Part 645 – National Range and Pasture Handbook

Subpart E – Inventory, Assessment, and Monitoring for Grazing Lands

645.0501 General Information

A. Purpose

The purpose of this subpart is to provide guidance on how to conduct inventories and assessments and how to set up monitoring plots on grazing lands. It provides a summary of remote sensing tools commonly used by NRCS and information on data capture and storage devices that are available. Information is included on how inventories, assessments, and monitoring data are used in conservation planning, developing ecological site descriptions, and used in National Resources Inventory (NRI). Instructions for using common tools for inventorying, assessing, evaluating, and rating areas of interest or planning areas are described in full; and the subpart provides information on vegetation sampling techniques, links, and references for ease in locating tools and helpful documents, if those procedures are not covered fully in this subpart.

B. Introduction

(1) Inventory, assessment, and monitoring resources are important activities conducted by range and pasture specialists in the conservation planning process. Collecting appropriate natural resource, economic, and social information about the planning area can be used to:
   (i) Identify existing or potential resource concerns or opportunities.
   (ii) Further define existing and potential resource concerns and opportunities.
   (iii) Clarify those resource concerns.
   (iv) Formulate and evaluate alternatives.
   (v) Gather pertinent information concerning the affected resources, the human considerations, and operation and management (NRCS, National Planning Procedures Handbook, 2020).
   (vi) Evaluate the effectiveness of implemented conservation practices to address resource concerns.

(2) The resource inventory is the identification of Soil, Water, Air, Plant, Animal, Energy and Human resources (SWAPAE+H) and Special Environmental Concerns (SECs) that are present and are the basis of all planning efforts. This information furthers the understanding of the presence of the natural resources in the planning area (NRCS, 2020).

(3) For NRCS staff, Step 1 (Identify Problems and Opportunities) and Step 2 (Determine Objectives) of the nine steps of Conservation Planning are the best guides to deciding what to inventory and the degree of detail that is needed in the process.

(4) There is no single method for collecting information on grazing lands. No single measurement or technique provides enough information to guide management in all situations (Smith et al. 2012). Inventory, assessment, and monitoring are different processes – although related – that usually require different protocols and sampling methods. It is important to distinguish between the respective purposes of inventory, assessment, and monitoring activities, with inventory and assessment activities typically preceding monitoring and contributing to where, what, and how things will be monitored later in the planning and evaluation process (Bern et al. 2006).

C. Uses of NRCS Grazing Land Inventory, assessment, and monitoring data

(1) Inventory, assessment, and monitoring data can be used not only for conservation planning but also to study conservation treatment effects, to establish the baseline data for monitoring, determine resource concerns, and other uses including:
   (i) Coordinating grazing history, stocking rate, and animal performance records in determining guides to initial stocking rates.

(ii) Development of ecological site descriptions and preparing soil survey manuscripts.
(iii) Studies of conservation practice treatment effects.
(iv) Analyzing wildlife habitat values.
(v) Planning watershed and river basin projects.
(vi) Assisting and training landowners and operators in monitoring vegetation trends and the impact of applied conservation practices and programs.
(vii) Exchanging information with research institutions and agencies.
(viii) Preparing guides and specifications for recreation developments, beautification, natural landscaping, roadside planting, and other developments or practices.
(ix) Directing Plant Material Center program activities.
(x) Developing modeling tools.
(xi) Helping to direct policy.

(2) Data collected during inventories, assessment, and monitoring results can be used for Ecological site description (ESD) development, with data collected for ESDs more extensive than data for conservation planning inventories. Ecological site development requires collections of biomass data, a review of local history related to reference plant communities, and correlation to a specific soil component. The National Ecological Site Handbook describes the tiers of data required for provisional and approved ecological site products: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcseprd1291232

(3) The Conservation Effects Assessment Project (CEAP) quantifies the environmental effects of conservation practices and programs. The process includes research, modelling, assessment, monitoring, and data collection. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/ceap/

(4) The NRI Grazingland On-site Study collects and produces scientifically credible information by assessing the status, condition, and trends of land, soil, water, and related resources on the Nation's non-federal lands, in support of efforts to protect, restore, and enhance the lands and waters of the United States. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/nri/

(5) Inventory data are used to determine and document the environmental effects of conservation decisions through the NRCS Environmental Effects policy and National Environmental Protection Act (NEPA) requirements. NEPA was written to ensure that Federal decision-makers take into account the environmental effects of their proposed actions and consider ways to avoid, minimize, or mitigate adverse effects before implementing the action. This is also the purpose of the NRCS environmental evaluation process. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/ecosciences/ec/?cid=nrcsdev11_000340.

(6) Hydrologic model development is an important activity in NRCS that requires data collection from a unique set of variables, including plant cover and slope. The Rangeland Hydrology and Erosion Model (RHEM) is a soil erosion model to predict soil loss specific to rangelands. Manuals, handbooks, and facts sheets are available for the RHEM tool and can be found on the NRCS Rangelands web site at: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/rangepasture/range/?cid=STELPRDB1043345. More information on Ecohydrology on rangelands can be found in Subpart G of this handbook.

645.0502 Remote Sensing for Inventory, Assessment, and Monitoring of Grazing Lands

A. Remote sensing is a methodology for data collection, analysis, and the parameterization of environmental models from satellite data. Remote sensing requires an interdisciplinary approach to be able to interpret the data received and make it operational. Remote sensing technology is rapidly changing with frequent new developments. The USDA-NRCS Geospatial Sciences website is a source for current information at https://geospatial-sciences-nrcs.hub.arcgis.com/.

B. Remote sensing integration is the simultaneous use of field and remote-sensing data for inventory, assessment, and monitoring. Remote sensing technology can increase efficiency, reduce the amount of field data that needs to be collected, and allow better extrapolation of field data to the landscape, improving the ability to inventory and monitor large and diverse landscapes. Field data are used to validate remotely sensed data products and to provide information on indicators that cannot be remotely sensed. Remote sensing integration supported by the Bureau of Land Management's Assessment, Inventory and Monitoring (AIM) Strategy are also used by NRCS and includes the following from validation or characterization of remotely sensed products:

(1) Field data to validate remote-sensing based products like vegetation classification and landscape level maps of attributes such as bare ground, biomass production, and invasive species prevalence.
(2) Improving field-based estimates with remote sensing data. The precision of field-based estimates can be improved by adding remote sensing data as co-variants.
(3) Aiding in the selection of field sampling locations. Use remote sensing products such as vegetation indices and classifications to capture landscape patterns of interest for management (Toevs 2011).
(4) Supplement field-based sampling with image-based sampling. Unmanned Aircraft Systems (UAS) or drones can provide a collection of high-resolution images to supplement field plot-level data. Access issues, quantity of samples, and sampling intensity can be addressed using UASs. See GM-170-402 - Part 402 – Aviation Management – Unmanned Aircraft Systems for NRCS policy, procedures, and guidelines on the use of UAS.

C. Remote Sensing Tools and Products

(1) Remote sensing technology is a rapidly developing and changing field. Other remote sensing tools and products used for NRCS conservation planning will be reviewed as they are developed. An annotated catalog of geospatial workflow enhancements and geodatabase models developed is referenced here for use in NRCS Field, Area, State, and Regional offices used for conservation planning.
(2) Remote sensing products that are currently available provide estimates of:
    (i) Plant cover (by life form)
    (ii) Bare ground
    (iii) Biomass
    (iv) Annual production
    (v) Canopy height
    (vi) Elevation

D. The following remote sensing products are currently available for use in grazing land inventory, monitoring, and assessment. Each of these tools requires field validation:

(1) **Rangeland Brush Evaluation Tool (RaBET)** estimates canopy cover of woody plant species but is limited to use in specific Major Land Resource Areas (MLRAs). This operational product allows land managers and NRCS to assess spatial and temporal changes in woody vegetation over large heterogeneous landscapes and provides them with a tool to assess where the greatest need for treatment exists (Collins et al. 2018). More information can be found at: https://rangelandsgateway.org/dlio/15355.
(2) **Rangeland Analysis Platform (RAP).** The Rangeland Analysis Platform (RAP; https://rangelands.app) is a free online application providing vegetation maps (30m resolution) across rangelands of the western U.S. from 1986 to present. Products leverage satellite data, NRI, and other plot data to produce maps of annual percent cover of perennial forbs and grasses, annual forbs and grasses, shrubs, trees, and bare ground (Allred et al. 2021), as well as herbaceous production (lbs/ac) every 16 days and annually (Jones et al. 2021). RAP provides an easy-to-use interface for NRCS conservationists to visualize rangeland heterogeneity and analyze trends of vegetation cover and production

from pasture to watershed scales. RAP can be used throughout the NRCS Conservation Planning Process to help planners inventory rangeland resources, identify and prioritize areas for management, and evaluate outcomes of practices. Examples of applications include area-wide planning to reduce woody encroachment and invasive species, prescribed grazing and drought contingency planning, and monitoring vegetation responses to conservation practices. RAP Help Resources can be found at: https://support.rangelands.app.

(3) **Normalized Difference Vegetation Index (NDVI)** is a measure of the state of plant health based on how the plant reflects light at certain frequencies (some waves are absorbed, and others are reflected). Chlorophyll is a health indicator, strongly absorbs visible light, and the cellular structure of the leaves strongly reflect near-infrared light. When the plant becomes dehydrated, sick, afflicted with disease, etc., the spongy layer deteriorates, and the plant absorbs more of the near-infrared light, rather than reflecting it. Thus, observing how NIR changes compared to red light provides an accurate indication of the presence of chlorophyll, which correlates with plant health (Earth Observing System). For more information: https://eos.com/make-an-analysis/ndvi/.

(4) **GrassCast** is an optional tool that forescasts an area's peak standing grassland biomass for the whole growing season. Managers can use GrassCast to form a more educated guess about the upcoming growing season. It can help inform the design of proactive drought management plans, trigger dates, stocking dates, and grazing rotations.

GrassCast works by using well-known relationships between historical weather and grassland production. It combines current weather data and seasonal climate outlooks (from NOAA Climate Prediction Center) with a well-trusted grassland model (DayCent) to predict total biomass (lbs/acres) for individual counties, compared to their 38-year average. For more information: https://grasscast.unl.edu/.

(5) **FuelCast** is a fuel and rangeland production forecasting system. It leverages Google Earth Engine and Tensorflow to process near real-time weather and remote sensing data. It provides weekly forecast estimates of magnitude and timing of annual production and fuel across coterminous US rangelands with free, near real-time information to rangeland managers, fire specialists, and producers. For more information: https://www.fuelcast.net/dl.

(6) **Land PKS-Land Potential Knowledge System (LandPKS)**. See figures E-1 and E-2. The USDA-ARS Jornada provides a number of tools for soil and ecological site identification, data collection, and for accessing data, information, and knowledge. As of September 2021, the LandPKS mobile application provided the following functions for pastures and rangelands:

(i) Soil texture determination (video key)
(ii) Soil color determination (using a grey card or yellow Post-It Note© for reference)
(iii) Soil and ecological site for a location and adjacent map units using GPS, map, or hand-entered location (requires internet access, then stored on phone for location)
(iv) Soil and ecological site identification based on location + user inputs (e.g., soil texture by depth, soil color by depth, rock fragment volume by depth)
(v) Habitat information for ~ 100 species
(vi) Data collection (with on-phone and private or public cloud storage and data portal access)
(vii) NRI-compatible (but less detailed) vegetation cover, height, gap
(viii) Utilization
(ix) Soil health (NRCS Cropland In-Field Assessment with all methods)
(x) In-app user support (tap on question mark)

Figure E-1. Land PKS-Land Potential Knowledge System (LandPKS).

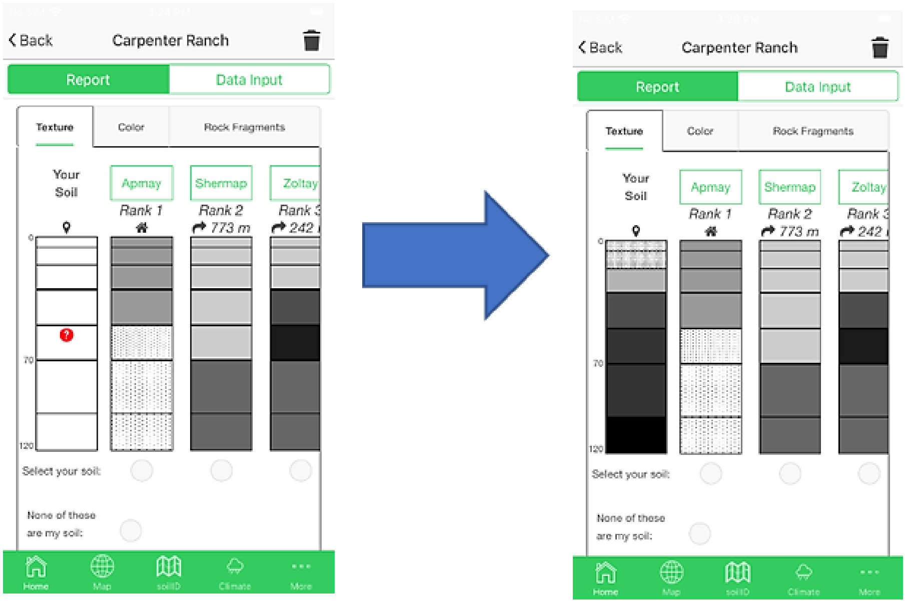


Figure E-2. Emilio Carrillo, NRCS Rangeland Management Specialist using Land PKS.

(xi) The current version requires a gmail login; future versions likely will not.

(xii) The Jornada, in cooperation with the BLM, NRCS, and other partners, will continue to make these and additional functions available in the future, and any data collected will continue to be available. Like all technology, these tools are constantly being updated and improved, and the specific form may change. More information: https://landpotential.org/. https://jornada.nmsu.edu/

(7) **Light Detection and Ranging (LiDAR)** is a remote sensing method that measures distance to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with a sensor. Differences in laser return times and wavelengths are used to make a digital 3-D point cloud of the target. As with all remote sensing products, each individual LiDAR data collection is a "snap-shot in time" and is created with a variety of sensors that are constantly changing in capabilities and performance over time. Differences in the type of elevation product and the quality of the digital data for different applications are a result of the sensor and processing techniques. Guidance on quality standards and how data quality is assessed and are available from the Federal Geographic Data Committee (FGDC) National Standards for Spatial Data Accuracy, NSSDA Part 3, and the USGS 3DEP Standards and Specifications. NRCS also provides guidance for Using LiDAR for Planning and Designing Engineering Practice: https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=36637.wba.

(i) The classified LiDAR point cloud can be used to create high resolution elevation raster datasets of the Digital (bare earth) Terrain Model (DTM) and the Digital

Surface Model (DSM). A properly classified LiDAR point cloud can be used to model vegetation structure and produce maps of canopy height for each raster cell location. Generally, the elevation data derivatives are most effective in determining woody plant canopy heights that are greater than four feet. However, this would need to be validated for each data collection by examination of the product's metadata or ground truth verification.

(ii) LiDAR is also used to obtain information on the height distribution of plant communities and for interaction of Digital Surface Model (DSM) plant heights with satellite or aerial photography imagery for plant communities. The user of LiDAR elevation derivatives for vegetation analysis will need to be aware of the "snap-shot in time" factor because many of the LiDAR data sources for NRCS are several years old. Current developments in UAV technology are making it possible to have a digital surface model available for current vegetation characterization.

(iii) LiDAR elevation derivatives are also used to develop stream flow networks, model hydrology, and detect concentrated flow areas and gully erosion, even under significant forest canopy conditions. This is a very complex topic and not easily generalized. NRCS has provided support for the production of several recorded video sessions describing how LiDAR elevation derivatives can be processed and applied for hydrology and terrain analysis.

(iv) Not all NRCS field offices have access to LiDAR imagery. Contact the NRCS State GIS Specialist for information on LiDAR image coverage for the area of interest.

645.0503 Data Capture and Storage

A. Electronic devices for capturing inventory, assessment, and monitoring information are available in NRCS field offices. The use of these devices assists in quick data capture and reduces transcription errors from paper copy to data analysis programs and reports.

B. Data storage of inventory, assessment, and monitoring information for conservation planning is typically kept in the individual client's hard copy casefiles or electronically within the Documents Management System (DMS).

C. The Conservation Assessment Ranking Tool (CART) is a database system that captures resource concerns and existing conditions based on resource inventory questions, along with existing practices, planned condition, and planned practices. The CART data are geo-spatially referenced to planning land units (PLUs) within a client's conservation desktop (CD) practice schedule in the client's case file. CART data are stored in the National Planning and Agreements Database (NPAD), allowing the data to be queried for analytical purposes.

D. Other options exist with partnering organizations to store inventory data in databases such as with the Jornada's Database for Inventory, Monitoring and Assessment (DIMA; https://jornada.nmsu.edu/monit-assess/dima). DIMA is an Access© database which enables field data collection. It also provides calculations and reports upon completion of data collection (handy for Interpreting Indicators of Rangeland Health and comparing data to previous years while in the field). Core methods monitoring data (e.g., data collected according to Herrick et al. 2018 and IIRH v5) can also be stored and accessed through ARS's Landscape Data Commons, which houses interagency inventory monitoring and assessment data, including BLM, AIM, and NRI data.

E. Environmental Systems Research Institute (ESRI) products are an example of other software systems available to NRCS for developing data collection apps like ArcGIS Survey 123. This can document the georeferenced point of assessment, soils, ESDs, photos, and indicator and attribute ratings for the Interpreting Indicators of Range Health (IIRH) protocol in the field via an iPhone. These data are stored in geoportals and displayed using geoportal or ArcMap. Other options include developing a dashboard to display current data. The data collected in the field are stored and applied to support conservation planning process, program delivery, and ESD development.

F. Few software systems are available to NRCS that provide the full range of standardized NRCS rangeland, pastureland, and grazed forestland inventory, assessment, and monitoring methods. The Vegetation GIS Data System (VGS) is one program available to NRCS that offers a robust system for efficiently capturing and storing inventory, assessment, and monitoring data electronically. See figure E-3. Calculations and reports are created from the data and are available immediately for review and discussion while in the field with land managers. Access to photographs from previous data collections can be compared while in the field, and the GPS unit support spatially links data to the collection site. The VGS program, support information, and training resources are available at: https://vgs.arizona.edu/.

G. Point data collected for ecological site description development are presently stored within the National Soil Information System (NASIS). This database includes plot data collected on Production and Composition Records forms such as Estimating and harvesting (double sampling) Production Form, Grazable Forest Land Evaluation-Forest Land Status and Condition Record Data Sheet (ECS-4 Appendix E-A, Exhibit E-A-1 and Exhibit E-A-2) and the Soil-Woodland Correlation Field Data Sheets (ECS-5, Appendix E-A, Exhibit E-A-3). Refer to the National Ecological Site Handbook for instruction on accessing, entering, or editing data collected for ecological site development.

Figure E-3. NRCS Rangeland Management Specialist, Josh Tashiro is performing the Line Point Intercept monitoring protocol; and NRCS Range Specialist Rian Nials records on a tablet with VGS software the foliar cover of the plant species and ground cover touched by the pin on the Stark Ranch, Texas.

645.0504 Inventory and Assessment

A. Natural resource inventorying is the process of acquiring information and objective data about the planning area, including the presence, condition, distribution, and abundance of vegetation, soil, water, biotic communities, natural and human-induced changes in resources, severity of resource concerns, and to help identify opportunities for improvement and determine which strategies may be most appropriate in given conditions. Inventories and assessments can be used to establish the baseline data for monitoring, in addition to the primary objective of generating the contextual soil, climate, topographic, and other information that is necessary to interpret assessment and monitoring data. They should be spatially explicit and geospatially locatable to enable data storage and retrieval.

B. Step 3 is the inventory phase of NRCS's nine steps of conservation planning. Collecting the appropriate natural resource, economic, and social information about the planning area is used to:

(1) Identify existing or potential resource concerns or opportunities.
(2) Further define known existing and potential resource concerns and opportunities.
(3) Clarify resource concerns.
(4) Formulate and evaluate alternatives.
(5) Gather pertinent information concerning the affected resources, the human considerations, and operation and management.
(6) Evaluate the effectiveness of implemented conservation practices in addressing resource concerns.

C. Some primary purposes and commonly conducted inventories are to document the occurrence, location, and current condition of physical habitats and features – or determine site conditions, forage production, species diversity, identify rare or threatened plant communities, endangered species, or locate and characterize fragile, rare, or sensitive areas.

D. Assessments are part of the inventory process that provide a rating of deviation from what is happening onsite to some value that is considered normal or within the natural range of variation for the site. Assessments are the estimation or judgement of the status of ecosystem structure, function, or processes, and can be conducted by gathering, synthesizing, and interpreting information from inventories or by completing specific protocols, such as Interpreting Indicators of Rangeland Health (IIRH). They can be a combination of quantitative and qualitative data. When associated with inventory information and quantitative monitoring, assessments can provide early warnings of potential resource problems and opportunities and can be used to help select monitoring sites and protocols in the development of monitoring programs.

E. In this subpart, several important inventory, assessment, and monitoring tools on range and pasturelands are described with directions for use and examples provided. Additional tools, especially those used in the NRCS National Resource Concern List and Planning Criteria, have referrals to the protocol documents with URL links provided. Predictive tools are covered in Subpart F: Managing Grazing lands.

(1) For use on Rangelands:
  (i) **Interpreting Indicators of Rangeland Health (IIRH)**, Version 5 will be used for assessing the condition of ecological functions on rangelands and is a specific assessment tool recognized in NRCS planning criteria to identify resource concern criteria thresholds. IIRH is essential for conservation planning on rangelands (Technical Reference 1734-6 V5, Interpreting Indicators of Rangeland Health; Pellant et al. 2020). https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/rangepasture/range/?cid=stelprdb1068410.
  (ii) **Similarity Index** is used to compare current vegetation in terms of kinds, proportions, and amounts on an ecological site to the documented composition of any plant community.
  (iii) **Rangeland Trend Worksheet** is a rating of the direction of change that may be occurring on a site. The plant community and the associated components of the ecosystem may either be moving toward or away from the reference state or another desired plant community or state.
  (iv) Other methods for collecting data on rangelands are the National Resources Inventory (NRI) method. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/processes/?cid=nrcs143_014072 and the Bureau of Land Management Assessment, Inventory, and Monitoring (AIM) Strategy at: https://landscape.blm.gov/geoportal/catalog/AIM/AIM.page#:~:text=The%20Assessment%2C%20Inventory%2C%20and%20Monitoring,on%20the%20nation's%20public%20lands.

(2) For use on Pasturelands:
  (i) **Guide to Pasture Condition Scoring (PCS)** is used for assessing the ecological condition on pastureland through the visual evaluation of 10 indicators, which rate pasture vegetation and soils. This is a specific assessment tool recognized in NRCS planning criteria to identify resource concern criteria thresholds on pasture. (Ogles et al. 2020). https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/pasture/?cid=stelprdb1045215
  (ii) **Describing Indicators of Pasture Health (DIPH)** is designed to provide information about how well ecological processes – such as the water cycle, energy flow, and nutrient cycling – are functioning on pastureland. This also is a specific assessment tool recognized in NRCS planning criteria to identify resource concern criteria thresholds on pastureland (Spaeth 2021). The entire DIPH protocol is found later in this subpart.
  (iii) Other methods for collecting data on pasturelands are the National Resources Inventory (NRI) method. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/processes/?cid=nrcs143_014072 and the Bureau of Land Management Assessment, Inventory, and Monitoring (AIM) Strategy at: https://landscape.blm.gov/geoportal/catalog/AIM/AIM.page#:~:text=The%20Assessment%2C%20Inventory%2C%20and%20Monitoring,on%20the%20nation's%20public%20lands.

(3) For use on all grazing lands:
  Sampling Vegetation Attributes, Interagency Technical Reference, is an interagency inventory/monitoring guide that provides the basis for consistent, uniform, and standard vegetation attribute sampling that is economical, repeatable, statistically reliable, and provides many of the primary sampling methods used across the West (Culloudon 1999). https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044175.pdf.

(4) For use on riparian areas:
  (i) **Stream Visual Assessment Protocol, V2 (SVAP2)** is a stream assessment tool for qualitatively evaluating the condition of aquatic ecosystems associated with wadeable streams and is used to determine the presence of a resource concern, or to document the current condition of a suspected resource concern in NRCS planning (Boyer 2009). https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/ndcsmc/?cid=nrcs143_009158.
  (ii) **Proper Functioning Condition (PFC) Assessment for Riparian Areas**. The PFC protocol addresses the physical functioning of perennial or intermittent lotic (flowing water) riparian systems, such as rivers or streams (Dickard 2015). https://www.blm.gov/documents/national-office/blm-library/technical-reference/riparian-area-management.
  (iii) **Riparian Area Management Proper Functioning Condition Assessment for Lentic Areas**. This technical reference provides instruction for the application of the lentic PFC protocol and addresses the physical functioning perennial or intermittent lentic riparian-wetland systems, such as swamps, ponds, or marshes (Gonzalez, M.A. and S.J. Smith 2020). https://www.blm.gov/sites/blm.gov/files/docs/2020-12/TR%201737-16%20Layout%2012102 0.pdf.

645.0505 Production as Part of Inventorying and Assessment

A. Production data collected by NRCS are most commonly based on weight measurements. Weight is the most useful expression of the productivity of a plant community or an individual species. The terminology associated with vegetation biomass is normally related to production. It has a direct relationship to forage units for grazing animals that other measurements do not have. It indicates the amount of energy flow through the ecological system and represents the total quantity of organic material produced within a given period by vegetation (Society for Range Management 1998; Technical Note 190-PM-76 “Rangeland Vegetation Measurements”). Addressing and managing plant productivity and health is one of the main resource concerns for NRCS in conservation planning on grazing lands.

B. Production is determined by estimating the annual aboveground growth of vegetation and is valuable for comparing different ecological sites or states within a state-and-transition model in an ESD. Production data by species help characterize the site and provide information on potential resource concerns with structure and composition of the plant community, supply information on useable forage for livestock, and can help evaluate habitat for wildlife needs. Production and composition in an area are influenced by soils, topography, climate, weather, ecological site, fertilization, cultivation history, grazing history, irrigation, and other natural and human-caused activities.

C. Production data should be obtained at a time of year when measurements are valid for comparison with similar data from other years, other sites, and various conditions being evaluated. Timing in collecting production data is an important factor influencing results, as some growth is used by insects and rodents, some is lost to weathering, affected by recent weather conditions, or the data are taken early in the growing season before full production is reached. Therefore, these determinations are typically reconstructed to correct for these factors.

D. When considering vegetation data, it is important to understand what vegetation attribute is being referenced. There are five basic attributes of vegetation that are measured (TN 190-PM-76):

(1) Production
(2) Frequency
(3) Density
(4) Cover
(5) Structure

E. Each vegetation attribute includes different types, sampling techniques, and data interpretation possibilities. A clear understanding of the variety of types (definitions) is needed to interpret and compare data. Some definitions of production are included below. Frequency, density, cover, and structure are described in more detail under their respective headings later in this subpart. Figure E-4 shows one method for measuring production.

Figure E-4. Production techniques involve clipping, weighing and plot frames at some point to directly measure, correct estimates, or extrapolate data (TN 190-PM-76). Photo credit: Nebraska Extension Service.

(1) Gross primary production is the total amount of organic material produced, both above-ground and below-ground (Coulloudon et al. 1999).
(2) Biomass is the total amount of living plants and animals above and below-ground in an area at a given time (Society for Range Management 1998).
(3) Standing crop is the amount of plant biomass present above-ground at any given point in time. It is often modified to include above-ground and below-ground portions and may further be modified by the descriptors "dead" or "live" to more accurately define the specific type of biomass (Society for Range Management 1998).
(4) Peak standing crop is the greatest amount of plant biomass above-ground present during a given year (Coulloudon et al. 1999).
(5) Total Annual Production is all above-ground plant biomass produced during a single growing year, including woody material and regardless of palatability or accessibility to grazing animals. Total annual production is expressed in pounds per acre (lb/ac) (Herrick et al. 2009).
(6) Total forage production is vegetation production that is palatable and utilized by herbivores (Coulloudon 1999).
(7) Useable forage production is that amount of total forage production expected to be used by a type of livestock or wildlife. Different types of herbivores have differences in what useable forage is to them. Example would be the difference in cattle versus deer diets.
(8) Allocated forage is the difference of the desired amount of residual material subtracted from the total forage (Coulloudon 1999).
(9) Browse is the portion of woody plant biomass accessible to herbivores (Coulloudon 1999).
(10) Aboveground Net Primary Production is an indicator of an ecosystem’s ability to capture solar energy and covert it to organic carbon or biomass. It can be affected by environmental variability and is typically measured by clipping peak live plant material.
(11) Net primary production (NPP) is the net increase in plant biomass within a specified area and time interval. It is the amount of carbon uptake during photosynthesis after subtracting plant respiration. This measure is an important indicator for studying the health of plant communities. NPP may change in response to seasonal and drought-related drying conditions and topography.

F. Definition of production for various kinds of plants:

(1) Herbaceous plants—These plants include grasses (except bamboos), grass-like plants, and forbs. Annual production includes all above-ground growth of leaves, stems, inflorescences, and fruits produced in a single year (Habich 2001).
(2) Woody plants
    - Deciduous trees, shrubs, half shrubs, and woody vines—Annual production includes leaves, current twigs, inflorescences, vine elongation, and fruits produced in a single year (Habich 2001).
    - Evergreen trees, shrubs, half-shrubs, and woody vines—Annual production includes current year leaves (or needles), current twigs, inflorescences, vine elongation, and fruits produced in a single year (Habich 2001).
    - Yucca, agave, nolina, sotol, and saw palmetto—Annual production consists of new leaves, the amount of enlargement of old leaves, and fruiting stem and fruit produced in a single year. If current growth is not readily distinguishable, consider current production as 15 percent of the total green-leaf weight plus the weight of current fruiting stems and fruit (Habich 2001).
(3) Cacti, Pricklypear, and other pad-forming cacti—Annual production consists of pads, fruit, and spines produced in a single year plus enlargement of old pads in that year. If current growth is not readily distinguishable, consider current production as 10 percent of the total weight of pads plus current fruit production (Habich 2001).

(4) Barrel-type cactus—Consider annual production as five percent of the total weight of the plant, other than fruit, plus the weight of fruit produced in a single year (Habich 2001).

(5) Cholla-type cactus—If current growth is not readily distinguishable, consider annual production as 15 percent of the total weight of photosynthetically active tissue plus the weight of fruit produced in a single year (Habich 2001).

G. Methods for determining production and composition for specific situations. Collecting production and composition data for ecological site determinations

(1) Production is one of the characteristics used to describe an ecological site where plant community productivity and species composition of the plant community are evaluated. The ESD is the main source of information on rangeland and is used for assessing the productivity and health, and structure and composition of the plant community during conservation planning.

(2) The species composition and production amounts in ecological sites are based on the plant communities that are typical and known to occur. Therefore, interpretations of a plant community are not limited solely to species that have value for domestic livestock. For more information on ESDs see Subpart B. For more guidance on sampling for ESD site development refer to the National Ecological Site Handbook (NESH).

H. Methods for determining plant production and species composition in the field

(1) Production and composition of a plant community can be determined by one of the following ways. All three methods require some adjustment depending on factors like timing, growth stage, drying and utilization, etc. The method selected depends on the intended use of the data and circumstances around collecting the data.
(i) estimating a plot
(ii) a combination of estimating and harvesting (double sampling) a plot
(iii) harvesting a plot

(2) Some plants are on state lists of threatened, endangered, or otherwise protected species. Some plants also have harvesting restrictions due to cultural significance in an area. Regulations concerning these species may conflict with harvesting procedures described. For example, barrel-type cactus in some states is a protected species, and harvesting is not allowed. The weight of such plants is to be estimated unless special permission for harvesting is obtained. Conservationists determining production should be aware of such plant lists and regulations.

(3) Production and composition data of a plot can be collected by one of the three methods listed above. However, setting up the transect to collect the plot data is consistent across the three collection methods. Complete instructions for running a production-composition transects are found under the Double sampling plot method below.

(4) When estimating or harvesting plants for NRCS, include all parts of all plants within the quadrat. Include all parts of herbaceous plants and shrubs outside the vertical projection of the quadrat, as long as the base is within the quadrat. See figure E-8. Other agencies, such as BLM, may have different protocols for determining plot-based above-ground vegetation production. Both agency approaches are comparable when adequate plots are sampled.

I. Estimating

(1) Weight units—The relationship of weight to volume is not constant. Therefore, production and composition determinations are based on weight estimates, not on comparison of relative volumes. The weight unit method is an efficient means of estimating production and lends itself readily to self-training. This method is based on the following:
(i) A weight unit is established for each plant species occurring on the area being examined.

(ii) The size and weight of a unit varies according to the kind of plant (figure E-9). For example, a unit of 5 to 10 grams is suitable for small grass or forb species. Weight units for large plants may be several pounds or kilograms (Habich 2001).

(2) Other considerations—length, width, thickness, and number of stems and leaves, ratio of leaves to stem growth, form, and relative compactness of species (Habich 2001).

(3) The following procedure (exhibit E-1) can be used to establish a weight unit for a species. A video demonstration of the procedure is available on the Agriculture Research Service-Jornada Experimental Range website at: https://www.youtube.com/watch?v=hIgYAEWHUHI or under Plant Production at: https://jornada.nmsu.edu/monit-assess/training/videos.

Exhibit E-1. How to establish a weight unit for a species (Habich 2001):

Step 1. Decide on a weight unit (in pounds or grams) that is appropriate for the species.

Step 2. Visually select part of a plant, an entire plant, or a group of plants that will most likely equal this weight.

Step 3. Harvest and weigh the plant material to determine actual weight.

Step 4. Repeat this process until the desired weight unit can be estimated with reasonable accuracy.

Step 5. Maintain proficiency in estimating by periodically harvesting and weighing to check estimates of production.

The procedure for estimating production and composition of a single plot is:

Step 1. Estimate production by counting the weight units of each species in the plot.

Step 2. Convert weight units for each species to grams or pounds.

Step 3. Harvest and weigh each species to check whether estimates of production are higher or lower than actual weight for the species from the plot.

Step 4. Compute species composition for the plot based on actual weights to check species composition estimates.

Step 5. Repeat the process until proficiency in estimating is attained.

Step 6. Periodically repeat the process to maintain proficiency in estimating.

Step 7. Keep the harvested materials, when necessary, for air-drying and weighing to convert from field (green) weight to air-dry weight.

J. Steps for Conducting an inventory using the Estimating and harvesting method (double sampling). For more information see Coulloudon et al. 1999.

(1) The double-sampling method is used to make most production and composition determinations. Whenever feasible, obtain production data from vegetation that has not been grazed since the beginning of the current growing season. Make determinations near or shortly after the end of the growing season of the major species and give consideration to species that mature early in the growing season.

(2) Equipment—The following equipment is needed:
- (i) Production form (see figures E-10 and E-11)
- (ii) Sampling frames or hoops
- (iii) One stake: 3/4- or 1-inch angle iron not less than 16 inches long
- (iv) Herbage Yield Tables for Trees by Height, DBH, or Canopy
- (v) Clippers
- (vi) Paper bags
- (vii) Kilogram and gram spring-loaded scales with clip
- (viii) Tree diameter measuring tape
- (ix) Steel post and driver
- (x) Oven for drying vegetation
- (xi) Air-dry weight conversion tables
- (xii) Rubber bands
- (xiii) Pin flags

(xiv) Compass

(3) Step 1—The most important factor in obtaining usable data is selecting representative areas (critical or key areas) in which to conduct the study. Transects and sampling points need to be randomly located within the critical or key areas. Determine if the planning area needs to be stratified or separated out by certain differences such as diverse vegetation types or condition, different ecological sites, or is influenced by management changes. Additional stratification criteria are selected where production and composition information are needed to address a specific resource concern, such as pollinator habitat or riparian area condition. In conservation planning, a strict statistical randomization design is not needed. Determine the sample area based on "subjectivity without preconceived bias." More information on stratifying can be found in Volume II Monitoring Manual-Design, Supplementary methods and Interpretation, Herrick et al. (2009).

(4) Step 2—Verify the soil and ecological site by digging a hole and documenting soil features on the data collection form (see Subpart B for more instructions). Where more than one ecological site exists in the planning area, determine the acreage of the major ecological sites that occupy the largest areas. Collect production data on each major ecological site and plant community phase in the planning area.

(5) Step 3—Select a randomized transect layout. Numerous layout designs can be used in different protocols. Several are mentioned here with references. Other systematic sampling procedures can be used to fit the need during the inventory process.

(i) An example of a linear layout is referenced in Sampling Vegetative Handbook (Coulloudon et al. 1999) attributes with an example provided here in figure E-5. If a linear transect is chosen, determine the transect bearing and select a prominent distant landmark such as a peak, rocky point, etc., that can be used as the transect bearing point.

(ii) The 2021 National Resources Inventory Grazingland Instructions uses the following production protocol: Herbaceous production quadrats are centered on transect marks at 12.5, 37.5, 62.5, 112.5, and 137.5 feet on the NE/SW and NW/SE transects for the ESD option. See figure E-6. For the NRI data collection option, herbaceous production quadrats are centered on marks at 12.5 and 137.5 feet on the NW/SE transect and 37.5, 62.5 and 112.5 feet on the NE/SW transect. Quadrat size can be 1.92, 4.8, or 9.6 square feet. More information is at: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/nri/.

(iii) The Interpreting Indicators of Rangeland Health Version 5 protocol gives an example of a five-plot minimum random layout where one plot is near the center of the evaluation/study area and then four plots are established in each quarter of the evaluation area. To randomly establish the plots in this way, select a random direction (azimuth) between 0 and 360 degrees and a random number less than 10. In the middle of the evaluation area, face the random direction and then take steps equal to the random number less than 10. This will be the starting point for the first production plot (figure E-7). Place the frame on the ground with the edge against your toe. Next, select four random bearings within each quarter of the evaluation area (0–90, 91–180, 181–270, and 271–360 degrees) and four random numbers less than 10 to pace along each bearing starting from plot 1. Make sure the random pace numbers remain within the evaluation area.

Figure E-5. Randomized Linear Plot Design.

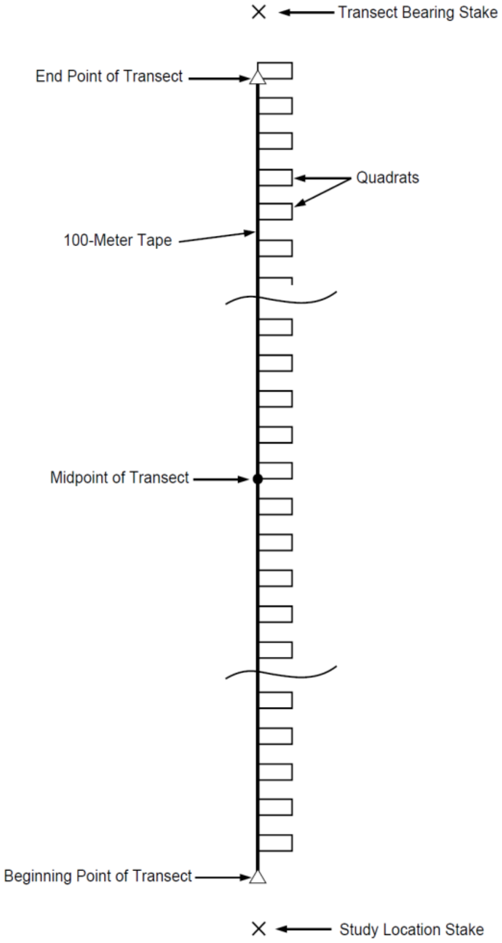


Figure E-6. Transects and associated production quadrats for the NRI data collection option (USDA, National resources inventory grazing land on-site data collection, Handbook of instructions, 2021).

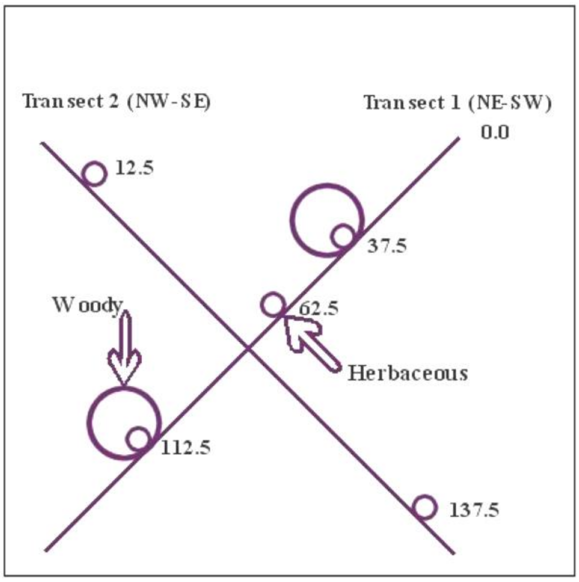
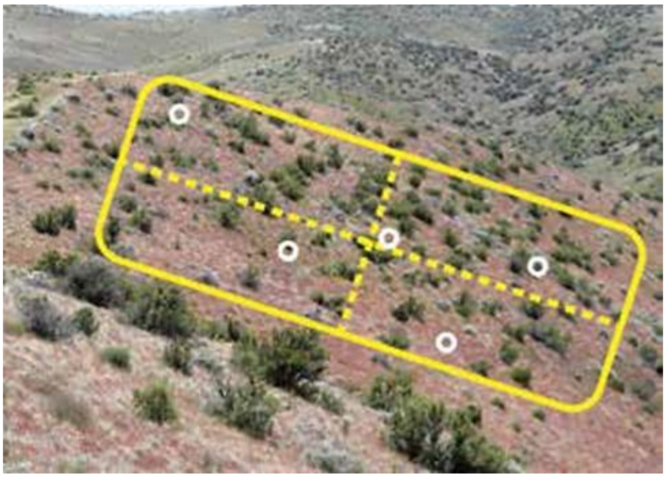


Figure E-7. Example of five annual production plot locations that were selected randomly in an evaluation/study area (Pellant et al. 2005, 2020).



(6) Step 4—Number of Quadrats. The number of quadrats selected depends on the purpose for which the estimates are to be used, uniformity of vegetation, and other factors. Different recommendations are associated with a minimum number of plots needed for different protocols, but usually a minimum of 5 to 10 plots is selected for data to be used in determining production. If vegetation is very irregular, and 10 plots will not provide an adequate sampling, additional plots should be selected. See the estimating required sample size table at the end of this section for the number of samples required at a percent probability level.

(i) The size and shape of quadrats must be adapted to the vegetation community to be sampled. Plots can be circular, square, or rectangular. The area of a plot can be expressed in square feet, acres, or square meters. If vegetation is short enough to allow plot markers to be easily placed, use 1.92-, 2.40-, 4.80-, and 9.60-square foot plots to determine production in lbs/acre. The 9.6-square foot plot is generally used in areas where vegetation density and production are light, generally less than 3,000 lbs/acre. The smaller plots, especially the 1.92-square foot plot, are satisfactory in areas of homogeneous, dense vegetation generally greater than 3,000 lbs/acre like that occurring in meadows, some pastures, and throughout the plains and prairie regions. Plots larger than 9.6 square feet should be used where vegetation is very sparse and heterogeneous.

(ii) If the vegetation is very sparse or consists of trees or large shrubs, larger plots must be used. If the tree or shrub cover is uniform, a 66- by 66-foot plot or 0.1 acre is suitable. If vegetation is unevenly spaced, a more accurate sample can be obtained by using a 0.1-acre plot, that is 4.356 feet wide and 1,000 feet long. For statistical analyses, 10 plots of 0.01 acre are superior to a single 0.1-acre plot. If vegetation is mixed, two sizes of plots generally are needed. A series of 10 square or rectangular plots of 0.01 acre and a smaller plot, such as the 9.6-square foot plot nested in a designated corner of each larger plot, is suitable. The 0.01-acre plot is used for trees or large shrubs, and the smaller plot for lower growing plants. Weights of the vegetation from both plots are then converted to pounds per acre. If the plots are nested, production from both plots must be recorded in the same units of measure.

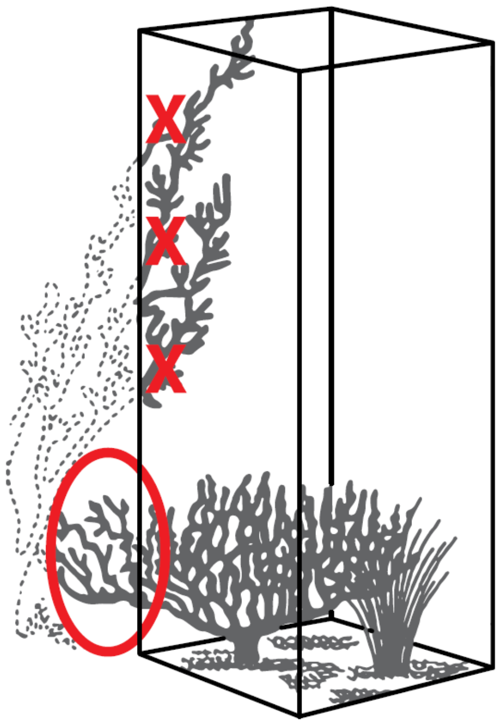
(7) Step 5—Mark the location of each study site with a reference point. It is common to take a GPS reading to be able to go back to the site or upload the information into an electronic folder or download onto a map.

(8) Step 6—Weight Units. Double sampling requires the establishment of a weight unit for each species occurring in the study area to be sampled. All weight units are based on current year's growth.

Procedures for Establishing Weight Units: Decide on a weight unit that is appropriate for each species (figure E-9). A weight unit could be an entire plant, a group of plants, or an easily identifiable portion of a plant, and can be measured in either pounds or grams.

- Visually select a representative weight unit.
- Harvest and weigh the plant material to determine the actual weight of the weight unit.
- Maintain proficiency in estimating by periodically harvesting and weighing to check estimates of production.

Figure E-8. Example of NRCS approach for estimating annual production in a plot. This approach includes portions of plants rooted inside the plot that extend outside the plot (circled). This approach does not include portions of plants rooted outside the plot that overhang inside the plot (red Xs) (Pellant et al. 2005, 2020).



- Estimating Production of a Single Quadrat:
  – Estimate production by counting the weight units of each species in the quadrat.
  – Convert weight units for each species to grams or pounds.
  – Harvest and weigh each species to check estimate of production.
  – Repeat the process until proficiency is attained.
  – Periodically repeat the process to maintain proficiency in estimating.
  – Keep the harvested material, when necessary, for air-drying and weighing to convert from green weights to air-dry weights.
- Alternate Method of Establishing Weight Units:
  – Decide on a weight unit that is appropriate for each species (figure E-9). A weight unit could be an entire plant, a group of plants, or an easily identifiable portion of a plant, and can be measured in either pounds or grams.
  – Visually select a representative weight unit.
  – Instead of weighing the material, save it by securing it with rubber bands so portions are not lost.
  – Use this as a visual model for comparison at each quadrat in the transect. Record on the proper forms only the number of weight units. Do not record the estimated weights.

- Weigh each weight unit at the conclusion of the transect. Weighing the weight unit before the conclusion of the transect might influence the weight estimates.
- Convert the weight units on the form to actual weight by multiplying the number of units by the weight of the unit.
- Harvested weight unit material is not saved for determining air-dry weight conversion. Air-dry conversions are determined from clipped quadrats.

(9) Step 7—Temporarily mark the quadrat by placing a pin flag next to the quadrat so that it can be relocated later if this quadrat is selected for clipping. Be sure to flag every quadrat.

(10) Step 8—Estimate and record the weight of each species in the quadrat by means of the weight-unit method (method selected in Step 6).

(11) Step 9—Continue the transect by establishing additional quadrats according to layout design selected.

(12) Step 10—After weights have been estimated on all quadrats, select the quadrats to be harvested.

(i) The quadrats selected should include all or most of the species in the estimated quadrats. If an important species occurs on some of the estimated quadrats but not on the harvested quadrats, it can be clipped individually on one or more other quadrats.

(ii) The number of quadrats harvested depends on the number estimated. At least one quadrat should be harvested for each seven estimated to adequately correct the estimates (see table E-1).

Table E-1. Number of Quadrats Harvested per Number Estimated (Coulloudon, TR 1734-4, 1999).

Number of quadrats Estimated	Minimum Number of Quadrats to be Weighed
1–7	1
8–14	2
14–21	3
22–28	4
29–35	5
36–42	6

(13) Step 11—Harvest, weigh, and record the weight of each species in the quadrats selected for harvesting. Harvest all herbaceous plants originating in the quadrat at ground level. On rangeland, harvest all of the current year’s leaf, twig, and fruit production of woody plants located in the quadrats. On native pasture and grazable woodland, harvest the current leaf, twig, and fruit production of woody plants within the plot up to a height of 4 1/2 feet above the ground (Coulloudon 1999).

(14) Step 12—Correct estimated weights by dividing the harvested weight of each species by the estimated weight for the corresponding species on the harvested quadrats. This factor is used to correct the estimates for that species in each quadrat. A factor of more than 1.0 indicates that the estimate is too low. A factor lower than 1.0 indicates that the estimate is too high.

(15) Step 13—Reconstruct values for percent of growth made during the year, and percent of growth grazed or otherwise lost. Use growth curves from the ecological site description to reconstruct weights to 100 percent of annual growth values. See the Similarity Index form for instructions on reconstructing the production of a site.

(16) Step 14—After quadrats are estimated and harvested and correction factors for estimates are computed, air-dry percentages are determined by air-drying the harvested materials or by selecting the appropriate factor from an airdry percentage table (Appendix E-D). Values for each species are then converted to air-dry pounds per acre or kilograms per hectare for all quadrats.

(17) Step 15—Average weight and percentage composition can then be computed for the sample area by multiplying the weight by the number of acres within each area to get the total pounds available. Add the total areas together within an operating unit, for example

by pasture to calculate total production for that planning area. Use table E-2 to convert grams to pounds per acre.

Table E-2. Conversion to pounds per acre (# of plots x size = total area).

10 x 0.96	= 9.6 ft^2	multiply grams times 10.0	=	pounds per acre
10 x 1.92	= 19.2 ft^2	multiply grams times 5.0	=	pounds per acre
10 x 2.40	= 24.0 ft^2	multiply grams times 4.0	=	pounds per acre
10 x 4.80	= 48.0 ft^2	multiply grams times 2.0	=	pounds per acre
10 x 9.60	= 96.0 ft^2	multiply grams times 1.0	=	pounds per acre
10 x 96.0	= 960.0 ft^2	multiply grams times 0.1	=	pounds per acre

(i) Data Analysis—This technique involves destructive sampling (clipped pots), so permanent transects or quadrats are not recommended. Since the transects are not permanently marked, use the appropriate nonpaired test. When comparing more than two sampling periods, use ANOVA. See table E-3 to estimate the required number of samples.

(ii) If plant communities consist of a mixture of warm and cool-season species, at least two determinations may be needed during a single production year. The following procedure should then be used:

- Select two periods that will yield the best estimate of the growth of most of the important species.
- At the first determination, estimate and harvest only the species that are mature or nearly mature.
- At the second determination, select a new set of plots for estimating and harvesting all other species, but record the data on the same form used for the first determination.

K. Use the following procedure to estimate the vegetative production and composition of a conservation planning area:

(1) Determine if the planning area needs to be stratified or separated out by certain differences such as diverse vegetation types or condition, different ecological sites, or is influenced by management changes. Additional stratification criteria will be selected where production and composition information are needed to address a specific resource concern, such as pollinator habitat or riparian area condition.

(2) Where more than one ecological site exists in the planning area, determine the acreage of the major ecological sites that occupy the largest areas. Select one of the inventory methods to estimate the production of each major ecological site and plant community phase in the planning area.

(3) Estimate or harvest production, in pounds per acre for each of the stratified areas within the planning unit. See figures E-10 and E-11.

(4) Compute species composition, by weight, of each of the areas from the production data.

(5) Adjust the production and composition values to air dry weight.

(6) Reconstruct values for percent of growth made during the year and percent of growth grazed or otherwise lost. Use growth curves from the ecological site description to reconstruct weights to 100 percent of annual growth values (see the Similarity Index form for instructions on reconstructing the production of a site).

(7) The Estimating required sample size chart in table E-3 provides a method for determining the number of plots required for an adequate sample or use a minimum plot sample size feature in vegetation collection systems like the Vegetation Geospatial Data System (VGS) when available.

Figure E-9. Examples of Weight Units.

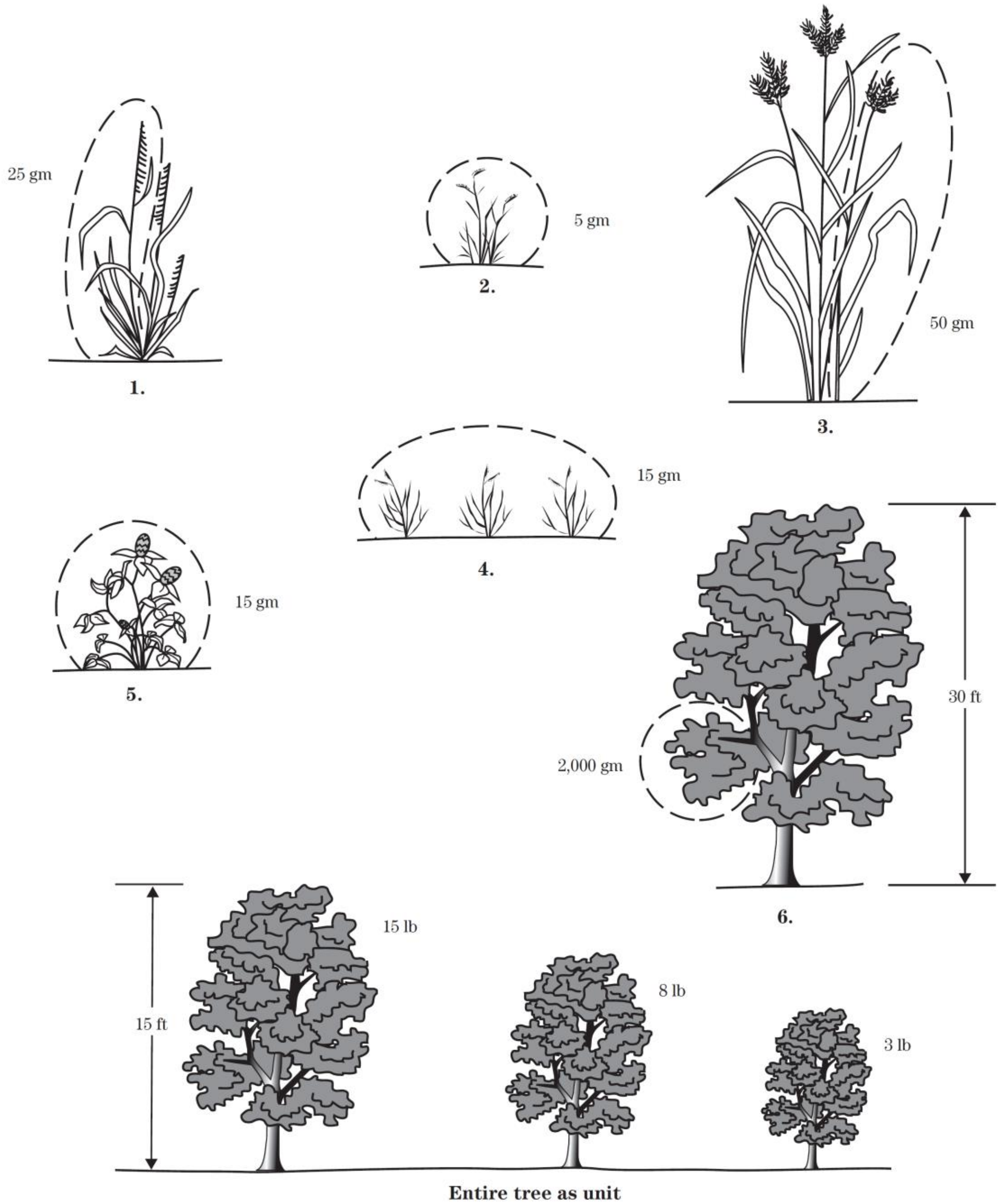


Figure E-10. Estimating and harvesting (double sampling) Production Form.

Page ____ of ____

Production

Study Number	Date	Examiner	Allotment Name & Number	Pasture
Transect Location		Quadrat Size	Transect Bearing	

	Plant	Estimated or Clipped Weight Per Species										Wt Clipped Plots			QCF	%Dry	Wt All	Avg	Pct
Plant Name	Symbol	(Circle Plots that are Clipped) (3)										Est	Clip	Dry		Wt	Plots	Yield	Comp
(1)	(2)	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Totals																			

Notes (use other side or another page)

Figure E-11. Estimating and harvesting (double sampling) Production Form Example.

Page 1 of 1

Production

Study Number 13N-41E-27-04 | Date 9/30/95 | Examiner Rex Johnson | Allotment Name & Number Round Mtn 11078 | Pasture Ridge

Transect Location 2 miles north of Jack's well on the left hand side of the road. | Quadrat Size 9.6 sq. ft. | Transect Bearing 225°

Plant Name (1)	Plant Symbol (2)	Estimated or Clipped Weight Per Species (Circle Plots that are Clipped) (3) P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	Wt Clipped Plots Est (4)	Clip (5)	Dry (6)	QCF (7)	%Dry Wt (8)	Wt All Plots (9)	Avg Yield (10)	Pct Comp (11)
Black Grama	BOER 2	12	16	5		16	8		3	8	3	8	9		1.12	55	71	43.7	12
Curly Mesquite	HIbe	7		12	7		4	9		3		12	13		1.08	60	42	27.2	8
Blue Grama	BOGR 2	3	4	3	7	4		1	8		5	8	7		.87	60	35	18.3	5
Sideoats Grama	BOCU		8		1		12	5		7	3	3	4		1.33	55	36	26.3	7
Bush Muhly	MUPO2					3						3	3		1.00	55	3	1.6	1
Sixweeks Grama	BOBA			1					6	2	6	7	8		1.14	60	15	10.3	3
3-AWN	ARIST			10				5			8	18	16		.88	60	23	12.1	3
	VUOC					3	1			3	3	3	2		.66	55	10	3.6	1
	GiliA	3		5	8		1		2	12	1	6	7		1.16	40	32	14.8	4
Lotus		2	1		3	5		1	5		6	6	7		1.16	40	23	10.7	3
Lupin			3	2		6	1	7		2	1	3	4		1.33	40	22	11.7	3
Pepperweed					2		2		3	4	3	3	4		1.33	40	14	7.4	2
Burroweed	HAGR	25		18	12			30		7		18	20		1.11	65	92	66.4	18
Mesquite	PRJU		32			20	45		15		28	28	31		1.10	50	140	77	21
Wolfberry	Lyph			20				12		15		20	22		1.10	65	47	33.6	9
Totals																		364.7	100

Notes (use other side or another page)

Table E-3. Estimating required sample size chart. A preliminary sample of five quadrats (4.8 ft^2) yielded the following weights in grams:

Sample Number:	**Weight (grams)**
1	200
2	250
3	275
4	300
5	250
6	225
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Number of Samples (n) required to estimate the mean within 10% of the Sample Mean:	
95% probability level:	14.0
90% probability level:	9.0
80% probability level:	5.0

250.0	□ = mean
6	Number of samples (n)
1250.00	Variance of sample x (s)2

L. Harvesting—This method is like the double-sampling method except that all plots are harvested. The double-sampling procedures for estimating weight by species and the subsequent correction of estimates do not apply. If the harvesting method is used, selection and harvest of plots and conversion of harvested weight to air-dry pounds per acre are performed according to the procedures described for double sampling.

M. Dry-weight rank

(1) The dry-weight rank method determines species composition. It consists of observing various quadrats and ranking the three species which contribute the most weight in the quadrat. It is important to establish a photo plot and take both close-up and general view photographs with this method.

(2) Dry-weight rank results are expressed only as percentage values. The benefit of the method is that a large number of samples can be obtained very quickly. It also deals with estimates of production, which allows for better interpretation of the data to make management decisions. The method is suitable on rangeland, pastureland, and understory of forest lands with small shrubs. It does not work well on large shrubs and trees themselves. The dry-weight rank method is described in detail in Sampling Vegetation Attributes, Interagency Technical Reference 1734-4, 1999. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044175.pdf.

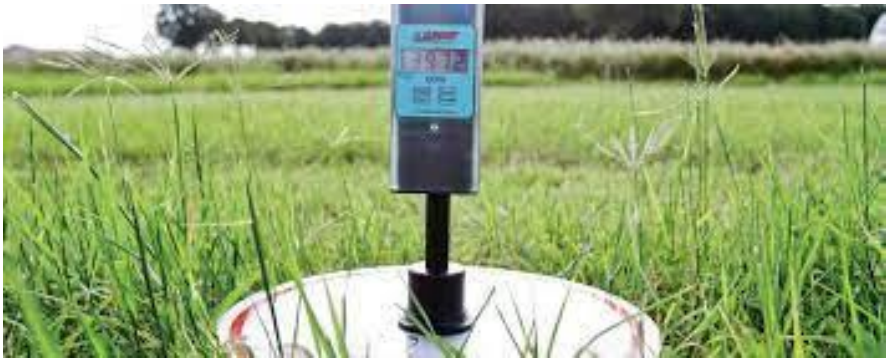
N. Rising Plate Meters

(1) The rising plate meter is a commonly used tool for estimating forage mass in pastures with one to two forage plant species. See figure E-12. This method relies on both plant height and density. It is a device that consists of a weighted plate that slides over a shaft. As the meter is placed over forage, the forage is compressed to the point where it supports the plate. The plate meter measures the compressed height or density of the forage. This

measurement is correlated with forage bulk density and then converted to dry matter yield using a calibration equation. The rising plate meter method is more precise than the pasture ruler but requires a greater investment in both time and money. Calibration of the plate meter is required for the type of forage to be measured, especially in pastures with multiple forage species whose yield estimations are influenced by differences in growth habit and growth rate of the forages. The level of error in measuring forage mass with rising plate meters can vary widely. Therefore, striving for a calibration error of 10 percent or less of clipped pasture yields is recommended to avoid major miscalculations in forage budgeting.

(2) Commercial manufacturers of rising plate meters often have instructions for collecting and using calibration samples to predict pasture dry matter. University extension services may also have developed conversion factors needed to convert plate meter heights to dry matter in lbs/acre for various species. Pastures are usually not uniform, so when estimating pasture dry matter, the more rising plate meter readings that are taken, the more accurate the estimate will be. It is recommended to take at least 30 measurements, or a measurement every few steps while walking through a sample area.

Figure E-12. Rising Plant Meter. Photo credit: The Samuel Roberts Noble Foundation.



(3) Using and calibrating a rising plate meter is described in detail in Determining Pasture Yield from Pennsylvania State University at: https://extension.psu.edu/determining-pasture-yield.

(4) Video demonstration by the Dairy Farmers of America is available titled Measuring Pasture with a Rising Plate Meter at: https://www.youtube.com/watch?v=9zp8PRConnM.

O. Pasture Sticks

(1) Pasture rulers or pasture sticks are used to assist in estimating forage yield and provide a beneficial tool for helping conservation planners and land managers calibrate their visual estimates and knowledge of pasture production. See figures E-13 and E-14.

(2) Pasture sticks vary from state to state and offer different features for estimating forage production based on forage type, and dry matter yield for those forages. They are usually developed in partnership with a university and based on correlation research work of forage height to dry matter yield. It is important that the correct pasture stick is used for the area to be sampled.

(3) Grazing sticks look like simple measuring devises but are really a measurement system (Smith et al. 2010). Most pasture sticks consist of a ruler to measure forage height, a density meter to estimate stand density, a table to convert density to dry matter yield, and guidance on start and stop grazing heights for various plant species. Forage height is observed and recorded by walking through a pasture at a set step or pace interval, usually 25 to 30 depending on the size of the sampling area. Ensuring all spots are measured, including the height of bare spots as well as areas of dense growth, and are recorded avoids bias and miscalculated yields. Keeping your eye on the horizon until you land on a point to sample also helps prevent bias on where to sample.

(4) The number of observations or estimates needed is dependent upon the size of the pasture, topography, and uniformity of the forage stand. Adequate sample numbers are key to obtaining a reliable estimate of production for the area. If pastures have more than one soil type that exhibits a different pasture state or different forage group, then each of the soil types should be sampled. Height data is averaged and then divided by the number of samples. Calibration of the stick through harvest methods will improve the accuracy of the estimates. General instructions taken from the University of Kentucky's Using a Grazing Stick for Pasture Management (Smith 2010) are:

(i) Step 1—Select estimation areas consisting of one soil taxonomic unit. This should be a benchmark soil or taxonomic unit that is an important component of an ecological site. Use the stratification guidelines in subpart B for pastures that are not uniform in soils, ecological site, topography, or forage yield.

(ii) Step 2—Identify the plant species or mix of plant types for each estimation area.

(iii) Step 3—Use the ruler to measure forage height. Height is not a measure, but rather an average of the tallest plants. Spread your hand and lower it onto the canopy. The average height is measured at the point where you feel very modest resistance from the plant canopy. Record the height for each sample location in the pasture and then calculate the average height for the pasture.

(iv) Step 4—Determine density of the forage stand at each location where a height measurement was obtained by sliding the stick under the grass canopy with the density meter visible. Count the markings visible and record the density reading. Stand density is the amount of ground surface covered with standing forage. For the Kentucky protocol, the goal is to place the pasture into one of three density categories (< 75 percent, 75–90 percent, or > 90 percent). Some sticks have a density-yield chart on them to obtain the estimated dry matter per inch of height in pounds per acre.

(v) Step 5—Estimate forage dry matter yield per inch for the plant type in the sampling area by calculating the average stand density for each location and compare to the density yield table on the stick. For example, in measuring a tall fescue pasture, and the estimate is that the available forage covers 85 percent of the ground area, this pasture would be assigned to the middle density category of 75 to 90 percent cover. According to table E-4, this density rating would be between 150 and 200 lbs of DM per acre-inch. Based on the assessment of the stand, assign a yield. The thicker the stand, the closer the yield will be to the upper end of the range. Since 85 percent is in the upper end of this density category, 200 lbs of DM per acre-inch would be a good estimate. If the average stand height is eight inches and the goal is to maintain three inches of stubble after grazing, available forage equals: 5 inches x 200 lbs/acre-inch = 1,000 lbs DM/acre.

(vi) Step 6—Calculate the forage yield of the planning area by adding the estimated forage yields of each sampling area.

Table E-4. Estimated dry matter yield per acre inch based on density and forage type. (Smith 2010).

Forage	Density		
	<75%	75–90%	>90%
	Dry Matter Yield (lbs)		
Tall fescue or orchardgrass	50–150	150–200	200–300
KY Bluegrass	50–100	100–175	175–250
Cool-season grass (clover)	50–125	125–200	200–275
Bermudagrass	100–200	200–300	300–400
Alfalfa	75–150	150–225	225–300
Red clover	75–125	125–175	175–250

Figure E-13. Estimating Density with a Pasture Stick. Photo Credit: NRCS Churchville, Maryland.

Figure E-14. Using a pasture stick. Photo credit: NRCS Churchville, Maryland.

(5) Detailed instruction for using and calibrating a pasture stick are described in the University of Kentucky Cooperative Extension Service publication, Using a Pasture Stick for Pasture management-AGR-191. http://www2.ca.uky.edu/agcomm/pubs/agr/agr191/agr191.pdf.

  (i) A video demonstration using a pasture stick developed for South Dakota is available at: https://www.youtube.com/watch?v=c9CylrlqVvI.

  (ii) Consult your local Land Grant University or Extension Agent for more localized information if it has not been developed in your area.

(6) Units of production and conversion factors

  All production data are to be expressed as air-dry weight in pounds per acre (lb/ac). The field weight must be converted to air-dry weight. This may require drying or the use of locally developed conversion tables. Conversion tables for metric weights is listed in table E-5.

Table E-5. Conversion factors.

To convert	To	Multiply by
Metric units		
Kilogram per hectare	Pounds per acre	0.891
Kilograms	Pounds	2.2046
Hectares	Acres	2.471
English units		
Pounds per acre	Kilograms per hectare	1.12
Pounds	Kilograms	0.4536
Acres	Hectares	0.4047

(7) Converting green weight to air-dry weight

(i) If precise production figures are needed or if air-dry weight percentage figures have not been previously determined and included in locally developed tables, retain and dry enough samples or harvested material to determine air-dry weight percentages. Tables of the percentage of total weight that is air-dry weight for various types of plants at different stages of growth are provided in tables E-6 through E-10. These percentages are based on currently available data and are intended for interim use. Air-dry weight percentages listed in the tables can be used for other species having growth characteristics like those of the species listed in the tables. States that have prepared their own tables of air-dry percentages based on actual field experience should substitute them for these tables. Local conservationists are encouraged to develop these tables for local conditions and species. Some interpolation must be done in the field to determine air-dry percentages for growth stages other than those listed. Appendix E-D (NRCS Oregon Range Technical Note No. 27 – Dry Weight Percentages of Selected Oregon Grasses, Grass-likes, Forbs, Vines, Shrubs, and Trees) provides additional dry weight percentages of selected Oregon plant species.

(ii) The relationship of green weight to air-dry weight varies according to such factors as exposure, amount of shading, time since last rain, and unseasonable dry periods. Several samples of plant material should be harvested and air-dried each season to verify the factors shown or to establish factors for local use. Fresh samples should be brought from the field in paper sacks and kept long enough (usually 10 days) until all water is lost, and the weight of the sample stabilizes for an accurate final weight.

Table E-6. Percentage of air-dry matter in harvested grass plant material at various stages of growth.

Season	Grasses	Before heading out, initial growth to boot stage (%)	Headed out, boot stage to flowering (%)	Seed ripe; Leaf tips drying (%)	Leaves dry; Stems partly Dry (%)	Apparent dormancy (%)
Cool Season	wheatgrasses Perennial bromes bluegrasses Prairie junegrass	5	45	60	85	95
Warm Season Tall Grasses	bluestems Indiangrass switchgrass	30	45	60	85	95
Warm Season Midgrasses	Sideoats grama tobosa galleta	40	55	65	90	95
Warm season short grasses	Blue grama buffalograss Short three-awns	45	60	80	90	95

Table E-7. Percentage of air-dry matter in harvested tree material at various stages of growth.

Trees		New leaf and twig growth until leaves are full size (%)	Older and full-size green leaves (%)	Green fruit (%)	Dry fruit (%)
Evergreen coniferous	Ponderosa pine, slash pine-longleaf pine	45	55	35	85
	Utah juniper				
	Rocky mountain juniper				
	Spruce				
Live oak		40	55	40	80
Deciduous	Blackjack oak	40	50	35	85
	Post oak				
	hickory				

Table E-8. Percentage of air-dry matter in harvested shrub material at various stages of growth.

Shrubs		New leaf and twig growth until leaves are full size (%)	Older and full-size green leaves (%)	Green fruit (%)	Dry fruit (%)
Evergreen	big sagebrush	55	65	35	85
	bitterbrush				
	ephedra				
	algerita				
	gallberry				
Deciduous	snowberry	35	0	30	85
	rabbitbrush				
	snakeweed				
	Gambel oak				
	mesquite				
Yucca and yucca-like plants	yucca	55	65	35	85
	sotol				
	saw-palmetto				

Table E-9. Percentage of air-dry matter in harvested form material at various stages of growth.

Forbs		Initial growth to flowering (%)	Flowering to seed maturity (%)	Seed ripe; leaf tips dry (%)	Leaves dry; stems drying (%)	Dry (%)
Succulent	violet	15	5	60	90	100
	waterleaf					
	buttercup					
	bluebells					
	Onion, lilies					
Leafy	lupine	20	40	60	90	100
	lespedeza					
	compassplant					
	balsamroot					
	tickclover					
Fibrous leave or mat	phlox	30	50	75	90	100
	mat eriogonum					
	pussytoes					

Table E-10. Percentage of air-dry matter in harvested cacti material at various stages of growth.

Succulents	New growth pads and fruits (%)	Older pads (%)	Old growth in dry years (%)
Pricklypear and barrel cactus	10	10	15+
Cholla cactus	20	25	30+

(8) Determining production of tree or large shrub vegetation

(i) Determining production of trees and large shrubs by harvesting portions of stands is time consuming and impractical for regular field conservation planning procedures. Research scientists have devised, with some success, methods for calculating the relationship between current year’s production as it relates to measurements of crown width or height and basal area. Because of these limitations, it is recommended that range and pasture management specialists are to use the following procedures in preparing guides for determining tree and large shrub production values on rangeland and naturalized pastureland:

- Select a few sample trees for each species. Samples should reflect variations in tree size, form, and spacing.
- Determine production through a combination of estimating and harvesting. For estimates, establish appropriate weight units. These units can be an entire small tree or a branch or cluster of branches from large trees (see figure E-9). Determinations from sample trees should include all components of current year’s production including current twig growth (< ¼ inch). Exclude bark and wood. Current leaf and twig production can be easily identified for some species. Field determinations of production can be based on current leaf production only if data are available to indicate the percentage that various components contribute to total production. For species requiring two years for fruit maturity, half the weight of mature fruit represents the current production of fruit.
- Expand woody plot estimates to 0.1 acre or larger. Record production for each tree or large shrub. If the 0.1- or 0.01-acre or the 400-square meter plots are used in stands of trees, the likelihood of the plot boundary hitting the bole of a tree is high. Include trees with 50 percent or more of their bole rooted in the plot. List component species, tree size, aspect, growth forms, number of trees, and density of the canopy.
- Repeat this process for stands of various kinds of trees or large shrubs. Based on data thus collected, prepare guides that list the approximate annual production of stands of various kinds of trees or large shrubs (see figures E-15, E-16, and E-17).

(ii) Instructions for use of figures E-15 and E-16 Foliage denseness classes:

Determine yields of juniper and pinyon pine by:

– On 0.1- or 0.01-acre plots selected by random, tally crown diameter per tree and foliage denseness (sparse, medium, and dense) on each tree. From the figures, find yield per tree for each tree by crown diameter and foliage denseness from the proper table (range site) and record this opposite each tree. Add this column of weights. Multiply by 10 on 0.1-acre plots and by 100 on 0.01-acre plots. This number is pounds per acre annual yield.

– On 0.1- or 0.01-acre plots selected by random, tally crown diameter and foliage denseness for each tree. Average the crown diameter for the dense foliage trees; likewise, for the medium and sparse separately. Find the weight per tree in the proper tables opposite for average crown diameter and multiply this figure by the number of trees in the foliage class. Do this for each foliage class. Add the three figures. Multiply by 10 on the 0.1-acre plots and by 100 on the 0.01-acre plots to get yield per acre.

Figure E-15. Foliage denseness classes graphic.

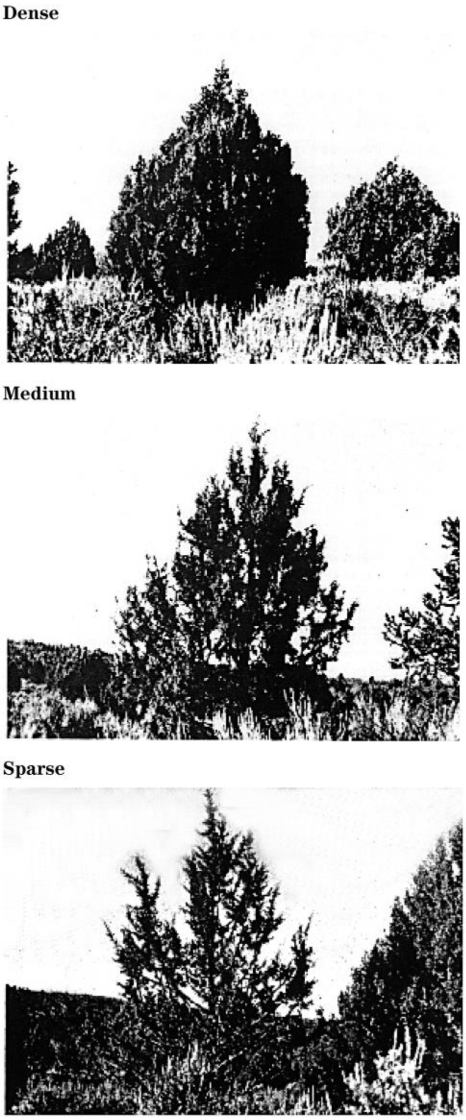


Figure E-16. Foliage denseness classes for juniper trees.

Guide for Determining Current Yield of Utah Juniper in Utah Upland Stony Loam (Juniper) Site
Current Yield Air Dry Pounds

Crown diameter ft)	Weight per tree	10 trees	50 trees	100 trees	200 trees	300 trees	400 trees	500 trees
Sparse foliage								
1	0.1	1	5	10	20	30	40	50
2	0.3	3	15	30	60	90	120	150
3	0.6	6	30	60	120	180	240	300
4	1.0	10	50	100	200	300	400	500
5	1.3	13	65	130	260	390	520	650
6	1.6	16	80	160	320	480	640	800
7	1.9	19	95	190	380	570	760	950
8	2.3	23	115	230	460	690	920	1150
9	2.6	26	130	260	520	780	1040	1300
10	2.9	29	145	290	580	870	1160	1450
11	3.3	33	165	330	660	990	1320	1650
12	3.6	36	180	360	720	1080	1440	1800
13	4.0	40	200	400	800	1200	1600	2000
14	4.4	44	220	440	880	1320	1760	2200
15	4.7	47	235	470	940	1410	1880	2350
16	5.1	51	255	510	1020	1530	2040	2550
17	5.5	55	275	550	1100	1650	2200	
18	5.8	58	290	580	1160	1740	2320	
19	6.2	62	310	620	1240	1860	2480	
20	6.6	66	330	660	1320	1980	2640	
Medium foliage								
1	0.1	1	5	10	20	30	40	50
2	0.3	3	15	30	60	90	120	150
3	0.6	6	30	60	120	180	240	300
4	1.0	10	50	100	200	300	400	500
5	1.4	14	70	140	280	420	560	700
6	1.9	19	95	190	380	570	760	950
7	2.5	25	125	250	500	750	1000	1250
8	3.1	31	155	310	620	930	1240	1550
9	3.8	38	190	380	760	1140	1520	1900
10	4.6	46	230	460	920	1380	1840	2300
11	5.4	54	270	540	1080	1620	2160	2700
12	6.2	62	310	620	1240	1860	2480	
13	7.2	72	360	720	1440	2160		
14	8.1	81	405	810	1620	2430		
15	9.1	91	455	910	1820	2730		
16	10.2	102	510	1020	2040			
17	11.3	113	565	1130	2260			
18	12.4	124	620	1240	2480			
19	13.6	136	680	1360				
20	14.8	148	740	1480				
Dense foliage								
1	0.1	1	5	10	20	30	40	50
2	0.3	3	15	30	60	90	120	150
3	0.7	7	35	70	140	210	280	350
4	1.2	12	60	120	240	360	480	600
5	1.9	19	95	190	380	570	760	950
6	2.7	27	135	270	540	810	1080	1350
7	3.6	36	180	360	720	1080	1440	1800
8	4.7	47	235	470	940	1410	1880	2350
9	5.9	59	295	590	1180	1770	2360	
10	7.2	72	360	720	1440	2160		
11	8.6	86	430	860	1720	2580		
12	10.2	102	510	1020	2040			
13	11.9	119	595	1190	2380			
14	13.7	137	685	1370	2740			
15	15.6	156	780	1560				
16	17.7	177	885	1770				
17	19.9	199	995	1990				
18	22.2	222	1110	2220				
19	24.6	246	1230	2460				
20	27.2	272	1360	2720				

Figure E-17. Foliage denseness classes, continued.

Annual Foliage and Fruit Production per Juniper Tree on Different Sites and for Different Foliage Classes

Crown diameter	Site Upland loam foliage and fruit sparse/medium/dense			Upland stony loam foliage and fruit sparse/medium/dense			Upland gravelly loam foliage and fruit sparse/medium/dense			Upland shallow loam foliage and fruit sparse/medium/dense			Upland shallow hardpan foliage and fruit sparse/medium/dense		
1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.2
2	0.2	0.3	0.4	0.4	0.3	0.3	0.4	0.4	0.5	0.2	0.2	0.5	0.3	0.4	0.5
3	0.4	0.6	0.9	0.7	0.6	0.7	0.6	0.7	0.9	0.4	0.5	1.0	0.7	0.9	1.4
4	0.6	1.1	1.5	1.0	1.0	1.2	1.0	1.1	1.5	0.7	0.8	1.6	1.2	1.6	2.4
5	0.9	1.6	2.1	1.3	1.4	1.9	1.3	1.6	2.1	1.0	1.3	2.2	1.8	2.6	3.8
6	1.3	2.1	3.1	1.6	1.9	2.7	1.7	2.1	2.7	1.4	1.8	2.9	2.7	3.7	5.4
7	1.6	2.8	4.0	1.9	2.5	3.6	2.1	2.6	3.5	1.7	2.4	3.8	3.6	5.0	7.4
8	2.0	3.5	5.1	2.3	3.1	4.7	2.6	3.2	4.3	2.2	3.1	4.6	4.7	6.5	9.6
9	2.5	4.3	6.3	2.6	3.8	5.9	3.1	3.9	5.1	2.6	3.8	5.6	6.0	8.2	12.2
10	3.0	5.2	7.6	2.9	4.6	7.2	3.6	4.6	6.0	3.1	4.6	6.6	7.4	10.1	15.1
11	3.5	6.2	9.0	3.3	5.4	8.6	4.1	5.3	7.0	3.6	5.5	7.6	9.0	12.1	18.2
12	4.0	7.2	10.5	3.6	6.2	10.2	4.7	6.1	8.0	4.2	6.5	8.8	10.7	14.4	21.7
13	4.6	8.3	12.1	4.0	7.2	11.9	5.2	6.9	9.1	4.7	7.6	9.9	12.6	16.9	25.5
14	5.2	9.4	13.9	4.4	8.1	13.7	5.8	7.8	10.2	5.3	8.7	11.2	14.6	19.5	29.6
15	5.9	10.6	15.6	4.7	9.1	15.6	6.5	8.7	11.3	6.0	9.9	12.4	16.7	22.4	33.9
16	6.5	11.9	17.5	5.1	10.2	17.7	7.1	9.6	12.5	6.6	11.1	13.8	19.0	25.5	38.6
17	7.2	13.2	19.4	5.5	11.3	19.9	7.8	10.5	13.7	7.3	12.4	15.1	21.5	28.7	43.6
18	8.0	14.6	21.5	5.8	12.4	22.2	8.4	11.5	15.0	8.0	13.8	16.6	24.1	32.1	48.9
19	8.7	16.1	23.7	6.2	13.6	24.6	9.1	12.5	16.3	8.7	15.3	18.0	26.9	35.5	54.5
20	9.5	17.6	26.0	6.6	14.8	27.2	9.8	13.6	17.6	9.5	16.8	19.6	29.8	39.5	60.4

General Soil Features Associated with Sites Named in "Guides for Determining Current Yield of PIMO and JUOS in Utah"

Site name	Precipitation zone (in)	Range in slope (%)	Soil depth	Coarse fragments in profile	Range in AWC (in)
Upland stony loam	12–16	5–30	Deep to very deep over bedrock	50% (45 60% at soil surface)	2–4 (6)
Semidesert stony loam	8–12	5–30	50 in over bedrock	50% (45-60% at soil surface)	2–4
Upland gravely loam	12–16	4–15	35–40 in	35–65%	2–3
Upland loam	12–16	3–20	40 in to bedrock	35–60% (in upper profile	3–6
Upland shallow hardpan	12–16	5–20	6–20 in over hardpan	15–60% (often nonskeletal)	1.5–3
Upland shallow loam	12–16	8–60	14–20 in (15 in) to bedrock	75%	0.5–1.5

645.0506 Density and Frequency

A. Several variables important to grazing land health and trend cannot be quantified using production data alone; therefore, other techniques must be used to quantify vegetation characteristics of an area. For instance, density and frequency measurements can be helpful in attributing the vegetative community within an area of interest. Density is often used to determine the effects of management practices or vegetation treatments targeting a specific plant. A measure of the target plant density is taken before and after treatment to determine the degree of control achieved by the treatment. Frequency records the presence of species in quadrants or plots placed repeatedly across a stand of vegetation. Frequency reflects the probability of finding a species at any location in the vegetated area (USDA Landscape Toolbox 2021).

B. Density is the number of individual plants rooted per unit area. Density measurements are useful where cover varies widely and can provide information important for conservation practice planning. Choosing a plot size, the number, and placement within the plots is all that is required for simple density techniques (TN 190-PM-76).

C. Density measurements are used to determine the establishment success of seedings or for monitoring specific plant species of concern such as threatened or endangered plants or noxious weeds. The density of plants that contribute to heavy fuels such as trees and shrubs is important information when planning for prescribed burns. The lack of continuity of fuels for carrying fire can also be determined from plant density measurements. With rhizomatous plants, there can be confusion about how an individual is counted, since a single organism can comprise large areas, exhibiting multiple stems (TN 190-PM-76).

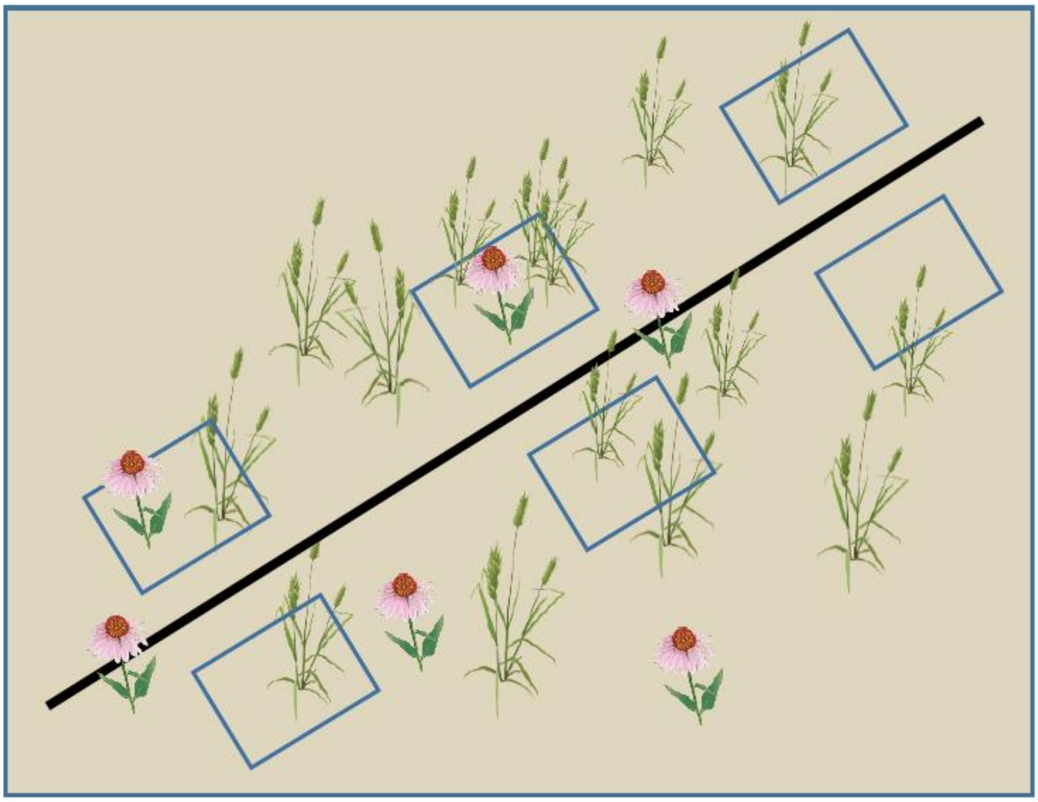
D. Methods for determining plant density

(1) Density is the number of individual plants per unit of area. It should only be used to compare plants of similar life forms, e.g., annuals to annuals, shrubs to shrubs. Two methods used for determining density are described in Volume 2 of Monitoring Manual for Grassland, Shrubland and Savannah Ecosystems (Herrick et al. 2009):
(i) quadrat frame
(ii) belt transects

(2) Remote sensing imagery may be useful for determining density of trees. Use the belt transect method to validate small tree or large shrub density measurements obtained from remote sensing products.

(3) Density measurements for grasses and forbs are desired in the example shown in figure E-18. For density, plants are counted within quadrats of a known size. Here, there are seven grasses in the six 1-m² quadrats, so grasses receive a score of 7/6 or 1.17 plants/m². Likewise, there are two forbs in the six quadrats, thus receiving a score of 2/6 or 0.33 plants/m².

Figure E-18. Density example.



E. Frequency is the ratio between the number of sample units that contain a species and the total number of sample units. The concept of frequency is only the presence or absence of species in a specified size of plot. These measurements provide information about the spatial distribution of different species and is used to help determine if a change in vegetation is occurring. The size of the plot used has a great influence on the outcome (TN 190-PM-76).

Choosing the appropriate size for the plot frame is a key variable in making frequency data meaningful, sensitive to changes, and statistically valid. “Nested” plot techniques allow for multiple plot sizes in a frame to choose an appropriate size for each species. Frequency frames may be implemented as paced or measured transects (Coulloudon, TR 1734-4, 1999). “Rooted” frequency (requiring a plant to be rooted in the frame to be counted) is one variation in this technique that can affect results (TN 190-PM-76).

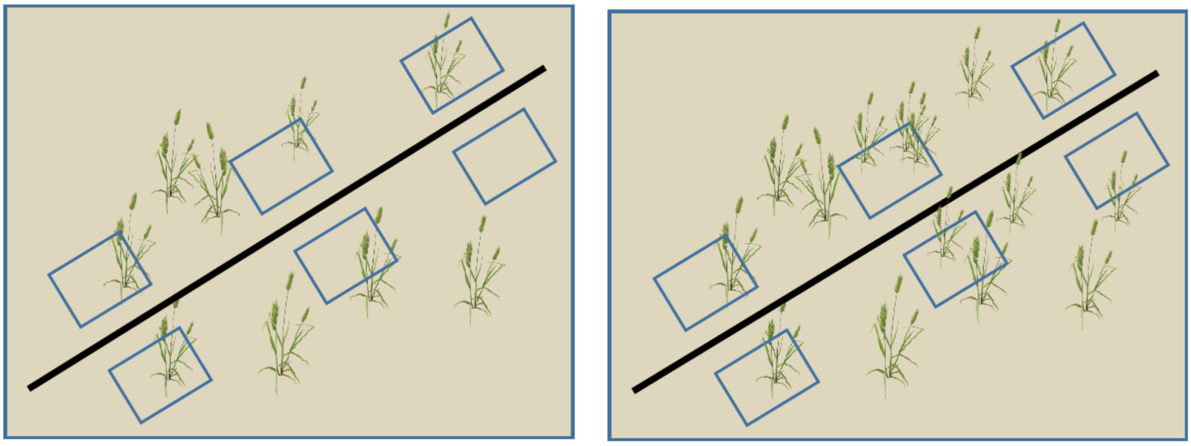
F. Methods for Determining Frequency

(1) Frequency methods describe the abundance and distribution of species and is useful as a baseline in an inventory for detecting changes in a plant community over time. Frequency is generally expressed as a percentage of the number of times a species is present in a given number of sampling units.

(2) Frequency methods should not be the only data collected on a site. It should accompany cover data to assist in later interpretation of changes that may be occurring on the site through follow-up monitoring. The Rapid method and the Intensive method are both described in the Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems Volume II Design, supplementary methods and Interpretation (Herrick et al. 2009) https://jornada.nmsu.edu/files/Core_Methods.pdf.

(3) A frequency example is shown in figure E-19. A transect is laid out with six 1-m² quadrats in subsequent years. In year one (left) four of the quadrats contain plants rooted in the frame, therefore receiving a frequency of 4/6 or 66 percent. In year two (right) more plants have established, and now five of the quadrats contain target species, therefore receiving a frequency of 5/6 or 83 percent. With frequency, it does not matter that there may be multiple target species within the quadrat. Only quadrats containing target plants are counted (TN-190-PM-76).

Figure E-19. Frequency example.



645.0507 Cover

A. Definitions and differences in terms used for cover.

(1) Cover measurements can be used to quantify ground cover of litter, seedlings, microphytes (algae, lichen, and moss), and the exposure and condition of the soil surface. Cover is generally referred to as the percentage of ground surface covered by vegetation (Coulloudon, TR 1734-4, 1999). Cover is also important from a hydrologic perspective where the variables of interest might include basal cover of perennial and annual species, litter, coarse fragments, rills, and foliar and canopy cover above the soil surface. Collecting vegetation data can be labor intensive and time consuming, even when using remote sensing technology, because field verification is required to validate remotely sensed data. Therefore, monitoring environmental change using other non-destructive

techniques such as cover, or a combination of techniques, such as cover and density, is often used depending upon the resource information needed.

(2) Numerous concepts and definitions of cover exist. Cover is generally referred to as the percentage of ground surface covered by vegetation. The resource objective being measured will determine the definition and type of cover measured (Coulloudon, TR 1734-4, 1999) (see figure E-20).

(i) Vegetative cover, live or dead, is total cover of vegetation on a site.

(ii) Foliar cover is the area of the soil surface covered by the vertical projection of the aerial portions of plants. Small openings in the canopy are excluded. Essentially, it is any area of a plant that a raindrop would intercept before hitting the soil surface.

(iii) Canopy cover is the area of the ground covered by the vertical projection of the outermost perimeter of the natural spread of plant foliage, either living or dead, that is still attached to the root. Small openings within the canopy are included. Remote sensing products measure canopy cover.

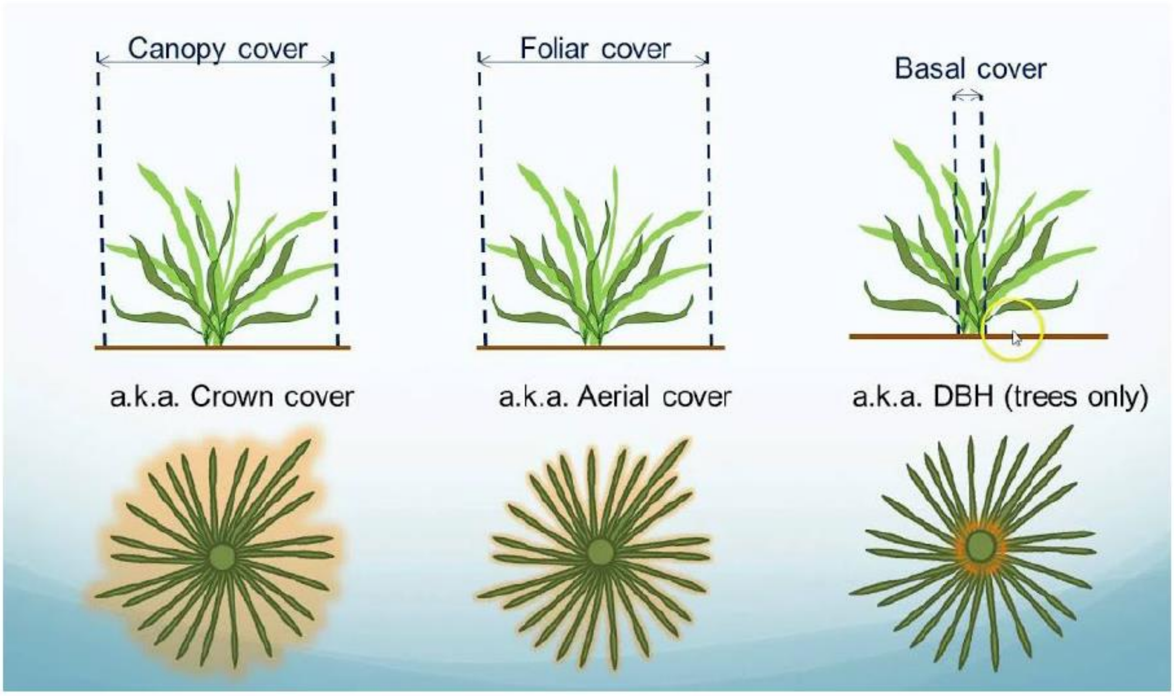
(iv) Basal cover is the cross-sectional area of the stem or stems of a plant or of all plants in a stand that occupy the ground surface.

(v) Ground cover is the cover of all plants, litter, rock, and gravel on a site. This includes lichens, moss, and biocrusts.

(vi) Bare ground is all land surface not covered by vegetation rock or litter.

(3) This variety of concepts can cause confusion and potential incompatibility between data sets. To be of value, the same type of cover measurement must be used and documented for each evaluation of a given experiment or project.

Figure E-20. Illustration of three different cover concepts (Laurie Abbott, NMSU, TN 190-PM-76).



B. Methods for determining cover

(1) Remote sensing methods—Several remote sensing methods for determining cover are developing and changing rapidly. Section 645.0501 mentions four methods that can provide estimates of cover at various scales. The level of detail needed and the purpose for which the information is to be used will determine which method to select. The following ground-based methods are used to validate cover data obtained from remote sensing products.

(i) Methods for determining canopy cover, foliar cover, basal cover, and bare ground.

(ii) Choosing a technique for cover measurements depends largely on the concept of the cover that is of interest. Some techniques can record observations for multiple concepts of cover simultaneously. Cover measurements are usually expressed as a percentage.

- Techniques that utilize a 2-dimensional plot frame (i.e., Daubenmire) (Coulloudon, TR 1734-4, 1999) are well suited to record canopy or basal cover (TN 190-PM-76), as shown in figure E-21.
- Techniques that utilize a linear transect (i.e., line intercept) (Coulloudon, TR 1734-4, 1999) are well suited to record canopy cover (TN 190-PM-76).
- Techniques that utilize points (i.e., line point intercept, step-point) (Coulloudon, TR 1734-4, 1999) are well suited to record foliar cover (TN 190-PM-76).
- Techniques that record cover gaps (i.e., canopy gap or basal gap intercept) (Herrick, et al. 2005) observe an inverse of cover for the size and distribution of areas without vegetation canopy cover (TN 190-PM-76).
- Various techniques have rule sets to deal with issues such as live vs. dead vegetation, overlapping cover, and proximity to the ground surface. These must be clearly defined when interpreting and reporting results (TN 190-PM-76).

C. Interpretation—A variety of interpretations can be made from cover data, including plant community composition (where species specific data is recorded). Cover data are used to inform several tools and models including wildlife habitat evaluation guides (WHEG), Interpreting Indicators of Rangeland Health (IIRH), and the Rangeland Hydrology and Erosion Model (RHEM). For monitoring purposes, trend is implied depending on if the particular species cover is increasing or decreasing. Basal cover is considered preferable for this purpose because it is less sensitive to annual weather or growing conditions. However, basal cover should only measure the live portion of a plant such as a bunch grass, not the former crown that may have died (TN 190-PM-76).

D. Additional information on Cover can be found in the NRI/AIM protocols.

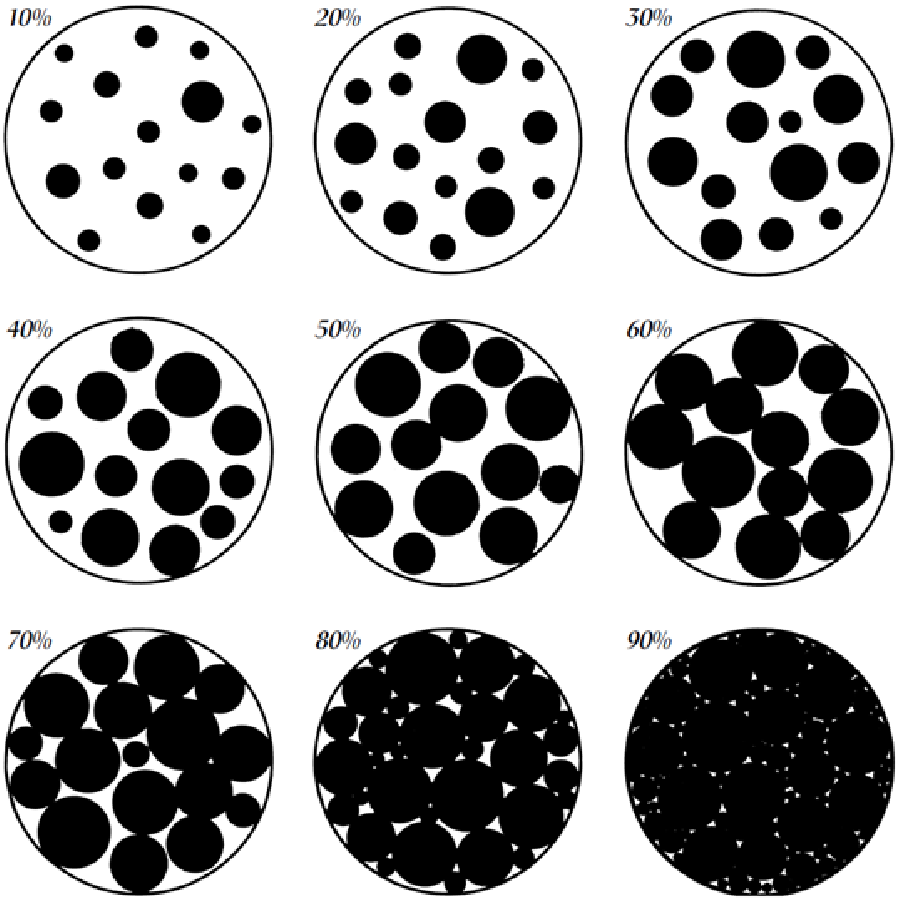
645.0508 Composition

A. Composition is a calculated attribute rather than one that is directly collected in the field. It is the proportion of various plant species in relation to the total of a given area. It may be expressed in terms of relative cover, relative density, or relative weight.

B. Composition has been used to describe ecological sites and to assist in evaluating the condition of range, pasture, and grazed forest land. Composition can provide information about plant species of interest such as pollinator plants, threatened or endangered plants, or noxious and invasive plants. Composition is calculated by dividing the individual value (weight, density, percent cover) for a species or group of species by the total value of the entire population (Coulloudon, TR 1734-4, 1999).

C. Comprehensive interpretation of plant production and composition determinations requires that data be representative of all species having measurable production. Rangeland, pastureland, and other grazing lands may be used or have potential for use by livestock and wildlife, including insects such as pollinators, as recreation areas, as a source of certain wood products, for scenic viewing, and for other soil and water conservation purposes. The value of plant species for domestic livestock grazing is often not the same as that for wildlife, recreation, beautification, and watershed protection. The principles and concepts of ecological sites are based on the total plant community. Therefore, interpretations of a plant community are not limited solely to species that have value for domestic livestock.

Figure E-21. Visual guide to different levels of cover using a 2-dimensional circular frame (TN 190-PM-76).



645.0509 Structure

A. Structure is the vertical and horizontal distribution of vegetation in space, the height and area occupied by different plants or life forms (and spatial diversity) in a community (Herrick et al. 2005). The concepts of structure include height, area, shape, foliage density, and visual obstruction. The most common use of structure is for wildlife habitat interpretations (TN 190-PM-76).

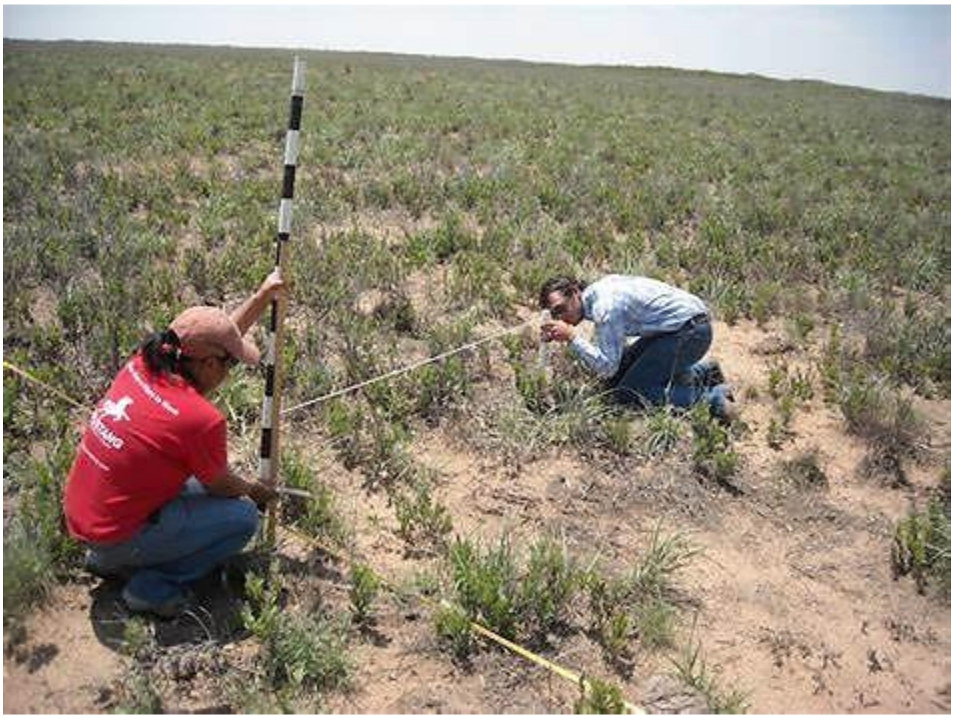
B. Structure techniques, like the Robel Pole (figure E-22), typically measure vegetation in layers on vertical planes.

C. Measurements generally look at the vertical distribution by either estimating cover of each layer or by measuring the height of the vegetation (Coulloudon, TR 1734-4, 1999; Herrick et al. 2005; TN 190-PM-76).

D. Some techniques use photo guides to assign foliage density classes.

E. percent visual obstruction and foliage height diversity are examples of interpretations from structure data. Specific interpretations of wildlife habitat quality for particular species can be made from structure data (TN 190-PM-76).

Figure E-22. Using a Robel Pole to measure structure. Photo credit: Lesser Prairie Chicken Initiative.org.



645.0510 Utilization

A. Utilization data and residual measurements are important in evaluating the effects of grazing and browsing (Coulloudon, TR 1734-3, 1999).

(1) Utilization measures the percentage of annual herbage production that has been removed. It is generally the percentage of available forage that has been consumed or destroyed.

(2) The main purpose for determining utilization is to consider whether seasonal or within-season adjustments are needed in grazing management or stocking rate. Utilization data, in combination with the phenological growth stage of the plants being grazed, and weather data are used to make day-to-day adaptive grazing management decisions.

(3) Residual measurement is the determination of herbage material or stubble height left. Residual measurements and utilization data can be used to: (a) identify use patterns, (b) help establish cause-and-effects interpretations of range trend data, and (c) aid in adjusting stocking rates when combined with other monitoring data (Coulloudon, TR 1734-3, 1999). https://www.blm.gov/sites/blm.gov/files/documents/files/Library_BLMTechnicalReference1734-03.pdf.

B. NRCS does not specify universal utilization standards for grazing use. The concept of “take half-leave half” has traditionally been a generalization used to make short term grazing management decisions, but the amount of forage planned for grazing use is site-by-site dependent upon the plant species being grazed, how much forage is present to begin with, resource conditions, and objectives set toward meeting a specific plant health productivity goal or site goal. Utilization data alone do not provide adequate information to determine whether management actions are meeting management objectives. Targeting a planned utilization level or stubble height is one way to achieve short-term land management, while cover, frequency or density measurement can help evaluate long-term management objectives.

C. Determining the actual use of key species in key grazing areas is the first of many factors considered in assessing baseline grazing management. If the key species and key grazing areas are correctly selected, it is an indicator of the degree of grazing use for the total plant community.

Utilization is expressed as a percentage of the proportion of current year's forage production that is consumed or destroyed by animals. All methods of determining utilization are estimates, with most utilization studies using peak standing crop as an estimate of current-year production, which is always less than total production.

D. Utilization Studies and Residual Measurements (Interagency Technical Reference, 1999) contains detailed information on the short and long-term use of utilization data, frequency, and timing of collecting data, various methods for making determinations of utilization for herbaceous and woody plant species, and instruction for mapping utilization patterns for determining livestock distribution. NRCS documentation of utilization and stubble height is recorded electronically through VGS or on hardcopy forms in each state's FOTG, usually on a Proper Grazing Use Form, such as pictured in figures E-23 and E-24.

> Montana NRCS has put together a short video on the importance of rangeland utilization monitoring and the benefits to ranching operations. The video can be accessed at: https://www.youtube.com/watch?v=t1ktrC6S09c&list=UUIMKAToX5kCtp9KCfnX2BFg&index=6.

E. Methods for determining utilization of key plant species

(1) Utilization Cages—Weight comparisons of grazed versus ungrazed plants within a grazed area using utilization cages offer an opportunity to visually observe and quantitatively measure the seasonal level of grazing use. Ungrazed plants of key species occurring within movable exclosures, located in key grazing areas, are clipped and weighed at the end of the grazing season within the grazed area. The weight of these plants is then compared with that of grazed plants of the key species clipped outside the exclosure. Figure E-25 is an example of an exclosure.

(i) There are several cage types, including:

- Enclosure—one to more than 25 acres to test grazing systems.
- Exclosure—smaller plots to measure recovery rates or natural trends.
- Seasonally Protected—an exclosure within the enclosure plot where various management systems are applied to represent multiple kinds of animals due to their preference and seasonal use of different forage and browse plants.

(ii) Sizes: Because of construction and maintenance costs, exclosures are inherently limited in size. Small exclosures are susceptible to site-specific peculiarities of litter accumulation and fence effects. The interior of a small exclosure is more likely to be influenced by its surroundings, so exclosures should be large enough that the area inside the fence can potentially develop along an independent trajectory from the area outside. This is important for the type of animals that might influence herbage removal. Exclosures, at a minimum, should be large enough so that several normal sized plants of the species of interest can be observed.

- The minimum size needed to effectively capture natural variation can vary according to ecological circumstances and therefore present a challenge when sites are very heterogeneous. Size of utilization exclosures is generally not as complex on pasturelands.

Figure E-23. Standard Proper Grazing Use Form.

Proper Grazing Use

Cooperator____________________________________

Grazing unit	Acres	Species of grazing animal	Season of Use	Location of Key Grazing Area	Key Plant(s) for Judging Proper Grazing Use	Minimum Percent of Key Species at End of Grazing Period (or Pounds per Acre)	Actual percent or pounds remaining 19___	19___	19___	19___	19___

Conservationist Assisting with Planning

____

Name and Date

Initials of Conservationist Assisting with Application					
Dates of Application Checks					

Proper Grazing Use Directions

Grazing Unit: Enter in this column the name of the pasture or field used by the cooperator or the number from the conservation plan map.

Acres: Enter in this column the acreage of the grazing unit.

Species of Grazing Animal: Enter in this column the species and class of livestock being grazed such as: dry cows, cow-calves, ewes and lambs, yearling cattle, 2-year steers, yearling sheep, goats, deer, horses, elk, etc.

Season of Use: Enter in this column the season that unit will be grazed such as: fall, winter, spring, summer, or by months: Sept. - Oct, Nov. - Mar, May- Jul, etc.

Location of Key Grazing Area: Enter in this column a description of the key grazing area. This may be an ecological site, it may be a portion of a site, or it might be a particular location within the grazing unit such as: S-W portion of grazing unit starting about 200 yards from pond to fence.

Key Plant(s) for Judging Proper Grazing Use: Enter in this column the species by common name on which you and the cooperator decide proper grazing use will be judged. There may be occasion when you will select two species, in this case enter the name of both species.

Minimum Percent of Key Species at End of Grazing Period: Enter in this column, the percent by weight, of the current year's growth of the key species that should be left ungrazed at the end of the grazing season. Where specifications call for a certain number of pounds of forage to be left ungrazed per acre of the key species, then the specified pounds per acre should be entered in this column.

Actual Percent or Pounds Remaining: Enter in this column, by calendar year, the percent, by by weight, or pounds remaining of the selected key species in the grazing unit. This measurement should be based on the key species on the key grazing area, at or near the end of the grazing call for use in percent of current year's growth, enter percentage of growth ungrazed. If use is specified in amount of forage to be left ungrazed in pounds per acre, then enter pounds per acre left ungrazed.

Figure E-24. Proper Grazing Use Form Example.

Cooperator Farmer Joe

Grazing Unit/Field	Species of Grazing Animal	Season(s) of Use	Location of Key Grazing Area	Key Species	Planned Percent Utilization or Stubble Height of Key Species	Applied Utilization or Stubble Height 20 17	20____	20____	20____
1	Cattle	Spring	(coordinates)	pubescent wheatgrass	6"	7"			
2	Cattle	Spring, Sum, Fall	Near Transect 1	bluebunch wheatgrass	35%	30%			
				green needlegrass	35%	35%			
3	Cattle	Spring, Sum, Fall	1/2 mi N of reservoir	western wheatgrass	50%	40%			
					Initials of Conservationist Assisting w/ Application	SD			
					Dates of Application Checks	9/1/2017			

Cooperator -- Name and Date

Sunny Day 5/1/16

NRCS Conservationist Assisting with Planning -- Name and Date

Figure E-25. 8-foot x 8-foot Grazing Exclosure. Photo credit: Brenda Simpson, National Grazing Land Team.

(iii) Uses:

- Exclosure terminology, placement, size, maintenance, monitoring data, monitoring study design, and documentation are all parts of a plan to deploy an exclosure. The objective is to provide a comparison of the amount of herbage left compared with the amount of herbage produced during a time period. Regular, repeated monitoring is needed to account for inter-annual variation attributable to precipitation and growing conditions. Monitoring schedules should also be consistent with respect to seasonal variation in livestock and wildlife use.
- Exclosures are flexible range management tools that can trigger management decisions and be used to inform:
  – Relatively short-term evaluation of herbivore influence on range productivity and composition.
  – Relatively moderate-term monitoring of trends and changes in plant community phases or state transitions.
  – Relatively long-term identification of the normal range of variation characteristic of natural plant communities.
- Cage movement should be based on the objectives of what is being monitored. Many times, annual movement is recommended to reduce the side effects of the cage itself and to better reflect only the effects of removing grazing for that current year.
- Limitations:
  – Exclosures are tools to manage the use of vegetation by certain types of animals – a dynamic ecological process. A tool intended to control a constantly changing process will need constant attention and adjustment.
  – A reliable monitoring program is characterized by a set of representative monitoring sites, consistent data collection methodology, committed time, funding, and frequent evaluation.
  – Objectivity is required to recognize the difficulties of field sampling due to the many variables encountered on rangeland. The more elements present, the greater the chance for variation in the vegetation.
  – Cages used to protect plants from grazing can affect growth, usually positively, by altering microclimate, addition of nutrients by birds perching on the cage, or other factors (Owensby 1969; Fults 2017).
  – Cages can also reduce wind speed and insolation by 10–20 percent, create more stable and generally higher relative humidity, and in most instances, reduce temperature, particularly during periods of high insolation.

  - Even if a large number of paired exclosures are selected (grazing versus no grazing), the error of estimation could be significantly high if the vegetation is non-uniform.
  - Plant responses to protection can be negative. Tueller and Tower (1979) and Fults (2017) found that within two years of exclosure, bitterbrush significantly reduced production of browse, leaves and fruit (from stagnation). Other studies have noted a reduction in nutritional values such as decline in crude protein of plants inside the cage (Fults 2017).
- Placements:
  - Cages should be rigid and strongly set in locations of general grazing pressure. If cages are going to be moved annually, they need to be built with mobility in mind.
  - They should be constructed or placed away from other structures, roads, watering points, and travel paths. Many times, exclosures will be placed in key grazing areas.
  - Reasons to leave cages for more than one growing season include monitoring for plant diversity and potential viable seed sources within the soil bank (Fults 2017).
- Use in Grazing Management Plans:
  - Exclosure cages help determine utilization at the end of the grazing or growing season. The analysis considers whether to increase or decrease stocking during the next grazing season. Exclosures help measure the degree of use of the key forage species during the next grazing season. Monitoring exclosures can help meet the basic management objective to remove no more than 50 percent (by weight) of the current year’s growth or some other desired percent (Fults 2017).
  - An approach to fine tuning a grazing management plan is to use multiple exclusion cages, placing one cage on a representative location at the beginning of the growing or grazing season. Place the second on a similar location but add a clipping treatment to remove standing vegetative growth. This results in a uniform beginning height. Be sure not to clip so close to the ground that the growing points are harmed. The first cage allows a comparison of overall differences between utilized and dormant. The second cage allows comparison of growth and vigor under use and non-use conditions (Fults 2017).
- Another method for gathering comparison grazed data is to do a step transect measuring the height of key species plants that are grazed, then compare this to the heights in the protected exclosure cages. Develop a height-weight relationship by:
  - Sample several ungrazed key species of normal size or similar number of culms.
  - Clip the plant to within ¼ inch of the ground. Wrap the clipped plant with thread from base to top to retain all leaves and culms.
  - Measure heights of clipped plants to the nearest inch and determine the average height and average weight.
  - Clip the top inch, weigh plant, record and repeat at one-inch intervals until the last inch of the plant base is reached.
  - Determine the average height-weight relationship.
  - Measure the key species height inside of the exclosure and compare to key species outside the exclosure. A step transect outside of the exclosure can provide an average of the key species in the grazed area.
  - Key species height (ht.) utilization = (species ht. inside exclosure) – (species ht. outside the exclosure) / species ht. inside exclosure X 100%.
    - Example: 16 inches (inside) – 5 inches (outside)/16 inches X 100 = 68.75% of height.
    - Convert height to weight and use the same formula for key species weight utilization (Fults 2017).

– An abbreviated procedure that gives a strong visual guide is to balance the clipped and wrapped ungrazed plant on your finger to determine the stubble heigh at 50 percent, then further estimation can be made from that point. See figure E-26.

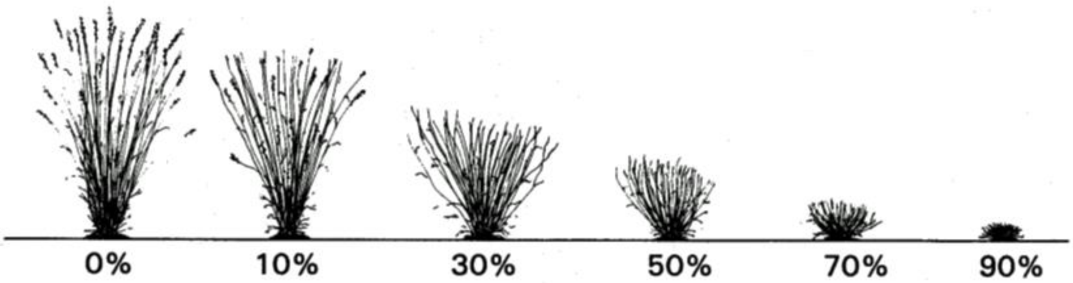
Figure E-26. Balancing 50 percent by weight using your finger. Photo credit: Shane Green, NRCS National Grazingland Team.

(2) Use of grazed-class photo guides

(i) In some locations, series of photographs illustrating various degrees of grazing use, expressed in percentage by weight, are available for some plant species. Guides based on actual clipping and weighing of plants of the key species provide a relatively simple and rapid means of determining approximate grazing use. These guides are helpful in illustrating how plant weight is not evenly distributed throughout the height of any given plant species.

(ii) Photo guides should be used only in the locality where they are prepared and only for the plant species specifically appraised. The procedure is to visually compare a series of plants of the key species with photographs illustrating various degrees of plant use, and to tally the number of plants occurring in each grazed class. Extremes in growing condition must be considered when using photo guides. See figure E-27 for example.

Figure E-27. Grazed Class Photo Guides (Kingery et al. 1992).



(3) Stubble heights – stop grazing heights – residual heights needed

(i) The concept of this method is to measure stubble height, or height (in centimeters or inches) of herbage left ungrazed at any given time. This method would be used after stubble height standards for specific plant communities have been developed (Colloudon 1999). It can be used when minimum residual herbaceous heights help address or prevent a resource concern. As an example, a stubble height of four inches might be specified to provide streambank protection, to trap sediments in a certain area, and rebuild degraded stream channels in riparian areas. Another example would be that minimum stubble heights are needed on bunch grasses to help ensure nesting habitat requirements for ground-nesting birds are available.

(ii) Stubble height is expressed in inches and can be correlated to production on pasture sticks. Accuracy in stubble height measurement is affected by plant community characteristics. Sites with inconsistent plant composition and varying palatability can make stubble height measurements and interpretation of data difficult. For these reasons, stubble height measurements should focus on key plant species, or species groups. Stubble height should be recorded and averaged by key species, not averaged across multiple species. Averaging or grouping the data should only be done among species with relatively similar growth forms.

(iii) Enough stubble height measurements should be collected to reflect grazing use variability across the extent of the sampling area. Select species groups, where appropriate, to reduce the total sampling requirements or increase precision within a given sample number.

(iv) Follow the methods described in Utilization Studies and Residual Measurements, Interagency Technical Reference, 1999, for procedural instructions on obtaining utilization data. Further guidance may be found in state technical notes and Land Grant University publications.

(4) Utilization Gauges

(i) Utilization gauges developed by the US Forest Service primarily in the Southwestern Region (R-3) provide height-weight relationships to help land managers better determine utilization. The gauge was developed from height-weight curves for forage species within the southwest region. See figure E-28.

(ii) The gauge is easily portable and is easily read and understood by landowners. The ungrazed height is set at the top of the dial, the grazed height is read across the dial, and the percent utilization is read in the window by species (Aldon et al. 1984). Clip and weigh procedures should periodically occur to validate the reliability of the gauge for the region it is being used in.

Figure E-28. US Forest Service Utilization Gauge. Photo credit: Monte Topmiller, NRCS Range Specialist.

(5) Ocular estimates of percentage grazed

Qualified conservationists who are trained and experienced in making actual weight comparisons of grazed versus ungrazed plants can make ocular estimates of the percentage removal of key species in a key grazing area. If this method is used, it is important to demonstrate the actual weight procedure to the cooperator on one or more gazing units.

J. Determining utilization of browse plants

(1) The degree of utilization of current growth of browse plants is an important factor needed for properly planning and managing land for use by wildlife or livestock. However, utilization of browse has seasonal limitations during the early part of the growing season or before current use has taken place on seasonal range. Several other indicators are also of value in appraising the general trend in production of a stand of browse plants. These indicators often reveal more about the stand than current utilization alone. These can be observed and interpreted at any time of the year. These indicators include:

(i) Age classes of key plant species—Age class is probably the most important single factor in judging trend in a stand of browse plants. If all plants are mature, the stand is not maintaining itself and will thin out as older plants die. The presence of adequate numbers of seedlings and young plants of the key species is indicative of a healthy, self-perpetuating stand. Browse plants generally do not reproduce every year, resulting in pulses of several age classes represented in a healthy stand. Animals usually prefer seedlings and young plants. Consequently, a degree of use for mature plants often results in overutilization of younger plants. Each age class needs separate degrees of use to judge proper utilization.

(ii) Evidence of hedging of the key plant species—The degree of hedging reflects past use and the productive ability of browse plants. Moderate hedging may be desirable for some species because it stimulates growth and keeps plants from growing out of reach of animals. Severe hedging results in the death of many branches and, if continued for a long time, may cause death of entire plants. If only a single year's growth extends beyond old-hedged contours, recent use has been heavy. Parts of two or more years' growth beyond old-hedged contours suggest that browsing pressure has recently been reduced and that trend is upward.

(iii) Use of plant growth more than one year old—When overall utilization is heavy, browsing animals often consume parts of plants that are older than the current growth. Continued use of older growth results in rapid decline and death of plants.

(iv) Evidence of browse lines—If a browse line is apparent, plant growth within reach of animals has declined. Very distinct browse lines indicate that plants have already grown beyond the reach of animals. Such plants may be vigorous and productive because of unused growth above reach of animals, but they produce little or no available forage.

(v) Presence of dead twigs and branches—Some mortality of plant parts is normal, but excessive amounts of dead or weak limbs, branches, twigs, or even entire plants indicate that past use was too heavy and that the stand is deteriorating.

(vi) Relative size of plant parts—Light pruning or browsing often stimulates growth of leaves and sprouts to more than normal size. Continued heavy use, however, results in small and weak leaves, twigs, and fruiting stems. Repeated heavy use of sprouts gradually reduces their size. If properly used, species of root-sprouting ability produce sprouts following fire or other disturbances. However, weakened plants do not. Overutilization reduces or eliminates fruit and seed production.

(vii) Significant use of low-preference species—Plants of low preference are ordinarily lightly used unless species of higher preference are not available or have been too heavily used. If significant use is made of a species that animals ordinarily use sparingly or not at all, the key species is being abused.

(viii) Amount of reproduction of low-preference species—Excessive reproduction of a low preference species generally indicates that the key species has declined to the extent that it is unable to compete with other plants.

(ix) Condition of animals—The physical condition and reproductive ability of wildlife or livestock reflect the amount and quality of plants available for forage. This indicator is not infallible because animals may remain in good condition for a while, even on seriously abused ranges, if succulent growth is available. Also, supplemental feeding of animals often masks the effect of inadequate natural forage supplies.

(2) None of the indicators, by itself, is a completely reliable indicator of the overall utilization of the plant community. All evidence must be carefully evaluated as a basis for determining needed adjustments in management or stocking and for determining needed harvest of browsing animals.

(3) The Browse Resource Evaluation worksheet (see figure E-29) can be used for judging composition, trend, and utilization of the browse plant resource. Figures E-30 and E-31 illustrate how to use the worksheet. Figure E-30 records the determination of trend and records utilization during the next three fall and winter seasons. Figure E-31 illustrates the same location following a prescribed burn. The change in trend is recorded, and utilization will be recorded at the appropriate time.

K. Utilization mapping to determine grazing animal distribution

(1) Utilization is seldom uniform on rangeland, pastureland, and grazed forest land. Utilization patterns may result from factors such as topography, distance from water, supplementation areas, locations of shade and shelter, as well as animal preferences for plant species in specific locations. These factors cause grazing animals to either concentrate or distribute themselves over an area in a pattern that can change seasonally or remain the same from season to season.

(2) The installation of facilitating practices such as fences and providing shade and watering sources, along with managed grazing and strategic locations of salt and supplemental feed and livestock herding are the main NRCS conservation practices planned and installed to manipulate livestock distribution. Develop a utilization pattern map for those planning areas where livestock distribution may be a management concern before installation of these facilitating practices. Use GIS tools to delineate ecological sites, areas of steep topography and other barriers to the grazing animal and distance to water sources. See Subpart F Management of Grazing Lands for more information.

L. Regrowth following utilization

Regrowth is plant growth that occurs following grazing. Residual measurements are based on the amount of forage used at a point in time and is independent of annual production. The term utilization refers to the amount of forage use annually (the entire season). Residual measurements recorded for various periods of use during the year cannot be added together to get utilization for the entire year.; i.e., 30 percent utilization of 6 inches of plant growth available in the spring, and 30 percent utilization of 12 inches of plant growth in the fall do not add up to 60 percent utilization for the year.

645.0511 Assessments

A. Field assessments on range and pastureland are integral steps in USDA-NRCS conservation planning and in National Resource Inventory (NRI) Field Studies. The science and the tools for assessing both range and pastureland continue to evolve and are necessary for NRCS planning and National Resource Inventory activities to describe land condition, health, and the functionality of ecological processes.

B. Conservation planning assistance to rangeland owners and managers should include the use of assessment tools, as well as incorporating professional judgment that is based on experience and knowledge of the rangeland ecosystems. For more information on NRCS conservation planning, see Subpart D of this handbook and the National Planning Procedures Handbook.

Figure E-29. Browse Resource Evaluation worksheet.

Browse Resource Evaluation

Cooperator: ____________________ Ecological site: ____________________
Pasture: ____________________ Location in pasture: ____________________
Kinds of browsing animals: ____________________ Examiner: ____________________
Goals for browse resource: ____

Date of initial evaluation: ____/____/____

	Browse composition – Occurrence			Browse trend – Hedging or browse line			Browse trend – Reproduction		
	Abundant	Common	Scarce	Not evident	Moderate	Severe	Abundant	Adequate	Not adequate
Preferred species									
Desirable species									
Non-preferred species									

Browse composition

Judge composition and trend based on majority of evidence

- Good
- Fair
- Poor

Browse trend

- Upward
- Stable or not apparent
- Downward

Note: ____
____

Utilization of current year's growth

Key species	Season of use	Planned use percent	Actual use percent – Years							
			Date observed							

Instructions for Browse Resource Evaluation Worksheet

The worksheet can assist managers evaluate the composition and trend of the browse resource, as well as document the actual use of key browse species over time. This information is used to identify problems, formulate alternatives, and measure progress in attaining browse management goals.

Browse composition evaluates the occurrence of browse species according to preference categories. Species are designated as preferred, desirable, or non-preferred based on the species of browsing animal and the appropriate ecological site descriptions.

Occurrence: After a thorough observation of the area, determine the occurrence of each listed species and place a checkmark or an x in the appropriate block as defined.

Abundant The species dominates or characterizes the area observed; it makes up greater than 5% canopy and often greater than 20%.
Common The species is easily found, but is not present in abundance; it usually makes up 1–5% canopy.
Scarce Insignificant amounts of the species is present and may be difficult to find; it usually makes up far less than 1% canopy.

Browse composition is judged as good, fair, or poor based on the preponderance of entries in the shaded boxes. For example, if there were four entries in the fair blocks, one in the good blocks, and 2 in the poor blocks, the overall browse composition would be judged as fair.

Browse trend evaluates the health and vigor of the browse resource based on signs of past use and on reproduction. Hedging and browse lines are distinctive growth forms that occur on shrubs or trees subjected to long term heavy use. After a thorough examination of the selected species in the area, determine the level of hedging or browse line and status of reproduction and place a check mark or x in the appropriate block as defined below.

Hedging or browse line: Hedging is evaluated on short shrubs which are entirely or mostly within reach of browsing animals. Browse line is evaluated on taller shrubs and trees where a portion of the plant is above browsing height.

Not evident On shorter plants, there is little or no evidence of hedging. On taller plants, there is little or no reduction of lower growth. Production of lower branches and twigs is similar to those above the reach of animals.
Moderate On shorter plants, most recent year's twigs have been browsed, resulting in branching and rebranching from lateral buds; growth form is somewhat compact. On taller plants, there is a visible thinning of growth up to browsing height; lower branches and twigs are considerably less productive than those beyond reach of the animals.
Severe Shorter plants are very compact or have a stunted appearance; may be characterized by very short twigs, stubby branches, small leaves, low production or excessive number of dead branches. On taller plants, a browse line is strikingly evident; there is little or no production on twigs within reach of animals; most lower branches are absent.

Browse trend is judged as upward, stable (or not apparent), or downward based upon the preponderance of entries in the shaded boxes.

Reproduction: A reproduction evaluation is made to determine the future potential of a species in the community. The presence of young seedlings is only one measure of reproduction. The survival of new plants for the first 1 to 5 years is often the limiting factor, even though new seedlings or root sprouts may be present in some abundance in some years. A good distribution of various age plants from young to fully mature is a better indicator of successful reproduction.

Abundant The population of a species is increasing in the community; more young plants are present than are old plants.
Adequate Sufficient seedlings and young plants are present to approximately maintain the appropriate population status of the species in the community; plants that are decadent or dying are being replaced by new plants.
Inadequate Few or no seedlings or young plants are present; population is either declining or stagnated with mature plants.

Utilization of current year's growth—This section is used to record the actual degree of use on key species in the same area over a period of years. Browse use is usually determined sometime between late fall and late winter. Degree of use is expressed as the percentage, by weight, of the current year's twig and leaf production within reach of browsing animals that has been consumed. Use is most easily estimated by comparing accessible twigs to twigs which are inaccessible to browsing animals. Determinations should be made by observing many twigs on a number of different plants. Current year's twig growth is distinguished from older twigs by color, texture, and size.

Figure E-30. Completed Browse Resource Evaluation worksheet showing trend and utilization.

Example - Browse Resource Evaluation

Cooperator: B.J. Smith
Ecological site: Low Stony Hill
Pasture: Lower Canyon
Location in pasture: 3/4 mile N of spring
Kinds of browsing animals: Goats, deer
Examiner: L. Jones
Goals for browse resource: Recovery of preferred species; Reduction in juniper

Date of initial evaluation: 6 / 12 / 94

	Browse composition			Browse trend					
	Occurrence			Hedging or browse line			Reproduction		
	Abundant	Common	Scarce	Not evident	Moderate	Severe	Abundant	Adequate	Not adequate
Preferred species									
Mt. mahogany		X				X		X	
Spanish oak		X				X			X
Hackberry		X				X			X
Redbud		X				X		X	
Desirable species									
Shin oak	X				X			X	
Evergreen sumac	X				X			X	
Non-preferred species									
Juniper	X			X			X		
Persimmon		X			X		X		

Browse composition

Judge composition and trend based on majority of evidence

- Good
- Fair
- Poor

Browse trend

- Upward
- Stable or not apparent
- Downward

Note: Goats removed Dec. 94; Deer only in 95; Presburn Feb. 96; Goats in summer 96.

Utilization of current year's growth

Key species	Season of use	Planned use percent	Actual use percent – Years: 94	95	96					
Mt. mahogany	Sp-fall	50	80+	70	60					
Hackberry	Sp-fall	50	80+	60	60					
Shin oak	Sp-fall	50	65	20	35					
EG sumac	Yearlong	50	50	20	35					
		Date observed	12-4	10-9	11-6					

Figure E-31. Completed Browse Resource Evaluation worksheet showing change in trend at same site as used in Example 1.

Example - Browse Resource Evaluation

Cooperator: B.J. Smith
Ecological site: Low Stony Hill
Pasture: Lower Canyon
Location in pasture: 3/4 mile N of spring
Kinds of browsing animals: Goats, deer
Examiner: L. Jones
Goals for browse resource: Continue recovery of preferred species

Date of initial evaluation: 7 / 30 / 97

	Browse composition			Browse trend					
	Occurrence			Hedging or browse line			Reproduction		
	Abundant	Common	Scarce	Not evident	Moderate	Severe	Abundant	Adequate	Not adequate
Preferred species									
Mt. mahogany			X			X		X	
Spanish oak		X			X			X	
Hackberry		X			X			X	
Redbud		X			X		X		
Desirable species									
Shin oak	X			X			X		
Evergreen sumac	X			X			X		
Flameleaf sumac			X		X		X		
Non-preferred species									
Juniper			X	X					X
Persimmon		X		X				X	

Browse composition

Judge composition and trend based on majority of evidence

- Good
- Fair
- Poor

Browse trend

- Upward
- Stable or not apparent
- Downward

Note: Fire killed much mahogany; Fire killed all juniper; Sumacs invigorated by fire.

Utilization of current year's growth

Key species	Season of use	Planned use percent	Actual use percent – Years							
Mt. mahogany	Sp-fall	50								
Hackberry	Sp-fall	50								
Shin oak	Sp-fall	50								
EG sumac	Yearlong	50								
			Date observed							

C. Use on Rangelands

(1) Ecological sites on rangeland are evaluated with the client during the collection and analysis phase of the planning process so that a greater level of understanding of the rangeland resource can be achieved by both the NRCS employee and the client. The inventory process and evaluations of ecological sites on a grazing unit provide the

opportunity to work with the client to identify resource concerns and sources, as well as opportunities to maintain or improve the land, and increase the knowledge level of the client. Ecological Site Descriptions can be found in the Ecosystem Dynamics Interpretive Tool (EDIT), and more information on ESDs can be found in Subpart B.

(2) A rangeland ecological site may be assessed in at least three distinct, but associated ways: Trend, Similarity Index, and Interpreting Indicators of Rangeland Health. Although the three methods are associated, they are not interchangeable. These assessments and ratings cannot be extrapolated from one to the other. These three assessment tools evaluate the rangeland site from different perspectives and are not necessarily correlated.

645.0512 Trend

A. Trend is a rating of the direction of change that may be occurring on a site. The plant community and the associated components of the ecosystem may be either moving toward or away from the reference plant community or some other desired plant community or vegetation state, rangeland trend, or planned trend, respectively. At times, it can be difficult to determine the direction of change. See Subpart B for more information on Ecological Sites and State-and-transition models.

B. The kind of trend (rangeland trend or planned trend) being evaluated must be specified. Trend is an important tool used in the NRCS planning process and is significant when planning the use, management, and treatment needed to maintain or improve the resource. Trend is a tool used in the national resources concern list and planning criteria. This rating indicates the direction of change in the plant community on a site. It provides information necessary for the operational level of management to ensure that the direction of change will enhance the site and meet the objectives of the manager. The present plant community is a result of a sustained trend over a period of time and should be considered when making grazing management decisions.

(1) Rangeland trend is defined as the direction of change in the present on-site plant community relative to the reference state in an ESD state-and-transition model. It is only applicable on rangelands that have ecological site descriptions identifying the reference plant community. It can be determined as apparent trend or measured trend. <u>Apparent trend</u> is a point in time determination of the direction of change. <u>Measured trend</u> requires measurements of the trend indicators over a period of time. Rangeland trend can be monitored on all rangeland ecological sites. It is described as:
(i) Toward – moving towards the reference or top state of the plant community
(ii) Not apparent – no change detectable
(iii) Away from – moving away from the reference or top state of the plant community

(2) Planned trend is defined as the change in plant composition within an ecological site from one plant community type to another relative to management objectives. The desired plant community should be stable and provide protection to the soil, water, air, plant, and animal resources (SWAPA). It is described as:
(i) Positive – moving towards the desired plant community or objective
(ii) Not apparent – change not detectable
(iii) Negative – moving away from the desired plant community or objective

(3) Planned trend provides feedback to the manager and grazing land specialist about how well the grazing management plan is working on a site-by-site basis. It can provide an early opportunity to make adjustments in stocking rates, timing, duration, and frequency of grazing. Planned trend can be monitored on all native and naturalized grazing land plant communities. It may also be determined on any ecological site where a plant community other than the reference plant community is the desired objective, but where SWAPA resource concerns are also met.

C. Attributes for determining trend

(1) The relative importance of the factors used in trend analysis vary in accordance with differences in vegetation, soils, and climate. Evaluating any one of these factors on an

ecological site may indicate whether the plant community is improving or declining. A more accurate evaluation of trend, however, can be ascertained if all or several of the factors are considered in their proper relation to each other. Figure E-32 is a worksheet for determining range and planned trend.

(2) Invading undesirable plants—Native plant communities evolve within their environment and slowly change over time as environmental factors change. Major short-term changes in the plant composition, however, do not normally occur unless induced by significant disturbances. These disturbances include but are not limited to heavy continuous grazing by livestock, severe or prolonged drought, abnormally high precipitation, exotic species invasion, or unnatural burning frequencies.

(i) If the plant community is changing as a result of heavy grazing, the perennial species are most sensitive to damage by grazing decrease. This may lead to a relative increase in species of lower forage value or successional stages, or both. When improved management occurs in areas where the plant cover has been severely depleted, increases in low-quality plants may indicate improvement since these plants may be the first to respond and re-establish.

(ii) When disturbances that caused a decline in the plant community are removed, the present plant community may respond in one of several ways. It may appear to remain in a steady or static state that is departed from the reference plant state, or it may transition along pathways leading to one of several identifiable plant communities including those in the reference state

(iii) Original species that have declined in abundance because of past misuse will often increase over time. For this to occur, seed or vegetative parts must still be available, growing conditions must be similar (soil profile, hydrologic characteristics, microclimate), and space for re-establishment must be available and not have been displaced by other species such as exotic annual and perennial grasses, forbs, shrubs, or trees.

(iv) Once established, certain woody and other long-lived perennial plants may persist and may require high energy expenditures, such as prescribed burning, herbicide application, mechanical treatment, or other applications of supporting practices to restore a more desired state or reference plant community.

(v) Invasive plants on the site indicate a major change in the plant community. Some invaders, particularly annuals, however, may flourish temporarily in favorable years, even when the existing plant community may be moving towards management objectives. A significant, though temporary, increase in annuals and short-lived perennials may also occur during a series of wet years even though the general trend is toward the desired objectives.

(vi) Changes in species composition from one plant community type to another generally follow a pattern. Although all changes in amounts of species on a site are not always predictable, general successional patterns for specific sites, plant species, climates and rangeland use often can be predicted. These successional changes in plant composition are usually not linear and vary because of localized climatic history and past use patterns.

(2) Seedlings and young desired plants—Changes in a plant community depend mainly on successful reproduction of the individual species within the community. Evidence of this reproduction can be by young seedlings, plants of various ages, and tillers, rhizomes, and stolons. The extent to which any of these types of reproduction occurs varies according to the growth habits of the individual species, site characteristics, current growing conditions, and the plant's use. In some plant communities, reproduction is often largely vegetative, so the mere absence of seedlings does not always indicate a change in plant community. A significant number of seedlings and young plants of species indigenous to the site, however, usually indicates a positive trend. Variation in seedling recruitment resulting from abnormal weather patterns should be recognized.

(3) Plant residues and litter—The extent to which plant residue accumulates depends primarily on the production level of the plant community, the amount of plant growth

removed by grazing, haying, fire, insects, wind or water, and the decomposition rate of the plant biomass on the site. In hot and humid climates, the rate of decomposition of plant residue may be so great that little or no net accumulation occurs. Conversely, in cold climates decomposition is generally slow. When using plant residue to judge trend in plant communities, careful consideration should be given to the level of accumulation that can be expected for the specific ecological site, plant species, and climate.

Excessive grazing, below-normal production, recent fires, and abnormal losses caused by wind or water erosion may result in an accumulation of plant residue below what is considered reasonable for the site. In the absence of these factors, progressive accumulation of plant residue generally indicates positive changes in the plant community. Residue may accumulate rapidly for some kinds of plants, especially woody species or annuals. When the amount characteristic for the reference plant community is exceeded, such accumulations of residue are not necessarily an indication of an improving plant community.

(4) Vigor of desired key plants is reflected primarily by the size of a plant and its parts in relation to its age and the environment in which it is growing. Many plants that form bunches or tufts when vigorous may assume a sod form if their vigor is reduced. Length of rhizomes or stolons is also a good indication of the vigor of a parent plant, as these parts are usually fewer and shorter if a plant is in a weakened status. Periodic drought is common in many rangeland environments and will lower the apparent vigor and annual productivity of ecological sites, while often retaining the current plant community.

Cryptogamic plants like mosses, lichens and ferns develop new growth during favorable periods that add to the total structure and biomass of the plant community. When considerable amounts of live cryptogamic material are destroyed, several years may be required for these plants to fully replace lost tissue.

(5) Soil factors—Unfavorable conditions of the soil surface may significantly affect trend. Compaction, splash erosion, and crusting may occur if plants or plant residue are lacking on the soil surface.

(i) Compaction and crusting impede water intake, inhibit seedling establishment and vegetation propagation, and increases soil surface temperature. These conditions often increase rates of water runoff and soil loss, reduce effective soil moisture, and generally result in unfavorable plant, soil, and water relationships. Improvement in the plant cover following good management is delayed if such soil conditions exist. Bare ground, soil crusting, stone cover, compaction from trampling, plant hummocking, or soil movement may indicate a negative trend in a plant community.

(ii) These soil indicators, however, can sometimes be misleading as they can also occur naturally under certain circumstances. For example, plant hummocking is natural on silty soil sites that are subject to frost heave. Other sites do not support a complete plant cover. Bare ground crusting, rock fragments on the soil surface, and localized soil movement may be normal for the site. Even when induced by misuse, the soil surface trend indicators are not nearly as sensitive as those changes in the plant cover. For information on normal characteristics of a site, see the appropriate correlated Ecological Site Description.

Figure E-32. Trend Determinations.

Trend Determinations

Ecological Site____
Reference Plant Community_____________________________________
Location____
Cooperator____________________

Initial Trend Determination: Date:________ Conservationist____________

Plant Factors (circle as appropriate)

Vigor of desired key plants:	Good	Fair	Poor
Seedlings & young desired plants:	Abundant	Some	None
Decadent plants:	Many	Some	None
Plant residues & litter:	Abundant	Adequate	Inadequate
Invading undesirable plants:	None	Some	Many

Soil Factors (circle as appropriate)

Surface erosion:	Slight	Moderate	Severe
Crusting:	Slight	Moderate	Severe
Compaction: :	Slight	Moderate	Severe
Percent bare ground:	Less than expected	Normal	More than expected
Gullies & rills:	None	Few	Numerous
Overall soil degradation:	Slight	Moderate	Severe

Other Factors

Major invading species:____
Canopy and/or cover percent____

Overall Trend Rating (s): (Circle the appropriate kind of trend and rating)

Range Trend (Toward or away from historic climax plant community)

Toward **Not apparent** **Away from**

Planned Trend (Toward or away from desired plant community)

Positive **Not apparent** **Negative**

Followup Trend Determination: Date:________ Conservationist__________

(to be made in subsequent years following initial trend determination)

Plant Factors (circle as appropriate)

Vigor of desired key plants:	Good	Fair	Poor
Seedlings & young desired plants:	Abundant	Some	None
Decadent plants:	Many	Some	None
Plant residues & litter:	Abundant	Adequate	Inadequate
Invading undesirable plants:	None	Some	Many

Soil Factors (circle as appropriate)

Surface erosion:	Slight	Moderate	Severe
Crusting:	Slight	Moderate	Severe
Compaction: :	Slight	Moderate	Severe
Percent bare ground:	Less than expected	Normal	More than expected
Gullies & rills:	None	Few	Numerous
Overall soil degradation:	Slight	Moderate	Severe

Other Factors

Major invading species:____
Canopy and/or cover percent____

Overall Trend Rating (s): (Circle the appropriate kind of trend and rating)

Range Trend (Toward or away from historic climax plant community)

Toward **Not apparent** **Away from**

Planned Trend (Toward or away from desired plant community)

Positive **Not apparent** **Negative**

645.0513 *Section Reserved for Similarity Index.*

645.0514 Interpreting Indicators of Rangeland Health Assessments

A. The following section is a review of some of the main concepts of the Interpreting Indicator of Rangeland Health Assessments Tool (IIRH)(Technical Reference 1734-6, Version 5) for information. To use the IIRH assessment, you must refer to the IIRH Technical Reference itself for complete instructions. TR 1734-6 can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/rangepasture/range/?cid=stelprdb1068410 or Interpreting Indicators of Rangeland Health v5 – Landscape Toolbox.

Note: Consistent assessments require precisely following the guidance in the Technical Reference. Wherever it provides different or more complete information, the official guidance is the Technical Reference.

B. The ability to assess rangelands consistently between scientists, landowners, and agency personnel, and in terms that the public can understand, is important. Identifying functioning and non-functioning ecological processes and resource concerns needs to be communicated in common and recognizable terms (Pellant et al. 2005, 2020). Interpreting Indicators of Rangeland Health (IIRH) is a qualitative assessment that provides a relatively rapid technique to rate three attributes of ecological processes, including biotic integrity, soil/site stability, and hydrologic functioning. Seventeen observable indicators are assessed separately and are used to develop the score collectively for the three attribute level ratings (table E-19).

Table E-19. Attributes with Indicators

<table>
<tr><th>Soil/Site Stability</th><th>Hydrologic Function</th><th>Biotic Integrity</th></tr>
<tr><td colspan="2">1. Rills</td><td>12. Functional/Structural Groups</td></tr>
<tr><td colspan="2">2. Water Flow Patterns</td><td>13. Dead or Dying Plants or Plant Parts</td></tr>
<tr><td colspan="2">3. Pedestals and/or Terracettes</td><td>15. Annual Production</td></tr>
<tr><td colspan="2">4. Bare Ground</td><td rowspan="2">16. Invasive Plants</td></tr>
<tr><td colspan="2">5.Gullies</td></tr>
<tr><td>6. Wind-Scoured and/or Depositional Areas</td><td colspan="2">14. Litter Cover and Depth</td></tr>
<tr><td>7. Litter Movement</td><td>10. Effects of Plant Community Composition and Distribution on Infiltration</td><td>17. Vigor with an Emphasis on Reproductive Capability of Perennial Plants</td></tr>
<tr><td colspan="3">8. Soil Surface Resistance to Erosion</td></tr>
<tr><td colspan="3">9. Soil Surface Loss and Degradation</td></tr>
<tr><td colspan="3">11. Compaction Layer</td></tr>
</table>

C. Rangeland Health has been defined by an interagency committee as “The degree to which the integrity of the soil, vegetation, water, and air, as well as the ecological processes of the rangeland ecosystem are balanced and sustained. They defined integrity to mean maintenance of the functional attributes characteristic of a locale, including normal variability.”

D. The IIRH procedure was developed to be used by individuals who are experienced and knowledgeable with the protocol, either through formal training or working with those who have training and experience. This procedure requires a solid understanding of ecological processes, vegetation, and soils for each of the sites where it is applied. The protocol is designed to be used within the context of landscape classification systems, such as ecological sites or an equivalent unit, and be used with an appropriate reference sheet describing the natural range of variability for the 17 indicators at a given site. IIRH relies on the use of a qualitative (non-measurement) procedure to assess the functional status of each indicator to provide a preliminary evaluation of the three attributes of rangeland health (Pellant et al. 2005, 2020).

E. The purpose and intended application of the IIRH is to provide guidance in making range health assessments. The IIRH tool is designed to:

(1) Be used within the context of a landscape classification system, such as ecological sites or equivalent units.
(2) Be used with an appropriate reference sheet describing the natural disturbance regime within the natural range of variability for the 17 indicators at a given site.
(3) Be used only by people who are knowledgeable and experienced with the protocol and the ecological system being evaluated (including formal training or working closely with others who have training and experience).
(4) Provide a preliminary evaluation of the three attributes of rangeland health (soil/site stability, hydrologic function, and biotic integrity) at an evaluation area by rating all 17 indicators and considering them in the attribute rating step of the assessment.
(5) Be used to communicate fundamental ecological concepts to a wide variety of audiences.
(6) Improve communication by focusing discussion on critical ecosystem properties and processes.
(7) Assist in identifying monitoring priorities and selecting monitoring sites.
(8) Assist land managers in identifying areas that are at risk of degradation and where resource problems or management opportunities currently exist.
(9) Be used as a tool for prioritizing landscapes for potential types of restoration (Pyke 2011; Pyke et al. 2018).

F. The IIRH tool is not to be used to:

(1) Identify the cause(s) of resource problems.
(2) Make grazing and other management decisions.
(3) Monitor land or determine trend.
(4) Independently generate national or regional assessments of rangeland health.

G. Training is available for NRCS staff through the AgLearn “Interpreting Indicators of Rangeland Health” web-based course and through the AgLearn in-person “Interpreting Indicators of Rangeland Health” course. Interested individuals outside the NRCS agency may have opportunities for training through partnering agencies and organizations like the National Grazing Land Coalition and instructional videos on the Jornada Website https://jornada.nmsu.edu/monit-assess/manuals/assessment.

H. The Interpreting Indicators of Rangeland Health Technical Reference 1734-6 Version 5, complete with all instructions, can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/rangepasture/range/?cid=stelprdb1068410.

I. NRCS Use:

(1) NRCS uses the IIRH Assessment in helping decide where resource concerns are found on rangelands. Since the tool’s purpose is to help provide a qualitative analysis of ecological processes, it is a suitable assessment tool to delineate thresholds where resource concerns within the biotic integrity, the soils/site stability, and hydrologic function of a site exist. NRCS considers a resource concern as a resource condition that does not meet minimum acceptable levels as established by resource planning criteria in section III of the Field Office Technical Guide and the National Resource Concern List and Planning Criteria document (NRCS 2020).
(2) A resource concern implies degradation of the soil, water, air, plant, animal, or energy resource base to the extent that sustainability or the intended use of the resource is impaired. Planning criteria is a quantitative or qualitative statement of the minimum level of treatment required to address a given resource concern and may be assessed using

specific tools or through client and planner observation (NRCS 2020). For rangelands, the IIRH assessment is used to set planning criteria thresholds for multiple resource concerns.

J. Attributes of Rangeland Health—The final product of this qualitative assessment is not a single rating but an assessment of the three attributes. The three attributes are defined as:

(1) Soil/site stability—the capacity of an area to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water and recover this capacity when a reduction does occur.
(2) Hydrologic function—the capacity of an area to capture, store, and safely release water from rainfall, run-on, and snowmelt (where relevant), to resist a reduction in this capacity, and to recover this capacity when a reduction does occur.
(3) Biotic integrity—the capacity of the biotic community to support ecological processes within the natural range of variability expected for the site, to resist a loss in the capacity to support these processes, and to recover this capacity when losses do occur. The biotic community includes plants (vascular and nonvascular), animals, insects, and microorganisms occurring both above and below the ground (IIRH 2020).

K. Each of these three attributes is summarized at the end of the evaluation form (figures E-43 and E-44) based on a preponderance of evidence approach, using the applicable indicators. An example of the preponderance of evidence is in part where the majority of indicators for each attribute fall. For example, if four of the soil/site stability indicators are in “moderate” and six are in “slight to moderate,” the departure for the soil/site stability attribute would be rated as “slight to moderate” assuming that the interpretation of knowledge of ecological site properties, processes, and other information and local knowledge support the rating (Pellant et al. 2005, 2020).There are cases however when some indicators need to be weighted more heavily in the decision of the attribute rating.

L. “Weighting” or placing more value on specific indicator(s) may be appropriate and allowable in some cases. For example, if several of the four indicators that were rated “moderate” are particularly important to this site, a “moderate” rating for the entire attribute can be supported (Pellant et al. 2005, 2020). Critical indicators such as functional structural groups, invasive plants and vigor with an emphasis on reproductive capability of perennial plants are indicators that could be important to “weight”. For example, on a site that has several invasive plant species trending towards dominating the area, the impact of these species on the native plant composition and future integrity of the site would warrant weighting these indicators (USDA-NRCS NGLT 2022). Conversely, when an indicator has a “none to slight” rating due to the indicator having a low possibility of occurrence to the site, then that indicator may be given a lower weight for the final attribute score. For example, rills developing in a playa may be nearly impossible to occur, as rills rarely form in these bottomland positions, so a “none to slight” rating may be assigned, but a lower weighting or consideration of the rill indicator may be appropriate in the final attribute score (Pellant et al. 2005, 2020).\

M. It is important that the assessor complete the field notes section on the evaluation form (figures E-43 and E-44) for all indicators and specifically document why the process is modified to fit specific cases.

N. There are also cases when additional indicators to the standard 17 indicators are appropriate. These 17 are not meant to be all inclusive for all rangelands. The indicators of the protocol should always be evaluated, but in cases where additional indicators may add to or improve sensitivity in detecting changes to the attributes, they are appropriate to use and should be ranked (Pellent et al. 2005, 2020).

O. Optional indicators must significantly improve the quality of the evaluation by providing additional information about ecological function of the system and site being evaluated and must be relative to at least one of the three attributes (Pellant et al. 2005, 2020). For example, a biological soil crust indicator may be applied in ecological sites where these crusts play a particularly important biological or physical role (see figure E-40) (e.g., nitrogen fixation or soil stabilization). A generic evaluation matrix example for this optional indicator is shown here in table E-20. Other examples of additional indicators could be native plant diversity and pollinator forb species (with more examples in the IIRH Technical Note). Also, weigh the benefits of maintaining a consistent protocol against the expected improvement in the assessment when using optional indicators. Coordinate the development of optional indicators with the NRCS State range management specialist (Pellant et all, 2005, 2020).

Figure E-40. Biological soil crust-El Morro National Monument-photo credit Brenda Simpson, National Grazingland Team.

Table E-20. Generic descriptors of the five departure categories for the optional indicator of biological soil crusts.

Optional Indicator	Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
Biological Soil Crusts	Occurring only in protected areas; very limited suite of life forms.	Largely absent in plant interspaces; occurring mostly in protected areas.	Occurring in protected areas and with a minor component in interspaces.	Occurring throughout the site but continuity is broken.	Largely intact and nearly matches site potential.

P. Evaluating rangeland health ecological attributes

(1) The attributes represent a suite of interrelated ecological properties such as species composition and processes like the water cycle (the capture, storage and redistribution of precipitation), energy flow (conversion of sunlight to plant and then animal matter), and the nutrient cycle (the cycle of nutrients through the physical and biotic components of the environment).

(2) Due to complexity of ecological processes and their interrelationships, direct measures are usually not feasible. However, observable biological and physical components can be used as indicators of the functional status of these processes. These three attributes are rated with five possible categories which describe the degree of departure from conditions described in the reference sheet. See table E-21.

Table E-21. The three attributes of rangeland health and the rating categories for each attribute.

Soil/Site Stability (SSS)		**Hydrologic Function (HF)**		**Biotic Integrity (BI)**
Attribute ratings are based upon departure from ecological site descriptions in these categories				
Extreme to Total	Moderate to Extreme	Moderate	Slight to moderate	None to slight

(3) Evaluations of rangeland health ecological attributes must be able to distinguish between changes that are within the natural range of variability and those that are outside the natural range of variability of the ecological site (ES). The natural range of variability is defined as the deviation of characteristics of biotic communities and their environment that can be expected given natural variability in climate and natural disturbance regimes. The natural disturbance regime describes the kind, frequency, and intensity of natural disturbance events that would have occurred on an ecological site prior to European influence (ca.1600) (Winthers et al. 2005; Pellant et al. 2005, 2020).

(4) Natural disturbances include, but are not limited to, native insect outbreak, wildfires, native wildlife activities (herbivory, burrowing, etc.) and weather cycles including extremes like drought, wet periods, varying temperatures, snow, and wind events.

(5) The natural range of variability does not include influences of nonnative plant or animal species and also does not encompass soil degradation, such as accelerated erosion, organic matter loss, changes in nutrient availability, or soil structure degradation, beyond what would be expected (Pellant et al. 2005, 2020).

(6) The ecological site description (ESD) provides the standard from which indicators will be evaluated. All attributes, both measured and observed, must be compared to the attributes as described in the ecological site description reference sheet. The relative importance of the attributes is site dependent, and values and degree of variability for each attribute may be different from site to site. To the extent possible, the natural range of variability and types and sources of spatial and temporal variability should be described for each indicator in the reference sheet (table E-22).

Q. Indicators

Ecological processes are difficult to observe or measure in the field because most rangeland ecosystems are complex. Indicators are components of a system whose characteristics (presence or absence, quantity, distribution) are used as an index of an attribute (three rangeland health attributes: SSS, HF or BI) that is too difficult, inconvenient, or expensive to measure. There is no one indicator of ecosystem health. Instead, a suite of key indicators is used for the assessment (Karr 1992). Just as the Dow Jones Index is used to gauge the strength of the stock market, different combinations of the 17 indicators are used to gauge the attributes of soil/site stability, hydrologic function, and biotic integrity (table E-22). For each indicator, the same five departure descriptors are used to describe what is seen on the site, based upon departure from the ecological site description: None to Slight, Slight to Moderate, Moderate, Moderate to Extreme, and Extreme to Total (Pellant et al. 2005, 2020).

R. Evaluation Area

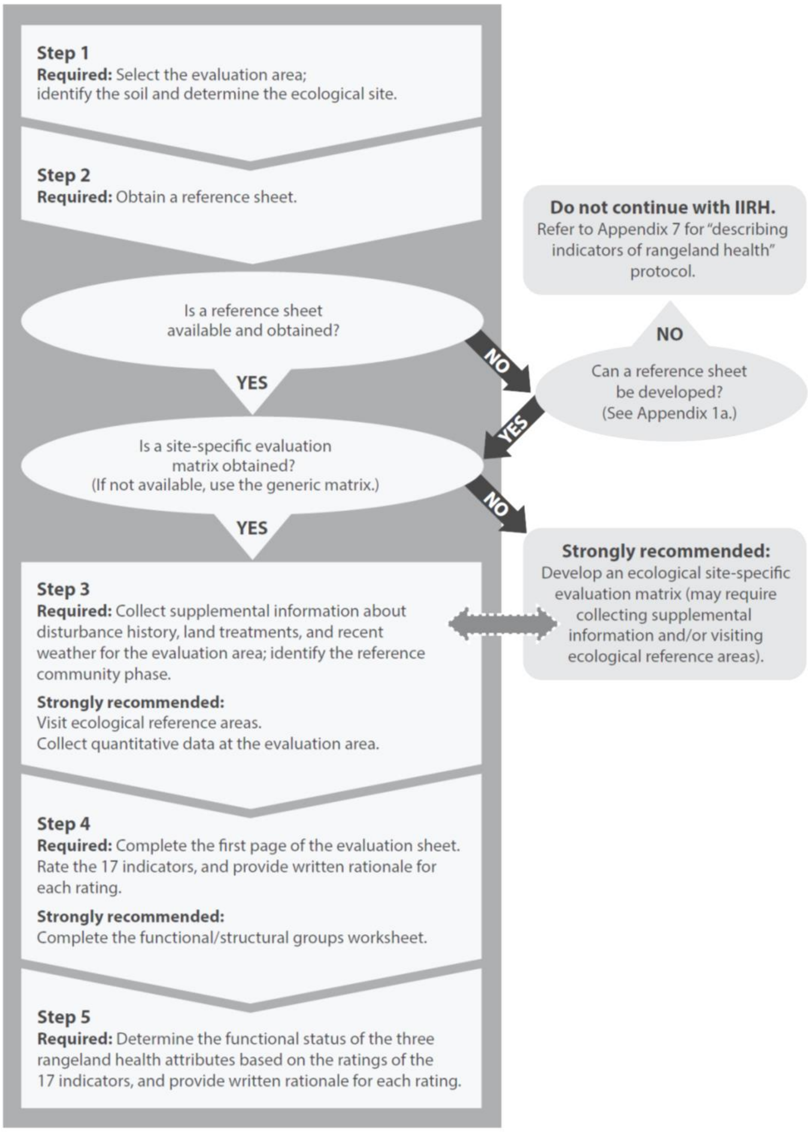
(1) The rangeland health evaluation is site specific using the rangeland ecological site description reference sheet as the standard for comparison. The evaluation area (area of interest) should be large enough to include the natural variability associated with each ecological site being assessed. Interest in an evaluation area may be based on concerns about current conditions, lack of information on conditions, or public perceptions of conditions (Pellant et al. 2005, 2020).

(2) When selecting the IIRH evaluation areas, it is important to consider how the resulting assessments may be combined to evaluate the condition of a larger landscape. Properly developed sample designs that incorporate randomized site selection and meet specific

assessment objectives can allow assessment results to be extrapolated across larger landscape units (e.g., management unit, watershed, ecoregion). This can help identify areas where management actions may potentially have the greatest impact (Pellant et al. 2005, 2020).

(3) Timing is also a factor in planning assessments. Although IIRH is a point-in-time, it should be conducted when the indicators are accessible and readily observed. During, or soon after the growing season, is generally the optimal time to conduct an assessment. Knowledge of local phenology patterns can assist evaluators in conducting the assessment when plant species are still recognizable (e.g., forbs) and their potential for reproduction can be rated. See the flowchart in figure E-41 from the IIRH Technical note on steps to completing a IIRH assessment (Pellant et al. 2005, 2020).

Figure E-41. Flowchart for completing an assessment of rangeland health using the IIRH protocol.



(4) Upon arrival at the location, the evaluator(s) should use observations of landscape position and soil profile characteristics to determine the ES. Assessments are conducted on an ecological site basis, so it is preferable to select evaluation areas that do not encompass more than one ecological site. If there are small components of other ES within the evaluation area, do not include them in the assessment; or if more than one major ES occurs in an evaluation area, complete a separate assessment for each site

(Pellant et al. 2005, 2020). It is advisable to spend some time walking the site to become familiar with the plant species, soil surface features, and the variability of the area.

(5) It is important that the correct ESD is used for the site. Soil surveys provide the foundation for describing and mapping ecological sites. The Web Soil Survey tool provides soils and ESD identification with the use of the Area of Interest tool: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx. After an Area of Interest is identified, the tool can attribute the area with soil map delineations and correlated ES. Note that there may be multiple correlated ecological sites to a soil map unit because ESs are correlated at the soil map unit component scale. Although the tool provides valuable information, all data should be verified on-site in the field. See Subpart B for instructions on identifying an ecological site on an evaluation area and for describing and hand-texturing soils on a site.

(6) An IIRH assessment cannot be completed without a reference sheet, and a reference sheet cannot be generated without an ES or equivalent unit with which it is associated. See Appendix 7 in the IIRH Technical Reference to help determine whether an IIRH assessment can be completed. If not, complete a protocol called “Describing Indicators of Rangeland Health” or DIRH to document information on the soil profile and the current status of IIRH indicators (Herrick et al. 2019; IIRH 2020). Instructions for completing the DIRH protocol are found in Appendix 7 of the IIRH Technical Reference.

(7) The DIRH protocol is designed to be used in two ways. First, where the DIRH protocol is completed on what are believed to be relatively undegraded lands based on other evidence (e.g., knowledge of historic disturbance regimes), data from similar intact locations in the same ecological site can be combined and used to help develop or revise the reference sheet. Second, DIRH data can be collected on land with no known reference, regardless of its level of degradation, and then used at a later date to support completion of an IIRH assessment after a reference sheet has been developed. For more information on using the DIRH protocol see the IIRH Technical Reference at: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/rangepasture/range/?cid=stelprdb1068410.

S. Ecological Site Description Reference Sheets

(1) The reference sheet describes the range of expected spatial and temporal variability of each indicator within the natural disturbance regime based on the ES (or equivalent unit) and is required to conduct an IIRH assessment. Reference sheets are part of most ESDs. If a reference sheet is not available, one must be developed using the directions and the checklist in Appendix 1a in the Interpreting Indicators of Rangeland Health Technical Reference (TR) 1734-6 Version 5, also found in Subpart B.

(2) Before developing or revising a reference sheet, refer to the EDIT (Ecosystem Dynamics Interpretive Tool) website: https://edit.jornada.nmsu.edu/ and contact the NRCS State rangeland management specialist to determine if there is a reference sheet developed. Complete instructions on developing a reference sheet are in Appendix 1a of the IIRH TR 1734-6. Table E-22 and E-23 shows a correctly populated reference sheet.

Table E-22. Example of a completed reference sheet for ecological site R010XY019ID.

Ecological Site Name: Loamy 12"–16" p.z. Ecological site code: R010XY01ID
Author(s)/participant(s): J. Thompson
Contact for lead author: stateRMS@nrcs.gov (555) 555-1234
Composition based on (check one): ☐ Cover ☐ Annual Production
Metadata storage location: Contact lead author or NRCS Idaho state conservationist's office

Indicators. For each indicator, describe the potential for the site using the reference sheet checklist. Where possible, (1) use quantitative measurements; (2) include expected range of values for above- and below-average years and natural disturbance regimes for each community phase within the reference state, when appropriate; and (3) cite data sources used. Continue descriptions on separate sheet.

1. Rills: Rills are not expected on this site, except 1–2 years after wildfire or multiyear droughts. Following these events, shallow rills < 1 m in length may develop on slopes > 10 percent.

2. Water flow patterns: Water flow patterns rarely occur on this site on slopes < 5 percent. On slopes > 5 percent, narrow (< 12”), short (1–5’ long), and disconnected water flow patterns may occur following high precipitation storms, affecting < 20 percent of the site. Water flow patterns occurring on > 5 percent slopes may nearly double in length, width, and connectivity for 1–3 years following wildfire or after multiyear droughts.

3. Pedestals and/or terracettes: Neither pedestals nor terracettes are expected to occur on slopes < 10 percent, except for 1–2 years following wildfires or multiyear droughts. Occasional pedestals may occur around bunchgrasses in shrub interspaces on slopes > 10 percent in association with water flow patterns.

4. Bare ground: Bare ground ranges from 15–20 percent. Bare ground patches should be small (< 12” diameter) and not connected. Bare ground may increase to as much as 30 percent 1–3 years after wildfire, and bare soil patches may be up to 24” in diameter. Animal activity (burrows and ant mounds) may occasionally result in isolated bare patches up to 5’ in diameter.

5. Gullies: Gullies do not occur on this site.

6. Wind-scoured and/or depositional areas: Wind-scoured areas do not occur on this site. Occasionally, thin, isolated soil deposits may be observed under shrubs, affecting < 5 percent of the site.

7. Litter movement: On slopes < 5 percent, fine litter is expected to move less than 6”, and coarse litter does not move. On slopes > 5 percent, as much as half of the fine litter falling in the interspaces may move up to 12”, but coarse litter generally does not move. Litter accumulations, if any, are small and usually occur at the bases of perennial bunchgrasses in the shrub interspaces on slopes > 5 percent. Litter dams are not expected.

8. Soil surface resistance to erosion: Stability class ratings from the soil stability test should be > 4.5 overall, with ratings of 4 or greater in the interspaces and 5 or greater under perennial plant canopy. Finer textured soils within this ecological site are expected to have overall ratings of > 5. Soil stability may temporarily decline up to 1 category following wildfire, due to decreases in biotic soil crusts and organic matter.

9. Soil surface loss and degradation: The surface horizon (A) should be 6–10” (roots growing throughout) with a moderate, very fine granular structure and a diversity of soil pores throughout. The subsurface (B) horizon is friable; structure is medium subangular blocky. The surface (A) horizon color is 7.5YR 3/2 (moist), and the subsurface (B) horizon color is 10YR 4/3 (moist).

10. Effects of plant community composition and distribution on infiltration: Deep-rooted perennial bunchgrasses are dominant, nonsprouting shrubs are subdominant, and perennial forbs are a minor component. Following wildfire (1–5 years), deep-rooted perennial grasses dominate, with a

subdominant component of perennial forbs. For the first year following wildfire or a multiyear drought, infiltration will be slightly reduced due to lack of ground cover. After 1 year following the preceding disturbances, deep-rooted perennial bunchgrasses and shrubs are again distributed evenly to provide sufficient ground cover to catch snow and increase infiltration. These processes are particularly important on slopes > 10 percent, where runoff has the potential to increase in the absence of well-distributed perennial grasses

11. Compaction layer: No compaction layers occur naturally on this site. No natural soil features that may be confused with a compaction layer occur on this site.

12. Functional/structural groups: The site is dominated by perennial grasses and nonsprouting shrubs, depending on the time since fire. Nonsprouting shrubs may become dominant 15–30 years post-fire. Following wildfire, nonsprouting shrubs are greatly reduced, and perennial forbs become a subdominant component. Expected diversity of perennial forbs is higher at the upper end of the precipitation range for this site (> 5 species). The expected fire return interval across which the three phases develop is 15–30 years.

13. Dead or dying plants or plant parts: A few (< 10 percent) dead centers naturally occur in bunchgrasses and will increase to 15 percent following a multiyear drought. Nonsprouting shrubs may have up to 10 percent dead branches as plants age, usually occurring in community phase 1.1. Sagebrush may have a large increase in dead branches with moderate mortality in patches up to 3 acres as a result of Aroga moth infestation.

14. Litter cover and depth: Total litter cover is expected to be 20–30 percent and at a depth of 0.25–0.5 inches under shrubs and < 0.1 inches under grass canopy. Litter may be reduced to 10–20 percent in cover and near zero depth for 1–2 years following wildfire or multiyear drought.

15. Annual production: Annual production is 1,100 pounds per acre in a year with normal precipitation and temperatures. Low and high production years should yield 850 and 1,400 pounds per acre, respectively. Annual production may be reduced by 40–60 percent the first year following a wildfire or following a multiyear drought. Annual production may increase for 3–6 years following wildfire due to perennial bunchgrass response.

16. Invasive plants: Western juniper, cheatgrass, medusahead, spotted knapweed, and rush skeletonweed. Western juniper may occur in trace amounts in community 1.3 but has the potential to increase to a subdominant or dominant in the absence of wildfire and act as an invasive on this site. Other than western juniper, the listed invasives are not expected to occur in the reference state. The site has increased susceptibility to invasion by rush skeletonweed, spotted knapweed, and exotic annual grasses following wildfire.

17. Vigor with an emphasis on reproductive capability of perennial plants: Plants in all functional/structural groups should be capable of reproducing annually under normal weather conditions. Vigorous mature cool-season, deep-rooted perennial grasses typically have a basal diameter of > 10 cm. Vigor and reproductive capability may be somewhat reduced during drought or for 1 year following a wildfire. At least 50 percent of plants should still have reproductive capability during droughts that last 1–2 years

Table E-23. Example Indicator 12 Functional/Structural Groups for ecological site R010XY019ID.

Dominance Category1	Relative Dominance of F/S Groups for Community Phases in the Reference State Minimum expected number of species for dominant and subdominant groups is included in parentheses.		
	Dominance based on1: Annual Production X or Foliar Cover		
	Phase 1.1 (5–15 years post-fire)	Phase 1.2 (1–5 years post-fire)	Phase 1.3 (15–30+ years post-fire)
Dominant	Cool-season, deep-rooted perennial bunchgrasses (4)	Cool-season, deep-rooted perennial bunchgrasses (4)	Nonsprouting shrubs (2)
Subdominant	None	Perennial forbs (3)	Cool-season, deep-rooted perennial bunchgrasses (4)
Minor	Nonsprouting shrubs; sprouting shrubs; cool-season, shallow-rooted perennial bunchgrasses	Sprouting shrubs; cool-season, shallow-rooted perennial bunchgrasses	Perennial forbs; cool-season, shallow-rooted perennial bunchgrasses; biological soil crusts[1]
Trace	Perennial forbs; biological soil crusts[1]	Nonsprouting shrubs; biological soil crusts[1]	Sprouting shrubs; evergreen trees[2]

[1] Biological soil crust dominance is determined based on cover, rather than production. If biological soil crusts are an expected dominant or subdominant group, the number of expected life forms (e.g., lichen, moss) is listed, rather than number of individual species.
[2] May not occur on the site.

T. Obtain an Evaluation Matrix

(1) The matrix is required to conduct an IIRH assessment. The matrix provides general descriptions of key characteristics and degrees of departure, forming a relative scale from “none to slight” to “extreme to total” departure for each of the 17 indicators. The descriptor for “none to slight” comes from the reference sheet and reflects the effects of the natural disturbance regime and natural range of variability of each indicator in the reference state (Pellant et al. 2005, 2020).

(2) See the IIRH Technical Reference, Version 5, Appendix 2 for a generic evaluation matrix and in table E-25 in this subpart. The generic evaluation matrix can be used to conduct an IIRH assessment using the ecological site classification system (ecological site descriptions and appropriate reference information are available). But it is strongly recommended to obtain or develop an ecological site-specific evaluation matrix because it can more accurately describe the possible range of variation for each indicator compared to the generic evaluation matrix. Instructions for developing a specific site evaluation matrix are included in Appendix 2 of the IIRH Technical Reference (Pellant et al. 2005, 2020).

U. Collect Supplemental Information

Supplemental information improves an evaluator’s ability to conduct an informed and accurate assessment. Local knowledge is a valuable source of this supplemental information which includes:

(1) recent weather (required), including precipitation for the past two years
(2) land treatments and disturbance history (required)
(3) information about wildlife, livestock, recreation, or other uses (recommended)
(4) photographs of the evaluation area (strongly recommended)
(5) quantitative data to help train evaluators in rating some indicators and support assessments (strongly recommended, see table E-24 in this subpart; table 5 in the IIRH Technical Reference)

Table E-24. Selected indicators of rangeland health and associated measurement methods that are commonly used to collect related quantitative indicator values.

Rangeland Health Indicator	Measurement Method[1]	Quantitative Indicator Value
Bare ground (indicator 4)	**Line point intercept**	Bare ground percent
	Gap intercept	Size of intercanopy or basal gaps
Soil surface resistance to erosion (indicator 8)	**Soil stability test**	Soil surface stability values
Effects of plant community composition and distribution on infiltration (indicator 10)	Production by species[2]	Functional/structural group composition by weight
	Line point intercept	Functional/structural group composition by cover
Functional/structural groups (indicator 12)	**Line point intercept**	Functional/structural group composition by cover
	Production by species[2]	Functional/structural group composition by weight
Dead or dying plants or plant parts (indicator 13)	**Line point intercept**	Proportion of dead plants or plant parts intercepted
	Belt transect	Proportion or density of dead or dying plants
Litter cover and depth (indicator 14)	**Line point intercept**	Litter cover
Annual production (indicator 15)	Total harvest[2] Weight units[2]	Total annual production
Invasive plants (indicator 16)	Production by species[2]	Invasive plant composition by weight
	Line point intercept	Cover of invasive species
	Belt transect	Density of invasive plants

[1] Core methods are bold.
[2] Note that the protocol outlined in Appendix 8 provides a measurement of total annual production. Refer to subpart E 645.0502.F for protocols to determine species composition by weight.

V. Rate the 17 Indicators

(1) The recommended protocol to conduct an IIRH assessment is for the evaluator(s) to complete a general reconnaissance of the evaluation area to determine how much variability exists for each indicator on the site. This enables the evaluator(s) to become familiar with the plant species, relative dominance of functional/structural groups, soil surface features, rangeland health indicators, and variability associated with the ecological site in the evaluation area. When completing the IIRH protocol as an interdisciplinary team, indicators are rated using a consensus approach (Pellant et al. 2005, 2020).

(2) The reference sheet describes the range of expected spatial and temporal variability for each indicator within the natural disturbance regime for an ES. The rating of each indicator in the evaluation area is based on that indicator’s degree of departure from the “none to slight” category, which is taken from the appropriate reference sheet. When indicator conditions match the description for the reference, the indicator is rated “none to slight” (Pellant et al. 2005, 2020).

(3) Refer to the evaluation matrix or ecological site-specific evaluation matrix (if available) to determine which descriptor best describes the departure from the “none to slight” descriptor and enter that rating on the evaluation form (figures E-43 and E-44). The narrative descriptors for each indicator form a relative scale from “none to slight” to “extreme to total” departure. The evaluation matrix often includes several short sentences describing characteristics of the departure of an indicator. Not all indicator departure descriptors will match indicator conditions observed in the evaluation area, particularly when using the generic evaluation matrix. Evaluators should select the departure rating for which the majority of the descriptors best describe the departure of the indicator (e.g.,

use a “best fit” approach) while strongly considering those descriptors that fall in greater departure rating categories (see IIRH Technical Reference Table 6). Each indicator rating should be supported with comments in the spaces provided on the evaluation form (figures E-43 and E-44) (Pellant et al. 2005, 2020).

(4) Short descriptions of each of the 17 indicators taken from the Technical Reference (Pellant et al. 2005, 2020) are included here for information, but it is critical to read and refer to the IIRH Technical Reference to get all the instructions, photos, and examples on running the protocol correctly.

The Technical Reference can be assessed here: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/rangepasture/range/?cid=stelprdb1068410.

- Rills (Indicator 1)

  Rills are small, intermittent watercourses with steep sides, usually only several centimeters deep (SSSA 1997). They are generally linear erosion features that mostly run parallel to the slope. For most soils and ecological sites, the potential for rill formation increases as the degree of disturbance (loss of cover) and slope increases. Rills usually end at a concentrated water flow pattern, a terracette, or an area where the slope flattens, and deposition occurs. Rills may connect into a drainage and erosion network on some sites, but for most sites, rills will not be connected.

- Water Flow Patterns (Indicator 2)

  Water flow patterns are the paths that water takes as it moves across the soil surface during periods when surface water from rain or snowmelt exceeds soil infiltration capacity. This process is commonly referred to as sheetflow or overland flow. Water flow patterns follow the natural microtopography of the landscape. These patterns are generally evidenced by litter, soil or gravel redistribution, or pedestalling of vegetation or stones that break or divert the flow of water (Morgan 1986). Length, width, and number of water flow patterns are influenced by the number and kinds of obstructions to water flow provided by basal intercepts of living or dead plants, biological soil crusts, persistent litter, or rocks. They may be continuous or appear and disappear as the slope, perennial plant density, and microtopography change.

- Pedestals and/or Terracettes (Indicator 3)

  – Pedestals indicate the movement of soil by water or wind from the base of plants or from around rocks or persistent litter, giving them the appearance of being elevated. Accelerated erosion is likely to be occurring on a site when the number of pedestals is more than what is defined as expected for the site in the reference state (within the natural disturbance regime). In some cases, plant roots may be exposed due to this accelerated erosional process.

  – Terracettes are “benches” of sediment deposition that form behind or between obstacles, such as rocks, plant bases, or large litter, when soil and other materials are redistributed by water movement. As the degree of soil movement by water increases, terracettes may become more numerous, and the area of soil deposition becomes larger. The relatively higher elevation of the soil on the upslope side of a terracette is an indication of soil deposition by moving water or of soil erosion below the terracette.

- Bare Ground (Indicator 4)

  Bare ground is exposed mineral soil not covered by vegetation (live or dead and basal and canopy cover), gravel/rock, visible biological soil crusts, or litter. These ground surface cover materials intercept raindrops, reduce soil particle detachment (raindrop splash erosion), and reduce soil movement by water and wind (Weltz et al. 1998; Pellant et al. 2020).

- Gullies (Indicator 5)

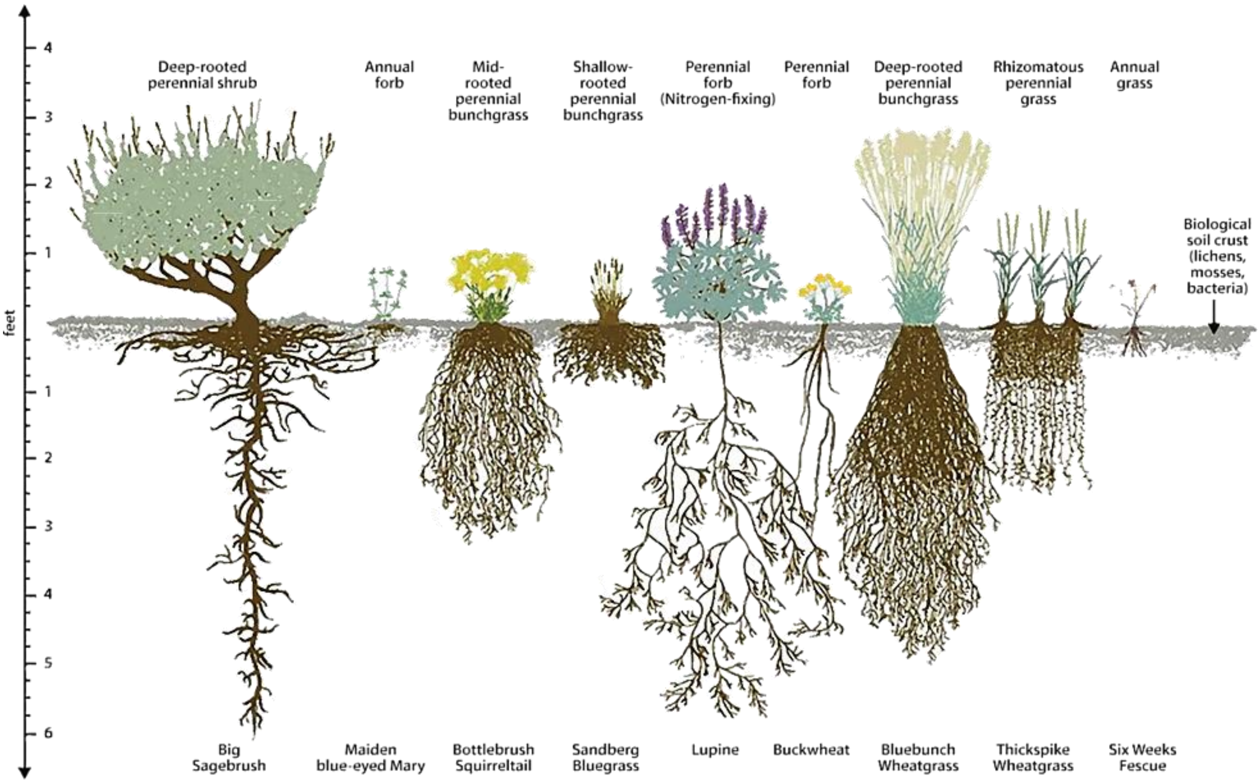
Gullies are well-defined channels cut into the soil by ephemeral water flow that normally follow natural drainage channels. Gullies can develop from enlarged rills; however, gully formation may be much more complex and usually involves an interrelationship between the: (1) volume, speed, and type of runoff; (2) susceptibility of the soil to erosion; and (3) changes in ground cover caused by inappropriate land uses and treatments (Morgan et al. 1997; Pellant et al. 2020).

- Wind Scoured and/or Depositional Areas (Indicator 6)
  Wind-scoured areas, including blowouts, are formed as finer particles of the topsoil are blown away, sometimes leaving residual gravel, rock, or exposed roots on the soil surface (Anderson 1974). Blowouts are defined as "a hollow or depression of the land surface, which is generally saucer or trough-shaped, formed by wind erosion, especially in an area of shifting sand, loose soil, or where vegetation is disturbed or destroyed" (SSSA 1997). Blowouts are included within the following discussion of wind-scoured areas and within the assessment of this indicator. Depositional areas are locations where windblown soil accumulates; the deposited soil may originate from either on- or offsite. Soil deposition due to water movement is not included when assessing this indicator.
- Litter Movement (Indicator 7)
  - Litter is the uppermost layer of organic debris on the soil surface – essentially the freshly fallen or slightly decomposed vegetal material (SRM 1999). In this technical reference, litter includes dead plant material, including leaves, stems, and branches, that are detached from the plant. Duff (dead plant material that is decomposed so that leaves, stems, and branches are difficult to recognize) is not included in the litter movement indicator.
  - Litter movement refers to the change in location of litter due to water or wind. The distance, amount, and size of litter being moved are signs of the extent to which water or wind erosion may be occurring.
- Soil Surface Resistance to Erosion (Indicator 8)
  - This indicator assesses the resistance of the soil surface to erosion by water. Resistance depends on soil stability and on the spatial variability in soil stability relative to vegetation and microtopographic features (Morgan 1986). Soil surfaces may be stabilized by: (1) soil organic matter that has been fully incorporated into aggregates at the soil surface; (2) adhesion of decomposing organic matter to the soil surface; and (3) biological soil crusts (Wills et al. 2017).
  - The presence of one or more of these factors is a positive indicator of soil surface resistance to erosion (Blackburn et al. 1992; Pierson et al. 1994). Soil texture (especially clay content and sand size) and clay mineralogy affect potential stability: coarse sandy soils have inherently lower stability. This indicator is more highly correlated with water erosion (Blackburn and Pierson 1994; Pierson et al. 1994) than with wind erosion. However, susceptibility to wind erosion also declines with an increase in soil organic matter (Fryrear et al. 1994) and biological soil crust cover (Belnap and Gillette 1998).
- Soil Surface Loss and Degradation (Indicator 9)
  Soil surface loss and degradation is the reduction in soil surface depth, organic matter, porosity, and structure as a result of wind or water erosion, and it is indicative of long-term change in rangeland health. The loss or degradation of part or all of the soil surface layer or horizon is an indication of a loss in site potential (Dormaar and Willms 1998; Davenport et al. 1998).
- Effects of Plant Community Composition and Distribution on Infiltration (Indicator 10)
  This indicator reflects effects of vegetation composition and spatial distribution on the infiltration capacity of the soil within the evaluation area and the amount of time water is retained on the soil surface. The term infiltration for this

indicator encompasses both the entry of water into soil and the movement of water into the soil profile.

- Compaction Layer (Indicator 11)
  A compaction layer is a near-surface layer of dense soil caused by impact on or disturbance of the soil surface. A compaction layer can be caused by application of weight or pressure at or below the soil surface. Compaction layers restrict water percolation (Willat and Pullar 1984; Thurow et al. 1988a), plant growth (Wallace 1987), and nutrient cycling (Hassink et al. 1993), potentially reducing infiltration and increasing runoff and changes in plant composition and production.
- Functional/Structural Groups (Indicator 12)
  - Functional/structural groups are plant species (including nonvascular plants such as visible biological soil crusts) that are grouped together on the basis of similar growth forms or ecophysiological roles (table E-23 and figure E-42).
  - Function typically refers to the ecophysiological role that plants and biological soil crusts play on a site. This may include the plant's life cycle (e.g., annual, monocarpic perennial, or perennial), phenology, photosynthetic pathway, nitrogen fixer associations, sprouting ability, and water infiltration (including biological soil crusts).
  - Structure refers to plant growth forms (e.g., trees, vines, shrubs, grasses, forbs, and nonvascular plants, such as visible biological soil crusts) within the community. Structure may be subdivided to group species with similar growth forms based on height, growth patterns (bunch, sod-forming, or spreading through long rhizomes or stolons), root structure (fibrous or tap), rooting depth, or sprouting ability.
  - The functional/structural groups indicator assesses shifts in expected types and proportions of functional/structural groups within the context of the plant community phases that are described for an ecological site under the natural disturbance regime (Pellant et al. 2005, 2020).
  - For instruction on developing the Functional/Structural Groups table in the Reference Sheet, see the Technical Reference Version 5 Appendix 1b.
- Dead or Dying Plants or Plant Parts (Indicator 13)
  Dead or dying plants and dead or dying stems, branches, leaves, etc., are a natural phenomenon in all perennial plant communities. Ecological reference areas in the same ecological site can provide a point of comparison to determine expected dead or dying plants or plant parts given recent weather at the time of assessment.
- Litter Cover and Depth (Indicator 14)
  Litter is the uppermost layer of organic debris on the soil surface—essentially the freshly fallen or slightly decomposed vegetal material (SRM 1999). In this technical reference, it includes dead plant material, including leaves, stems, and branches, detached from the plant.
- Annual Production (Indicator 15)
  Annual production represents the energy captured by plants through the process of photosynthesis, given recent weather conditions. It is the net quantity of aboveground vascular plant material produced within a growing season. It is not a measurement or estimate of total standing biomass (which includes the previous growing season production).

Figure E-42. Root morphology of common plants in a sagebrush steppe ecosystem (adapted from Sage Grouse Initiative 2016). See Natura (1995) for a similar diagram of root morphology of common plants in a mixed prairie ecosystem (Pellant et al. 2005, 2020).



- Invasive Plants (Indicator 16)
  Invasive plants (for purposes of the IIRH protocol) are plant species that are typically not found on the ecological site or should only be in the trace or minor categories under the natural disturbance regime and have the potential to become a dominant or codominant species on the site if their establishment and growth are not actively controlled by natural disturbances or management interventions. A primary characteristic of invasive plant species is their ability to persist on an ecological site and influence ecological processes (Chambers et al. 2014). See the Technical reference for more information on ruderal, noxious, introduced and native plant applicability.
- Vigor with an Emphasis on Reproductive Capability of Perennial Plants (Indicator 17)
  Plant vigor relates to the robustness of a plant in comparison to other individuals of the same species. Vigor is reflected primarily by the size of the plant and its parts in relation to the plant’s age and the local environment in which it is growing (SRM 1999). A plant’s reproductive capability is dependent on having adequate vigor and the ability to reproduce given the constraints of climate and herbivory. Inflorescence (e.g., seed stalks) and flower production are basic measures of reproductive potential for sexually reproducing plants and clonal production (e.g., tillers, rhizomes, or stolons) for vegetatively reproducing plants.

Table E-25. IIRH Generic Evaluation Matrix.

Departure from Reference Sheet Indicator	Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
1. Rills	Numerous and frequent throughout. Nearly all are wide, deep, and long. Occur in exposed and vegetated areas.	Moderate in number at frequent intervals. Many are wide, deep, and long. Occur in exposed areas and in some adjacent vegetated areas.	Moderate in number at infrequent intervals. Moderate width, depth, and length. Occur mostly in exposed areas.	Scarce and scattered. Minimal width, depth, and length. Occur in exposed areas.	Reference sheet narrative inserted here.
2. Water Flow Patterns	Extensive. Long and wide. Erosional and/ or depositional areas widespread. Usually connected.	Widespread. Longer and wider than expected. Erosional and/ or depositional areas common. Occasionally connected.	Common. Lengths and/or widths slightly to moderately higher than expected. Minor erosional and/ or depositional areas. Infrequently connected.	Scarce. Length and width nearly match expected. Some minor erosional and/ or depositional areas. Rarely connected.	Reference sheet narrative inserted here.
3. Pedestals and/or Terracettes	Pedestals extensive; roots frequently exposed. Terracettes widespread.	Pedestals widespread; roots commonly exposed. Terracettes common.	Pedestals common; roots occasionally exposed. Terracettes uncommon.	Pedestals uncommon; roots rarely exposed. Terracettes scarce.	Reference sheet narrative inserted here.
4. Bare Ground	Substantially higher than expected. Bare ground patches are large and frequently connected.	Much higher than expected. Bare ground patches are large and occasionally connected.	Moderately higher than expected. Bare ground patches are moderate in size and sporadically connected.	Slightly higher than expected. Bare ground patches are small and rarely connected.	Reference sheet narrative inserted here.
5. Gullies	Sporadic or no vegetation on banks and/ or bottom. Numerous nickpoints. Significant active bank and bottom erosion, including downcutting. Substantial depth and/or width. Active headcut(s) may be present.	Intermittent vegetation on banks and/ or bottom. Nickpoints common. Moderate active bank and bottom erosion, including downcutting. Significant depth and/or width. Active headcut(s) may be present.	Occasional vegetation on banks and/ or bottom. Occasional nickpoints and/or slight downcutting. Moderate depth and/or width. Active headcuts absent.	Vegetation on most banks and/or bottom. Few nickpoints and/or minimal downcutting. Minimal gully depth and/or width. Headcuts absent.	Reference sheet narrative inserted here.

Departure from Reference Sheet Indicator	Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
6. Wind-Scoured and/or Depositional Areas	Extensive. Wind scours usually connected. Large soil depositions around obstructions.	Common. Wind scours frequently connected. Moderate soil depositions around obstructions.	Occasionally present. Wind scours infrequently connected. Minor soil depositions around obstructions.	Infrequent and few. Wind scours rarely connected. Trace amounts of soil deposition around obstructions.	Reference sheet narrative inserted here.
7. Litter Movement (Wind or Water)	Extreme movement of all size classes (including large). Significant accumulations around obstructions or in depressions.	Moderate to extreme movement of small to moderate size classes. Moderate accumulations around obstructions or in depressions.	Moderate movement of mostly small size classes. Small accumulations around obstructions or in depressions.	Slight movement of small size classes. Minimal or no accumulations around obstructions or in depressions.	Reference sheet narrative inserted here.
8. Soil Surface Resistance to Erosion	Extremely reduced throughout.	Significantly reduced in most interspaces or plant canopies and moderately reduced throughout.	Significantly reduced in at least half of plant interspaces or plant canopies or moderately reduced throughout.	Some reduction in plant interspaces or plant canopies or slightly reduced throughout.	Reference sheet narrative inserted here.
9. Soil Surface Loss and Degradation	Soil surface horizon very thin to absent throughout. Soil surface structure similar to or more degraded than subsurface. No distinguishable difference between surface and subsurface organic matter content.	Severe soil loss or degradation throughout. Minor differences in soil organic matter content and structure between surface and subsurface layers.	Moderate soil loss or degradation in plant interspaces with some Degradation beneath plant canopies. Soil organic matter content is markedly reduced.	Slight soil loss or degradation, especially in plant interspaces. Minor change in soil organic matter content.	Reference sheet narrative inserted here.
10. Effects of Plant Community Composition and Distribution on Infiltration	Changes in plant community (functional/ structural groups) composition and/or distribution are expected to result in a severe reduction in infiltration.	Changes in plant community (functional/ structural groups) composition and/ or distribution are expected to result in greatly decreased infiltration.	Changes in plant community (functional/ structural groups) composition and/ or distribution are expected to result in a moderate reduction in infiltration.	Changes in plant community (functional/ structural groups) composition and/ or distribution are expected to result in a slight reduction in infiltration.	Reference sheet narrative inserted here.

Departure from Reference Sheet Indicator	Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
11. Compaction Layer	Extensive and/ or strongly developed (thickness and density); may severely restrict root penetration.	Widespread and/ or moderately to strongly developed (thickness and density); may greatly restrict root penetration.	Moderately widespread and/ or moderately developed (thickness and density); may moderately restrict root penetration.	Not widespread and/or weakly developed (thickness and density); may weakly restrict root penetration.	Reference sheet narrative inserted here.
12. Functional/ Structural (F/S) Groups			Indicator rating is based on the greatest departure of the four subindicators.		
12a. Relative dominance	All expected dominant F/S groups are now minor, trace, or missing.	Dominant F/S group(s) has become minor or trace, or a minor or trace group is now dominant.	Dominant F/S group(s) has become subdominant.	Subdominant F/S group has become minor or trace, or a minor or trace F/S group has become subdominant.	Resembles expected relative dominance.[1]
12b. F/S groups not expected	F/S group(s) not expected is now dominant.	F/S group(s) not expected is now subdominant.	F/S group(s) not expected is now minor.	F/S group(s) not expected is now trace.	None.
12c. Number of expected F/S groups[2]	Severely reduced (missing ≥ 76% of expected F/S groups).	Greatly reduced (missing 51–75% of expected F/S groups).	Moderately reduced (missing 26–50% of expected F/S groups).	Slightly reduced (missing ≤ 25% of expected F/S groups).	All expected F/S groups are present.[1]
12d. Total combined number of species expected in dominant and subdominant F/S groups	Severely reduced (missing ≥ 76%).	Greatly reduced (missing 51–75%).	Moderately reduced (missing 26–50%).	Slightly reduced (missing 10–25%).	Missing less than 10% of expected number of species in dominant and subdominant F/S groups.[1]
13. Dead or Dying Plants or Plant Parts (dominant, subdominant, and minor functional/ structural groups	Extensive mortality and/ or dying plants/ plant parts in species within expected functional/ structural group(s).	Widespread mortality and/ or dying plants/ plant parts in species within expected functional/ structural group(s).	Moderate mortality and/ or dying plants/ plant parts in species within expected functional/ structural group(s).	Occasional mortality and/ or dying plants/ plant parts in species within expected functional/ structural group(s).	Reference sheet narrative inserted here.
14. Litter Cover and Depth	Largely absent with minimal depth or extensive with much greater depth relative to site potential and recent weather.	Greatly reduced or greatly increased cover and/or depth relative to site potential and recent weather.	Moderately more or less cover and/ or depth relative to site potential and recent weather.	Slightly more or less cover and/or depth relative to site potential and recent weather.	Reference sheet narrative inserted here.

Departure from Reference Sheet Indicator	Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
15. Annual Production[3]	20% or less of potential production based on recent weather.	21–40% of potential production based on recent weather.	41–60% of potential production based on recent weather.	61–80% of potential production based on recent weather.	Reference sheet narrative inserted here (annual production > 80% of potential).
16. Invasive Plants	Dominant throughout.	Common throughout.	Scattered throughout.	Uncommon.	Nonnative invasive plants not present. If native invasive species are present, composition matches that expected for the ecological site.
17. Vigor with an Emphasis on Reproductive Capability of Perennial Plants (dominant, subdominant, and minor functional/ structural groups)	Vigor and capability to produce seed or vegetative tillers in species within the expected functional/ structural group(s) are extremely reduced, or functional/ structural group(s) is no longer functionally present.	Vigor and capability to produce seed or vegetative tillers in species within the expected functional/ structural group(s) are greatly reduced.	Vigor and capability to produce seed or vegetative tillers in species within the expected functional/ structural group(s) are moderately reduced.	Vigor and capability to produce seed or vegetative tillers in species within the expected functional/ structural group(s) are slightly reduced.	Reference sheet narrative inserted here.

[1] For the appropriate reference community phase.
[2] Must be functionally present.
[3] When developing an ecological site-specific evaluation matrix, use these same percentage categories.

Figure E-43. Blank Evaluation Form for Interpreting Indicators of Rangeland Health.

Interpreting Indicators of Rangeland Health Version 5 Evaluation Form (page 2)	
Evaluation area name or ID:	Date:

Departure from Expected	Code	Instructions
None to slight	N-S	(1) Assign 17 indicator ratings, record comments and any measurements.
Slight to moderate	S-M	(2) In the attribute rating tables at the bottom of the form, write the indicator number in the appropriate column for each indicator applicable to the attribute.
Moderate	M	(3) Assign overall rating for each attribute based on preponderance of evidence.
Moderate to extreme	M-E	
Extreme to total	E-T	(4) Provide rationale for each attribute rating in writing.

Indicator	Rating			Comments
1. Rills	S	H		
2. Water flow patterns	S	H		
3. Pedestals and/or terracettes	S	H		
4. Bare ground (observed): _____ %	S	H		
5. Gullies	S	H		
6. Wind-scoured and/or depositional areas	S			
7. Litter movement (wind or water)	S			
8. Soil surface resistance to erosion Interspace: _____ Plant canopy: _____	S	H	B	
9. Soil surface loss and degradation	S	H	B	
10. Effects of plant community composition and distribution relative to infiltration		H		
11. Compaction layer	S	H	B	
12. Functional/structural groups a. Relative dominance: ____ b. F/S groups not expected at the site: ____ c. Number of F/S groups: ____ d. Spp # in dom & subdom F/S groups: ____			B	
13. Dead or dying plants or plant parts			B	
14. Litter cover and depth Observed cover: ____% Depth: ____ cm / in		H	B	
15. Annual production: Pounds or Kilograms Observed: ____ ÷ Expected ____ = ____			B	
16. Invasive plants			B	
17. Vigor with an emphasis on reproductive capability of perennial plants			B	

Soil/Site Stability "S" *(10 indicators)*		**Hydrologic Function "H"** *(10 indicators)*		**Biotic Integrity "B"** *(9 indicators)*	
Attribute Rating: ____	Rationale:	Attribute Rating: ____	Rationale:	Attribute Rating: ____	Rationale:
E-T | M-E | M | S-M | N-S		E-T | M-E | M | S-M | N-S		E-T | M-E | M | S-M | N-S	

Figure E-44. Example of Populated Evaluation Form.

Interpreting Indicators of Rangeland Health Version 5 Evaluation Form (page 2)

Evaluation area name or ID: Big Sage_CM_14 | Date: 8/14/2018

Departure from Expected	Code	Instructions
None to slight	N-S	(1) Assign 17 indicator ratings, record comments and any measurements.
Slight to moderate	S-M	(2) In the attribute rating tables at the bottom of the form, write the indicator number in the appropriate column for each indicator applicable to the attribute.
Moderate	M	
Moderate to extreme	M-E	(3) Assign overall rating for each attribute based on preponderance of evidence.
Extreme to total	E-T	(4) Provide rationale for each attribute rating in writing.

Indicator	Rating		Comments
1. Rills	S H	N-S	No rills observed in evaluation area
2. Water flow patterns	S H	S-M	Short, disconnected waterflow patterns 3' long and up to 1' wide in plant interspaces on slopes > 5%
3. Pedestals and/or terracettes	S H	S-M	Occasional pedestalled bunchgrasses associated with water flow patterns on slopes > 5%
4. Bare ground (observed): 32 %	S H	M-E	Bare ground is much higher than expected, with bare patches > 2' that are occassionally connected
5. Gullies	S H	N-S	None
6. Wind-scoured and/or depositional areas	S	N-S	Minor soil deposits found around perennial plant bases; no wind scours noted – matches what is expected for the site
7. Litter movement (wind or water)	S	S-M	Displacement of fine material up to 2' associated with water flow patterns on slopes > 5%. Coarse litter does not appear to be moving
8. Soil surface resistance to erosion Interspace: 3.2 Plant canopy: 3.8	S H B	M	Observed values are consistently 1-2 categories lower than expected
9. Soil surface loss and degradation	S H B	S-M	A-horizon is thinner (5 cm) and lighter (10yr 4/2) in color than expected
10. Effects of plant community composition and distribution relative to infiltration	H	S-M	Deep-rooted perennial grasses are somewhat reduced, resulting in slightly less infiltration, especially on steeper slopes
11. Compaction layer	S H B	S-M	Thin, weakly developed compaction layer in interspaces, ~2" thick
12. Functional/structural groups a. Relative dominance: S-M b. F/S groups not expected at the site: M c. Number of F/S groups: N-S d. Spp # in dom & subdom F/S groups: N-S	B	M	Annual grasses are not expected for this site, but now a minor component; relative dominance has shifted towards shrubs with a decrease in perennial grasses. Biological crust cover is substantially lower than expected
13. Dead or dying plants or plant parts	B	S-M	Approx. 20% of deep-rooted bunchgrasses have slight crown die-out which is not expected given the normal precipitation over the past two years
14. Litter cover and depth Observed cover: 38 % Depth: 0.1 cm in	H B	N-S	Amount is slightly higher than expected however depth is on the lower end of what is expected for site
15. Annual production: Pounds or Kilograms Observed: 775 ÷ Expected 1100 = 70%	B	S-M	Production is reduced relative to that expected relative to recent weather (normal year) based on ocular estimate
16. Invasive plants	B	M-E	Cheatgrass is common
17. Vigor with an emphasis on reproductive capability of perennial plants	B	N-S	Perennial plants at the site are producing seed and have good vigor. Crown diameter is an average of 4-6" on mature bunchgrasses

Soil/Site Stability "S" *(10 indicators)*

Attribute Rating: S-M

E-T	M-E	M	S-M	N-S
			5	
			9	
			7	6
			3	5
	4	8	2	1

Rationale: Bare ground is higher than expected & soil stability has declined impacting site stability

Hydrologic Function "H" *(10 indicators)*

Attribute Rating: S-M

E-T	M-E	M	S-M	N-S
			11	
			10	
			9	5
			3	14
	4	8	2	1

Rationale: Bare ground is higher than expected and soil stability has declined; Soil compaction & degradation of A horizon may impact hydrologic function

Biotic Integrity "B" *(9 indicators)*

Attribute Rating: M

E-T	M-E	M	S-M	N-S
			15	
			13	
		12	11	17
	16	8	9	14

Rationale: Annual grasses invading site; biotic integrity & site productivity are moderately affected

W. Determine the Functional State of the Three Attributes

The IIRH protocol relies on the collective experience and knowledge of the evaluator(s) to classify each indicator and then to interpret the collective rating of the indicators into one summary rating of departure for each attribute of rangeland health. The interpretation process is the critical link between indicator observations and determining the status of each rangeland health attribute. Therefore, evaluators should complete the attribute ratings before leaving the evaluation area. Record justification for the attribute ratings at the bottom of the evaluation form (figures E-43 and E-44). Use tables E-26, E-27, and E-28 for information about the interrelationships between the indicators as they relate to each attribute.

Table E-26. Interrelationships of the indicators associated with the soil/site stability attribute rating.

Indicator	Relationship to the Soil/Site Stability Attribute Rating
1. Rills	Increased occurrence of rills is indicative of loss of soil stability and accelerated erosion by water. Rills can transport significant amounts of soil, which may be lost from or redistributed on the site.
2. Water Flow Patterns	Increased occurrence of water flow patterns indicates accelerated water erosion resulting in soil movement within (and possibly off) a site. Water flow patterns are visual evidence of interrill erosion caused by overland flow, which has been identified as the dominant sediment transport mechanism on rangelands (Tiscareño-Lopez et al. 1993).
3. Pedestals and/or Terracettes	Increased occurrence of pedestals indicates accelerated soil erosion by water or wind. Increased occurrence of terracettes is evidence of reduced soil stability resulting in accelerated erosion by water. Erosional pedestals within a site may be associated with soil surface loss and degradation where soil has eroded around numerous plant or rock pedestals.
4. Bare Ground	Increased bare ground leaves soil more vulnerable to water erosion resulting from raindrop impact, splash erosion, and soil particle disaggregation and to wind erosion resulting from saltation of soil particles. When soils lack protective cover of vegetation, biological soil crusts, and rocks, water or wind may move across the soil surface leading to accelerated soil erosion. Bare ground found in large patches may contribute to a greater amount of soil erosion than the same amount of bare ground found in many small patches.
5. Gullies	Gullies are concentrated areas of soil loss from accelerated water erosion. They are a natural feature of very few landscapes and are usually indicative of significant landscape instability. Considerable amounts of soil may be lost from sides and headcuts of gullies. The amount of loss of soil and water through a gully can be greater than from rill and inter-rill erosion, and the effects are more concentrated. Gullies can also affect physical soil properties at a site (Poesen et al. 2003).
8. Soil Surface Resistance to Erosion	Increased incidence of wind-scoured areas indicates reduced soil and site stability resulting in soil loss by wind erosion. Once wind erosion has begun, soil material below the surface layer that may have been protected by litter or soil crusts may be more susceptible to erosion. Increased incidence of depositional areas is indicative of wind erosion that may be occurring within the evaluation area or in adjacent areas. Soil is usually deposited as disaggregated particles, which may be more susceptible to subsequent wind or water erosion.
9. Soil Surface Loss and Degradation	Litter movement from the point of origin indicates that water or wind erosion may be occurring. Litter concentration has been shown to be closely correlated with inter-rill erosion (water flow patterns).

Indicator	Relationship to the Soil/Site Stability Attribute Rating
10. Effects of Plant Community Composition and Distribution on Infiltration	Soil stability is directly tied to the soil surface's resistance to water erosion. Higher soil aggregate stability means soil particles are more strongly "glued" to each other and therefore less likely to be detached by raindrop impact, overland flow, or wind. Soil surface resistance to erosion may have a spatial relationship with other indicators such as bare ground, which also influences soil/site stability. Reduced soil surface resistance to erosion is associated with reduced infiltration rate, increased runoff, and increased erosion.
11. Compaction Layer	Soil surface loss and degradation indicates past erosion. Signs of soil degradation, including structure changes and reduction of organic matter, may also increase susceptibility to future erosion. Soil surface loss and degradation is an indicator of long-term change in rangeland health and often persists after vegetation cover has recovered. The degree of soil surface loss and degradation may help determine whether a site has the capability to recover ecosystem function or whether a physical threshold has been crossed.
14. Litter Cover and Depth	Soil stability may be impacted when the compaction layer reduces infiltration to the point that surface runoff increases, which increases the potential for water erosion.

Table E-27. Interrelationships of the indicators associated with the hydrologic function attribute rating.

Indicator	Relationship to the Hydrologic Function Attribute Rating
1. Rills	Rills concentrate and facilitate rapid water movement on slopes causing water to be lost from or redistributed on the site. Increased occurrence of rills indicates reduced hydrologic function resulting from decreased infiltration.
2. Water Flow Patterns	Increase in number, length, depth, and width and connectivity of water flow patterns indicates increased water movement (overland flow) on (and possibly off) a site. Increases in size and connectivity of water flow patterns are likely associated with an increased size and number of bare ground patches. Connected water flow patterns can form a drainage network which may connect to rills or gullies. When the soil surface is stable, but infiltration is reduced, overland flow may form water flow patterns with minimal evidence of erosion; however, these features are indicative of reduced hydrologic function.
3. Pedestals and/or Terracettes	Increased occurrence of pedestals and/or terracettes is indicative of reduced hydrologic function. Pedestals caused by water erosion and terracettes are indicators of reduced infiltration resulting in greater overland water flow, sediment transport, and deposition. Pedestals may also be caused by wind erosion, but the resultant soil loss may subsequently impact hydrologic function. Soil surface loss and degradation is likely to be observed around erosional pedestals.
4. Bare Ground	When soils lack protective cover of vegetation, biological soil crusts, litter, and rocks, water is more likely to move across the soil surface prior to infiltration, affecting hydrologic function due to accelerated water loss from a site. Increases in bare ground and bare ground patch size and connectivity can also increase a site's vulnerability to erosion and promote further declines in hydrologic function.
5. Gullies	Gullies are indicative of loss of hydrologic function because they can channel large amounts of water offsite. The amount of loss of water through a gully is generally greater than through water flow patterns or rills, and the effects are more concentrated. Gullies can also affect water table levels at a site (Poesen et al. 2003).
8. Soil Surface Resistance to Erosion	Reduced soil surface resistance to erosion is associated with reduced infiltration rate, increased runoff, and increased erosion. Reductions in soil stability values indicate that soil particles are more likely to be dispersed in water. Dispersed particles may form physical crusts, which limit infiltration and thus impact hydrologic function. Soil surface resistance to erosion may have a spatial relationship with other indicators such as bare ground, which also influences hydrologic function.

Indicator	Relationship to the Hydrologic Function Attribute Rating
9. Soil Surface Loss and Degradation	Potential infiltration rates are controlled by soil texture, while the actual infiltration rate is controlled by soil surface structure and porosity. Hydrologic function is impacted when loss of soil organic matter or degradation of surface horizon structure decrease infiltration rates and water holding capacity. Soil surface loss and degradation is an indicator of long-term change in rangeland health and often persists after vegetation cover has recovered. The degree of soil surface loss and degradation may help determine whether a site has the capability to recover ecosystem function or whether a physical threshold has been crossed.
10. Effects of Plant Community Composition and Distribution on Infiltration	Plant community composition and distribution relative to infiltration reflects the unique contributions of functional/structural groups and their associated species in modifying infiltration. Plant rooting patterns, litter production and associated decomposition processes, height, basal area, and spatial distribution can all affect infiltration. Changes in vegetation composition and distribution can also affect hydrologic function by modifying evapotranspiration, soil water storage, and snow entrapment.
11. Compaction Layer	Compaction layers may negatively impact hydrologic function by restricting water infiltration through the soil profile. In some cases, the compaction layer reduces infiltration to the point that surface runoff increases.
14. Litter Cover and Depth	Litter influences hydrologic function by intercepting raindrops, obstructing overland flow, promoting infiltration, reducing evapotranspiration, and reducing erosion (Hester et al. 1997; Pierson et al. 2007; Thurow et al. 1988a, 1988b). Reductions in litter cover may be associated with increases in bare ground. Thick, contiguous litter mats may intercept moisture from small precipitation events, reducing infiltration.

Table E-28. Interrelationships of the indicators associated with the biotic integrity attribute rating.

Indicator	Relationship to the Biotic Integrity Attribute Rating
8. Soil Surface Resistance to Erosion	Biotic factors, including biological soil crust and vegetation composition and cover, litter composition and decomposition, and root growth, all influence soil aggregate stability. Reduced soil surface stability usually reflects lower soil biotic integrity because soil biological processes depend on organic matter inputs and biological decomposition processes to form and maintain stable soil aggregates. These changes, in turn, affect biotic integrity because a stable soil surface provides the environment necessary for most germination and establishment of plant species.
9. Soil Surface Loss and Degradation	Soil surface loss and degradation reflect changes in biotic integrity because of the role of soil biotic activity in creating and maintaining soil structure. These changes, in turn, affect biotic integrity because the soil surface provides the environment for most germination and establishment of plant species. It also provides the environment for soil microorganisms that enhance soil fertility, water holding capacity, and stability. In most sites, the soil at and near the surface has the highest organic matter and nutrient content. Soil organic matter generally controls the maximum rate of water infiltration into the soil and is essential for successful seedling establishment (Wood et al. 1997). Soil surface loss and degradation is an indicator of long-term change in rangeland health and often persists after vegetation cover has recovered. The degree of soil surface loss and degradation may help determine whether a site has the capability to recover ecosystem function or whether a physical threshold has been crossed. The loss or degradation of part or all of the soil surface layer or horizon is an indication of a loss in site potential (Dormaar and Willms 1998; Davenport et al. 1998).
11. Compaction Layer	Compaction layers can restrict the distribution of plant roots, especially fibrous roots, through the soil, limiting the ability of vegetation to extract nutrients and moisture from the soil profile. Compaction layers can also reduce soil water holding capacity, decreasing moisture availability for plant growth. Compaction can also reflect a reduction in biotic integrity because it indicates that the factors that cause compaction are not balanced by recovery processes, including plant root growth.

Indicator	Relationship to the Biotic Integrity Attribute Rating
12. Functional/ Structural Groups	A mixture of plant functional and structural groups appropriate to a site can promote community resistance to plant invasions and resilience to disturbances (Pokorny et al. 2005; Chambers et al. 2014). A change in the relative dominance or number of species in functional/structural groups may have a negative effect on ecosystem processes and overall biotic integrity. Both the presence of functional/structural groups and the number of species (or life forms for biological soil crusts) within these groups have a significant positive effect on ecosystem processes (Tilman et al. 1997).
13. Dead or Dying Plants or Plant Parts	Plant mortality and recruitment are two processes that drive changes in plant populations and communities. This indicator addresses mortality, while indicator 17 indirectly addresses recruitment. If plant mortality exceeds recruitment, biotic integrity of the stand may decline and undesirable plants (e.g., invasive plants) may increase.
14. Litter Cover and Depth	Litter provides a source of soil organic material and raw materials for onsite nutrient cycling (Whitford 1988, 1996), helps moderate the soil microclimate, provides food for microorganisms, and plays a role in enhancing erosion resistance by dissipating the energy of raindrops and obstructing overland flow (Hester et al. 1997; Thurow et al. 1988a, 1988b). Increased litter accumulation may influence biotic integrity by reducing sites for seed germination and may be an indicator of reduced decomposition rates. Litter accumulation may be correlated with indicator 15 (annual production).
15. Annual Production	This is the only indicator that is directly linked to the ecological process of energy flow. Solar energy is converted into chemical energy by photosynthesis. The amount of solar energy captured in primary production (e.g., energy flow) represents the total amount of energy available for utilization by animals. Reduced annual production may be linked with reduced plant vigor, reduced litter, or changes in functional/ structural groups.
16. Invasive Plants	Invasive plants impact an ecosystem's type and abundance of species, their interrelationships, and the processes by which energy and nutrients move through an ecosystem. These impacts can influence both biological organisms and physical properties of a site (Olson 1999) and may range from slight to severe depending on the species involved and their degree of dominance. Invasive species may adversely affect a site by increased water usage (e.g., salt cedar/tamarisk in riparian areas) or modifying disturbance regimes (e.g., shortened fire return intervals in annual grass-invaded sites).
17. Vigor with an Emphasis on Reproductive Capability of Perennial Plants	Plant vigor and reproductive capability are key components in ensuring that, when favorable recent weather conditions are present, recruitment can occur to balance plant mortality (indicator 13). Plant community composition and therefore resiliency are dependent on the availability of plants with the capability to reproduce and for recruitment to occur (Svejcar et al. 2014).

X. After Completing the Assessment

Managers may use the final ratings of attributes of rangeland health to identify where to focus monitoring efforts or where management opportunities may exist. Areas with a "moderate" departure rating are often ideal for implementing monitoring studies or for making management changes since they should be the most responsive to management actions. Prior to implementing management actions, it is important to review other available relevant information to understand the cause of resource problems and monitor trends in vegetation and soils condition. Additional monitoring may be useful regardless of the departure rating, dependent on future changes in uses or management of an area. More IIRH Forms can be found in the Technical Reference.

645.0515 Pasture Condition Scoring for Health Assessments

A. Two pasture assessment tools are available in NRCS and provide for "quick assessment" of current conditions and management. Both tools are qualitative and semi-quantitative if field data are needed.

(1) **Pasture Condition Scoresheet II (PCSS II)** (USDA-NRCS 2020 Guide to Pasture Condition Scoring) provides the visual evaluation of 10 indicators, which rate pasture

vegetation and soils. Each indicator or factor has five possible ratings, ranging from lowest (poorest) condition (1) to highest (best) condition (5). The indicators are tallied into an overall score (50) for the pasture unit or utilized as individual scores and compared with the other nine indicators. Indicators receiving the lowest scores can be targeted for corrective action.

(2) **Determining Indicators of Pasture Health (DIPH)** is a detailed assessment tool and includes a matrix of indicators that can be used to determine the preponderance of evidence for three separate pastureland ecosystem attributes: biotic integrity, soil/site stability, and hydrologic function. DIPH is a similar methodology to IIRH V5 (Pellant et al. 2020), although there are specific indicators that are relevant to pastureland systems in DIPH. DIPH may be used as a standardized approach similar to IIRH to conduct a more comprehensive pasture assessment of hydrologic function, soil and surface stability, and biotic integrity.

B. Pasture Condition Score. Introduction—Pasture condition scoring (PCS) is a systematic way to assess how well a pasture is being managed and resources protected. The National Pasture Condition Scoring Guide and Score Sheet provides a systematic way to check how well a pasture is managed and can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/pasture/?cid=stelprdb1045215. Forms can be found in the PCS Guide and in this subpart.

(1) A pasture rated with a high score is well-managed with productivity (plant and animal) being sustained or enhanced. By rating the key indicators common to all pastures, pasture condition can be evaluated, and the primary reasons for a low condition score can be identified. A low rating typically means the pasture has one or more challenges or resource concerns, such as poor plant growth, weedy species invasion, poor animal performance (low forage quantity and quality), visible soil loss, increased runoff, and impaired water quality in or adjacent to the pasture.

(2) The PCS should be performed several times a year during critical management periods throughout the grazing season. The revised "Pasture Condition Score Sheet" (PCSS) (see tables E-29 and E-30) should be used to rate individual pastures. Regardless of the time of year selected to do the PCS, the best time to score a pasture is just before it is grazed. The PCS should be performed.
  (i) As a benchmark condition of the pasture.
  (ii) Early in the growing season before grazing events occur.
  (iii) At peak forage supply periods.
  (iv) At low forage supply periods.
  (v) At plant stress periods such as drought or very wet conditions.
  (vi) When conservation practices (management) have been fully applied.

(3) For best results, the livestock manager and conservation planners should evaluate the pastures the same time each year to note changes in the condition of the pasture. PCS results can be useful in deciding when to move livestock or planning other management actions. It assists in identifying which improvements are most likely to improve pasture condition or livestock performance.

(4) The PCS is not a replacement for doing a forage inventory or forage production estimates. The pasture planner should consider other available data such as pasture state information in an ecological site description (ESD) or pasture and hay suitability groups.

(5) PCS involves the visual evaluation of 10 indicators, listed and described below, which rate the pasture vegetation and soils. Rating subjectivity can be reduced by incorporating quantitative measures. For example, using the step-point method for evaluation (figure E-45) can provide measured results for five of the indicators (percent desirable plants, percent legume, live plant cover, plant diversity, and plant residue). Also, by pacing to measure the livestock concentration areas and using a shovel to quickly evaluate the soil compaction and soil regenerative indicator, the user of the PCSS and the guide can have confidence in each indicator rating and the total score.

Figure E-45. The step-point method can provide data for five indicators.

(6) On the PCSS, each indicator or factor has five possible ratings, ranging from lowest (poorest) condition "1" to highest (best) condition "5." This objectively identifies the extent of any pasture challenges and helps determine the likely causes. Evaluate each indicator separately. The indicators can then be combined into an overall score for the pasture unit or utilized as individual scores and compared with the other nine indicators. Indicators receiving the lowest scores can be targeted for corrective action. The plant vigor indicator is one of the last ones rated because previous indicators in the assessment give insight into the plant health and productivity of the pasture.

C. Indicator Descriptions: Percent Desirable Plants

(1) These are the key species that provide most of the quality forage ingested by the grazing animal being fed. The percent is calculated by dry matter weight. In this indicator assessment, determine the type and amount of plants within the pasture that the livestock will readily graze that are desirable and intermediate (figure E-46).

(i) Desirable species—Desirable species are well-adapted to the site, are readily consumed, show persistence, and provide high tonnage and quality, with sufficient fertility for a significant part of the growing season. The most desirable species may be grazed first and close to the ground in poorly managed systems, and therefore may decline in prevalence. Meanwhile, other less palatable species that can avoid grazing impacts may increase. These less-desirable species can eventually displace the desirable ones since they are grazed less, if at all. This replacement is important to this indicator and should not be overlooked when the desirability score is low. Some examples of desirable species are orchardgrass, white clover, Kentucky bluegrass, and big bluestem. Refer to your State or regional desirable plant list, and ideally, by grazing livestock type (cattle, sheep, goats) for scoring this indicator. Desirable, intermediate, and undesirable species will depend upon geographic region and livestock type.

(ii) Intermediate Species—Intermediate species are adapted to the prevailing site conditions; just as desirable species are. Intermediate species are those which, while eaten, provide low production or lose quality fast, are only eaten by certain livestock species, and often have a short-lived grazing-use period. Intermediates increase as desirable species are selectively grazed out but will be the next set of species to decrease if grazing management doesn't intervene. When adequate forage allotments are presented to livestock, the utilization rate of these species will be less than that of the desirable species. Examples of intermediates are dandelions, wild plantains, barnyard grass, and hop clover.

(iii) Undesirable Species—Undesirable species are those that typically are not eaten (rejected) by most livestock, cause undesirable side effects when eaten, or have little or no forage value. They include some woody invaders, noxious weeds, toxic plants, and plants that crowd out more desirable species. A few forages are undesirable during a specific growth stage when they produce toxins. On severely overstocked sites, such as exercise lots, undesirable species will become the only surviving plants. Examples of undesirable species are nimblewill, wild garlic, horsenettle, and buttercup. Record notes in the comment section of the scoresheet for invasive species creating plant pest pressure concerns. Some woody plants such as brush species may be present in the ratings of 1, 2, or 3 on this indicator in amounts economically impacting the herbaceous desirable species and should be noted in the rating.

Figure E-46. Cattle grazing desirable species.

(2) Estimate visually the proportion (percent) of desirable species present in the entire sward by dry matter weight and score accordingly. The technique of estimating dry weight through visual assessment requires training and knowledge of plant identification. The use of the step-point method is highly recommended for this indicator (figure E-45).

D. Indicator Descriptions: Percent Legume

(1) This indicator measures the average amount (percent) of legume present in a forage stand during the growing season, expressed as dry matter weight. The percent legumes present at a given time during the growing season can vary considerably, depending upon climate (especially heat), stability, and seasonal growth cycle of the legumes being assessed, the timing and severity or laxity of grazing events, and the timing and level of agronomic inputs.

(2) Legumes are important sources of nitrogen for pastures and improve the forage quality of the pasture mix when they comprise at least 20 percent of total air-dry weight of forage. Deep-rooted legumes also provide grazing during hot, dry periods in midsummer.

(3) Pastures can sometimes be limited in nitrogen, especially ones lacking enough legumes and low in organic matter. Nitrogen excreted by animals often is not distributed well due to lack of pasture management or the location of water, mineral, or shade except in some types of grazing systems such as high-density short-duration grazing. Pastures with few or no legumes will need added nitrogen for increased forage production. Legumes growing along with grasses in pastures have been shown to improve animal intake and performance.

(4) If the proportion of legumes is too high, especially legumes with bloat potential, forage consumption can cause bloat and thus be detrimental to ruminant livestock health. Legume cells rupture easily after ingestion, causing a high fermentation rate to occur in the rumen. This causes the formation of gas bubbles in a stable foam, which can lead to the rumen distending and causing lung malfunction. When bloating legumes, such as clovers and alfalfa (see your State's plant list for additional species), are greater than 40 percent of total forage dry weight, bloat incidence in ruminants is likely without preventative steps.

(5) To perform this indicator, visually estimate the percentage of legume present in the total forage biomass (figure E-47). When conducting the visual assessment on most introduced cool-season legumes – except red clover which has a higher dry weight (90 percent) and alfalfa (100 percent) – the estimate will need to be reduced by approximately 50 percent of the visual estimate when converting to a dry matter weight basis. Most legumes have their leaves in the upper part of the plant with only stems below. Thus, the upper part of the plant appears denser visually when compared to grasses which are denser at the base of the plants. For rare cases where legume percentages are greater than 40 percent of the stand, but still are less than 40 percent bloat-type legumes, rate as a 5.

Figure E-47. Visually estimating the percentage of legumes present.

Legumes at 6% by dry weight (approximately 10% visual wet).

Legumes at 15% by dry weight (approximately 30% visual wet).

Legumes at 27% by dry weight (approximately 50% visual wet).

E. Live Plant Cover (includes dormant)

(1) The percentage of the soil surface covered by live plants is important for pasture production and soil and water protection. This indicator rates how well the plant solar panel is working. The higher the leaf area, the higher the photosynthetic activity. A dense stand (high-stem count) of live leaf area ensures, when properly grazed, high animal intake and high sunlight interception for best forage growth. Bare, open spots allow for weed encroachment, increased water runoff during intense rains, soil erosion, and lost production. Attached, standing dead plant material can reduce forage quality, photosynthesis, and new tillering depending on the amount and height (see figure E-48).

(2) Live cover assessment can be determined at any time on continuously grazed pastures but is best done closer to optimal grazing heights. On rotational pastures, ideally estimate canopy cover of the paddock the day prior to livestock entry. This will represent the best possible condition. If cover rates fair or lower at this growth stage, management changes

are recommended. It can also be used to assess post-grazing events to determine if adequate residual is left or not.

Figure E-48. How good is my solar panel?

(3) Several things can influence live plant cover, especially time of year, rest period prior to review, forage present, weather conditions, and management. Forages can be easily placed into three different stages.

(i) Stage one plants are short and immature, having high quality but low production. Stage one plants are good for being a solar panel, but they lack the surface area of stage two, which generally ends right at the early boot stage for grasses.

(ii) Stage two has the greatest live leaf surface area and normally the best forage quality.

(iii) The third stage has maturing vegetation of lower quality and dormant vegetation. Although this stage has the greatest volume of forage available, mature and dormant plants are performing less photosynthesis, and forage quality is less.

(4) The management factor in live plant cover is very important. Frequency of grazing, length of grazing period, stop-grazing height, stocking rates and density, length of rest period, and nutrient management are factors to be managed to achieve the highest production of quality forage for animal growth.

(5) There are times when letting the forage mature longer can certainly be a positive move, especially to grow deeper roots and potentially build soil organic matter. Dormant forage and stockpiled forage may not be the best collector of sunlight but should not be scored as the 5-point category, but could still score moderately well on the PCS scoresheet if everything else is met.

(6) Accordingly, forage stands with dead or dying intact material should be rated lower. This includes attached standing dead plant material. This material is not collecting sunlight, and it is not desirable for the livestock, although some fiber benefits occur early in the season. Too much standing dead material may cause the forage to be rejected by the grazing animal or lead to other forages being selectively grazed. Note that when forage is dormant, consider stockpile for future use.

(7) Visually estimate percent live cover of all species. Assign a value based on live green leaf canopy. If the estimate is inconclusive, or difficult to complete because of the complexity of species or stage of growth, then use the step-point method to estimate; or use a camera-based, accurate green canopy cover measurement tool.

F. Plant Diversity

(1) This indicator is done by dry matter weight. Forage production varies throughout the grazing season because of changing weather, growing degree days, management, and insect or disease pressures. Increasing diversity can help moderate negative changes. Having multiple dominant desirable forage species in a pasture offers some "insurance," and it is more likely that something can be productive under a wide range of conditions. Warm season grasses, for example, can provide quality forage during hot, dry summer

periods for areas where adapted, when most cool-season forage tend to go dormant. Low species diversity makes pastures more vulnerable to stress and to changing conditions (see figure E-49).

(2) The plant diversity score describes the number and abundance of well-represented forage plants and functional groups. For the PCS scoresheet rating, desirable forage species must comprise more than 50 percent of the total biomass to score above a 1. Any time undesirable species outnumber desirable plant species, the score will be 1. Refer to the State or regional desirable plant list and ideally by grazing livestock type (species).

Figure E-49. Warm-season grasses are a functional group that when present in the system can ease summer slump periods.

(3) The PCSS considers a dominant species to be one that makes up at least 15 percent of the pasture biomass by dry weight. Dominant species contribute substantially to the total forage biomass, and having several similar dominant desirable species helps to spread the production and lower the risk.

(4) A functional group includes plant species that have similar management requirements, biological contributions, and attributes. For most of the United States, the four basic functional groups for improved pastures are cool-season grasses, warm season grasses, legumes, other grazable non-leguminous forbs (e.g., brassicas, forage chicory, dandelion) or a functional group designated by the State. A functional group is counted even if it has non-dominant species, if the group collectively makes up 15 percent of the pasture biomass.

(5) Plants from different functional groups are most compatible when they can be successfully managed together. Mixed species pastures with at least two functional groups and three or more well-represented forage species are generally the most productive. Higher total diversity within a functional group does not ensure higher productivity and may cause animals to avoid some species and graze others heavily, as species differences in palatability and maturity are more likely. The greatest benefit for the grazing system is often achieved by the addition of another functional group.

(6) Adding legumes to the stand increases protein and energy, improves forage quality, boosts production, fixes nitrogen for the grasses in the stand, are agronomically sound, environmentally friendly, and economically advantageous. The addition of forbs can provide plants with deeper roots that can bring up nutrients from deeper in the soil profile, provide some additional drought tolerance to the pasture, and often provide highly preferred species that livestock desire.

(7) Some climates may have other functional groups to assess to accomplish the desired outcomes of this indicator.

(8) The PCS scoresheet rating for diversity balances the number of dominant desirable species within a functional group and the number of functional groups to provide a score that indicates general forage productivity and manageability.

G. Plant Residue and Litter as Soil Cover

(1) Soil cover is important to slow evaporation, maintain and stabilize ideal soil temperatures, be a carbon and food source for soil life, deter erosion, and to help with water infiltration (Figure E-50). Residue is dead plant material in varying states of decay.

Figure E-50. Moving the cover to examine the surface for residue.

(2) Decomposing surface residue is detached plant material that typically creates a light duff layer directly on the soil surface. It is highly subject to microbial activity and is in constant flux. Litter is generally the uppermost layer of detached residue on the soil surface including freshly fallen or slightly decomposed vegetative material. This can include flattened plant material from a recent grazing event with high stock densities that may still be attached. Litter is slightly more stable for a longer period depending on the presence and amount of biological activity.

(3) In a well-managed system, some plant residue and litter should always be present. Extremely active biological systems, such as an intensely grazed dairy or beef finishing operations, where vegetation is consistently grazed in the vegetative stage, often lack enough residue and litter during much of the season. This can be resolved if needed by increasing the rest period and thus allows more trampling of mature forages onto the soil surface.

(4) Excessively high amounts of residue, especially litter, can interfere and slow down new tiller growth, and tie up nitrogen. These systems often lack enough biological activity. This can be resolved if needed by shortening the rest period, adding more diversity, especially legumes, and increasing stock density.

(5) Grazing events, grazing systems, soil biology and life, weather, and management are constantly changing and often quite fluid. The percentage of ideal cover is not exact but should be in most cases a minimum of 60 percent with good soil biological activity. The higher the requirements of microbial life, the higher amount of residue and litter is needed to support it.

(6) First assess the amount of bare soil. Cover is easily assessed during the step-point method by gently moving the aboveground plant cover to one side with your hand or foot if needed to see if soil cover is provided between plants and under the canopy (figures E-50 and E-51). The soil should be covered by either live plants and tillers or residue. Visually estimate the percent cover between live plants in the stand. The step-point method is a good quantitative way to do this.

H. Grazing Utilization and Severity

(1) The proper amount and frequency of grazing are critical in maintaining productive pastures. Close and frequent grazing causes loss of vigor, reduces density of desired species and yield, can promote erosion, and have impact on bite size and intake. Differences in species, plant maturity, stocking rate, location and distance to water, shade, and mineral availability may cause uneven grazing to occur.

Figure E-51. Estimate the amount of bare soil. When bare soil is easily seen it is rated a “1.” This should not be common.

(2) Grazing utilization and severity are directly related to uniformity of grazing by livestock, except when continually overgrazing. Though an overgrazed pasture may look uniform, the impact of this severity places such pastures in the lowest rating. Uniform grazing results in almost all desirable and intermediate species being grazed to a targeted residual or “stop-grazing” height or slightly higher. Uniform grazing, without overgrazing, usually only exists when proper grazing management techniques are employed and especially where smaller allocations are made.

(3) Nonuniformity is spotty or patterned grazing that appears uneven throughout a pasture, with some plants or parts of paddocks grazed heavily and others grazed lightly or not at all. Individual forage species are being selected by the livestock based on their palatability, nutritional value, amounts of other forages available, and location in the pasture.

(4) Selectivity is also affected by differences in stage of maturity among species, amount of forage offered to livestock, their length of stay in the paddock, and the livestock stocking density. In most instances, livestock will readily select younger plants over more mature ones. Livestock will also usually refuse to graze where manure and urine have recently been deposited. This leads to a continuing cycle of uneven grazing patterns and reduced efficiency.

(5) Zone grazing occurs when one end of the pasture is heavily grazed, and the other end is lightly grazed or ungrazed. It often occurs on pastures with long walking distances from one end to the other, especially when shady areas, windbreaks, hay, creep, or mineral feeding and watering sites are a long distance from some parts of the field. Pastures with abrupt topography changes can also cause zone grazing.

(6) For this indicator solely visually assess. When zone grazing is occurring, along with some uneven grazing throughout, rate it a 3. Rate the pasture a 4 if the pasture is uniformly grazed to target residual heights but there is some zone grazing occurring.

(7) While understocking will lead to more selectivity and the potential for uneven grazing, continual overstocking can result in pastures being uniformly grazed (mowed lawn appearance) but to heights that are too low to maintain all the desirable species. These uniformly overgrazed pastures should be rated low on the score sheet.

I. Livestock Concentration Areas

(1) Concentration areas are places in pastures where livestock return frequently and linger near feeding areas, gates, water, mineral or salt, or shade. These areas may have reduced vegetative cover, increased bare ground, and have concentrated animal waste. Livestock trails to and from these preferred areas can create pathways that may increase erosion and become conduits for sediment, nutrients, and pathogens to nearby water bodies.

(2) This indicator addresses the potential impacts on water quality by assessing the size of the disturbed areas and the connectivity to adjacent water bodies through trailing and

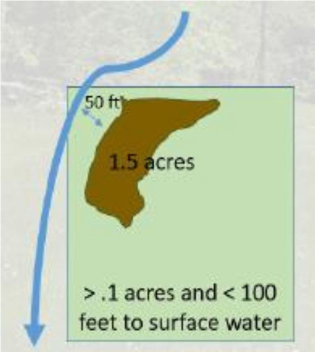
location. Livestock concentration areas near water sources or with direct conveyance to surface water can create resource concerns. Additionally, these areas on pervious soils over shallow ground water can also create water quality problems from introduced contaminants when close to adjacent waterbodies.

(3) For estimates and comparisons, one square acre is 208 feet by 208 feet, and 10 percent of that or 0.1 of an acre is 66 feet by 66 feet. When assessing pastures that are less than one acre, use 10 percent of grazing unit area as an alternative to 0.1 acres, to determine score. See examples in figure E-52.

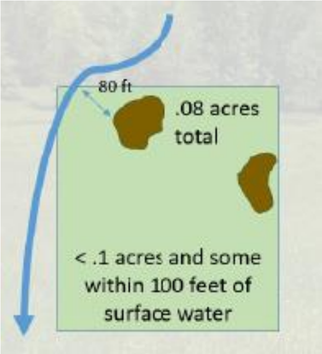
(4) Pace unknown distances and assess the amount of concentration area for this indicator.

Figure E-52. Examples of point ratings.

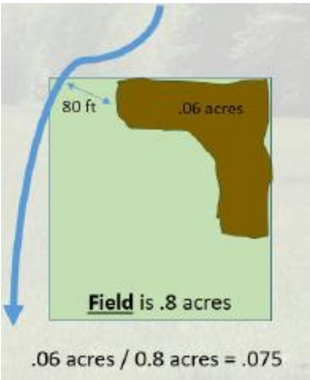
Example of a 1-point rating. Concentration areas are within 100 feet of water body and more than .1 acre in size.



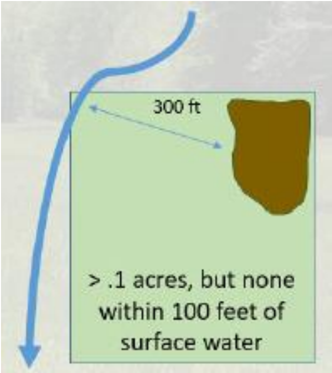
Example of a 2-point rating. Concentration areas are within 100 feet of water body and less than .1 acre in size.



Example of a 2-point rating where the field is less than 1 acre. It receives a rating of a 2.



Example of a 3-point rating. Concentration areas are greater than 100 feet of water body and more than .1 acre in size.



Example of a 4-point rating. Concentration areas are greater than 100 feet of water body and less than .1 acre in size.

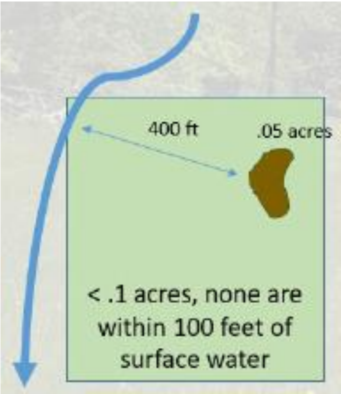


Figure E-53. Compaction is one of the most detrimental resource concerns.

J. Soil Compaction and Soil Regenerative Features

(1) Soil compaction is the diminished pore space between soil aggregates that hold air and water (figure E-53). Compaction reduces a pasture's ability to infiltrate water by minimizing pore space and increasing bulk density of the soils, negatively affecting hydrologic function, nutrient cycling, and the energy flow throughout the pasture ecosystem. Compaction affects the ability of plant roots to access water and nutrients. Increased runoff resulting from soil compaction creates the potential to transport contaminants such as sediment, nutrients, and pathogens to surface water, degrading water quality.

(2) Roots can be diminished by not only compacted layers, but also from overgrazing and haying. Shallow or sparse roots that do not move deeper in the soil profile, especially when there are no limiting layers, are good indicators these possible management activities are occurring.

(3) Soil regenerative features focus on the condition of plant roots and the abundance of soil life, both of which can improve important soil attributes like structure and organic matter. Soils with roots growing deep and downward have the potential to feed a large and diverse population of soil life. See figure E-54. These soil organisms can improve water-holding capacity, nutrient cycling, plant productivity, plant health and nutrient density.

(4) To evaluate, use a shovel to dig a hole in the pasture, large enough to see the indicator features.

(5) If a comparison is needed or desired, locate one hole in a protected area, such as a fence line where grazing can occur, but soil is not adversely affected by hoof action, and the other within the pasture away from the protected area and on the same soil type to compare differences in soil features. Soil features to observe and or to compare in the soil of each hole are:

Figure E-54. Healthy pasture soils should have good aggregates, vertical roots, and soil life.

(i) Ease of getting the shovel into the soil.
(ii) Soil structure – look for platiness and aggregates in the top twelve inches.
(iii) Rooting depth.
(iv) Root morphology and direction of growth, roots should be growing downward through the soil profile.
(v) Color-contrasting color changes in the soil with darker soil in the more biotically active upper layer.
(vi) Worms, tunnels, or other biotic presence and activity.

(6) When rating this indicator, begin with the primary sub indicators (compaction layer, then root characteristics) and use these two sub indicators as the main scoring factors, with the most adverse factor of the two sub indicators determining the score. Soil color and soil life sub indicators are secondary indicators and can be considered where applicable but used primarily for discussion with the manager and planning for improving soil health. When rating the compacted or platy layer, consider if the layer is within a zone where primary forage roots would typically extend to (not potentially).

K. Plant Vigor

(1) In simplest terms, plant vigor refers to the health of a plant. Another interpretation is the plant's robustness in comparison to others of the same species, relative to the size and age of the plant within the environment and weather where it is growing. A loss of plant vigor can cause a loss in desirable species and plant cover. Primary things to consider when rating plant vigor are color and rate of regrowth (recovery) following a grazing event, but also taking into consideration the grazing height of plants, size (density) of plants, and productivity. This indicator is purposely placed as one of the last indicators to score doing this PCS. The scorer can then use the earlier indicator scores information to better score plant vigor.

(2) Color is a major indicator of plant vigor. See figure E-55. Yellowing plants indicate drought, insect damage, or prolonged heavy usage (continuous grazing). Pale green grass plants can be indicative of low fertility or cool, wet, and poor soils and growing conditions. Fields where nitrogen-starved grasses exist will be obvious and have dark green spots under dung or urine patches with the rest of the pasture area or unit being pale in comparison. Frost-damaged plants will turn yellow or to a blue-gray cast depending on the severity of the cold damage.

(3) Leaf color can also change due to age. Older, lower leaves of plants turn yellow as they become more shaded, and nutrients are translocated from them to the younger leaves higher in the canopy. This type of progressive vigor decline on a single plant is critical to the producer timing the rotation of livestock from one pasture to the next. In general, color is a visual indicator of either mineral deficiencies or, occasionally, of over-fertilization.

Figure E-55. Recovery and forage color are good indicators of plant health.

(4) Over-fertilization is not separated out in this indicator but should be annotated in the notes when observed and rated a 1 if an issue. Excess applications of nitrogen can cause some major nitrate toxicity issues. A lush, lodged, very dark green-to-bluish-green grass can be indicative of over-fertilization especially by nitrogen. It can also occur where livestock have concentrated on a pasture such as at a permanent water trough or feed bunk. These spot areas are often ungrazed by livestock due to taste, smell, or post-ingestive feedback caused by low level nitrate poisoning indicators of plant health.

(5) Growth rate is a key trait of plant vigor, which is greatly affected by the management of the plant community. Plant recovery should be evaluated based on average growth rates for the plant community involved at the time of the season being rated. This is easier to evaluate on rotational pastures, because the last time an individual plant was grazed is likely to be known.

(6) Too often, the recovery period for the plants is too short. Ideally, when growth is slow, longer recovery is needed, and when growth is fast, shorter recovery is needed. Recovery is influenced by the time of year, the type of plants, and even manager goals, such as if it is planned to be used for stockpiled forage or not. It is highly influenced by how severely the pasture was used the last time it was grazed. The more severe the grazing (below recommended stop-grazing heights), the longer the recovery required. Most severe grazing occurs when a pasture is overstocked. Pasture plants when continuously grazed have little or no recovery. In contrast are pastures that are rarely grazed below stop-grazing heights and management is initiated at prime plant recovery and intake amounts. Make notes on any disease or insect stresses (pressure) on the plants. Using color as a plant vigor indicator may be difficult during a plant’s dormant season. Under such conditions, use the ratings of all indicators along with overall plant health and remaining leaf area to assist in a vigor score.

L. Erosion. Soil erosion involves the detachment, transport and redistribution of soil particles by forces of water, wind, or gravity. The types of erosion evaluated for pasture condition score are below.

(1) Sheet and Rill—Soil loss caused by water drop impact, drip splash from water dropping off plant leaves and stems onto bare soil, and a thin sheet of runoff water flowing across the soil surface. Sheet and rill erosion increase as cover decreases. Evidence of sheet erosion appears as small debris dams of plant residue that build up at obstructions or span between obstructions. Some soil aggregates or worm castings may also be washed into the debris’ dams. Rills are small, incised channels in the soil that run parallel to each other downslope. When rills appear, serious soil loss is occurring. This erosion type includes most irrigation-induced erosion.

(2) Streambank, Shoreline—When in pastures, channels or shorelines can have heightened erosion problems and loss of vegetative cover that typically grows on them. These accelerated damages can result from grazing animal traffic in or on them. Open channels may be intermittent or perennial flowing streams or dry washes. The factors that affect the extent of disturbance livestock cause to streambanks, shorelines, and their associated vegetation include:

(i) Livestock traffic patterns.

(ii) Frequency, duration, and intensity of use.

(iii) Attractiveness of these channels or banks as sunning, dusting, travel lanes, watering, grazing, or rubbing areas.

(iv) Channel shape and steepness of banks.

(v) Water flow characteristics (frequency, depth, sediment load, velocity, and turbulence).

(vi) Only consider erosion caused or influenced by livestock use.

(3) Wind—Wind erosion is the transport and deposition of soil from one location to another, occurring when heavier, windblown soil particles abrade, exposing soil and causing particles to become airborne. Deposition of the heavier soil particles occurs downwind of obstructions, such as fence lines, buildings, and vegetation. Often vegetative debris is

windrowed against obstructions and in extreme cases soil will abrade and smother vegetation.

(4) Gullies

(i) There are at least two type of erosion on this field. Circle both on the PCSS. The lowest rating score which accounts for the worst erosion present should be given.

Figure E-56. Gullies in a field.

(ii) Gullies are an advanced stage of water erosion, developing in situations where rill erosion has not been addressed. See figure E-56. Concentrated, fast-moving water can cause gully expansion through both mass soil caving along sides and head-cutting upslope, creating deep channels in the ground. Both ephemeral and advanced classic gullies should be addressed under this sub indicator. Circle or mark all erosion types found within the planning unit. Rate the indicator with the score for overall erosion as the lowest scoring point value of the erosion types.

Table E-29. Pasture Condition Score Sheet.

Operator:			**Date:**	
Evaluator:			**Pasture ID:**	
Soil(s), ESD(s) and or FSG(s):			**Livestock type:**	
Current Season's Precipitation (check one)	**Above Normal**	**Normal**	**Below Normal**	
Seasonal Temperature Trend (check one)	**Above Normal**	**Normal**	**Below Normal**	
Evaluate the site and rate each indicator based upon your observations. Scores for each indicator may range from 1 to 5. Sum the indicator scores to determine overall pasture condition score.				**Score**

Indicator	**1 Point**	**2 Points**	**3 Points**	**4 Points**	**5 Points**	**Points**
Percent Desirable Plants* (Dry Weight; for Livestock Type)	Desirable species <20% of stand.	Desirable species 20 – 40% of stand.	Desirable species 41 – 60% of stand.	Desirable species 61 – 80% of stand.	Desirable species exceed 80% of stand.	
Percent Legume by Dry Weight	<5% OR >50% bloating legumes.	5–10% legumes OR >40% bloating legume.	11–20% legumes.	21–30% legumes.	31–40% legumes. No grass loss; grass may be increasing.	
Live (includes dormant) Plant Cover	Less than 40% is live leaf canopy. Remaining is either dead standing material, or bare ground.	40–65% is live leaf canopy. Remaining is either dead standing material, or bare ground.	66–80% live leaf canopy. Remaining is either dead standing material, or bare ground.	81–95% live leaf canopy. Remaining is either dead standing material, or bare ground.	More than 95% live (non–dormant) leaf canopy. Remaining is either dead standing material, or bare ground.	
Plant Diversity by Dry Weight (see * footnote at end of table)	Diversity: Very low	Diversity: Low	Diversity: Moderate	Diversity: High	Diversity: Very high	
	<50% desirable species	2 dominant desirable species in 1 functional group	3 dominant desirable species in 1 functional group	4 dominant desirable species in 2 functional groups	4 dominant desirable species in 3 functional groups	
	OR	OR	OR	OR	OR	
	1 dominant desirable species in 1 functional group	2 functional groups each represented by minor species totaling ≥15%	2–3 dominant desirable species in 2 functional groups	3 dominant desirable species in 3 functional groups	4 dominant desirable species in 2 functional groups AND 1 additional functional	
	OR		OR	OR		

Indicator	1 Point	2 Points	3 Points	4 Points	5 Points	Points
	No dominant desirable species and all minor species in each functional group totaling <15%		3 functional groups each represented by minor species totaling ≥15%	3 dominant desirable species in 2 functional groups AND 1 additional functional group represented by minor species totaling ≥15%	group represented by minor species totaling ≥15%	
Plant Residue and Litter as Soil Cover (pull back canopy)	Bare soil is very easily seen;	Openings of bare soil can be seen fairly easily;	Small openings of bare soil can be seen, but minimal;	No bare soil is easily seen;	No bare soil is seen;	
	There is <20% cover on the soil surface or it is excessive, and slow to break down.	Soil cover is 21–40%.	Soil cover is 41–60%.	Soil cover is 61–80%.	Soil cover is >80% with good biological activity and decomposition of older residue.	
Grazing Utilization and Severity	Pasture is overgrazed throughout.	Pasture consists primarily of overgrazed and/or refused areas (former dung areas, older plants, undesired plants).	Pastures show uneven grazing throughout with heavier grazing near water or feeding areas, or distinct zone grazing.	Pasture grazed evenly throughout with minimal overgrazing with some under grazed small areas and heavier use near water sources.	Pasture grazed evenly throughout with no overgrazing.	
Livestock Concentration Areas (if field <1 acre, see ** footnote at end of table)	Livestock concentration areas are within 100 feet of, or are a direct conveyance to surface water, and cover more than 0.1 acre, including trails.	Livestock concentration areas are within 100 feet of, or are a direct conveyance to surface water, and cover less than 0.1 acre, including trails.	Livestock concentration areas are farther than 100 feet from and are not a direct conveyance to surface water, and cover more than 0.1 acre, including trails.	Livestock concentration areas are farther than 100 feet and are not a direct conveyance to surface water, and cover less than 0.1 acre, including trails.	Livestock concentration areas, including trails, not present.	
Soil Compaction and Soil Regenerative Features (see *** footnote at end of table)	Compaction: Dense or thick platy layer very distinct;	Compaction: Dense or moderate platy layer noticeable;	Compaction: Thin dense or platy layer still present;	Compaction: Minor dense or platy layer; good aggregates common (crumbly soil);	Compaction: No dense or platy layers; crumbly soil throughout;	

Indicator	1 Point	2 Points	3 Points	4 Points	5 Points	Points
Soil Compaction and Soil Regenerative Features (see *** footnote at end of table) Plant Vigor	Roots: Dominantly horizontal; most shallow/sparse;	Roots: Numerous horizontal; moderate amount shallow/sparse;	Roots: Some horizontal with increasing downward;	Roots: Few horizontal, more downward through the soil profile;	Roots: Abundant growth primarily downward through the soil profile;	w
	Color: Surface horizon same as subsoil;		Color: Surface horizon moderately darker than subsoil;		Color: Surface horizon dramatically darker than subsoil;	
	Soil Life: Few or no signs.	Soil Life: Signs scattered in surface layer.	Soil Life: Signs scattered throughout.	Soil Life: Signs numerous throughout.	Soil Life: Signs abundant throughout.	
	No plant recovery after grazing/harvest. Pale, yellow or brown, or severe stunting of desirable forage.	Some recovery. Yellowish green forage, or moderately or slight stunting of desirable forage.	Adequate recovery of desirable forage. Yellowish and dark green areas due to manure and urine patches.	Good recovery of desirable forage. Light green and dark green forage present.	Rapid recovery of desirable forage. All healthy green forage.	
Erosion (circle all that apply; the overall indicator score will be the lowest rating indicated)	Sheet and Rill: Plant density is insufficient to stop runoff, with poor infiltration. Erosion easily visible throughout pasture;	Sheet and Rill: Plant density slows runoff. Erosion present and easily seen on steeper terrain;	Sheet and Rill: Plant density good and runoff moderate. If present, erosion concentrated on heavily used areas;	Sheet and Rill: Plant density high, runoff low, good infiltration. May have evidence of past erosion if present;	Sheet and Rill: Plant density high, no runoff, good infiltration. No evidence of present or past erosion;	
Erosion (circle all that apply; the overall indicator score will be the lowest rating indicated)	Wind: Severe scoured areas and deposition throughout;	Wind: Scoured areas common, deposition effecting plants;	Wind: Occasional scoured areas, litter windrolled;	Wind: Minimal soil exposed, some detatched vegetation windrolled, minor plant damage;	Wind: No exposed soil;	
	Streambank and/or Shoreline: Banks bare, major sloughing, no bank vegetation;	Streambank and/or Shoreline: More than half the bank vegetation trampled; sloughing.	Streambank and/or Shoreline: Less than half the bank vegetation trampled; eroding at crossing/entrances.	Streambank and/or Shoreline: Eroding at crossings, entrances; all the bank vegetation is intact and banks are stable.	Streambank and/or Shoreline: Vegetation intact and stable, hardened crossings and alternative water sources used;	

Indicator	1 Point	2 Points	3 Points	4 Points	5 Points	Points
	Gully: Very large mass movement, caving sides.	Gully: Advancing upslope, increasing fingering extensions.	Gully: Not all active but extensions present.	Gully: Stable with vegetative cover.	Gully: None, drainage ways vegetative.	
					Total points	

* Use NRCS plant list for livestock species. Functional groups are as appropriate for your state (cool-season grasses, legumes, warm-season grasses, non-leguminous forbs). Any time there are more undesirables than desirables, it will be 1 point. Desirable species must total more than 50 percent of the total biomass. Dominant species are ≥15 percent. Functional groups must be ≥15 percent of stand to be counted.

** If field size is less than 1 ac. Use 10 percent of field size in place of 0.1 acre.

*** Use a shovel. Root and Compaction sub indicators are primary and should be considered first. Soil color and soil life are secondary sub indicators which can be considered where applicable

Table E-30. Overall Pasture Condition Score.

Overall Pasture Condition Score	Individual Indicator Score	Management Change Suggested
45 to 50	5	No changes in management needed at this time.
35 to 45	4	Minor changes would enhance, do most beneficial first.
25 to 35	3	Improvements would benefit productivity and/or environment.
15 to 25	2	Needs immediate management changes, high return likely.
10 to 15	1	Major effort required in time, management, and expense.

Overall Pasture Condition Score = ☐

645.0516 Determining Indicators of Pasture Health (DIPH): Technical Introduction

A. Introduction

Determining Indicators of Pasture Health (DIPH) is a detailed assessment tool and includes a matrix of indicators that can be used to determine the preponderance of evidence for three separate pastureland ecosystem attributes: biotic integrity, soil/site stability, and hydrologic function. DIPH is a similar methodology to IIRH V5 (Pellant et al. 2020), although there are specific indicators that are relevant to pastureland systems in DIPH. DIPH may be used as a standardized approach similar to IIRH to conduct a more comprehensive pasture assessment of hydrologic function, soil and surface stability, and biotic integrity.

B. Three health attributes are evaluated in both IIRH and DIPH and are designed to provide information about how well ecological processes – such as the water cycle, energy flow, and nutrient cycling – are functioning at a site. The three ecosystem attributes (soil and site stability, hydrologic function, and biotic integrity) are determined from specific indicators (some indicators are used for one or more of the three assessments) (table E-31). The methodology, DIPH, is more centric to the dynamics of the ecological site (ES). Various soil and plant variables may be different across the continuum of pasturelands in the U.S. Some pasture environments are capable of sustaining high species diversity and many different adapted forage species (including legumes) and soil biota such as earthworms, etc., while some pasture systems are limited in these respects by various environmental constraints. For example, a wide variety of cool season grasses and legumes may be grown and maintained successfully in humid cold temperate climates in New England, whereas a semiarid subtropical climate in Louisiana may only support a maximum diversity of two warm season pasture grasses (bermudagrass and Bahia grass), with no inherent introduced long-term sustainability of non-toxic legumes (which act as annuals). Therefore, rating these indicators should be evaluated with the ecological constraints associated with the ecological site.

C. Ecological site descriptions (if available) can provide valuable information about environmental parameters and reference conditions for specific indicators related to adaptability of certain forage species, legumes, invasive plants, as well as hydrology and erosion properties such as drainage, flooding, water flow paths, and propensity for rills, gullies, and erosion. Although ESD can be valuable documents that provide reference information related to climate-soils-plants-hydrology-management, both IIRH (section 7.1.4; Pellant et al. 2020) and DIPH can be used when ecological site information is not available.

D. The premise associated with IIRH and DIPH is that many unique site-specific effects and non-linear environmental relationships exist in grazingland ecosystems, and these methodologies provide a means of detecting changes in ecological attributes relative to a site's ecological potential. Toledo et al. (2016) compared the concepts of PCSS and IIRH and stated that there is a "need for an improved grazingland assessment tool that merges the relevant elements of both rangeland and pastureland assessment methods, while taking into account the differing ecosystem attributes and management objectives of the grazing lands where these methods are usually applied." Standardized grazingland assessment protocols based on ecological and land management principles would also ultimately improve national-level assessments (NRI) and would provide a valuable and efficient tool for assessing and managing grazing lands.

E. Assessment definitions:

(1) Soil/Site Stability—The capacity of an area to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water.
(2) Hydrologic Function—The capacity of an area to capture, store, and safely release water from rainfall, run-on, and snowmelt (where relevant), to resist a reduction in this capacity, and to recover this capacity when a reduction does occur.

(3) Biotic Integrity—The capacity of the biotic community to support ecological processes within the normal range of variability expected for the site, to resist a loss in the capacity to support these processes, and to recover this capacity when losses do occur. The biotic community includes plants, animals, and microorganisms occurring both above and below the ground.

F. Table E-31 shows the commonality between IIRH and DIPH. There are common and unique indicators for DIPH as they represent specific characteristics of pasture environments. Seven livestock management factors are in DIPH to focus on issues that are specific to livestock management. Certain indicators may not have issues, such as rill, wind, gully, and streambank erosion, and percent legumes. Therefore, the field assessment process can proceed quickly. Unlike a number score used in PCSS II, the "preponderance of evidence" (Pellant et al. 2005, 2020) is used to determine the functional status of the three rangeland health attributes in DIPH. The preponderance of evidence approach is used to select the appropriate departure category for each attribute and the overall decision for each of the three attributes. This assessment is based, in part, on where the majority of the indicators for each attribute fall under the five categories (none to slight, slight to moderate, moderate, moderate to extreme, and extreme to total).

Table E-31. Proposed Matrix for Determining Indicators of Pasture Health (DIPH). Comparison of indicators in rangeland health matrix and proposed matrix for Determining Indicators of Pasture Health. LMQF=Livestock Management Quality Factor.

Interpreting Indicators of Rangeland Health V 5	Attribute	Determining Indicators of Pastureland Health	Attribute
1. Rills	SSS, HF	Erosion (sheet and rill)	SSS, HF
2. Water-flow patterns	SSS, HF	Water-flow patterns	SSS, HF
3. Pedestals and/or terracettes	SSS, HF	Pedestals and/or terracettes	
4. Bare ground	SSS, HF	Bare ground %	SSS, HF
5. Gullies	SSS, HF	Erosion (gullies)	SSS, HF
6. Wind-scoured, blowouts, and/or deposition areas	SSS	Erosion (wind)	SSS
		Erosion (shoreline) if present	SSS, HF
7. Litter movement	SSS	Litter movement	SSS, HF
8. Soil surface resistance to erosion	SSS, HF, BI		
		Live plant foliar cover (hydrologic and erosion benefits)	SSS, HF
9. Soil surface loss and degradation	SSS, HF, BI	Soil surface loss and degradation	SSS, HF, BI
10. Effects of plant community composition and distribution on infiltration and runoff	HF	Effects of plant community composition and distribution on Infiltration and runoff	HF
11. Compaction layer	SSS, HF, BI	Compaction layer	SSS, HF, BI
12. Functional/structural groups	BI		
		Forage plant diversity	BI, LMQF
		Percent desirable forage plants (for identified livestock class)	LMQF
13. Dead or dying plants or plant parts	BI	Dead or dying plants or plant parts	BI
14. Litter cover and depth	HF, BI	Litter cover and depth	HF, BI
15. Annual production	BI	Annual production	BI, LMQF
16. Invasive plants	BI	Invasive plants	BI

Interpreting Indicators of Rangeland Health V 5	Attribute	Determining Indicators of Pastureland Health	Attribute
17. Vigor with an emphasis on reproductive capability of perennial plants	BI	Plant vigor with an emphasis on reproductive capability of perennial Plants	BI
		Percent non-toxic legumes (based on adaptability with ecol. site and/or what is expected stand and longevity for the site)	BI, LMQF
		Uniformity of use	HF, BI, LMQF
		Grazing and utilization	BI, SSS, HF, LMQF

G. If an ES does not exist, or the pasture state narrative is not complete, the DIPH matrix can be used as a "stand-alone" document to determine indicator status. If repeated DIPH assessments are made on a specific ES, data can be collected to help develop the narrative for pasture groups and the ESD converted pasture state. In table E-31, several indicators can be evaluated with ecological aspects inherent with the ecological site. For example:

(1) Annual production capacity
(2) percent non-toxic legumes (based on adaptability associated with ES or what is the expected stand for the site)
(3) Forage plant adaptability and projected diversity
(4) Litter amount and plant residue
(5) Erosion (sheet and rill)
(6) Erosion (gullies)
(7) Erosion (wind)
(8) Water flow patterns
(9) percent bare ground
(10) Soil health attributes
(11) Dynamics of weeds and invasive plants

H. Determining Indicators of Pastureland Health Matrix (DIPH)

(1) Complete evaluation sheet (table E-32) and proceed to the DIPH evaluation matrix (table E-33). This table includes five generic descriptors for each indicator, which reflect the range of departure from expected conditions for the site: none to slight, slight to moderate, moderate, moderate to extreme, and extreme to total. Since many ESs have not developed pasture state narratives to establish reference conditions for pasture stands, the DIPH evaluation matrix is used with generic descriptors.
(2) DIPH is conducted in the field, and each indicator is evaluated based on the scale in the matrix (table E-33). Determination of preponderance of evidence would follow the same approach as used in Pellant et al. (2005, 2020). The 22 indicators are rated individually to determine the attribute ratings. The five departure categories (table E-33) reflect the collective degree of departure of the appropriate indicators as described in the DIPH matrix. Degree of departure for each attribute is then rated from the preponderance of evidence of the appropriate indicators using the worksheet for DIPH (table E-34). This assessment provides an initial rating for the three attributes (soil and site stability, hydrologic function, and biotic integrity), which may be used with other applicable quantitative monitoring and inventory data (if available). Notes can be included to support observations in the field to assist in determining ratings for soil and site stability, hydrologic function, biotic integrity, and livestock management quality factor. Table E-35 is an example of indicator ratings with evaluation and notes.

I. Review for Preponderance of Evidence (tables E-36 and E-37, example of field notes)

(1) Soil and Site Stability

Slight-to-Moderate with two Moderate Concerns. The critical indicators related to erosion are rated slight-to-moderate; however, bare ground was rated moderate-moderately higher than expected with patches sporadically connected. Many of the problems related to soil stability can be largely corrected with prescribed grazing and improvement of biotic integrity factors with pest management practices of weedy and woody species invasion.

(2) Hydrologic Function

(i) Some of the key indicators such as bare ground, annual production, litter cover and depth, invasive plants, and grazing and utilization were rated moderate. The first three indicators above are important in proving protective cover to the soil surface, which is directly correlated with rainfall interception and reducing raindrop soil splash and sheet and rill erosion. Invasive plants such as shrubs can result in loss of understory cover, but this is not a problem on this site as invasive plants were largely Canada thistles. The main concern with bare ground, annual production, and litter cover and depth at moderate rating is that evaporation rates are higher than expected, and the result is depleted water-holding capacity which will affect plant growth and production. Overall water balance is now compromised but can be remedied with the planned rest schedule.

(ii) Uniformity of use was rated mod. To extreme (little-grazed or ungrazed patches where forage species are rejected cover 26–50 percent of the area). Patches are occasionally connected, and grazing and utilization were rated moderate (pasture utilization 60–65 percent; current utilization is temporary and not representative of continual management). The pasture will be rested from July 15 to end of August, so there is no real concern about over-grazing at the present time.

(3) Biotic Integrity

(i) Biotic integrity indicators ranged from slight to moderate to moderate-to-extreme. The overall attribute rating is moderate. Where indicators are rated moderate or worse, there is cause for concern. Since plant community shifts affect the quality of forage availability, species changes also affect soil surface stability and hydrology; e.g., shifts from bunchgrass to sodgrass result in lower infiltration capacity and the prevalence of higher runoff. Improvement is needed regarding the indicators rated as moderate for BI.

(ii) Annual productivity was moderate as was litter cover and depth. Uniformity of use was rated moderate-to-extreme (little-grazed or ungrazed patches where forage species are rejected cover 26–50 percent of the area). Patches are occasionally connected because of stands of undesirable weedy species (Canada thistle and yellow mustard).

(iii) Forage plant diversity, invasive species, plant vigor, dead or dying plants or plant parts, litter cover and depth, and uniformity of use were rated moderate or worse. Legumes are not adapted, based on Ecological site. Two dominant grass spp. And Canada thistles in overgrazed areas with yellow mustard. Overall plant diversity is low, compared to site potential and species that are adapted to this site. Invasive weed management is needed.

Table E-32. Determining Indicators of Pasture Health Evaluation Sheet.

Determining Indicators of Pasture Health Evaluation Sheet		
Evaluation Sheet ID (Landowner, Farm, Ranch etc.)		Date:
Management Unit:	Office:	
Observers:		
Ecological site ID and Code:		
Pasture State Narrative (Y/N):		
Soil Survey:	Map Unit:	Soil Component:
Surface Soil Texture:		
Position by GPS? Y/N:	Photos taken? Y/N:	
GPS Location:		
Location Description:		
Township: Range:	Section:	¼ Section:
Pasture Size (ac):	How many DIPH samples needed?	
Size (ac) represented by DIPH sample:		
Criteria used to select evaluation area:		
Natural Disturbances (list):		
Land treatments or conservation practices applied:		
Resource Concerns:		
Historic Grazing Intensity (Low, Mod, High):	Current Grazing Intensity (Low, Mod, High):	
Grazing System:		
Haying History:		
Offsite Influences on Pasture:		
Evaluation Area description Data		
Slope	Slope Shape (concave, convex, linear)	Aspect
Elevation:		
Avg. Annual Precipitation (in or cm)	Precipitation Range (in or cm):	
Precipitation to Date: (Below, Normal, Above)	Pct. Of normal precipitation received to date:	
Seasonal Climate Notes:		
Dominant forage species and estimated composition:		
Supporting Data for Range and Pasture Hydrology Model		
Representative Climate Station:	Bare ground (%):	
Foliar Cover (% composition): Bunchgrasses ( ); Sodgrasses ( ); Annual Grasses/Forbs ( );		
Perennial Forbs ( ); Shrubs ( ); Trees ( ); Other Vines ( )		
Ground Cover (%) litter ( ); rock ( ); biotic crusts ( ); basal plant cover ( )		
Remarks and Notes:		

Table E-33. Evaluation matrix used to rate the 22 indicators and five departure categories of the three attributes of pastureland health.

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
1. Erosion (sheet and rill)	Numerous and frequent throughout. Nearly all rills are wide, deep and long. Occur in exposed and vegetated areas.	Moderate in number at frequent intervals. Many rills are wide, deep, and long. Occur in exposed areas and in some adjacent vegetated areas.	Moderate in number at infrequent intervals. Moderate rill width, depth, and length. Occur mostly in exposed areas, and steeper slopes.	Scarce and scattered. Minimal rill width, depth, and length. Occur in exposed areas, and steeper slopes.	Current or past formation of rills – none.
2. Erosion (gullies)	Sporadic or no vegetation on gully banks and/or bottom. Numerous nick points. Significant active bank and bottom erosion, including downcutting. Substantial depth and/or width. Active headcuts may be present.	Intermittent vegetation on gully banks and/or bottom. Nick points common. Moderate active bank and bottom erosion, including downcutting. Significant width and/or depth. Active headcuts may be present.	Occasional vegetation on gully banks and/or bottom. Occasional nickpoints and/or slight downcutting. Moderate depth and/or width. Active headcuts absent.	Vegetation on most gully banks and/or bottom. Few nickpoints and/or minimal downcutting. Minimal gully depth and/or width. Headcuts absent.	None
3. Erosion, Wind-Scoured and/or Depositional Areas	Extensive. Wind blowouts/scours usually connected. Large soil depositions around obstructions.	Common. Wind scours frequently connected. Moderate soil depositions around obstructions.	Occasionally present. Wind scours infrequently connected. Minor soil deposition around obstructions.	Infrequent and few. Wind scours rarely connected. Trace amounts of soil deposition around obstructions.	None or as expected in reference ESD
4. Erosion (streambank or shoreline)	Banks bare, major vertical down cutting, major sloughing, little or no bank vegetation. Hydrology of riparian system severely altered.	More than half the expected bank vegetation absent, veg. trampled; sloughing and vert. banks active erosion. Hydrology of riparian system highly altered.	About half the bank vegetation trampled; active sloughing and downcutting. Hydrology of riparian system moderately altered.	Some indication of trampled bank vegetation, active sloughing downcutting, or vertical slopes are minimal. Hydrology of riparian system slightly altered.	Bank vegetation intact, minimal trampling and/or sloughing.
5. Water Flow Patterns	Extensive. Long and wide. Erosional and/or depositional areas widespread. Usually connected.	More numerous and widespread. Longer and wider than expected. Erosional and/or depositional areas common. Occasionally	Lengths and/or widths slightly to moderately higher than expected. Minor to moderate erosional and/or depositional areas.	Length and width nearly match expected. Some minor erosional and/or depositional areas. Rarely connected.	Natural, well vegetated, or as described in ESD

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
		connected.	Infrequently connected.		
6. Bare Ground (%)	Substantially higher than expected. Bare ground patches are large and frequently connected.	Much higher than expected. Major bare ground patches throughout stand, large and occasionally connected.	Moderately higher than expected. Bare ground patches are moderate in size and sporadically connected.	Slightly higher than expected. Bare ground patches are small and rarely connected.	Amount and size of bare areas match that expected for the site. Else, no bare ground in stand.
7. Pedestals and/or Terracettes	Pedestals extensive; roots frequently exposed. Terracettes, if present, are widespread.	Pedestals widespread; roots commonly exposed. Terracettes, if present, are common.	Pedestals common; roots occasionally exposed. Terracettes, if present, are uncommon.	Pedestals uncommon; roots rarely exposed. Terracettes scarce.	None Terracettes, none
8. Litter Movement (wind or water)	Extreme movement of all size classes (including large). Significant accumulations around obstructions or in depressions.	Moderate to extreme movement of small to moderate size classes. Moderate accumulations around obstructions or in depressions.	Moderate movement of mostly small size classes. Small accumulations around obstructions or in depressions.	Slight movement of small size classes. Minimal or no accumulations around obstructions or in depressions.	None or as described in ESD
9, Effects of Plant Community Composition and Distribution on Infiltration and Runoff * Assume that decreased infiltration causes a corresponding increase in runoff. Indicator 9 is correlated with Indicator 10	Changes in plant community (functional/structural groups) composition and/or distribution are associated with severe reduction in infiltration and a significant increase in runoff.	Changes in plant community (functional/ structural groups) composition and/or distribution are associated with significantly or greatly decreased infiltration and a large increase in runoff.	Changes in plant community (functional/structural groups) composition and/or distribution are associated with moderate reduction in infiltration and a moderate increase in runoff	Community (functional/ structural groups) composition and/or plant distribution are associated with moderate reduction in infiltration and slight to moderate increase in runoff.	Infiltration and runoff are as expected for pasture state in S&T model. Plant composition and corresponding soil physical properties are not impeding infiltration
10. Soil Surface Loss or Degradation	Soil surface horizon very thin to absent throughout. Soil surface structure similar to or more degraded than subsurface. No distinguishable difference between	Severe soil loss and/or degradation throughout. Minor differences in soil organic matter content and structure between surface and subsurface layers.	Moderate soil loss and/or degradation in plant interspaces with some degradation beneath plant canopies. Soil organic matter content is markedly	Slight soil loss and/or soil structure shows slight signs of degradation, especially in plant interspaces. Minor change in soil organic matter content.	No apparent soil loss or degradation (Reference ESD narrative)

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
	surface and subsurface organic matter content.		reduced.		
11. Compaction Layer	Extensive and/or strongly developed (thickness and density); may severely restrict root penetration and infiltrability.	Widespread and/or moderately to strongly developed (thickness and density); may greatly restrict root penetration and infiltrability.	Moderately widespread and/or moderately developed (thickness and density); may moderately restrict root penetration and infiltrability.	Not widespread and/or weakly developed (thickness and density); may weakly restrict root penetration and infiltrability.	No apparent compaction.
12. Live Plant Foliar Cover (hydrologic and erosion benefits)[1]	Less than 40% live foliar cover. Remaining is either dead standing material or bare ground.	40–60% live foliar cover. Remaining is either dead standing material or bare ground.	60–75% live foliar cover. Remaining is either dead standing material or bare ground.	75–95% live foliar cover. Remaining is either dead standing material or bare ground.	More than 95% live foliar cover. Remaining is either dead standing material or bare ground.
13. Forage Plant Diversity Note: (Legumes' adaptability based on what is expected for site in ESD)	Diversity severely lacking in comparison with site potential and/or with management objectives.	Low diversity in comparison with site potential and/or plant diversity not in accordance with management objectives.	Moderate diversity in comparison with site potential and/or plant diversity is not optimum with management objectives.	Diversity slightly decreased in comparison with site potential and/or plant diversity is somewhat lacking with management objectives.	High diversity of desirable forage plants in stand and/or plant diversity in full accordance with management objectives.
14. Percent Desirable Forage Plants (for identified livestock class)	Desirable forage species <20% dry weight.	Desirable forage species 20–40% dry weight.	Desirable forage species 40–60% dry weight.	Desirable forage species 60–80% dry weight.	Desirable forage species exceed 80% dry weight.
15. Invasive Plants	Invasive species dominate the site.	Invasive species common throughout the site.	Invasive species scattered throughout the site.	Invasive species present in infrequent disturbed areas within the site.	Invasive species rare, except in very infrequently disturbed areas.
16. Annual Production	Less than 20% of potential production. Considering recent	21–40% of potential production. Considering recent	41–60% of potential production. Considering recent	61–80% of potential production. Considering recent	Annual production >80% of potential. Considering recent

[1] To define all possible undesirables (invasives, shrubs, and other weedy herbaceous forbs would be difficult). 60 percent cover has been shown to be the breakpoint of foliar cover where soil surface is relatively protected (Gifford 1985; Thurow 1986).

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
	weather conditions	weather conditions	weather conditions	weather conditions	weather conditions
17. Plant Vigor with an Emphasis on Reproductive Capability of Perennials	Plant reproduction and/or recovery after use is extremely reduced. Pale, yellow or brown, or severely stunted plants.	Plant reproduction and/or recovery after use is greatly reduced. Yellowish green forage, or moderately or slightly stunted plants.	Plant reproduction and/or recovery after use is moderately reduced. Adequate recovery. Yellowish and dark green areas due to manure and urine patches.	Plant reproduction and/or recovery is slightly-to-moderately reduced after use. Good recovery. Light green and dark green plants present	Plant reproduction and/or recovery is what is expected for the site. Rapid recovery. All healthy green plants.
18. Dead or Dying Plants or Plant Parts	Extensive mortality and/or dying plants/plant parts concentrated in one or more functional groups.	Widespread mortality and/or dying plants/plant parts concentrated in one or more functional groups.	Moderate mortality and/or dying plants/plant parts concentrated in one or more functional groups.	Occasional mortality and/or dying plants/plant parts concentrated in one or more functional groups.	No apparent mortality and/or dying plants/plant or plant parts.
19. Litter Cover and Depth	Accumulation of litter cover and depth, and decomposition extremely out of balance with current weather conditions.	Accumulation of litter cover and depth, and decomposition mod-to-extremely out of balance with current weather conditions.	Accumulation of litter cover and depth, and decomposition moderately out of balance with current weather conditions.	Accumulation of litter cover and depth, and decomposition slightly out of balance with current weather conditions.	Accumulation of litter cover and depth, and decomposition as expected for the site, and with current weather conditions.
20. Percentage Nontoxic Legumes2 Note: if bloating legumes dominate the stand-by weight, rating = Extreme to Total. Substantial risk to livestock with and without bloat prevention protocols. Fields with high legume composition should be considered	If ES Altered Pasture State supports legumes, stands have less than 2% by weight and/or legume composition extremely out of balance with management objectives.	If ES Altered Pasture State supports legumes, stands have 2–5% by weight and/or legume composition mod-to-extremely out of balance with management objectives.	If ES Altered Pasture State supports legumes, stands have 5–15% by weight and/or legume composition moderately out of balance with management objectives.	If ES Altered Pasture State supports legumes, stands have 15–30% by weight and/or legume composition slightly out of balance with management objectives.	If ES Altered Pasture State supports legumes, stands have 30–35% by weight and/or legume use in accordance with management objectives.

[2] Note: some literature mentions maximum legume comp. at 40-50 percent to minimize bloat potential.

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
for hayland.					
21. Uniformity of Use	Little-grazed or ungrazed patches where forage species are rejected cover over 50% of the area. Rejected patches are generally connected. Or Uniform use due to overutilization.	Little-grazed or ungrazed patches where forage species are rejected cover 26 to 50% of the area. Patches are occasionally connected.	Little-grazed or ungrazed patches where forage species are rejected cover 10 to 25% of the area. Patches sporadically connected.	Light-grazed or ungrazed and unconnected patches where forage species are rejected are small and isolated (<10% cover). Urine and dung patches avoided.	Uniform grazing throughout pasture. Areas where forage species are rejected only present at urine and dung patches.
22. Grazing and Utilization Note: Utilization percentages can be temporarily adjusted in grazing rotation systems given that rest and/or deferment are planned.	Pasture severely overgrazed (>70% utilization), plant height continually below recommended graz. Ht. for spp. Livestock concentration areas > 10% of the pasture and transport contaminated runoff can directly into water channels unbuffered.	Pasture utilization 65–70%, plant height is continually below recommended graz. Ht. for spp. Livestock concentration areas and trails cover 5–10% of the area and drain into water channels unbuffered.	Pasture utilization 60–65%; current utilization is temporary and not representative of continual management. Isolated and unconnected livestock concentration areas and trails (<5% of area); can potentially drain into water channels unbuffered.	Pasture utilization 50–60%; plant height generally meets recommended graz. Ht. for spp. Some livestock trails and one or two small unconnected concentration areas.	Pasture utilization =<50%; plant ht. meets recommended graz.ht. for spp. No presence of livestock concentration areas or heavy use areas.

Table E-34. DIPH evaluation sheet (Part A) for preponderance of evidence with notes on field observations.

Preponderance of Evidence	Attribute	Rating	Field Obs., Notes and Comments
Erosion (Sheet and Rill)	SSS, HF		
Erosion (Gullies) if present	SSS, HF		
Erosion (Wind) if present	SSS, HF		
Erosion (Streambank/shoreline) if present	SSS, HF		
Water-flow Patterns	SSS, HF		
Bare ground %	SSS, HF		
Pedestals and Terracettes	SSS, HF		
Litter Movement	SSS, HF		
Effects of Plant Community Composition and Distribution on Infiltration and Runoff	HF		
Soil Surface Loss or Degradation	SSS, HF, BI		
Compaction Layer	SSS, HF, BI		
Live Plant Foliar Cover (hydrologic and erosion benefits)	SSS, HF		
Forage Plant Diversity	BI, LMQF		
Percent Desirable Forage Plants (for identified livestock class)	LMQF		
Invasive Plants	HF, BI, LMQF		
Annual production	BI, LMQF		
Plant Vigor with an Emphasis on Reproductive Capability of Perennial Plants	BI		
Dead or Dying Plants or Plant Parts	BI		
Litter Cover and Depth	HF, BI		
Percent non-toxic Legumes (based on adaptability of Ecol. Site and/or what is expected stand for the site)	BI, LMQF		
Uniformity of Use	HF, BI, LMQF		
Grazing and Utilization	BI, SSS, HF, LMQF		

Table E-35. DIPH evaluation sheet (Part B) for determination of preponderance of evidence.

Preponderance of Evidence	Attribute	E to T	M to E	Mod	S to M	N to S
Erosion (Sheet and Rill)	SSS, HF					
Erosion (Gullies) if present	SSS, HF					
Erosion (Wind) if present	SSS, HF					
Erosion (Streambank/shoreline) if present	SSS, HF					
Water-flow Patterns	SSS, HF					
Bare ground %	SSS, HF					
Pedestals and Terracettes	SSS, HF					
Litter Movement	SSS, HF					
Effects of Plant Community Composition and Distribution on Infiltration and Runoff	HF					
Soil Surface Loss or Degradation	SSS, HF, BI					
Compaction Layer	SSS, HF, BI					
Live Plant Foliar Cover (hydrologic and erosion benefits)	SSS, HF					
Forage Plant Diversity	BI, LMQF					
Percent Desirable Forage Plants (for identified livestock class)	LMQF					
Invasive Plants	HF, BI, LMQF					
Annual production	BI, LMQF					
Plant Vigor with an Emphasis on Reproductive Capability of Perennial Plants	BI					
Dead or Dying Plants or Plant Parts	BI					
Litter Cover and Depth	HF, BI					
Percent non-toxic Legumes (based on adaptability of Ecol. Site and/or what is expected stand for the site)	BI, LMQF					
Uniformity of Use	HF, BI, LMQF					
Grazing and Utilization	BI, SSS, HF, LMQF					

E-T	M-E	M	S-M	N-S
Soil & Site Stability Attribute Rating				

E-T	M-E	M	S-M	N-S
Hydrologic Function Attribute Rating				

E-T	M-E	M	S-M	N-S
Biotic Integrity Attribute Rating				

E-T	M-E	M	S-M	N-S
Livestock Management Quality Factor (LQMF Rating)				

Notes

Table E-36. Example DIPH evaluation sheet (Part A) for preponderance of evidence with notes on field observations.

Preponderance of Evidence	Attribute	Rating	Field Obs., Notes and Comments
Erosion (Sheet and Rill)	SSS, HF	SM	Evidence of past rills and gullies but vegetated and healed at present. Some rilling in livestock trails and along vehicle trail.
Erosion (Gullies) if present	SSS, HF	SM	Observed old past gullies, vegetated with graminoids and woody plants
Erosion (Wind) if present	SSS, HF	NS	No wind erosion observed
Erosion (Streambank/shoreline) if present	SSS, HF	N/A	No shorelines associated with field
Water-flow Patterns	SSS, HF	SM	Some water flow patterns have merged due to a high runoff event, signs of litter movement and debris dams against shrub bases
Bare ground %	SSS, HF	M	Expected bare ground <5%. Estimated bare ground 10–15%. Some bare ground patches connected
Pedestals and Terracettes	SSS, HF	SM	Some pedestals observed in water flow channels, some debris dams formed by recent runoff event
Litter Movement	SSS, HF	SM	Some litter and mulch movement in water flow channels observed
Effects of Plant Community Composition and Distribution on Infiltration and Runoff	HF	SM	Trend appears to be moving toward Kentucky bluegrass in overgrazed areas, replacing bunchgrass, primarily orchardgrass. Sod forming species are associated with decreased infiltrability (See Subpart G)
Soil Surface Loss or Degradation	SSS, HF, BI	SM	Some surface soil loss associated with history of cultivation in the past. Organic matter was undoubtedly lost during cultivation
Compaction Layer	SSS, HF, BI	SM	Compaction observed, mostly along livestock trails, fencelines, gate areas
Live Plant Foliar Cover (hydrologic and erosion benefits)	SSS, HF	SM	Plant foliar cover 85–90%, not optimum, but adequate for interception of raindrops
Forage Plant Diversity	BI, LMQF	ME	Forage diversity has declined from desirable bunchgrasses to sod forming K. bluegrass dominating site. Some Canadian thistles in overgrazed areas, and scattered Multiflora rose
Percent Desirable Forage Plants (for identified livestock class)	LMQF	ME	A transition is in progress and shifting from bunchgrasses to sodgrass. Weedy forbs such as mustards, sowthistle, prickly lettuce common, with multiflora rose and Canadian thistle patches
Invasive Plants	HF, BI, LMQF	M	Invasive species increasing such as Canadian thistle, multiflora rose in areas, and undesirable weedy forbs. Can be controlled, but action needed before threshold crosses to Mod to Ex.
Annual production	BI, LMQF	M	Annual production has decreased to about 50% of potential production due to increasing composition of Kentucky bluegrass and weedy forbs
Plant Vigor with an Emphasis on Reproductive Capability of Perennial Plants	BI	M	Vigor and composition of orchardgrass has diminished, and K. bluegrass gaining dominance in pasture.

Preponderance of Evidence	Attribute	Rating	Field Obs., Notes and Comments
Dead or Dying Plants or Plant Parts	BI	M	Observations conclude that orchardgrass plants are yellowing and dying due to moisture stress. K. bluegrass is very efficient at usurping available water with dense surface fibrous roots (see Subpart E)
Litter Cover and Depth	HF, BI	M	No litter cover in bare ground areas, overall ground cover of litter is < 2%
Percent non-toxic Legumes (based on adaptability of Ecol. Site and/or what is expected stand for the site)	BI, LMQF	ME	Legume composition <5%. Legumes' diversity reduced; dominant remaining legume is white clover. Area outside fence has higher legume composition and red clover.
Uniformity of Use	HF, BI, LMQF	M	Grazing distribution uneven, high use around pond area, uneven use extending from water source. Pond banks are experiencing sloughing due to high use.
Grazing and Utilization	BI, SSS, HF, LMQF	ME	Pasture grazing levels have exceeded moderate grazing. Heavy use around pond and extending from water source. Utilization about 70% in grazed areas.

Table E-37. Example DIPH evaluation sheet (Part B) for determination of preponderance of evidence.

Preponderance of Evidence	Attribute	E to T	M to E	Mod	S to M	N to S
Erosion (Sheