaneous Publication 1475, dated 1990. This map along with days of snow cover greater than 1 inch data help determine whether perennial forage crops can winter over without being killed or severely weakened. It determines the extent of their range of adaptability to cold weather. Some MLRA's that are extremely cold, but have snow cover most of the winter, can support forage crops that would be killed where the ground lies open most of the winter. For example, orchard-grass can survive in Maine in the interior under the snow cover, but winterkills occur readily along the Atlantic Coast where the snow cover is light or absent most of the winter. Where snow cover is nonexistent or rare, then only the average annual minimum temperature determines the winter survival rate of a forage crop and its varietal selection. Bermudagrass varietal selection has been done to make it more winter-hardy, for instance. This factor also interacts with humidity, wind, soil moisture, soil type, and winter sunshine. Most of the information on winter hardiness is observational using trial and error. Forage crops with a consistent stand loss or failure history winter after winter should not be recommended for planting in that MLRA.

(f) Average July temperature

Average July temperature is the opposite of the average annual minimum temperature. Some forage crops do not do well under intense heat. Cool-season forage crops cease to grow much above 86 degrees Fahrenheit. This heat combined with high humidity makes several cool-season forage species susceptible to virulent foliar diseases, reducing their stands or their quality. So much so, that selecting forage species more tolerant of the heat and humidity, generally warm-season grasses of the tropics or subtropics, is simpler. If cool-season forages are grown in areas of high summer heat and humidity, but cool winters, they generally are winter annuals used to extend the grazing season to a year-round scenario. If they are perennials, they need to be varieties that are summer-dormant, winter-growing ecotypes. Mediterranean ecotype orchardgrass is an example of a summer-dormant, winter-growing cool-season forage. Endophyte infected tall fescue acts in a similar fashion.

(g) Mean annual and growing season mean precipitation

Mean annual and growing season mean precipitation are indicators of adaptability range of forage crops. The western edge of the primary range of climatic adaptation of many introduced European forage crops is at the 98 degrees west meridian. They are also adapted to areas west of the Cascade Mountains in Washington and Oregon. In other places west of the 100th meridian, they may grow well at higher elevations or on irrigated lands. The reverse can be said for many native forage species of the Great Plains. The eastern edge of their primary area of climatic adaptation is at the 100th meridian. Mean annual precipitation is a less precise measure of adaptation in that most of the precipitation can be skewed to the nongrowing season in colder climates so that it is less effective for growing crops. Mean annual precipitation is used to delineate climatic moisture regimes of wet, humid, subhumid, semiarid, and arid. Arid regions have annual precipitation of 10 inches or less. Semiarid regions have an annual precipitation range of 10 to 20 inches, subhumid 20 to 40 inches, humid 40 to 60 inches, and wet greater than 60 inches. Growing season mean precipitation when coupled with soil available water holding capacity and potential evapotranspiration can predict the occurrence of soil moisture deficits that prevent crops from producing optimum yields. In areas where this deficit in crop moisture is large, irrigation is practiced where it is cost-effective and a source of irrigation water exists. Growing season mean precipitation of 20 inches is roughly the isoline that divides the United States between extensive irrigated acres and acres with little irrigation except on very low water holding capacity soils or specialty and turf crops.

(h) Monthly precipitation range

Monthly precipitation range in inches shows the normal range at the 2-year-in-10 probability. In most climates the range is important because it shows the uncertainty of dependable rainfall and the possibility of it being overly abundant at other times. Species selection can be based on drought tolerance where it is obvious that inadequate rainfall occurs from time to time and droughty soils are commonplace. When monthly rainfall amounts appear excessive, it is obvious that machinery and livestock movement may be slowed and damage can occur to waterlogged soils. Heavy monthly rainfall interfers with harvests unless they can be done quickly between rainfall events. Monthly rainfall data also shows the yearly distribution of rainfall. Coupled with temperature data, some forage production strategies can be explored to take advantage of the distribution as it presents itself. An example is growing winter forage crops where the winters are mild and winter moisture is abundant and perhaps is mostly lost to crop production by the summer growing season. The average monthly precipitation can be displayed to show how much the minimum and maximum deviate from the norm.

(i) Monthly temperature range

Monthly average minimum and maximum temperature range in degrees Fahrenheit at the 2-year-in-10 probability. Again, the monthly average temperature can be displayed to show how much the minimum and maximum deviate from the norm. These monthly temperatures bolster the growing season length data and hint at growing degree-day unit accumulation throughout the year. The best forage crop growing areas have average monthly mean temperatures between 50 degrees Fahrenheit and 68 degrees Fahrenheit for 4 to 12 months out of the year. Spring oats or barley, often used as a companion crop for forage seedings north of the 39th parallel, has its seeding date target set by the monthly average air temperature of 50 degrees Fahrenheit. Oats seedings should begin 2 weeks before the month that has an average air temperature of 50 degrees Fahrenheit. Forage seedings would then be planted with the oats using a drill with a small seed-planting unit attachment on it.

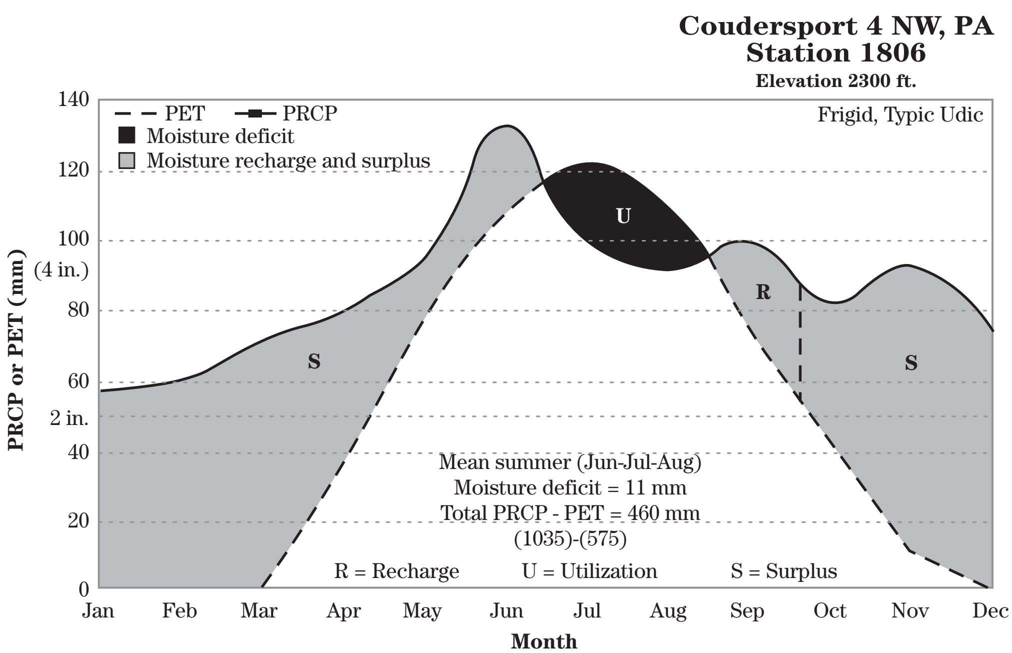
(j) Potential evapotranspiration

Potential evapotranspiration (PET) is the combined yearly loss of water from a given area that would evaporate from the soil-plant surface and transpire from a full plant canopy where the supply of water is unlimited. Actual evapotranspiration (AET) is the amount of water evaporated from the soil-plant surface and transpired by plants if the total amount of water is limited. An incomplete plant canopy may exist that would limit transpiration as well. AET is commonplace in dryland forage crop production in climates where growing season rainfall is sporadic enough to cause plant available soil moisture to be depleted. Plants undergo water stress, wilt, and consequently are unable to use as much water as they could. These problems are most serious in low water holding capacity soils and in climates where significant rainfall events can be several days apart. PET for various regions may be converted to estimates of the evapotranspiration of specific forage crops by using a derived specific constant for each crop, K_c (crop factor). For example, alfalfa has a K_c of 90 to 105. It, therefore, gives an estimate of how much irrigation water would be necessary to grow a forage crop for the year. PET can be derived from pan evaporation data retrieved from climatic stations collecting that information on a monthly basis to plot its distribution curve throughout the year. This plot along with a plot of monthly precipitation averages will show seasonal deficits and surpluses of precipitation versus loss and use through PET. Depending on the soil water holding capacity and its runoff potential, the data plot can indicate how much water is available for leaching and for crop production. It can also show how much of a shortfall in water can occur on a particular forage suitability group during the peak evapotranspiration period. See figure 3–5 for an example of this concept.

(k) Relative humidity

Relative humidity is expressed as a percentage measure of the amount of moisture in the air compared to the maximum amount of water vapor the air can hold at the same temperature and pressure. It greatly affects the drying rate of machine-harvested forage crops. Relative humidity is but one climate element that determines the most feasible method of harvesting a forage crop while optimizing forage quality. Incidence of cloudy weather and average number of days between 0.1-inch or greater rainfall events also determine whether forage crops are better conserved as silage, haylage, or dry hay. High humidity slows the drying rate considerably and can prevent dry hay from reaching a moisture content that is low enough to keep well in storage without

Figure 3–5 A plot of PET versus precipitation on a soil with an 8-inch AWC [1/] [2/]



Moisture balance for Coudersport 4 NW, Pennsylvania, based on a period of 1961–1990. PET calculated b Newhall Simulation Model (Van Wambeke et al., 1992)

1/ Note the water deficit for growing a crop during mid-summer. Yields are reduced without supplemental water or timely rainfalls in wetter summers.

2/ Adapted from Penn State University Experiment Station, Bulletin 873, Soil Climate Regimes of Pennsylvania.

preservatives or mechanical drying. The National Climatic Data Center of NOAA has compiled average relative humidity for selected climate stations over the United States for morning and afternoon hours. High nighttime humidity tends to produce heavy dew once the dew point (temperature at which water vapor in the air begins to condense on surfaces) is reached. This may linger well into the afternoon on very humid days, delaying the drying rate of cut forage considerably. Hot, humid climates also make a favorable environment for foliar diseases, especially ones caused by fungi and viruses. This makes many cool-season grasses poor choices for forage production that produce thin stands and low quality forage because of heavy foliar disease attack.

(l) Incidence of cloudiness

Incidence of cloudiness is expressed as the mean number of days per month by category of cloudiness. The cloudiness is determined for daylight hours only since the concern is about the quality of solar radiation. The three categories are clear, partly cloudy, and cloudy. For agronomic purposes, only the number of cloudy days recorded are of concern. Its main importance is its impact on the drying rate of cut forage crops. On a dry soil with an air temperature of 80 degrees Fahrenheit, drying takes more than twice as long under cloudy skies than on a sunny day. This can delay drying of hay by 2 days if there are only 8 hours of effective drying time per day. If the soil is wet from a previous rain event, drying time escalates further. Prolonged cloudy weather can also cause accumulation of nitrates in highly nitrogen-fertilized forages as well when the weather is cool. The levels may become high enough to poison livestock. The National Climatic Data Center of NOAA has compiled mean number of cloudy days for selected climate stations over the United States. It is in a table that also includes the number of clear and partly cloudy days.

(m) Average number of days between rain events

Average number of days between rain events of 0.1 inch or greater is derived information. The National Water and Climate Center in its TAPS database compiles the this information by month. To convert that information to the requested FSG data element, simply divide the total number of days during the harvest season months by the total number of rainy days in those months and round to the nearest whole number. This average, based on random probabilities, is going to be fairly accurate. However, it should be evaluated to make sure it truly reflects the normal time interval between rain events for the MLRA. This information is extremely important in making recommendations on forage harvest management. Management recommendations to speed drying should be made, such as using mower conditioners, tedders, chemical desiccants, and lacerators. Where relative humidity and incidence of cloudiness are high and time intervals between rain events are short, haymaking is impossible while still maintaining forage quality. Forage harvest alternatives of haylage or silage should be suggested in the FSG management section.

(n) Days of snow cover

Days of snow cover of 1 inch or greater is also available from the National Water and Climate Center's TAPS station data at the bottom of the table. This climate data element requires some interpretation to be useful. Winters are often said to be open, that is, with little snow cover. If this is accompanied by freezing temperatures, forages that are not cold tolerant can winterkill. Snow offers insulation to plants from freezing air temperatures. A snow cover of 4 inches with air temperatures to minus 13 degrees Fahrenheit kept soil temperatures below it from dropping. Snow cover must remain in late winter and early spring when plants have a lower cold resistance and severe temperature fluctuations above and below freezing are still possible. The author of the FSG report must decide whether snow cover is effective in keeping some forage crops from winterkilling. There is no general rule of thumb. While snow cover insulates plants and protects them from freezing temperatures, it can also lead to snow mold outbreaks in susceptible forage species. Where this is a problem, it should be noted in the management section of the FSG report.

600.0312 Soil factors that influence forage production

Landscape and soil properties from soil survey information that have a significant and direct effect on forage plant production and their management nationally are:

- Slope
- Drainage class
- Available water capacity
- Flooding and ponding, frequency and duration
- Soil reaction, acid and alkaline Soils
- Salinity
- Native fertility as measured by cation exchange capacity (CEC) and organic matter content
- Frost heave potential
- Trafficability as characterized by the Unified Soil Classification, surface rock cover, and drainage class
- Surface rock fragments
- Shrink-swell
- Depth to restrictive layers

Other measurable soil properties have an indirect effect on forage production and management. They help define or modify other soil properties; however, they, themselves, do not focus on an attribute of forage production clearly enough to be useful in assigning a soil map unit component to a suitability group. Soil texture is an example. It influences plant growth by impacting soil aeration, water intake rate, available water capacity, cation exchange capacity, permeability, erodibility, workability or trafficability, and in the case of surface stones, the amount of surface soil area upon which plants can grow. For FSG's, texture is an important soil property, but it is nonspecific. It is not precise enough to be of value in creating like soil capability groups. In some cases, a soil textural class may have some good features as well as bad, making it impossible to rate it overall. A sandy loam may have great permeability and trafficability, but have low water holding capacity and native fertility. Instead, those soil properties it does influence will be rated separately since specific values for them can be gathered from soil interpretation records.

600.0313 Landscape properties influencing forage suitability groups

As organized, the first two properties listed in the introduction of this part, slope and drainage class, are landscape properties.

(a) Slope

Slope has an impact on grazing lands for both humans and livestock. Coupled with aspect, it has a profound effect on plant growth. However, soil map units over much of the United States can each lie on many different aspects. Aspect, therefore, cannot be used to evaluate into which FSG a soil map unit component belongs. On a field-by-field basis, some further interpretation can be made if a predominant aspect exists.

(1) Limitation categories

For FSG's, slope classes are combined to form three limitation categories:

- **Slight—**nearly level, gently sloping, and undulating
- **Moderate—**strongly sloping, rolling, moderately steep, and hilly
- **Severe—**steep and very steep

(2) Importance to management considerations

The slope limitation categories are set up for two reasons. First, livestock tend to decrease their movement as slope increases. Grazing pressure on hilly ground becomes uneven as livestock ignore steeper areas in favor of more easily accessed areas. Watering facilities need to be more closely spaced as the landscape becomes more rugged. If not, overgrazing occurs near the water supply and more remote areas are lightly grazed, if at all. To overcome this limitation, more fencing and walkways are required to distribute grazing pressure evenly. Steep, hilly ground requires more troughs and pipeline to get water within the closer distances needed to keep livestock performance at an optimum level. As slope increases, trailing along walkways and fences will cause a heightened concentrated flow erosion hazard. Layout and construction of fences and walkways become more difficult, increasing expenses associated with their construction and maintenance. For instance, the need for more fence brace-assemblies increases as the topography becomes more rolling. Walkways may need to be paved, lengthened to reduce grade, and intersected with dips to reduce the length water travels down them.

The second reason involves machinery traffic movement on grazing land fields. In the slight category, machinery traffic is generally unrestricted by nearly level to undulating slopes. Renovation, mechanical harvest, fertilizing, liming, and clipping can be done readily.

In the moderate category, all the above machinery operations can still be done, but much more care must be taken to avoid accidents. Equipment maintenance increases as more strain is placed on transmissions and other components.

Steep to very steep slopes generally preclude wheeled power equipment. Track equipment can operate much more safely. Therefore, over much of the country, slopes greater than 30 percent generally preclude much agronomic improvement of the grazing land resource. This is primarily because of the lack of cost effective tracked vehicles to do specialized operations, such as liming and fertilizing fields.

(b) Drainage class

The second landscape property is drainage class. This factor along with available water capacity, flooding, and ponding deal with water supply issues that affect forage production and management. Too much or too little water has a tremendous impact on forage growth. It is often the overriding limiting environmental factor. Water is the major ingredient needed for plant growth. Much of it is transpired and lost to the atmosphere with less than 1 percent of the water taken up by plant roots used to produce food. It takes 300 to 1,000 pounds of water to produce just 1 pound of dry matter.

Because water use efficiency varies greatly among forage species, species selection can be done based on the availability of soil stored water. Warm-season species are more efficient water users than cool-season species. The range in dry matter production per inch of water in central Alabama, for example, goes from a high of 1,646 pounds for coastal bermuda-grass (warm-season species) to a low of 436 pounds for red clover (cool-season species).

Drainage class describes the frequency and duration of periods of water saturation or partial saturation of a nonirrigated and undrained soil. This is extremely important in species adaptation and selection. Some species have a broad spectrum of adaptation to soil drainage conditions. Others have a narrow band of adaptation. Some seeding mixtures have an even narrower band of suitability because one species or another in the mix may disappear because it is poorly adapted to the drainage conditions at the site. There is no reason to recommend a forage mix for a site, if one or more species will not compete successfully with others in the mix because of the adverse drainage conditions. Table 3–4 lists the forage species suitability based on drainage class.

(1) Drainage class suitability and productivity categories

The seven natural drainage classes must all stand alone because they influence productivity as well as suitability. They cannot be categorized using more generalized modifiers or lumped together. For instance, an excessively drained soil and a somewhat poorly drained soil may both have the same yield potential, but not for the same species. Well-drained soils and moderately well drained soils may have the same general suitability for the specie(s) in question, but the yield potential is unlikely to be the same.

The seven drainage classes defined in chapter 3 of the Soil Survey Manual are excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained.

Table 3–4 Forage species suitability based on soil drainage class [1/] [2/]

Species suited to all drainage classes:

Redtop   Reed canarygrass

Species and forage mixtures suited to all drainage classes except very poorly drained:

Arrowleaf clover	Cicer milkvetch	Switchgrass
Bahiagrass	Indiangrass	Tall fescue
Big bluestem	Kleingrass	Wheatgrass, slender
Caucasian bluestem	Smooth bromegrass	

Species and forage mixtures suited to excessively drained to moderately well drained soils (wet soil intolerant):

Alfalfa	Guineagrass	Sainfoin
Alyceclover	Hop clover	Sericea lespedeza
Bermudagrass, coastal	Jointvetch *(Aeschynomene falcata)*	Sirarto
Black medic	Little bluestem	Stylo
Cluster clover	Orchardgrass	Sudangrass or sudan-sorghum hybrids
Crimson clover	Pearl millet	Sweet clover
Crownvetch	Perennial peanut	Weeping lovegrass
Elephantgrass	Prairiegrass (*Bromus willdenowii*)	Winter small grains
Foxtail millet	Rose clover	

Species and forage mixtures suited to well drained soils to somewhat poorly drained soils (intolerant to dry or wet soils):

Annual lespedeza	Dallisgrass	Timothy
Bermudagrass, common	Kentucky bluegrass	Wheatgrass, pubescent
Carpon desmodium	Red clover	Wheatgrass, tall
Crabgrass	Rhodesgrass	

Species and forage mixtures suited to well drained to poorly drained soils (forages preferring high moisture soil regime):

Alemangrass [3/]	Bur clover	Rescuegrass *(Bromus catharticus)*
Alsike clover	Digitgrass	Singletary pea (also called caleypea or roughpea)
American jointvetch *(Aeschynomene americana)*	Eastern gamagrass	Strawberry clover
	Ladino clover	Vetch, hairy
Annual ryegrass	Lappa clover	Wheatgrass, thickspike
Ball clover	Limpograss	Wheatgrass, western
Bentgrass	Meadow foxtail	White clover
Berseem clover	Perennial ryegrass	
Birdsfoot trefoil	Persian clover	

Species and forage mixtures suited to well drained and moderately well drained soils only:

Brassicas (forage kale, rape, swedes, and turnip)	Kikuyugrass	Vetch, big flower
Chicory	Soybean	Vetch, common
Corn, silage or grazed stalks	Spring small grains	Wheatgrass, bluebunch
Field pea (Austrian winter and newer varieties)	Subterranean clover	Wheatgrass, crested
Greenleaf desmodium	Velvetbean	Wheatgrass, intermediate

See footnotes at end of table.

Table 3–4 Forage species suitability based on soil drainage class (continued)

Species and soil drainage class suitability range

Species	Drainage class range [4/]	Species	Drainage class range [4/]
Alemangrass	WD - VPD	Guineagrass	ED - MWD
Alfalfa	ED - MWD	Hop clover	ED - MWD
Alsike clover	WD - PD	Indiangrass	ED - PD
Alyceclover	ED - MWD	Jointvetch *(Aeschynomene falcata)*	ED - MWD
American jointvetch *(Aeschynomene americana)*	WD - PD	Kentucky bluegrass	WD - SPD
Annual lespedeza	WD - SPD	Kikuyugrass	WD - MWD
Annual ryegrass	WD - PD	Kleingrass	ED - PD
Arrowleaf clover	ED - PD	Ladino clover	WD - PD
Bahiagrass	ED - PD	Lappa clover	WD - PD
Ball clover	WD - PD	Limpograss	WD - PD
Bentgrass	WD - PD	Little bluestem	ED - MWD
Bermudagrass, coastal	ED - MWD	Meadow foxtail	WD - PD
Bermudagrass, common	WD - SPD	Orchardgrass	ED - MWD
Berseem clover	WD - PD	Pearl millet	ED - MWD
Big bluestem	ED - PD	Perennial peanut	ED - MWD
Birdsfoot trefoil	WD - PD	Perennial ryegrass	WD - PD
Black medic	ED - MWD	Persian clover	WD - PD
Brassicas (forage kale, rape, swedes, and turnip)	WD - MWD	Prairiegrass (*Bromus willdenowii*)	ED - MWD
Bur clover	WD - PD	Red clover	WD - SPD
Carpon desmodium	WD - SPD	Redtop	ED - VPD
Caucasian bluestem	ED - PD	Reed canarygrass	ED - VPD
Chicory	WD - MWD	Rescuegrass (*Bromus catharticus*)	WD - PD
Cicer milkvetch	ED - PD	Rhodesgrass	WD - SPD
Cluster clover	ED - MWD	Rose clover	ED - MWD
Corn, silage or grazed stalks	WD - MWD	Sainfoin	ED - MWD
Crabgrass	WD - SPD	Sericea lespedeza	ED - MWD
Crimson clover	ED - MWD	Singletary pea (also called caleypea or roughpea)	WD - PD
Crownvetch	ED - MWD	Siratro	ED - MWD
Dallisgrass	WD - SPD	Smooth bromegrass	ED - PD
Digitgrass	WD - PD	Soybean	WD - MWD
Eastern gamagrass	WD - PD	Spring small grains	WD - MWD
Elephantgrass	ED - MWD	Strawberry clover	WD - PD
Field pea (Austrian winter and newer varieties)	WD - MWD	Stylo	ED - MWD
Foxtail millet	ED - MWD	Subterranean clover	WD - MWD
Greenleaf desmodium	WD - MWD	Sudangrass or sudan-sorghum hybrids	ED - MWD
		Sweet clover	ED - MWD

See footnotes at end of table.

Table 3–4 Forage species suitability based on soil drainage class (continued)

Species and soil drainage class suitability range

Species	Drainage class range 4/	Species	Drainage class range 4/
Switchgrass	ED - PD	Wheatgrass, crested	WD - MWD
Tall fescue	ED - PD	Wheatgrass, intermediate	WD - MWD
Timothy	WD - SPD	Wheatgrass, pubescent	WD - SPD
Vetch, big flower	WD - MWD	Wheatgrass, slender	ED - PD
Vetch, common	WD - MWD	Wheatgrass, tall	WD - SPD
Vetch, hairy	WD - PD	Wheatgrass, thickspike	WD - PD
Velvetbean	WD - MWD	Wheatgrass, western	WD - PD
Weeping lovegrass	ED - MWD	White clover	WD - PD
Wheatgrass, bluebunch	WD - MWD	Winter small grains	ED - MWD

1/ Sources: Farm Soils, Worthen & Aldrich, 1956; FORADS database, 1990; Forages, Volume 1, 1995; Forage and Pasture Crops, 1950; Forage Plants and Their Culture, 1941; Southern Forages, 1991.

2/ Species shown must also be adapted to the climate found at the site. Some are not cold tolerant while others are not tolerant to hot and humid, or arid conditions.

3/ Thrives in ponded areas and on very poorly drained soils.

4/ Drainage class symbols:
ED—Excessively drained
WD—Well drained
MWD—Moderately well drained
SPD—Somewhat poorly drained
PD—Poorly drained
VPD—Very poorly drained

(2) Importance to management considerations

Most forage crops have been selected that grow best on well-drained soils, the preferred soil drainage class to cultivate. However, this is not universally true for all species selections. Some species have been selected that are adapted to droughty sites and others to very wet sites.

Drainage class also affects the timeliness of planting and harvesting of culturally managed forages. Moderately well drained to very poorly drained soils have varying degrees of wet soil conditions during the year that can delay field work, such as tilling and planting, and grazing by livestock. The wet or seasonally wet soils are easily compacted by wheeled machinery and by livestock hooves. Wheel ruts from machinery tires and pock marks (poaching) from livestock hooves commonly scar the soil surface where traffic by machinery and livestock, respectively, are allowed before the soils have dried to field capacity. This impairs future use and productivity of the soil by:

- Trapping rainfall, thereby increasing soil wetness
- Compacting soils, reducing soil air and restricting root penetration
- Damaging or destroying plants by direct mechanical injury
- Reducing ease of movement by machinery or livestock about the field

Excessively drained to well drained soils can be traversed anytime except under abnormally wet weather. Moderately well drained soils may need to be avoided during wet weather and for a period of up to 1 month afterwards. Somewhat poorly drained soils to poorly drained soils need to be avoided until the seasonal water table has receded down the soil profile to a depth of 12 inches for livestock and 18 inches for machinery. Very poorly drained soils may need to be avoided year-round, unless the vegetation growing on it can support the load put on it by livestock or machinery. Reed canarygrass is one forage that grows well on very poorly drained soils and can support loads well because of its dense and fibrous, diffused root system.

Water management for forage production varies with the drainage class. Excessively drained soils may need irrigation to produce the highest forage yield, even forages tolerant of drought. This is especially true in areas where growing season rainfall amounts are below 18 inches or summer rainfall is inconsistent. Soils that fall in the moderately well drained to very poorly drained classes can produce better forage yields if drained. However, the poorly drained and very poorly drained soils that have not been previously drained may serve as wetlands of value. Artificial drainage of wet soils increases available rooting depth and soil aeration. It allows the roots of most forage plants to respire freely and explore more of the soil mass for nutrients and plant available water. Generally, it is cheaper and easier to select and plant forage species adapted to the soil drainage class found at a site than it is to add or subtract water through irrigation or drainage, respectively. With high yielding and high value forage crops, such as alfalfa, producers often find it economically feasible to irrigate or drain soils to enhance yields.

600.0314 Soil properties influencing forage suitability groups

(a) Available water capacity

Available water capacity (AWC) differs from drainage class in that it deals only with plant available water on a site. AWC is a function of soil texture, organic matter content, salinity, clay type, and rooting depth. Available water capacity, as defined here, is the inches of plant available water held by the soil profile to the depth indicated for the soil moisture regime in which the soil map unit component belongs (table 3–5). Or, it is to the depth the first root restrictive layer is encountered, if less. AWC values should be zero for dense layers from which roots are excluded and zero for all soil layers below them. In some cases where soil internal drainage is poor, the root-restrictive layer very well could be water saturated soil. In other situations it could be a cemented pan or bedrock at a lesser depth than the two depths listed in table 3–5.

From a soil texture standpoint, the silt fraction in a soil has the most influence on AWC: The higher the silt fraction, the higher the AWC. Nonporous rock fragments reduce AWC in proportion to the volume they occupy. On saline soils, AWC is reduced 25 percent for each 4 millimhos per centimeter of conductivity of the saturated extract. In Oxisols and Ultisols, where kaolinite and gibbsite clays are present in high amounts, AWC may be 20 percent lower than in soils having 2:1 lattice clays. Soils high in organic matter have higher AWC than soils that share similar mineralogy, texture, and rooting depth, but are low in organic matter.

Table 3–5 Available water holding capacity limitation categories for forages [1/]

Limitation category [2/]	Soil moisture regimes: Aquic, perudic (in/40 in)	Udic, ustic (in/60 in)	Aridic, xeric [3/] (in/60 in)
Low	< 3	< 4	< 5
Moderate	3–6	4–8	5–10
High	> 6	> 8	> 10

1/ Sources: Cornell U. 1993; Fralish et al. 1978; Stout, Jung, and Shaffer, 1988; and Tisdale, Nelson, and Beaton 1985.
2/ Limited research conducted on available water holding capacity effects on forage production have used only three categories: low, moderate, and high.
3/ Aridic soil moisture regime soils require irrigation for domesticated grasses and legumes.

(1) Available water capacity limitation categories

Agronomically, delineating more than three AWC categories is hard to justify. The categories are low, moderate, and high. Forage researchers studying available water capacity effects on forage yield chose wide ranges in available water to detect statistically significant yield differences among soil series of varying available water holding capacity. For Udic and Ustic soil moisture regimes with up to a 60-inch soil profile, the low water holding capacity category has soils that store less than 4 inches of water in the root zone. In the moderate water holding capacity category, soils store between 4 and 8 inches of water in the root zone. In the high category, the soils hold more than 8 inches of plant available water in the root zone.

For Aridic and Xeric soil moisture regimes, the numbers change to 5 inches for low, 5 to 10 for moderate, and more than 10 inches for high. For aquic and perudic soils, the values are less than 3 inches for low, 3 to 6 inches for moderate, and more than 6 inches for high for a 40-inch soil profile depth. These soils need less water holding capacity because they are generally well supplied with rainfall or have a water table that allows natural subirrigation to occur. See table 3–5.

(2) Importance to management considerations

Available water capacity is significant because large quantities of water are needed to meet the evapotranspiration losses that invariably occur during the growing season. Rainfall alone cannot be depended upon to meet a forage crop's need for water during peak growth periods. This water must be supplied by stored soil water except in the most favorable rainfall areas, where it is abundant and timely during the growing season. Even in the humid Eastern United States, water holding capacity affects forage yield dramatically where summer heat and infrequent significant rain combine to increase forage plant water demand while limiting resupply. For example, moderately well drained soils on uplands that have too much water early in the growing season may have too little water by mid-summer for optimum forage production. This occurs when they have a moderate to low water holding capacity. In this instance, they may have a restrictive soil layer that excludes root growth and causes soil water to perch above it. Once the perched water drains away, the soil reservoir above the restrictive layer does not store sufficient plant available water to meet evapotranspiration needs during prolonged dry, hot weather.

Excessive wetness in the spring results in delays getting livestock or farm machinery on the soil to graze the forage or work the land, respectively. Later, too little water holding capacity to bridge midsummer drought stress results in reduced forage yields.

Low water holding capacity soils, when irrigated, need watering more often at lower dosages. Selecting forage crops that use water more efficiently is critical for maximum production without irrigation on these soils.

(b) Flooding and ponding, frequency and duration

A soil feature that is associated with water impacts on forage production and survival is flooding frequency and duration. Forage plants vary widely in their ability to withstand submergence. A second allied soil feature is seasonal high water table. When the seasonal high water table elevates above the soil surface in closed depressions, it is called ponding. Whether it is called flooding or ponding, standing water impacts forage plants intolerant to the period of submergence similarly. It will either kill or injure them. Where ponding occurs during the winter in climates where ice can form and remain for several days, forage crops can be weakened or killed as a result of toxic levels of carbon dioxide that build up under the ice sheet.

(1) Flooding limitation categories

Established flooding frequency classes are none, very rare, rare, occasional, frequent, and very frequent. For the purpose of FSG's sorting, the number of classes can be reduced to three. Do this by combining **none** with **very rare** and **rare**, leaving **occasional** as a separate category, and combining frequent with **very frequent**.

In the conservation planning of grazing lands, the probability of flood occurring under the **rare** class is too low to be significant to either the forage crop or the means of growing and harvesting it. The flooding frequency for the **occasional** class occurs often enough (about every other year statistically) to be of concern to the landowner and the planner.

The **frequent** and **very frequent** classes occur almost every year under normal rainfall conditions. How often flooding occurs during the year is of minor importance. One event can cause enough harm that ensuing events will have little further impact. Therefore, combining these two classes is acceptable for the purposes of conservation application and planning of grazing lands. Furthermore, submergence duration actually is more important to forage plant survival and health than the frequency of flooding or ponding. If water recedes quickly, little lasting damage occurs. The ponding frequency classes are none, rare, occasional, and frequent.

The flooding or ponding factor is a two-step process in determining to which FSG a soil map unit component belongs. First, there is the process of elimination from considering it to be a limitation or hazard at all. If it is not a feature of the soil map unit component or rarely a feature, place the map unit component into a **none-rare** class. If a soil map unit component has occasional flooding or ponding, then the duration of either becomes important. Forage plants differ widely in their ability to withstand varying lengths of submergence (table 3–6).

Table 3–6 Springtime (< 80 °F) inundation tolerance of selected forage species [1/] [2/]

Species	Average number of days of inundation
Tolerant of very long flooding (> 30 days)	
American jointvetch	49+
Alemangrass	49+
Bermudagrass	45 – 90
Buffalograss	45 – 90
Florida paspalum	30 – 60
Reed canarygrass	49+
Timothy	49+
Wheatgrass, slender	31 – 35
Wheatgrass, western	30 – 60
Tolerant of long flooding (7 – 30 days)	
Alfalfa	9 – 12
Alyceclover	7 – 14
Bahiagrass	15 – 25
Bluegrass, Canada	25 – 35 [3/]
Bluegrass, Kentucky	25 – 35 [3/]
Bluestem, big	7 – 14
Bluestem, silver	5 – 10 [4/]
Bromegrass; smooth	24 – 28
Clover, alsike	10 – 20
Clover, ladino	10 – 20
Clover, red	7 – 15
Clover, strawberry	10 – 20
Clover, sweet	9 – 12
Clover, white	10 – 20
Desmodium, carpon and greenleaf	7 – 14
Digitgrass	15 – 25
Eastern gamagrass	10 – 22
Fescue, tall	24 – 35 [3/] [5/]
	10 – 20 [6/]
Indiangrass	7 – 14
Johnsongrass	10 – 20
Kikuyugrass	7 – 14
Lespedeza, annual	5 – 8 [4/]
Lespedeza, sericea	10 [7/]
Limpograss	15 – 25
Milkvetch, cicer	9 – 12
Oatgrass, tall	15 – 20
Tolerant of long flooding (7 – 30 days)—Cont.	
Orchardgrass	15 – 25
Purpletop	10 – 20
Redtop	25 – 35
Rhodesgrass	15 – 25
Ryegrass, annual	15 – 20 [8/]
Ryegrass, perennial	15 – 25
Sainfoin	5 – 10 [4/]
Siratro	7 – 14
Switchgrass	15 – 30
Trefoil, birdsfoot	20 – 30
Wheatgrass, crested	7 – 10
Tolerant of brief flooding only	
Barley	3 – 6
Bluestem, little	3 – 6
Bluestem, yellow	3 – 6
Clover, crimson	3 – 6
Elephantgrass	3 – 6
Guineagrass	3 – 6
Jointvetch (*A. falcata*)	3 – 6
Lovegrass, weeping	3 – 6
Oats	3 – 6
Perennial peanut	3 – 6
Rye	3 – 6
Stylo	3 – 6
Wheat	3 – 6

1/ Sources: Barnes et al. 1995, Bolton and McKenzie 1946, Gilbert 1999, Heinrichs 1970, Rhoades 1964.
2/ Values shown are from research and only reflect flooding tolerance at springtime temperatures.
3/ Straddle tolerance classes, placed in this class to allow for survival under a slightly higher temperature regime.
4/ Straddle tolerance classes, depending on temperature regime, may want to place in tolerance to brief flooding only.
5/ Cool temperature area, less than 80 °F.
6/ Warm temperature area, more than 80 °F.
7/ Summer value, > 80 °F, no spring value given.
8/ Winter value, no spring value given.

Loss of stands because of flooding duration is also temperature dependent. It takes fewer days of submergence to cause stand loss or damage as soil temperature increases. A flooding study done on alfalfa in 1980 found it could endure 14 days of submergence at a soil temperature of 60 degrees Fahrenheit, 10 days at 70 degrees Fahrenheit, 7 to 8 days at 80 degrees Fahrenheit, and 6 days at 90 degrees Fahrenheit. Therefore, the time of year the flood occurs is important, as is the soil temperature regime common to the soil map unit component (fig. 3–6). For forage crop and pasture lands, the soil temperature regimes encountered in the United States are frigid, mesic, thermic, and hyperthermic. These terms are defined in the glossary.

Duration classes as setup by Part 618 of the National Soil Survey Handbook are:

- **Extremely brief**—0.1 to 4 hours (for flooding only)
- **Very brief**—less than 2 days
- **Brief—**2 to 7 days
- **Long**—7 days to 30 days
- **Very long**—more than 30 days

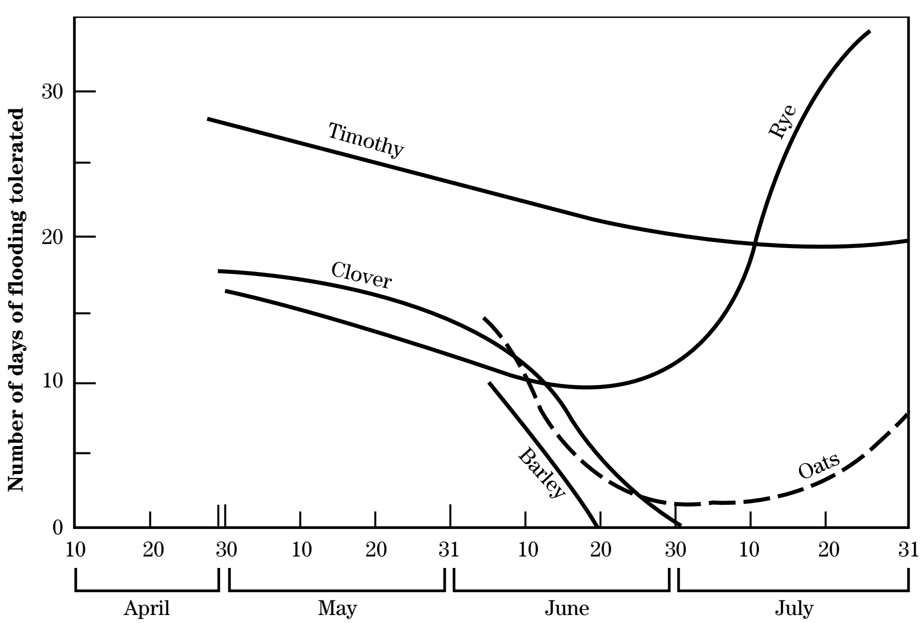
To be useful in determining forage crop survival, a soil temperature range should be specified for the anticipated time of year the flooding or ponding is most likely to occur. If spring flooding is most likely, base forage plant survival on soil temperatures that occur then, such as those shown in table 3–6 except as noted. Grazing land resource managers should be aware that dormant forages are little affected by submergence, provided the water does not turn into ice. Ladino clover is very susceptible to ice injury, for instance, with loss of stand occurring within 12 to 14 days under ice. Severe stand loss of alfalfa can occur after 20 days under ice. Meanwhile, common white clover can survive over 4 weeks of ice cover.

For FSG rating, the duration classes set up by the National Soil Survey Handbook can be condensed into three classes:

- **Brief**—less than 7 days
- **Long**—7 to 30 days
- **Very long**—greater than 30 days

Forage crops generally can withstand flooding for more than 2 days. This does not mean that crop loss associated with flooding will not occur. The aboveground dry matter accumulation before the event may be completely lost as a grazing or harvestable resource, but death of the plant does not occur. A delay in regrowth after the event may also occur.

Figure 3–6 Estimated number of days flooding is tolerated by various crop plants at different times of the growing season under Northern United States conditions, without the plants being destroyed (Source: Luthin 1957)



For assigning high water table soils to the proper FSG, keep in mind that duration of ponding is the length of time soil water is within 6 inches of the soil surface or above. Duration of ponding is in the soil database. Another entry in the soil database shows the span of time, by month, when ponding can occur. Season of occurrence, however, is not an estimate of duration. If duration is not stated, you need to estimate how long the ponded areas remain inundated or saturated.

(2) Importance to management considerations
The destruction of forage crops by inundation is a serious problem on many low-lying fields. Selection of forage species tolerant of the flooding duration that commonly occurs is the most cost-effective approach to dealing with a flooding or ponding problem. Forage crops by themselves are not high value enough to warrant extensive flood control solutions. Depending on their wetland value and the number, depth, distribution, and elevation to an adequate outlet, areas prone to ponding can be reshaped and graded to remove surface water to an outlet. This eliminates or decreases the loss of forage crops where ponding was a problem. In colder climates though, it may not eliminate ice sheet destruction of forage crops. Meltwater is too slow to move out when thaw periods are short.

(c) Soil reaction

Another soil factor affecting FSG's is soil reaction. This is the first factor that deals with a chemical property of the soil. It is also associated with soil water since the chemistry of the soil solution is important to forage growth. Soil reaction is the balance of exchangeable hydroxyaluminum ions, hydrogen ions (H^+), carbonate ions, and hydroxyl (OH^-) ions in the soil solution. Soil reaction is measured in pH units. The pH of a soil solution is the negative logarithm of the concentration of H^+ ion activity in the soil solution. When the soil pH is said to be at absolute neutral, pH = 7.0, an equal number of positively and negatively charged ions are in the soil solution.

(1) Importance to management considerations
Soil reaction is critical for forage growth and production. Some forage crops are tolerant of acid soil conditions. They out-compete forages better suited to alkaline or neutral soils for nutrients. Other forages may be better able to grow under alkaline soil conditions, while still others may only grow best under neutral soil reaction conditions. If the soil reaction is not going to be altered by soil amendments, select forage plants for a seeding mixture based on their ability to all prosper under the pH conditions at the site (table 3–7).

Soil reaction is also an important factor in nutrient and toxic element availability for plant uptake. Very acid soils decrease the solubility of most major plant nutrients as well as some micronutrients, such as molybdenum. Nutrients must be soluble in water to be adsorbed by plant roots. At the same time, very acid soils may release toxic amounts of aluminum, iron, and manganese.

At the other end of the scale, alkaline soils can also decrease plant nutrient solubility, principally phosphorus, boron, copper, iron, manganese, and zinc. Often, the largest problem with these alkaline soils though is their high salt content. The high salt content interferes with water uptake by many forage species and their photosynthetic rate. For instance, sodic soils, soils with a pH greater than 8.5, are generally unproductive for culturally managed forages because of excess sodium and OH^- ions that cause poor soil aggregation and plant root desiccation. Saline and saline-sodic soils are other alkaline soils. They have a pH less than 8.5, but have high amounts of soluble salts that interfere with plant growth. The management needed to address acid soils and alkaline soils is so different that it is best to split soil reaction into two categories: acid soils and alkaline soils.

Critical breakpoints on the pH scale need to be identified in relation to forage plant growth. Many of the agronomically managed forages have a wide range of adaptability to pH. Most prosper in the pH range from 5.6 to 7.3, moderately acid to neutral. As the pH drops below 5.5, strongly acid, increasingly more exchangeable aluminum is released. At pH 4.0, exchangeable aluminum has saturated the cation exchange sites in soils where it is abundant. Few forage plants survive, and none thrive. At pH 8.5 or greater, strongly alkaline, sodium carbonate is present in the soil in amounts that interfere with forage growth.

Table 3–7 Forage species suitability based on soil pH [1/] [2/]

Forage species suited to the narrowest pH range (6.1 – 7.3) near neutral

Cluster clover

Forage species suited to the widest pH range, 4.5–9.0 [3/]
(tolerant of very strongly acid to strongly alkaline soils)

Eastern gamagrass
Redtop
Rhodesgrass
Tall fescue

Forage species suited to a pH range of 5.6–7.3 (tolerant of moderately acid soils)

Brassicas (forage kale, rape, swedes, and turnip)
Indiangrass
Kentucky bluegrass
Soybean
Sudangrass or sudan-sorghum hybrids

Forage species suited to a pH range of 5.1–7.3 [3/] (tolerant of strongly acid soils)

Alemangrass
Alsike clover
American jointvetch (*Aeschynomene americana*)
Bentgrass
Carpon desmodium
Crabgrass
Foxtail millet
Hop clover
Jointvetch (*Aeschynomene falcata*)
Kleingrass
Kura clover

Forage species suited to a pH range of 4.5–7.3: [3/] (tolerant of very strongly acid soils)

Alyceclover
Annual lespedeza (*L. striata*)
Crownvetch
Kikuyugrass
Sericea lespedeza
Stylo

Forage species suited to a pH range of 5.6–8.4
(tolerant of moderately acid to moderately alkaline soils)

Annual ryegrass
Arrowleaf clover
Chicory
Dallisgrass
Elephantgrass
Field pea (Austrian winter and newer varieties)
Orchardgrass
Pearl millet
Persian clover
Prairiegrass (*Bromus willdenowii*)
Rescuegrass (*Bromus catharticus*)
Singletary pea (also called caleypea or roughpea)
Smooth bromegrass
Sweet clover
Vetch, hairy

Forage species suited to a pH range of 6.1–8.4 (tolerant of slightly acid to moderately alkaline soils)

Alfalfa
Ball clover
Berseem clover
Bur clover
Lappa clover
Meadow and creeping foxtails
Sainfoin
Wheatgrass, intermediate
Wheatgrass, thickspike

See footnotes at end of table.

Table 3–7 Forage species suitability based on soil pH [1/] [2/] —(Continued)

Forage species suited to a pH range of 6.7–9.0 (tolerant of alkaline soils)

Wheatgrass, bluebunch
Wheatgrass, crested
Wheatgrass, pubescent
Wheatgrass, slender
Wheatgrass, tall
Wheatgrass, western

Forage species suited to a wide pH range of 5.1–8.4 [3/]
(tolerant of strongly acid to moderately alkaline soils)

Annual lespedeza (*L. stipulacea*)
Bahiagrass
Big bluestem
Birdsfoot trefoil
Black medic
Caucasian bluestem
Cicer milkvetch
Coastal bermudagrass
Corn, silage or grazed stalks
Crimson clover
Digitgrass
Greenleaf desmodium
Guineagrass
Ladino clover
Limpograss
Little bluestem
Perennial peanut
Perennial ryegrass
Purpletop
Red clover
Reed canarygrass
Rose clover
Siratro
Spring small grains
Strawberry clover
Subterranean clover
Switchgrass
Timothy
Vetch, common
Weeping lovegrass
White clover
Winter small grains

Species and soil pH suitability range [3/]

Species	Soil pH suitability range	Species	Soil pH suitability range
Alemangrass	5.1 – 7.3	Brassicas (forage kale, rape, swedes, and turnip)	5.6 – 7.3
Alfalfa	6.1 – 8.4	Bur clover	6.1 – 8.4
Alsike clover	5.1 – 7.3	Carpon desmodium	5.1 – 7.3
Alyceclover	4.5 – 7.3	Caucasian bluestem	5.1 – 8.4
American jointvetch (*Aeschynomene americana*)	5.1 – 7.3	Chicory	5.6 – 8.4
Foxtail millet	5.1 – 7.3	Cicer milkvetch	5.1 – 8.4
Annual lespedeza (*L. striata*)	4.5 – 7.3	Cluster clover	6.1 – 7.3
Annual lespedeza (*L. stipulacea*)	5.1 – 8.4	Corn, silage or grazed stalks	5.1 – 8.4
Annual ryegrass	5.6 – 8.4	Crabgrass	5.1 – 7.3
Arrowleaf clover	5.6 – 8.4	Crimson clover	5.1 – 8.4
Bahiagrass	5.1 – 8.4	Crownvetch	4.5 – 7.3
Ball clover	6.1 – 8.4	Dallisgrass	5.6 – 8.4
Bentgrass	5.1 – 7.3	Digitgrass	5.1 – 8.4
Bermudagrass, coastal	5.1 – 8.4	Eastern gamagrass	4.5 – 9.0
Bermudagrass, common	5.1 – 8.4	Elephantgrass	5.6 – 8.4
Berseem clover	6.1 – 8.4	Field pea (Austrian winter and newer varieties)	5.6 – 8.4
Big bluestem	5.1 – 8.4		
Birdsfoot trefoil	5.1 – 8.4	Greenleaf desmodium	5.1 – 8.4
Black medic	5.1 – 8.4	Guineagrass	5.1 – 8.4

See footnotes at end of table.

Table 3–7 Forage species suitability based on soil pH [1/] [2/] —(Continued)

Species	Soil pH suitability range	Species	Soil pH suitability range
Hop clover	5.1 – 7.3	Sirato	5.1 – 8.4
Indiangrass	5.6 – 7.3	Smooth bromegrass	5.6 – 8.4
Jointvetch (*Aeschynomene falcata*)	5.1 – 7.3	Soybean	5.6 – 7.3
Kentucky bluegrass	5.6 – 7.3	Spring small grains	5.1 – 8.4
Kikuyugrass	4.5 – 7.3	Strawberry clover	5.1 – 8.4
Kleingrass	5.1 – 7.3	Stylo	4.5 – 7.3
Kura clover	5.1 – 7.3	Subterranean clover	5.1 – 8.4
Ladino clover	5.1 – 8.4	Sudangrass or sudan-sorghum hybrids	5.6 – 7.3
Lappa clover	6.1 – 8.4	Sweet clover	5.6 – 8.4
Limpograss	5.1 – 8.4	Switchgrass	5.1 – 8.4
Little bluestem	5.1 – 8.4	Tall fescue	4.5 – 9.0
Meadow and creeping foxtails	6.1 – 8.4	Timothy	5.1 – 8.4
Orchardgrass	5.6 – 8.4	Vetch, big flower	5.1 – 7.3
Pearl millet	5.6 – 8.4	Vetch, common	5.1 – 8.4
Perennial peanut	5.1 – 8.4	Vetch, hairy	5.6 – 8.4
Perennial ryegrass	5.1 – 8.4	Velvetbean	5.1 – 7.3
Persian clover	5.1 – 8.4	Weeping lovegrass	5.1 – 8.4
Prairiegrass (*Bromus willdenowii*)	5.6 – 8.4	Wheatgrass, bluebunch	6.7 – 9.0
Purpletop	5.1 – 8.4	Wheatgrass, crested	6.7 – 9.0
Red clover	5.1 – 8.4	Wheatgrass, intermediate	6.1 – 8.4
Redtop	4.5 – 9.0	Wheatgrass, pubescent	6.7 – 9.0
Reed canarygrass	5.1 – 8.4	Wheatgrass, slender	6.7 – 9.0
Rescuegrass (*Bromus catharticus*)	5.6 – 8.4	Wheatgrass, tall	6.7 – 9.0
Rhodesgrass	4.5 – 9.0	Wheatgrass, thickspike	6.1 – 8.4
Rose clover	5.1 – 8.2	Wheatgrass, western	6.7 – 9.0
Sainfoin	6.1 – 8.4	White clover	5.1 – 8.4
Sericea lespedeza	4.5 – 7.3	Winter small grains	5.1 – 8.4
Singletary pea (also called Caleypea or Roughpea)	5.6 – 8.4		

1/ Sources: Ball, D.M., et al., 1991, Southern forages; Barnes, R.F., et al., 1995, Forages; Brady, N.C., and A.G. Norman, 1957, 1965, 1970, Advances in agronomy, Vols. 9, 17, 22; Brady, Nyle C., 1974, The nature and properties of soils, 8th ed.; Dalrymple, R.L., et al., Crabgrass for Forage 1999; Hanson, A.A., et al., 1988, Alfalfa and alfalfa improvement; Kabata-Pendias, A., and H. Pendias, 1984, Trace elements in soils and plants; Piper, C.V., 1941, Forage plants and their culture; Undersander, D., et al., 1990, Red clover establishment, management, and utilization, UWEX A3492; Wild, Alan, 1988, Russell's soil conditions and plant growth, 11th ed; and Wheeler, W.A., 1950, Forage and pasture crops.

2/ Species shown must also be adapted to the climate at the site. Some are not cold tolerant, while others are not tolerant to hot and humid or arid conditions.

3/ Species listed here may be adversely affected by exchangeable aluminum or manganese on soils high in aluminum or manganese when pH is less than 5.5.

(2) Acid soils

A large part of the United States has a mantle of acid soils. They are soils that, to varying degrees, have been leached of their exchangeable bases (primarily calcium, magnesium, and potassium) by percolating soil water. The primary means to manage acid soils for forage production is to apply lime. This elevates the pH of the soil and the base saturation of the soil's cation exchange sites to a level that optimizes the growth of the selected crop. The hydroxyaluminum and H^+ ions on the cation exchange sites are neutralized by the carbonate and replaced by the bases contained in the lime, calcium alone, or calcium and magnesium. In the Northern United States, lime generally is added to raise acid soils to a slightly acidic o neutral pH, 6.5 to 6.8. However, some forage crops do not need that degree of pH correction. Bermudagrass stands need to be only limed to elevate the pH to 5.5. Lespedeza response to lime amendments is limted above 6.0. On Oxisol, Spodosol, and Ultisol soils in the warm, humid Southern United States, pH values should not be elevated above 6.2. Liming certain soils high in dispersible clays above that level in those soil orders reduced water percolation, soil tilth, growth of forages, and plant uptake of phosphorus and micronutrients.

(i) Acid soil limitation categories—To create FSG's for acid soils, the buffering ability as well as the typical pH range must be considered. Most land grant experiment stations and soil testing laboratories calibrate the lime requirement of the major soil series for the state they serve (fig. 3–7).

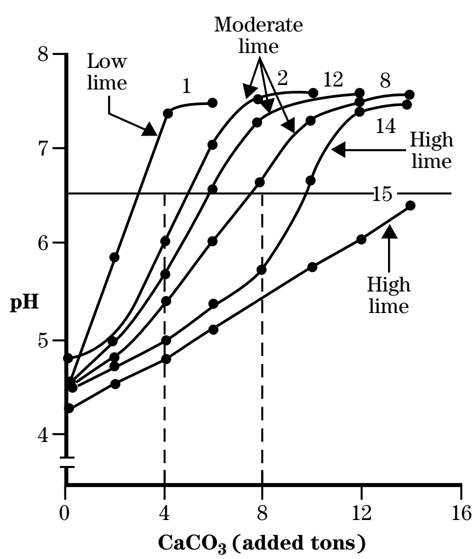
Soil series with similar lime requirements to raise the pH to the appropriate level for the crop to be grown can be grouped together. This may be done with as few as three categores: low, moderate, and high lime requirement. For those states without titration curves as shown in figue 3–7, the following rules-of-thumb can be used with some confidence.

- Soils with a **low** lime requirement have an average cation exchange capacity (CEC) less than 7 milliequivalents per 100 grams of soil (meq/100 g) regardless of pH level, or have a native pH above 6.2 regardless of CEC.
- Soils with a **moderate** lime requirement have an average CEC within the range of 7 to 15 meq/100 g and a native pH between 5.5 and 6.2.
- Soils with a **high** lime requirement have a native pH below 5.5 and a CEC greater than 7, or have a native pH between 5.5 and 6.2 with a CEC greater than 15 meq/100 g.

Figure 3–7 Titration curves for representative soils from Ohio after incubation with $CaCO_3$ for 17 months (adapted from Tisdale 1985)

Example: To raise pH to 6.5, lime requirement rating would be:

Low - 0-4 tons/acre of $CaCO_3$
Moderate - 4-8 tons/acre of $CaCO_3$
High - >8 tons/acre of $CaCO_3$



(ii) Importance to management considerations —Generally, liming soils is an inexpensive practice unless the rate of application exceeds 4 tons per acre or the local price of lime is high as a result of the travel distance to the nearest source of material. The materials used to lime soils are generally inexpensive. They are bulky, requiring heavy equipment to dig, crush, sieve (limestone rock), and load, and heavy trucks to transport to the site andspread. Properly liming soils increases the availability of many essential nutrients needed for plant growth while damping the availability of toxic elements, such as aluminum and manganese. It also tends to impove soil tilth of fine textured soils by increasing soil particle aggregation.

Soil pH response to liming differs from soil to soil depending on the amount of clay and humus particles in each and the number of cation exchange sites presented by these particles. Acid soils act as bffered weak acids and resist sharp changes in pH. Some are more buffered than others are. The degree of buffering is related primarily to the total amount of clay and organic matter in a soil. The nature of the clay lattices and their relative proportion in the soil also affect their buffering activity. Soils having 1:1 type lattice clays have less cation exchange sites than soils with 2:1 type lattice clays. Sands and loamy sands have small amounts of clay and organic matter in them and are, therefore, low in cation exchange capacity and poorly buffered. They require the least amount of lime to achieve desired soil pH levels. Meanwhile, silty clay loams and clay loams generally are highly buffered. Therefore, these soil textures require the most lime to elevate soil pH to a given level.

(iii) Aluminum toxicity associated with acid soils—In areas where some soils, primarily in soil orders Oxisol, Spodosol, and Ultisol of the Southeastern United States, cause plants to exhibit aluminum (Al) toxicity symptoms at low subsoil (subplow layer) pH levels (< 5), it is worthwhile to add this information to FSG's. This occurs on soils or acid mine spoils where exchangeable Al generally occupies more than 60 percent of the effective cation exchange capacity (CEC) of the soil or spoil within the upper 20 inches.

Forage plants differ widely in their ability to tolerate exchangeable and water soluble aluminum present in acid soils. Where acid mine spoils contained 3.9 meq/100 grams of exchangeable Al, 3 ppm of water soluble Al was present. This was enough to be toxic to the somewhat tolerant and intolerant forage species listed in table 3–8. The table lists forage plants according to their tolerance to water soluble Al in soils, as it was the most reliable differentiation measure. Unfortunately, exchangeable Al and the percentage of soil CEC it occupies are all that can be gleaned from soil test results if that. Some soil test reports only list hydrogen (H) ion when, in fact, it is a combination of Al and H. McKee et al. (1982) found no water soluble Al in the soils and spoils they studied that contained only 2.8 meq/100 grams of exchangeable Al. Some forage plants normally can tolerate acid soils. However, in the presence of toxic levels of Al, they either fail to grow or grow poorly. The main effect is the stunting of root growth and confining the root system within the top few inches of soil above the toxic zone of Al. This reduces nutrient and water uptake by the forage crop. Aluminum reduces soil phosphorus availability to plant roots. It also interferes with nutrient and water uptake by roots even within the stunted root mass.

Different soil series cause the same susceptible plant species to express aluminum toxicity symptoms at different concentrations of exchangeable aluminum. Even within the same soil series, site differences in toxicity based on soil exchangeable Al concentrations are often found. This is because of the differences in soil pH and other chemical properties that cause different levels of water soluble Al to be present at a given soil level of exchangeable Al. Within plant species, different cultivars differ widely in their susceptibility to aluminum toxicity. Therefore, use caution in stating what concentration level of exchangeable Al is toxic to a plant specie. It can be site and cultivar dependent.

(iv) Aluminum toxicity limitation categories—For FSG development in regions where aluminum toxicity has been verified, it would be best to create the following categories of limitation: slight, moderate, and severe potential for Al toxicity to occur.

Table 3–8 Forage plant tolerance to water soluble aluminum in soils 1/ 2/

Very tolerant (persisted at 17 ppm Al3+ and pH 3.3)	
Bluestem, big	Limpograss
Bluestem, little	Povertygrass
Eastern gamagrass	Poverty oatgrass
Indiangrass	
Tolerant (persisted at 6 ppm Al3+ and pH 3.3)	
Bluestem, Virginia (broomsedge)	Sericea lespedeza
Panicgrass	Weeping lovegrass
Somewhat tolerant (persisted at 1–2 ppm Al3+ and pH 4.0)	
Alsike clover	Partridge pea
Bentgrass, rough	Perennial ryegrass
Birdsfoot trefoil	Reed canarygrass
Caucasian bluestem	Redtop
Flatpea	Rye, winter
Hairyflower lovegrass	Switchgrass
Millet, Japanese	Tall fescue
Oats	Wheat
Orchardgrass	White clover
Intolerant (persistence reduced at 0.5 ppm Al3+ and pH 4.2)	
Alfalfa	Red clover
Annual ryegrass	Sorghum
Barley	Sorghum-sudan hybrids
Cicer milkvetch	Sweet clover, yellow
Creeping foxtail	Timothy
Crownvetch	Trefoil, big
Prairie sandreed	Trefoil, narrowleaf

1/ Sources: G.W. McKee, et al. 1982. Tolerance of 80 plant species to low pH, aluminum, and low fertility. Agron. Ser. No. 69, Pennsylvania State Univ.; C.D. Foy, 1997.

2/ Toxic concentrations listed are for frame of reference only. Cultivars within forage species vary in their reaction to water soluble Al concentrations in the soil as well, either more or less than the stated concentrations. However, the cultivars are tightly grouped enough to rarely end up in a different tolerance category.

National breakpoints for slight, moderate, and severe potential for Al are:

- **Slight—**Exchangeable Al is less than 30 percent of the effective CEC, or soil pH is greater than 5.5 within 20 inches of the soil surface. Some yield reduction of intolerant forage species. No noticeable yield reduction of tolerants.
- **Moderate—**Exchangeable Al is between 30 and 60 percent of the effective CEC, or soil pH is between 5.0 and 5.5 within 20 inches of the soil surface. Intolerant forage species yields reduced by at least half, wilt easily under any moisture stress, and show nutrient deficiency symptoms. Tolerant species have yields losses of 20 to 30 percent.
- **Severe—**Exchangeable Al is either greater than 60 percent of the effective CEC, 67 percent acidity saturation of CEC by sum of cations at pH 7, 86 percent acidity saturation of CEC by sum of cations at pH 8.2, or pH is less than 5.0 on mineral soils or is less than 4.7 on organics within 20 inches of the soil surface. Intolerant species fail to establish, or they are very weak. Tolerant species have yield losses over 30 percent.

(v) Importance to management considerations —The remedial measure for aluminum toxicity is the application of either lime or gypsum. To best alleviate plant symptoms of aluminum toxicity requires displacing exchangeable aluminum with calcium in soils at depth. This allows deeper root penetration by the forage crop. Gypsum is better in this situation because it can be surface applied and leaches downward through the soil. Some believe the gypsum produced as a by-product of phosphorus fertilizer production from fluorapatite rock phosphate is most effective in lowering available aluminum. The fluoride complexes with monomeric aluminum in the soil. The complex formed is leachable and moves out of the root zone. Typical rate of application is 1 to 3 tons per acre.

Lime is slow to move down into the soil profile. It, theefore, must be incorporated with deep tillage equipment to hae any immediate effect on subsoil pH levels. This is expensive and often prohibits the use of this management alternative. To eliminate aluminum toxicity, raise pH levels to 5.6 or 5.7.

(3) Alkaline soils

Alkaline soils occur primarily in areas where rainfall is limited or on highly weathered soils with restricted drainage. They are the converse of acid soils. The lack of percolating soil water results in little leaching of bases to any great depth. Surface evaporation and capillary movement of soil water upward actually concentrate bases and their salts near or at the soil surface. Alkaline soils are broken down further into four categories: calcareous, saine, saline-sodic, and nonsaline-sodic. This categorization is of critical practical importance in selecting proper management practices to make these soils useful to produce culturally managed forage crops.

Calcareous soils contain free calcium carbonates and range in pH from 7.4 to 8.4. They are neither saline nor sodic, but still affect forage suitability and soil management. The carbonates present in alkaline soils reduce phosphorus and micronutrient availability to forage crops not adapted to calcareous soils. Iron and manganese chlorosis of leaves commonly occurs on susceptible forae crops. Copper, zinc, and molybdenum deficiencie are also possible. Nitrogen fertilizers need incorporation into calcareous soils to prevent nitrite buildup or ammonia volatilization.

Saline soils have less than 15 percent of the cation exchange capacity occupied by sodium ions (ESP), the pH is below 8.5, and an electrical conductivity (EC) greater than 2 millimhos per centimeter (decisiemens per meter) at 25 degrees Celsius (fig. 3–8). Neutral soluble salts, chlorides and sulfates of sodium, calcium, and magnesium, cause the conductivity and interfere with the absorption of water by plants. They create a higher osmotic pressure in the soil solution than in the plant cells. This can cause cell collapse and less water uptake. Salts also interfere with nutrient ion exchange between the soil and plant root, causing nutrient deficiencies in the susceptible plant. Ridding these soils of the excess salts makes them productive for culturally managed forages. Where this entails leaching with irrigation water, receiving waterbodies and wetlands become increasingly saltier unless mitigation efforts are in place. Downstream impacts should not be ignored for any soils mentioned in this section.

Saline-sodic soils in their natural state differ from saline soils only in that exchangeable sodium ions occupy more than 15 percent of the cation exchange capacity (fig. 3–8). Sodium concentrations are now high enough to be toxic to most culturally managed forage crops. On these soils the excess salts and sodium must be removed to make the soil suitable for culturally managed forages. If only the salts are leached away, the soil can become quite alkaline unless buffered naturally by gypsum. This causes poor soil tilth making the soil nearly impervious to water, a poor growth medium, and difficult to till. When gypsum is present in the soil, forage plants can tolerate electrical conductivity of 2 dS/m higher than indicated in figure 3–8.

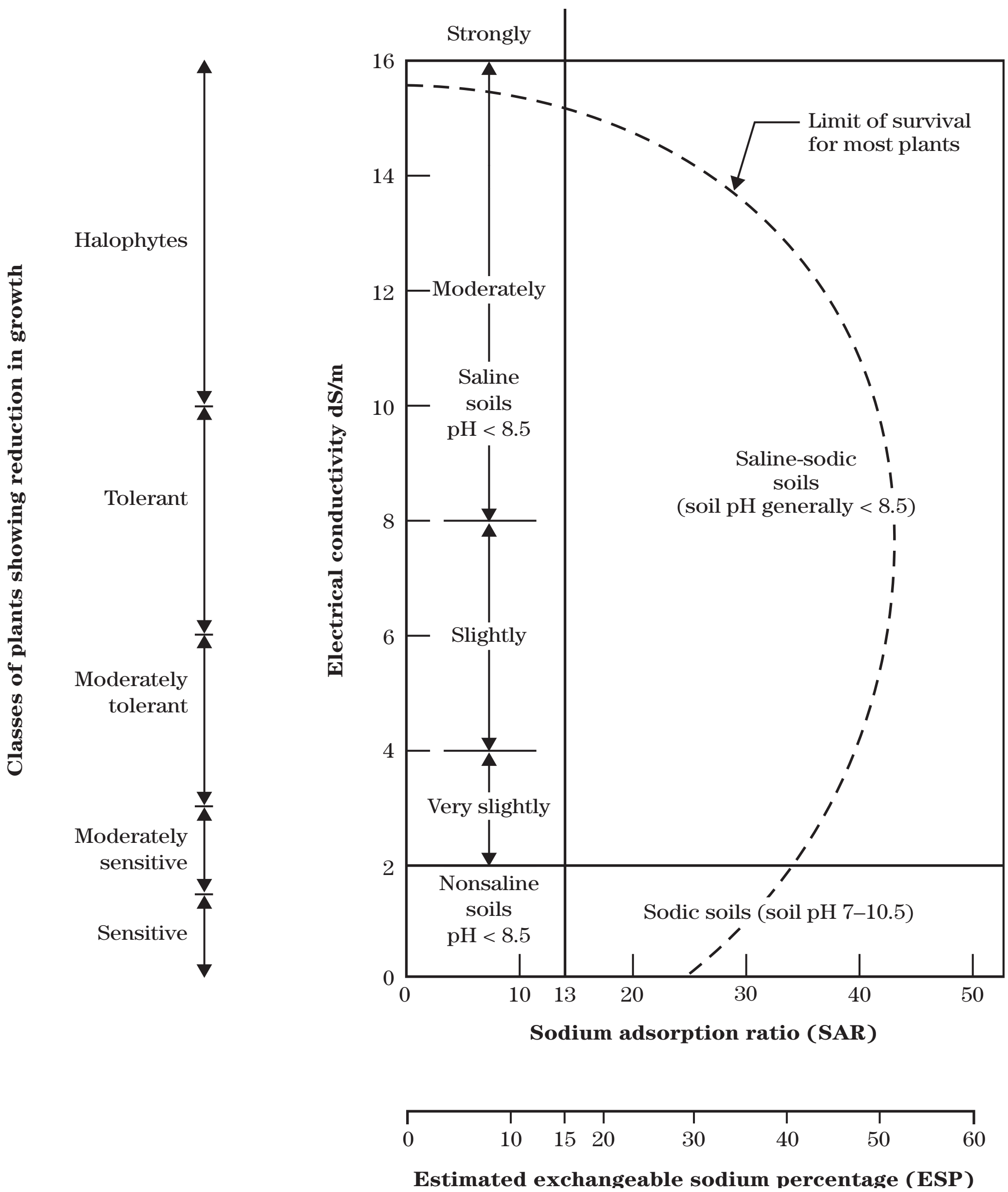
Nonsaline-sodic soils have so few soluble salts that the electrical conductivity is less than 2 millimhos per centimeter. owever, exchangeable sodium exceeds 15 percent of the total exchange capacity of these soils (fig. 3–8). Generally, sodic soils have a pH range of 7.0 to 10.5. Sodium and bicarbonate ions are present in concentrations that are toxic to all culturally managed forages. The bicarbonates are not directly toxic, but induce iron and manganese deficiencies in susceptible plants. The soils also have poor soil tilth because the sodium ions disperse clay and silt particles. When this occurs the soil aggregates are broken down making the soil dense and massive, a poor plant growth medium. These soils, while mostly confined to the arid Western United States, can also occur in depressional areas of highly weathered soils in the Eastern United States. These small depressions are often called slick spots. The soil surface is very black because of disperse organic material being brought to the surface by capillary action. The depressions also occur where saline-sodic soils were leached of their salts. See the paragraph preceding this one. Some nonsaline-sodic soils are actually acid soils, at least in the surface layer. The pH reading can be as low as 6.0. This is due to the absence of soil lime (calcite, aragonite, dolomite, magnesite, or some combination of these).

Alkaline soils have two features, salinity and sodicity, warranting further FSG sorting. Soil salinity is so critical to culturally managed forage crop production that is itdealt with as a separate factor apart from soil reaction. It is described at the end of this part on sodic soil management.

(4) Sodic soils associated with alkaline soils

Sodic soils respond well to treatment with chemical soil amendments and leaching with irrigation water.

Figure 3–8 Classification of nonsaline, saline, saline-sodic, and sodic soils in relations to soil ph, electrical conductivity, sodium adsorption ratio, and exchangeable sodium percentage, and the ranges of plant sensitivity to salinity and sodicity (adapted from Brady and Weil, 1999)



Here, calcium ions are used to displace sodium ions from the cation exchange sites within the top 6 to 12 inches of the soil. The chemical amendment of choice is dependent on the sodic soil class being treated, desired method of application, the cost and availability of the amendment, and to some extent, the speed of reaction with the soil. Chemical amendments generally selected are gypsum, sulfur, sulfuric acid, and lime-sulfur. Another amendment, lime, is used only when the sodic soil being treated contains litle to no native lime and pH readings would be driven below 6.0 by the other amendments.

Of the commonly used chemical amendments, sulfuric acid is the fastest acting. Sulfur is the slowest because soil micro-organisms must oxidize it first. This creates sulfur dioxide that combines with soil water to form sulfuric acid that then dissolves calcium from soil lime. Generally, lime-sulfur can be added to the irrigation water and applied in that manner on irrigated fields. Sulfur or lime must be spread and tilled into the soil. Gypsum can be spread and mixed into the soil, or applied with irrigation water. Sulfuric acid is sprayed on the soil or applied with irrigation water.

(i) Sodic soil limitation categories—Sodic soils are assigned to three classes governed by their response to chemical soil amendments:

- **Class 1** are sodic soils containing lime.
- **Class 2** sodic soils have a pH greater than 7.5, but are nearly free of lime.
- **Class 3** sodic soils have a pH less than 7.5 and no lime.

(ii) Importance to management considerations—Class 1 sodic soils respond well to any of the four amendments (gypsum, sulfur, sulfuric acid, or lime-sulfur). No lime is needed for this class as it is already in the soil.

Class 2 sodic soils may benefit from the addition of lime only if the acidifying amendments (sulfur, sulfuric acid, and lime-sulfur) are used and drive the soil pH below 6.0. The acid neutral amendment, gypsum, will not change the soil pH. In this case, no lime is required for a class 2 sodic soil.

Class 3 sodic soils may indeed be acid soils that have pH readings below 7.0. They can benefit from the addition of lime only. Generally though, lime is used in combination with one of the other sulfurous amendments.

Since sodic soils differ in their response to soil amendments, FSG's should distinguish into which of the three classes each soil series falls.

(d) Salinity

Soil salinity is a soil property of great importance over much of the Western United States where culturally managed forages are grown. It may be a general condition of a particular soil series, or it may occur as a saline seep area. The latter is caused when ground water with excessive salt concentrations draining across a soil or rock layer of low permeability surfaces at contact points between the impermeable layer and the ground surface, at rock fractures below the surface if under hydrostatic pressure, or at abrupt slope breaks. Seven types of seeps have been described and are illustrated in figure 3–9.

Saline soils may need leaching to lower their salt concentrations to levels that the forage crop to be grown will tolerate. This is accomplished best by applying excess irrigation water low in sodium and dissolved salts to cause downward percolation of water through the soil profile. Then, underlying tile drains convey the resultant leachate to an outlet. The soils must be pervious and high in calcium and magnesium. It is often necessary to land level and/or dike irrigated fields to pond water over the entire crop field. This allows for evenly distributed leaching of the soil profile of its excess salts by irrigation water. When growing forage crops, selecting salt tolerant ones (see table 3–9) is useful to protect a producer from crop failures even when saline soils have been leached. These soils tend to become salty again over time, especially if irrigated with water high in soluble salts. Therefore, planting salt-tolerant forage is insurance to guard against a gradual increase in soil salinity before treatment is initiated again. See NRPH chapter 5, section , accelerating practices irrigation water management and soil amendment application for an overview of treatment measures for growing forage crops on saline and sodic soils.

The salt tolerance data in table 3–9 apply to surface-irrigated forage crops and conventional irrigation management. Sprinkler-irrigated forage crops may suffer leaf burn from salt in the spray water contacting leaves and foliar salt uptake. The available data for predicting yield losses from foliar spray effects is limited. Sodium and chloride concentrations of 10 to 20 millimoles per liter in sprinkler irrigation water can cause foliar injury to at least alfalfa, barley, corn, and sorghum. The amount of damage also varies with the weather conditions, spray droplet size, and crop growth stage as well as from the salt concentrations in the irrigation water.

Figure 3–9 Seven geologic conditions for saline-seep development (source: Tanji 1990)

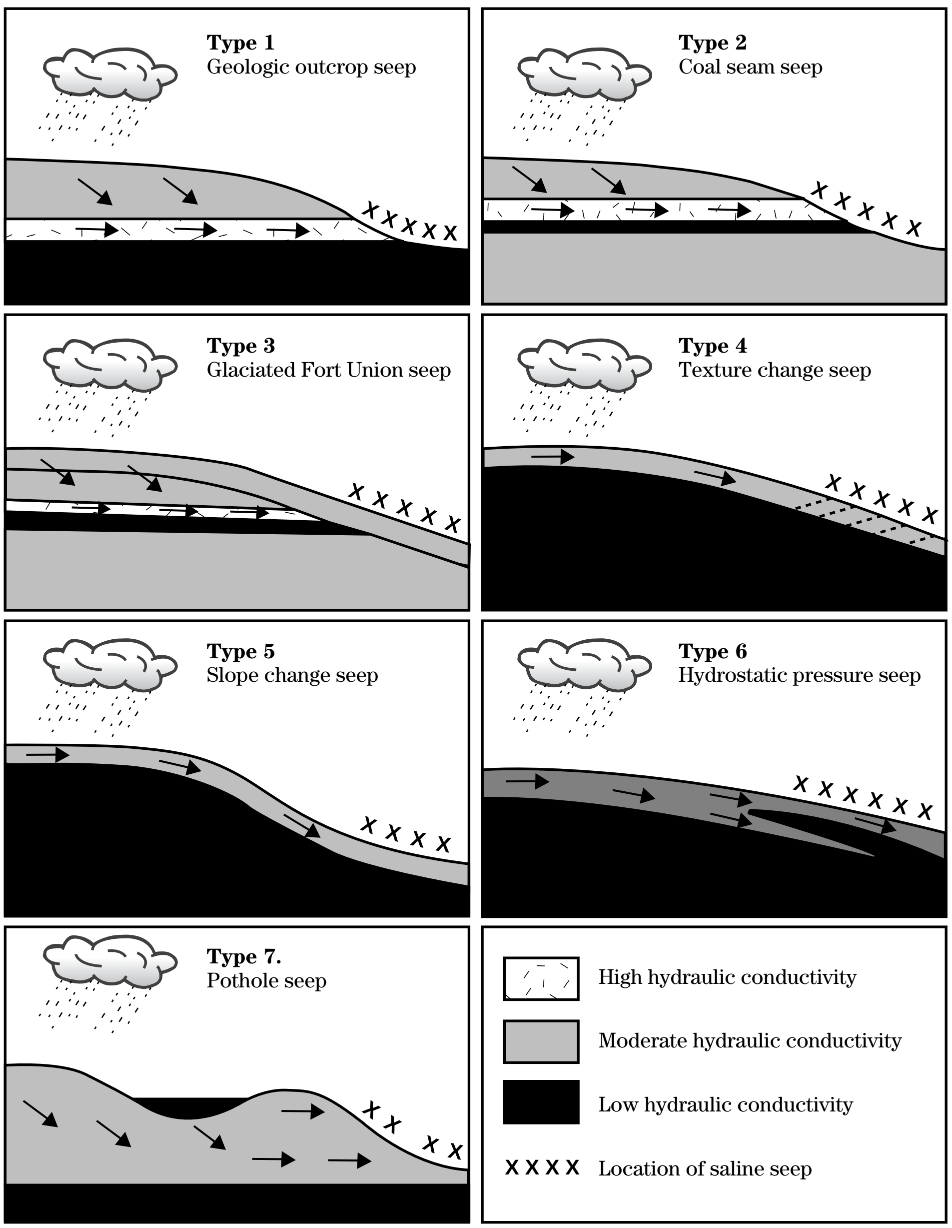


Table 3–9 Salt tolerance of forage grasses and legumes [1/] [2/]

Tolerant, 6–10 dS/m (millimhos/cm)	
Alkaligrass, nuttal	Saltgrass, desert
Alkali sacaton	Wheatgrass, fairway crested
Bentgrass, seaside creeping	Wheatgrass, tall
Bermudagrass	Wheatgrass, western
Crabgrass	Wildrye, Altai
Rape	Wildrye, Canadian
Rescuegrass	Wildrye, Russian
Rhodesgrass	
Moderately tolerant, 3–6 dS/m (millimhos/cm)	
Barley (forage)	Oats (forage)
Bromegrass, mountain	Panicgrass, blue
Bromegrass, smooth	Rye (forage)
Canarygrass, reed	Ryegrass, Italian
Clover, hubam	Ryegrass, perennial
Clover, sour	Sudangrass
Clover, white sweet	Trefoil, broadleaf birdsfoot
Clover, yellow sweet	Trefoil, narrowleaf birdsfoot
Dallisgrass	Wheat (forage)
Fescue, meadow	Wheatgrass, standard crested
Fescue, tall	Wheatgrass, intermediate
Grama, blue	Wheatgrass, slender
Hardinggrass	Wildrye, beardless
Milkvetch, cicer	
Oatgrass, tall	
Moderately sensitive, 1.5–3 dS/m (millimhos/cm)	
Alfalfa	Foxtail, meadow
Bentgrass, colonial	Kale
Bluegrass, Kentucky	Lovegrass species, Lehmann 50% more tolerant than others
Buffelgrass	Orchardgrass
Burnet	Sesbania
Clover, alsike	Siratro
Clover, berseem	Timothy
Clover, ladino	Trefoil, big
Clover, red	Turnip
Clover, strawberry	Vetch, common
Clover, white dutch	
Corn (forage)	

1/ Sources: Bernstein, L. 1958. Salt tolerance of grasses and forage legumes. USDA AIB 194; Brady and Weil, 1999; Dalrymple et al., 1999; Maas, 1986; Rhoades and Loveday, 1990.

2/ Brady and Weil, Maas, and Rhoades and Loveday updated original data by Bernstein. Species now appear in alphabetical order with regard to EC tolerance within class. Changes to species rating from the original Bernstein data only made if definitive newer data were presented. Additional species and their ranking added from Rhoades and Loveday table.

In the case of saline seeps, the growth of a deep-rooted forage crop, such as alfalfa, in the recharge area of the seeps actually becomes a treatment option. Another option is to abandon fallow farming if implicated with saline seep development. If crops use enough soil water in the recharge area during the time they are in the crop rotation, they can reduce or stop deep percolation and minimize or prevent saline seep reoccurrence.

(i) Salinity limitation categories—For FSG categorization, four categories of importance are used to determine how soils should be grouped from a salinity standpoint. Soils that have readings less than 2 millimhos per centimeter at 25 degrees Celsius are nonsaline. The four saline soil categories are:

- Very slightly saline—2 to 4 mmhos/cm (dS/m)
- Slightly saline—4 to 8 mmhos/cm (dS/m)
- Moderately saline—8 to 16 mmhos/cm (dS/m)
- Strongly saline—more than 16 mmhos/cm (dS/m)

(ii) Importance to management considerations—Very slightly saline soils can restrict the yields of sensitive forage crops. Slightly saline soils restrict the yield of most forage crops except the most tolerant. Moderately saline soils depress the yields of even salt tolerant forages and may render them less palatable. If the forage accumulates salts in its plant tissue, feeding it to livestock may cause them to scour (diarrhea). Strongly saline soils will not produce acceptable yields of any agronomic forage crop.

(e) Native fertility

Native fertility of soils determines their need for and response to added plant nutrients. The two indicators available nationwide from soil survey information are cation exchange capacity (CEC) and organic matter. Although they do not tell the complete story, they are consistently developed and available for all soil series.

Where available, information on native levels of phosphorus (P) and potassium (K) should be included in FSG reports. This information is available from the soil science department of some land grant universities. Some care must be taken in the use of that information, however. Around the United States, some soils have high levels of total native phosphorus and potassium, while others are quite low. Unfortunately, having a high total content does not necessarily translate into having a high level of available P or K. If soils are rated on their P or K supplying power, then this information could be used with confidence in establishing FSG's on this factor. However, if the soils are low in total P and K, this is a strong indicator that these soils are not particularly fertile mediums for plant growth. Soils of the southeastern and southern coastal plain of the United States are low in both nutrients.

(1) Cation exchange capacity

(i) CEC limitation categories—For FSG categorization, use three categories of soil CEC:

- **Low—**0 to 7 milliequivalents (meq)/100 grams of soil
- **Moderate—**7 to 15 meq/100 grams of soil
- **High—**more than 15 meq/100 grams of soil

The limits of each category may need to change depending upon the observed range of CEC values for all soil series in a state. The ranges given are examples only; however, they are often used as breakpoints for soil fertilizer recommendations.

(ii) Importance to management considerations —CEC is important. It indicates the soil's ability to retain in the rooting zone plant available nutrients that occur as cations. Low CEC soils hold few plant nutrient cations.These soils require frequent additions of smaller amounts of fertilizer than soils with high CEC. For instance, soil test recommendations for K, a cation, limit application rates because of this. Low CEC soils have lower recommended K fertilizer rates stated for them than those for high CEC soils. Putting too much K in the soil can lead to plant nutrient uptake imbalances if it was to occupy more of the exchange sites than is desirable, more than 5 percent K saturation. The optimum level of potassium is 2 to 3.3 percent of the soil's CEC.

Soil nutrient imbalances can adversely affect forage production and, at times, the ruminants feeding on them. Overfertilizing with nitrogen (N) or K may reduce magnesium (Mg) uptake by forages. Freshening cows eating low Mg content forages may get grass tetany, a malady caused by a diet deficient in Mg.

(f) Soil organic matter

(1) Limitation categories

Mineral soils must first be separated from organic soils to deal with soil organic matter influence on FSG's. Freely drained mineral soils are never saturated with water for more than a few days and have less than 20 percent organic carbon by weight. Seasonally saturated or artificially drained mineral soils have less than 12 percent organic carbon, by weight, if the mineral fraction has no clay; less than 18 percent organic carbon, by weight, if 60 percent of or more of the mineral fraction is clay; or a proportional content of organic carbon between 12 and 18 percent if the clay content of the mineral fraction is between zero and 60 percent.

Undrained saturated organic soils, such as peats and mucks, with no clay content must have 12 percent or more organic carbon. As clay content increases from 0 to 60 percent, organic carbon content must increase from 12 to 18 percent as a minimum. If clay exceeds 60 percent, organic carbon must exceed 18 percent for a saturated soil to be considered an organic one. Freely draining organic soils must contain 20 percent or more organic carbon regardless of clay content. Organic soils can be dealt with separately from a fertility standpoint. Generally, they are quite low in P, K, and available copper (Cu), while high in N and calcium (Ca).

Mineral soils can be broken out into four levels of organic matter to form FSG's:

- **Low in organic matter**—less than 1 percent organic matter
- **Moderate—**1 to 4 percent organic matter
- **High**—4 to 10 percent organic matter
- **Very high**—more than 10 percent organic matter

The latter category contains soils with a modifier in the name called mucky. Machinery tires and livestock hooves easily damage wet, mucky soils. To avoid damage to forage crops, defer grazing or machinery entry onto the mucky soil until ry. Organic matter is derived from organic carbon measurements by multiplying organic carbon by a factor of 1.72.

(2) Importance to management considerations

Soil organic matter content is important for a number of soil fertility reasons. It acts as a reservoir that supplies plant nutrients, N, P, sulfur (S), zinc (Zn), and boron (B), to growing forages. All of these nutrients exist as anions in the soil. Farmed soils generally do not have an anion exchange of any great importance. Therefore, these nutrients, as they are released through organic matter decomposition, become available for plant uptake unless fixed or until leached out of the root zone. To a certain extent organic matter content is an overlapping factor with CEC because in many soils it provides the majority of the cation exchange sites. However, it also promotes good soil structure by encouraging soil particle aggregation. This increases soil porosity, promotes water infiltration, increases available water holding capacity, decreases soil crusting, and makes soils less prone to compaction. A soil in good physical condition is more productive. Finally, soil organic matter acts as a buffer against rapid changes in acidity, sodicity, and salinity.

Mineral soils low in organic matter need low rate, split applications of N during the growing season on all grass forage stands. They have little N supplying power or holding ability. For this category in particular and the moderate category, the growing of legumes with grasses is beneficial in providing N to the grasses. Low organic matter soils are not likely to rise significantly in organic matter content when amended with organic materials or left in long-term sod, such as permanent pasture. Where they occur, climatic and soil conditions are too conducive to high rates of decomposition. Soils in the other categories of organic matter content need less frequent applications of N on all grass forage stands. At the very high category, N may be mineralized at levels sufficient to meet the needs of an all grass forage stand.

(g) Frost heave (potential frost action)

In the Northern United States, frost heave potential of soils has a direct bearing on legume and winter small grain survival. (NRCS soil scientists use the term *potential frost action.* Frost heave is a result of frost action.) Taprooted legumes can have their roots snapped in two by frost lenses. Legumes and some grasses are raised out of the soil several inches, exposing the roots. Many of the plants die of dehydration or freezing. The ones that do survive have reduced vigor and can suffer further damage by livestock hooves and machinery traffic. Soil temperatures must drop below 32 °F for frost heave to occur. Frost heave occurs when ice lenses or bands develop in the soil. These lenses drive an ice wedge between two layers of soil near the soil surface. The resultant wedge heaves the overlying soil layer upward, snapping roots. When the ground thaws, the overlying soil layer settles back down leaving the severed roots exposed to the air (fig. 3–10).

The approximate geographic boundary above which frost heave becomes a problem is the 250 degree-day below 32 degree Fahrenheit isoline shown in figure 3–11. This is the number of degree-days below 32 degrees Fahrenheit that can be expected in the coldest 1 year in 10. Silty and very fine sandy soils have the greatest potential to frost heave. They have small enough pores to hold enough water under tension to form an ice lens, but still coarse enough to transmit surrounding super-cooled soil water to the freezing front on either side of the ice lens.

(1) Limitation categories

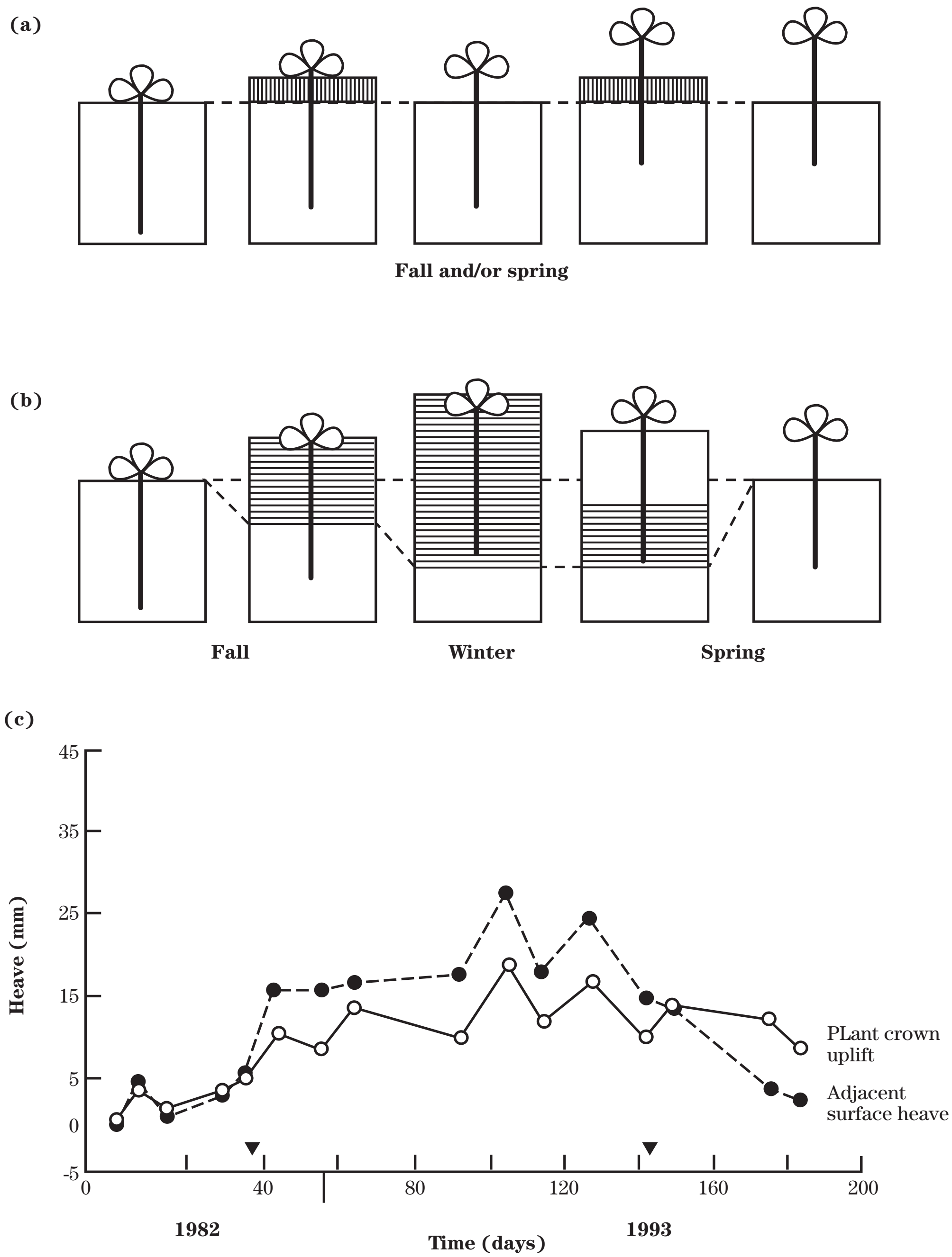
The three classes of frost heave potential are:

- **Low**—Soils are rarely susceptible to the formation of ice lenses. Frost heave of legumes or winter small grains unlikely.
- **Moderate**—Soils are susceptible to the formation of ice lenses, resulting in frost heave. Winters with few freeze and thaw cycles decrease likelihood of legume or winter small grain damage.
- **High—**Soils are highly susceptible to the formation of ice lenses, resulting in frost heave. Some legume or winter small grain plant loss or complete loss is probable yearly.

(2) Importance to management considerations

Do not confuse frost heave mortality with forage crop susceptibility to winter killing. Frost heave will occur no matter what the sugar, soluble protein, and water content of the roots are. The force created by an ice lens, 150 tons per square foot, is far beyond what a healthy root, or even, a reinforced concrete floor can endure. Winter killing results from a physiological condition that a nondormant forage crop or a weakened winter-dormant or cold-hardy forage crop can face. They are either short on plant antifreeze, called electrolytes, or do not have adequate food reserves to meet respiration and regrowth needs until spring green-up.

Figure 3–10 Frost heave of forage plant (source: Perfect, Miller, and Burton 1988)



(a) Incremental frost heave during freeze-thaw cycles.
(b) Large ice lens induced major frost heave.
(c) Typical upward displacement of soil and plant during frost heave season.

Whether a soil above the 250 isoline is prone to frost heave depends on its soil moisture regime and texture class. Family texture classes are assigned by soil moisture regime to the three frost action classes in exhibit 618–5 in the National Soil Survey Handbook. Climates that have little snow cover over winter, ample fall and winter precipitation, and several freeze and thaw cycles increase the incidence of frost heave damage.

Conservation practice measures to moderate frost heave incidence and damage are limited and will work only on soil textures that drain freely after treatment. Lowering the water table on aquic moisture regime soils, such as coarse-loamy, loamy-skeletal, and organic, may move them from the high potential class to the low. The best way to avoid frost heave damage is to select forage species that are less susceptible to its effect. It is best to avoid planting legumes, other tap-rooted forages, and winter small grains on high frost heave potential soils.

On moderate frost heave potential soils, legumes should be planted with grasses. The grass ground cover and root mass tend to insulate the soil. This may reduce the incidence of frost heave of the interplanted legume from year to year. A reduced stand life for the legume in the legume-grass mixture will most likely occur on such soils over those soils with a low frost heave potential. Alfalfa stands, for instance, will most likely remain for only 3 years on moderate frost heave potential soils. The stand life on soils with a low frost heave potential could easily double if managed properly and selected for disease resistance.

Fence maintenance can also increase on soils prone to frost heave. Wood or other wide diameter posts are pushed up similar to plant roots. Once jacked up, soil along the sidewalls of the cavity created under the post falls into the cavity and prevents the post from settling back to its original depth. Eventually the post is jacked partly out of the ground. It then begins to tip and pull out in the direction of the strongest pull by wire tension or dead weight of boards and push by animal pressure.

Figure 3–11 250 degree day Isoline (source: National Soil Survey Handbook, NRCS 1993)

(h) Trafficability

Trafficability is the condition presented by the soil that influences the degree of ease of movement by livestock, humans, or machinery across its surface. Large surface rock fragments (>10 inches) can restrict ease of movement or prohibit it entirely. However, because the fragments also have an impact on productivity, they are covered as a separate factor.

Another factor affecting soil trafficability is soil wetness. Soil that has a high water table, seasonally or year around, and slow water transmission rate can restrict or preclude livestock and machinery movement on it. Trafficability as affected by soil wetness can be rated using the drainage classes mentioned previously.

Another major soil condition that impacts trafficability is its plasticity characteristics. This is measured by determining the liquid limit and the plastic limit of a particular soil. The numerical difference between these two limits determines the plastic index for a soil. The plasticity index and the liquid limit then are used to classify soils under the Unified Soil Classification System. With increasing plasticity index and liquid limit values, trafficability worsens with wetted soils.

The last soil condition impacting trafficability is its organic matter content. Soils high in organic matter have low bearing strength especially when wet. Livestock and machinery sink into the ground easily when traversing wet organic soils. This soil condition is also addressed by the Unified Soil Classification System.

(1) Limitation categories

Trafficability limitation ratings are a composite of four variables: surface stoniness, drainage class, plasticity characteristics, and organic matter content. For FSG's, there is no need to group soils into any more than three groups: slight, moderate, and severe.

(i) Slight—Traffic across soil is unrestricted by surface rocks or wet weather. Includes soils in Unified Soil Classification groups GW, GP, GM, GC, SW, and SP with less than 0.1 percent of surface covered by stones or boulders and regardless of drainage class, and in Unified Soil Classification groups SM and SC that have less than 0.1 percent of surface covered by stones or boulders and are well drained to excessively drained.

(ii) Moderate—One or more of the following conditions exist. Surface stoniness interferes with cultural management of forages, but does not forbid it. Wet weather periods cause some damage to soil surface and forage stands or necessitates some delays in moving livestock and machinery onto the soil. Includes soils in Unified Soil Classification groups GW, GP, GM, GC, SW, and SP with a range of 0.1 to 3 percent of surface covered by stones or boulders and regardless of drainage class; Unified Soil Classification groups SM and SC that are moderately well drained, have a range of 0.1 to 3 percent of their surface covered by stones or boulders, or both; Unified Soil Classification groups CL and ML with a range of surface coverage by stones or boulders up to 3 percent and a range of drainage classes of moderately well drained to excessively drained; and Unified Soil Classification groups CH and MH with a range of surface coverage by stones or boulders up to 3 percent and a range of drainage classes well drained to excessively drained.

(iii) Severe—One or more of the following conditions exist. Surface stoniness forbids or causes excessive hardship in culturally managing forages. Soils are wet for prolonged periods, low in bearing strength, and easily deformed by hooves or machinery tires. It includes Unified Soil Classification groups OL, OH, and PT regardless of surface stone or boulder coverage and drainage class; all Unified Soil Classification groups when more than 3 percent the surface is covered by stones or boulders; Unified Soil Classification groups SM, SC, CL, and ML that are somewhat poorly drained to very poorly drained; and Unified Soil Classification groups CH and MH that are moderately well drained to very poorly drained.

(2) Importance to management considerations

Trafficability decreases under wet soil conditions on susceptible soils, dictating the need to defer grazing of livestock on pastures, hayland, and grazable cropland. Turning livestock into wet fields causes a great deal of poaching. The depressions and compaction left in the soil by livestock hoof imprints only worsen the ability to move about the field. The depressions trap and hold water, keeping the soil wet for a more prolonged period. The roughness created by the depressions slows livestock movement, as they become more tentative about which step to take next. Once poaching is initiated, the situation tends to get worse with time and successive wet periods. Livestock injury can also occur if trafficability becomes so bad as to cause them to sink deeply into the soil with each step taken. Trafficability problems for machinery can delay harvests to the point that forage quality suffers. Forage seedings may also be delayed, jeopardizing stand establishment. Lime and fertilizer may be broadcast only during mid-summer.

Trafficability problems due to wet, pliable soils may be corrected by providing adequate soil drainage where fields are wet over a wide spread area. This will not be done solely for this purpose as it is done to improve production. Cattle walkways and trails need paving materials and/or drainage to traverse wet soil areas to improve trafficability. Surface stoniness management is addressed below.

(i) Surface rock fragments

As mentioned earlier, depending on their size and abundance, surface stones can either restrict or halt the movement of livestock and machinery. They can cause injury to livestock and costly damage to machinery, such as broken sickle bars, broken or bent axles, and tire bruises and ruptures. They also can affect forage production because they occupy space on the ground surface, preventing the growth of forage plants at that location. When small cobbles or channers are widely scattered over the surface, this may not be a problem because forage plants can close their canopy over the stones. Rock fragments greater than 24 inches in diameter that create a very to extremely bouldery surface, however, greatly inhibit forage plant production. They simply occupy space that cannot be closed by converging plant canopies growing in the surrounding finer textured soil areas. This creates unproductive gaps in the forage stand.

The National Soil Survey Handbook, section 618.61, describes five types of surface rock fragments, based on size, kind, roundness, and shape, that impact grazing land suitability. They are:

- **Flat fragments only—**Channers, 0.1 to 6 inches, and flagstones, 6 to 15 inches long.
- **Non-flat fragments only—**Cobbles, 3 to 10 inches.
- **Fragments either flat or non-flat—**Stones, 10 to 24 inches, and boulders, more than 24 inches in diameter.

Surface cobbles and channers on permanent pastures have no great impact on forage production or utilization. They do present problems in renovating pastures and hayland, preparing seedbeds, planting, and seedling emergence of forages on cropland. Any large fraction of the cobbles and channers in or on the soil prematurely wears out soil working machinery. As their presence on the surface increases, the larger rock fragments increasingly impact permanent pastures.

(1) Limitation categories

The six groupings of soils by surface rock fragment content established for determining grazing land suitability are:

- **No Limitation—**No rock fragments of more than 3 inches are on the soil surface.
- **Slight—**Soil surface covered with less than 0.1 percent stones and boulders.
- **Moderate—**Stones or boulders cover from 0.1 to 3 percent of the surface.
- **Severe—**Stones or boulders cover from 3 and 15 percent of the surface.
- **Very severe—**Stones or boulders cover about 15 to 50 percent of the surface. They are so closely spaced that it is possible to step from stone to stone or jump from boulder to boulder nearly always without touching soil.
- **Unsuitable—**Stones or boulders cover more than 50 percent of the surface. Little or no culturally managed forage plants grow on the site other than those that can volunteer from seed or spread by rhizome or stolons from adjacent areas.

(2) Importance to management considerations

Rock picking would be the primary treatment measure to improve conditions for forage production and utilization on stony or bouldery grazing lands. Rock picking generally is cost-effective only up to 3 percent stones and boulders on the surface. Rock picking must be done more than once. When stony soils are cultivated from time to time over the years, more stones are uncovered. Rock picking would be minimal and sporadic for the slight soil group. The moderate soil group would require rock picking after almost all attempts at tillage. The severe soil group contains soil series that are best left as permanent pasture. Removal of some of the larger stones or boulders would improve trafficability to overseed, lime, or fertilize the pasture. The very severe soil group would yield only about 50 percent of the pasture forage produced on a similar nonstony soil. This group would preclude any improvement efforts.

Fence building starting at the moderate and going to the very severe stony soil group would get progressively harder, primarily because of the difficulty setting posts. The slight group still could have posts driven with rather good success. The moderate group would require mostly dug postholes or some rather random settings for driven posts. Building a suspension fence of some type where the number of posts needed is kept to a minimum is a better option on the severe and very severe groups. Postholes of proper depth would be hard to achieve on a soil series in either of these two groups without going to an auger capable of drilling into rock. Fencing contractors in stony locales use these augers, but cost per posthole goes up considerably. For these two groups, it might be worthwhile to drill holes into larger stones or boulders for line posts and set steel T-posts in them with the anchor plates removed. The stones would serve as anchors for the steel T-posts.

Digging trenches in stony soils is also much more difficult, especially if boulders are common. Where stones are large enough to hinder excavation, trench-digging limitations in stony soils will be similar to that of setting fence posts. Trench digging is often needed to bury pipelines for livestock water, to install drain tiles or tubing, to develop springs for livestock water, or to bury insulated electric fencing wire under gate openings. Stony soils not only hinder or preclude excavation; they often times require a granular backfill material to bed the pipe. This prevents a stone in the returned onsite backfill from crushing or deforming the pipe at the time of backfilling or later as the backfill settles around the pipe.

(j) Shrink-swell

Clayey surface soils high in smectite expand when wet and shrink while drying to a very exaggerated state. When dry, 1- to 2-inch-wide cracks commonly occur that run to a depth of 6 to 20 inches. The clay pedestals created are generally 8 to 16 inches wide. Therefore, the vegetation growing under such conditions must have a root structure resistant to such extreme contraction pressures. This condition can worsen on a poorly managed sodic soil. In the presence of ever increasing amounts of sodium, the smectite clay lattice that expands when wetted expands more and more. Soils having this high shrink-swell clay are called Vertisols.

(1) Limitation categories

The pronounced shrinking and swelling of some soils impact their use for forage production in two distinct ways. It influences the selection and establishment of forages on soils with high smectite clay content in the surface layer. It also influences fence design if the surface layer containing the high smectite clay is greater than 12 inches deep. Therefore, three forage suitability group categories are developed:

- **Slight—**Surface soils of kaolinitic mineralogy and clay loams, silty clay loams, and sandy clay loams of smectite mineralogy with a linear extensibility (LE) less than 6 percent.
- **Moderate—**Surface soils of smectite mineralogy with textures of clay, silty clay, and sandy clay with an LE greater than 6 percent, but less than 12 inches thick.
- **Severe—**Surface soils greater than 12 inches in depth with smectite mineralogy clays with an LE greater than 6 percent.

(2) Importance to management considerations

Clay, silty clay, and sandy clay surface soils of smectite mineralogy with an LE greater than 6 percent are poorly suited to growing domesticated grasses and legumes for livestock or wildlife use. The best-adapted forages for this soil condition are drought tolerant, perennial warm season bunchgrasses, annual bunchgrasses, and annual legumes. The latter two can be used to exploit wetter periods of the growing season. They should be selected to achieve their full growth potential before seasonal soil cracking and dry conditions limit plant growth.

Fences are impacted by high shrink-swell soils when the expandable clay layer is greater than 12 inches thick. They tend to tip as the clays expand and contract over time. To avoid this action, the posts must be set extra deep or anchored in place with rock jacks or other devices. Obviously if set deeper, this requires the use of longer posts and takes more time to install them. If anchoring devices are used, they also increase the time of installation as well as adding to the cost of materials. Therefore, construction and maintenance of fences on these soils are costly and time-consuming.

(k) Depth to restrictive layers

Although this soil property is largely accounted for under the available water holding capacity property, there are some additional limitations to forage production that should not be overlooked. Nutrient availability, loss of water to runoff, trench depth for pipelines and drainpipe, and post setting depth are impacted by depth to restrictive layers. Rooting depth does not only affect the amount of soil available for plant roots to explore for water, it also affects the volume of soil available for nutrient uptake by plants and water storage during rain events. Shallow soils produce more runoff than deep soils with the same infiltration rate. Their water storage reservoir is smaller. Therefore, less water is initially available for plant production regardless of the soil's available water holding capacity. Generally, shallow-rooted forage plants have the competitive advantage over deep-rooted forages on soils less than 20 inches deep to a restrictive layer. However, their yield potential is also correspondingly lower.

(1) Limitation categories

Soil depths greater than 40 inches deep to a restrictive layer pose no or slight limitations to forage production. Moderate depth soils, 20 to 40 inches deep, have moderate limitations to forage production. Soil depths less than 20 inches to a restrictive layer have severe limitations to forage production.

(2) Importance to management considerations

All forages have either their entire root mass within 40 inches of the soil surface or more than 90 percent of it. Most fencepost-setting depths do not exceed 40 inches. Trench depths, for drainage pipes, spring developments, and water lines, generally do not need to exceed 40 inches. Therefore, soils that do not have a restrictive layer within a depth of 40 inches pose no particular problem to forage production and grazing management practices.

On moderately deep soils, forage species with deep roots are less adapted and suffer some loss of yield potential. Corner, brace, and end post assemblies of fences need anchoring or angle stays and blocks if set shallower than normal design depths. Otherwise, special tipped posthole augers are needed to drill postholes to entire design depth. As trench depths decrease toward 20 inches, less soil is available to insulate water flowing in pipes laid in them from extreme heat or cold. In cold climates, water lines may need to be evacuated during low use periods or kept continually flowing. During hot weather, livestock water conveyed in shallow waterlines may be warmer than ideal for top production. Less soil cover is also available to protect the lines from crushing when wheel loads pass over them.

Where soils are less than 20 inches deep, high-yielding, deep-rooted forages have very low yield potential and shortened stand life. Shallow-rooted forages with lower yield potentials may need to be selected instead. Establishment of new forage stands on shallow soils may be more difficult because of restricted tillage options, droughtiness, and increased runoff and erosion potential where rainfall events may exceed soil storage capacity. Fencepost settings will be either shallow or set to full depth using rock drilling augers. Either way, fence expense will be high either as a maintenance cost or as an initial construction cost. Pipes laid in trenches less than 20 inches deep are more subject to temperature extremes and crushing by wheel loads. Drainage lines put in at depths less than 20 inches need closer spacing between lines than ones laid deeper. Pipes laid on top of restrictive layers, such as bedrock, often need to be bedded with gravel to prevent unequal load support that can cause a rupture if enough deflection occurs.

United States
Department of
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**Natural
Resources
Conservation
Service**

National Range and Pasture Handbook

Chapter 3 Ecological Sites and Forage Suitability Groups

Section 2 Forage Suitability Groups

Exhibits

Exhibit 3.2–1 Forage Suitability Group Description Example

(Data presented in this forage suitability group description are examples for content and format only.)

United States Department of Agriculture
Natural Resources Conservation Service, PA

G127NY401PA
Deep, channery, well drained, strongly acid, moderately steep upland soils

FORAGE SUITABILITY GROUP
Deep, channery, well drained, strongly acid, moderately steep upland soils

FSG No.: **G127NY401PA**
Major Land Resource Area: 127 – Eastern Allegheny Plateau and Mountains

Physiographic Features

This group of soils lies on hilltops and hillsides. Deeply incised watercourses are often present on the hill slopes occupied by this soil group. These watercourses run the length of the slope and parallel to each other. They may be intermittent or spring-fed.

	Minimum	Maximum
Elevation (feet):	1,200	2,300
Slope (percent):	15	25
Flooding:		
Frequency:	None	None
Duration:	None	None
Ponding:		
Depth (inches):	0	0
Frequency:	None	None
Duration:	None	None
Runoff Class:	High	Very high

Climatic Features

Snowfall ranges from 35 inches in the south to 90 inches in the north. Snow cover at depths greater than 1 inch average a high of 104 days at higher elevations in the north to a low of 20 days at lower elevations in the south. Growing season precipitation ranges between 22 and 32 inches. Average monthly precipitation is rather evenly distributed during the year, ranging from 2.4 inches to 5.3 inches. The lesser amounts of monthly precipitation occur in the winter. Precipitation events of more than 0.1 inch occur about every 3 to 4 days on average during the growing season. Average July temperature ranges from 66 degrees Fahrenheit to 73 degrees Fahrenheit. Relative humidity is high throughout the growing season averaging about 55 percent at mid-afternoon, increasing during the night to 85 percent at dawn. Potential evapotranspiration ranges from 22 to 27 inches.

Freeze-free period (28 deg)(days): (9 years in 10 at least)	105	172
Last killing freeze in spring (28 deg): (1 year in 10 later than)	May 01	Jun 02
Last frost in spring (32 deg): (1 year in 10 later than)	May 14	Jun 22

First frost in fall (32 deg): (1 year in 10 earlier than)	Aug 25	Sep 28
First killing freeze in fall (28 deg): (1 year in 10 earlier than)	Sep 08	Oct 11
Length of growing season (32 deg)(days): (9 years in 10 at least)	72	144
Growing degree days (40 deg):	3,700	5,300
Growing degree days (50 deg):	2,000	2,500
Annual minimum temperature:	–20	–10
Mean annual precipitation (inches):	41	47

Monthly precipitation (inches) and temperature (F):

2 years in 10:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. less than	1.38	1.41	1.96	2.04	2.61	2.28	2.70	2.57	2.08	1.64	2.31	2.03
Precip. more than	5.18	5.03	5.39	5.28	5.76	6.96	7.20	5.60	5.26	4.59	5.10	4.71
Monthly average:	3.03	3.00	3.42	3.48	4.00	4.87	4.51	3.92	3.78	3.20	3.78	3.24
Temp. min.	10.5	12.5	21.8	31.7	41.4	49.4	53.5	52.4	45.9	36.6	28.3	17.6
Temp. max.	36.2	39.2	50.0	62.2	73.0	81.8	85.8	83.8	76.8	64.8	52.7	40.3
Temp. avg.	23.2	26.0	35.6	46.9	57.3	65.4	69.4	67.8	61.1	50.2	39.8	28.6

Climate station	Location	From	To
PA4385	Johnstown, PA	1961	1990
PA1806	Coudersport, PA	1961	1987

Soil Properties

The soils in this group are moderately steep, deep, and well drained. Although considered deep, the soils in this group are underlain by sandstone, siltstone, or shale bedrock at depths of 46 to 54 inches. The topsoil is a channery loam to silt loam having 25 percent or more, thin, flat rock fragments as much as 6 inches long. Cation exchange capacity in the topsoil ranges from 12 to 20. Seasonal high water table is at a depth or more than 6 feet.

Drainage class:	Well drained	to	Well drained
Permeability class: (0 – 40 inches)	Moderate	to	Moderate
Frost action class:	Medium	to	Medium

	Minimum	Maximum
Depth:	46	54
Surface fragments >3" (% cover):	25	54
Organic matter (percent):	2.0	4.0
Electrical conductivity (mmhos/cm):	0	0
Sodium adsorption ratio:	0	0
Soil reaction (1:1) Water (pH):	3.6	6
Available water capacity (inches):	4	6
Calcium carbonate equivalent (percent):	0	0

Soil Map Unit List

Soil survey area	Map unit symbol	Soil component name
PA111 Somerset Co.	HaD	Hartleton channery silt loam
PA111 Somerset Co.	HoD	Hazelton channery loam
PA111 Somerset Co.	LeD	Leck Kill channery silt loam

Adapted Species List

The following forage species are considered adapted to grow on the soils in this group at their natural pH levels. If limed, other species can be selected that perform better at higher pH's near neutral. See soil interpretations section for list of those species. The additional forage species listed in the soil interpretations section will grow on the soils in this group, but they will produce less than 75 percent of the yield on sites most favorable to them.

No subjective ranking from the most adapted to the least is given among forage species in these tables. However, stand loss of perennial ryegrass is likely after a severe winter or hot, dry summer. Select cultivars of perennial ryegrass that have demonstrated cold tolerance. Drought tolerance is not a trait with cultivar differences of note.

Little, if any, irrigated forage production is carried on in this MLRA. However, there are periods in the summertime where supplemental irrigation would enhance forage production for several species. Irrigation of some species is considered not applicable for two reasons. If they are warm-species perennials, they would only marginally benefit from irrigation since they are drought and heat tolerant, and would face stiffer competition from cool-season invaders. Long-term stand longevity under irrigation without herbicide control of cool-season invaders is questionable. The other species where irrigation is listed as not applicable are weedy invaders. Although they would benefit from irrigation, there are better producing, more nutritious forages available that better justify the cost of supplemental irrigation. In this climate, irrigation is strictly supplemental and is rarely done because of its cost versus economic return in additional yield.

Cool-season Grasses	Dryland	Irrigated
Bentgrass—grazed only	X	X
Perennial ryegrass	X	X
Redtop	X	X
Reed canarygrass	X	X
Tall fescue	X	X
Timothy	X	X

Warm-season Grasses	Dryland	Irrigated
Big bluestem	X	
Causasian bluestem	X	
Eastern gamagrass	X	
Little bluestem	X	
Purpletop	X	
Switchgrass	X	

Legumes	Dryland	Irrigated
Alsike clover	X	X
Birdsfoot trefoil	X	X
Black medic—grazed only	X	
Crownvetch	X	X
Kura clover	X	X
Ladino clover	X	X
Red clover	X	X
Vetch, common	X	X
White clover	X	X

Other Perennial Forbs	Dryland	Irrigated
Bedstraw	X	
Chicory	X	X
Dandelion	X	
Plantain, various	X	

Annual Species	Dryland	Irrigated
Corn, silage (machine harvested)	X	X
Crabgrass	X	
Foxtail millet	X	X
Kale	X	X
Rape	X	X
Sorghum/sudangrass and crosses	X	X
Spring small grains	X	X
Swedes	X	X
Turnip	X	X
Winter small grains	X	X

X = Adapted

Production Estimates

Forage production limited by moderate water holding capacity of the soils and the often sporadic, limited rainfall during July and August combined with high daytime temperatures. Irrigation of switchgrass is not cost effective and may reduce stand life due to likely more rampant cool-season grass invasion. Therefore, no yield estimates are given for irrigated switchgrass.

Forage crop[1/]	- - - - - Dryland - - - - -		- - - - - Irrigated - - - - -	
	Management Intensity		Management Intensity	
	High (lb/ac)	Low (lb/ac)	High (lb/ac)	Low (lb/ac)
Alfalfa	8,000	4,000	12,000	9,000
Clover, red or Ladino	6,000	3,000	11,000	8,000
Corn silage	42,000	28,000	60,000	40,000
Legume-grass	8,000	4,000	13,000	10,000

1/ Production values are on as-fed basis.

Pasture	- - - - - Dryland - - - - -		- - - - - Irrigated - - - - -	
	Management Intensity		Management Intensity	
	High (AUM/ac)	Low (AUM/ac)	High (AUM/ac)	Low (AUM/ac)
Orchard-K. blue-white clover	4.0	2.0	6.0	4.0
Switchgrass	11.0	6.0		
Tall fescue	7.0	2.5	10.0	7.0
Tall fescue-Ladino clover	8.0	3.0	11.0	8.0

1 AUM = 790 lb

Forage Growth Curves

Growth Curve Number: PA1208
Growth Curve Name: Tall fescue, 120–140 day growing season
Growth Curve Description: Tall fescue dominated pasture, <5% legume

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	32	27	12	5	16	3	0	0

Growth Curve Number: PA1209
Growth Curve Name: Tall fescue-Ladino clover, 120–140 day growing season
Growth Curve Description: Tall fescue pasture with a Ladino clover component 25–40% by weight

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	15	30	22	8	6	14	5	0	0

Growth Curve Number: PA1205
Growth Curve Name: Orchardgrass-K. Blue-Wh. Clover, 120–140 day growing season
Growth Curve Description: Orchardgrass pasture with K. bluegrass and white clover components 20–30% each by weight

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	15	30	22	8	6	14	5	0	0

Growth Curve Number: PA1213
Growth Curve Name: Switchgrass, 120–140 day growing season
Growth Curve Description: Switchgrass pasture, <5% legume, minor cool-season grass invasion

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	0	21	32	31	16	0	0	0

Soil Limitations

Primary soil limitation for this group is the acidic nature of the surface and subsurface soil layers. These soils may be near neutral to strongly acid, depending on whether or not these soils have been limed in the past. If lime has been applied to bring the pH up to at least 6.0, then

Kentucky bluegrass,
smooth bromegrass,
orchardgrass,
and alfalfa

are additional climatically adapted forage species selections to those listed under Adapted Species.

Frost heave potential on these soils is moderate. Open winters after wet falls with significant freeze-thaw cycles may cause an occasional loss or reduction of alfalfa stands. Probability of alfalfa stand reduction or loss is once in 5 years on average.

Slopes are moderately steep. Additional caution should be used when driving wheeled equipment as slopes near 25 percent. Potential for severe cattle trail erosion and underutilized pasture areas is high. This is heightened by a single watering facility located at the upper or lower end of pasture more than 800 feet long in the direction of the slope. Fence construction on this soil group requires more line brace assemblies to maintain adequate wire fence tension as more breaks in grade are encountered than on smoother, flatter sloped soil groups.

Channery rock fragments will interfere with post setting and seedbed preparation somewhat. Tillage tools will wear out prematurely. The rock fragments are also largely responsible for the plant available water holding capacity (AWC) to be in the moderate range. The same soils without the channers are in the high AWC range. Forage production on these soils of moderate water holding capacity will be noticeably affected by wet and dry growing seasons. Long-term average yields given above are reflective of a 20 percent decrease in yield over soil groups having a high AWC.

Management Interpretations

For best forage production, lime should be applied occasionally to keep the pH at approximately 6.5 when soil tests indicate a need. Lime requirement for these soils is moderate. From 3 to 6 tons of lime per acre are needed to correct a previously unlimed soil to 6.5. Maintenance applications of 0.5 to 1 ton per acre may be called for intermittently when pH falls to 6.0.

These soils are low in organic matter if tilled for a typical crop rotation grown in the MLRA. On permanent pasture or hayland, these soils may have a moderate organic matter content of 2 to 4 percent. In either case, nonlegume forages respond well to nitrogen fertilizer applications. Split apply nitrogen to grasses based on expected yield for the current cutting or grazing period. Excess nitrogen leaches out of the root zone during winter dormancy or heavy rain events. Fall and winter N loss is due to the 18 to 21 inches of precipitation in excess of what can be held by the soil and not lost to evaporation.

Response to phosphorus (P) fertilizer applications on unfertilized, but limed soils is low to moderate. Liming the soils tend to make the native P more available damping the response to fertilizer P except when applied as a starter fertilizer for a new seeding.

Response to potassium (K) fertilizers is low. These soils naturally tend to have available K in the optimum range or above for their cation exchange capacity values. Legumes harvested for hay benefit most from K fertilization to replace that lost by harvest removal.

When taprooted legumes are grown, a compatible and adapted cool-season grass companion crop should be planted to cut down on frost heave losses or provide a fallback hay or pasture crop. If frost heave reduces the legume stand anyway, the grass will produce some forage. The grass will provide slightly better erosion control cover as well.

Forage yields for this soil group are constrained most by low pH and lack of nitrogen fertilizer applications when legumes are absent from the crop rotation or the forage stand. Second limiting factor is the AWC during dry years or prolonged dry spells during the growing season.

Large cattle and horse pastures with slopes above 15 percent have a worsening distribution of grazing pressure as slopes increase to 25 percent if a single water source is located at either the highest or the lowest elevation. Areas remote to watering facilities (greater than 800 feet away) will be underutilized. Meanwhile, areas within 800 feet of the watering facility will be used with increasing intensity as the watering facility is approached. For even grazing pressure distribution, place watering facilities at intervals along the entire elevational gradient. Paddock layouts should have long axes perpendicular to the slope. Place a portable water trough in each. Sheep grazing pressure distribution is not noticeably affected by elevational differences in a pasture on this soil group unless they choose a bedding ground area on a knoll.

Design cattle lanes serving paddocks to reduce their slope length and steepness while maintaining efficient paddock layout and fence length. When necessary to climb the slope, place regularly spaced waterbars or diversions across the lane to deflect water. Direct and extend them as needed to prevent diverted water from coming back on the lane downslope. Heavy use lanes require surfacing when rilling becomes evident.

Place brace assemblies for wire fences everywhere sharp breaks in grade occur. If steel T-posts or fiberglass rods are used, place a wood post every 50 to 100 feet on hill slopes with vertical curvature to keep the lowest stretched wire parallel with the ground surface while preventing these more flexible and shallower set posts and rods from tipping or bending.

When reseeding forages on these channery soils, drilling is preferred to a broadcast seeding. Drills achieve more uniform stands by deflecting most rock fragments from the drilled row. Broadcast seedings that are lightly tilled or cultipacked afterwards often have channers overlying seeds. Overlying channers cause stem breakage during emergence or prevent seedlings from ever getting to daylight. Untilled broadcast seedings have many exposed seeds. This causes seedlings to emerge unevenly or germinate and desiccate because of poor soil coverage and excessive drying from lying on partly or completely exposed rock fragments. Drill openers and coulters tend to wear out quickly and may break on occasion from rock abrasion.

First cut hay is difficult to field cure without rain damage because of high humidity and significant rain events occurring within 3 days of each other. Later cuttings are less likely to be rain damaged, but in wetter years, may also be damaged by rain and long exposure to sun while field curing. Tedders or inverters promote more even, quicker drying of the hay. An option to consider is harvest as haylage. Haylage production reduces the amount of drying time needed and will thus yield higher quality forage if ensiled and stored properly. Ordinarily, haylage can be wilted and harvested between rain events.

Management Dynamics

Liming these acidic soils allows for a wider selection of suitable forages and leads to increased forage production on previously unlimed soils. Depending on the forage species grown, increasing the surface soil pH to 6.5 will increase yields 20 percent for tall, warm-season perennial grasses to as much as 100 percent for alfalfa. Cool-season grasses will yield 50 percent more. Legume persistence will be increased.

Using facilitating practices of fencing and watering facilities to control livestock movement as mentioned earlier better distributes grazing pressure. This prevents areas of over- and under-utilization from developing. Overutilized areas evolve into low-growing sod formers and weedy rosette plants (dandelions and plantains). Bare areas will appear between plants in advanced stages of decline. Under-utilized areas tend to evolve toward taller-growing species. In more remote areas near wooded borders, woody vegetation, such as blackberry, prickly ash, and sumac, invade. Underutilized areas have more dead leaf and seed stalks than more closely grazed areas.

Since these soils are low in organic matter, they supply little mineralized soil nitrogen. Hence, nonleguminous forages respond well to nitrogen fertilizers. If grasses and nonleguminous forbs are yellowish green and urine spots are much darker green than their surroundings, nitrogen fertilizer is needed. Forage production can double.

FSG Documentation

Similar FSG's:

FSG ID	**FSG Narrative**
G127NY400PA	Deep, well drained, strongly acid, moderately steep upland soils. Nonchannery phase of the same soils on D slopes (15–25 percent). Higher available water capacity gives them production capabilities approximately 25 percent better. The absence of significant amounts of channers makes seedbed preparation easier, requires less equipment maintenance, and improves seedling survival. Post setting is also easier.

Inventory Data References:

Cornell U. Ag. Exp. Sta. Bull. 995—Interpretation of Chemical Soil Tests, FORADS Database-1995, AH 296—Land Resource Regions and Major Land Resource Areas of the United States, Penn State Ag. Exp. Sta. Bull. 873—Soil Climate Regimes of Pennsylvania, Penn State Agronomy Guide 1995-96, Penn State University Soil Characterization Laboratory Database System-1994, Soil Survey of Cameron and Elk Counties, Pennsylvania, and USDA, NRCS National Range and Pasture Handbook.

State Correlation:

This site has been correlated with the following states:
MD
NY
PA
WV

Forage Suitability Group Approval:

Original Author: Jim Cropper
Original Date: 12/1/00
Approval by:
Approval Date: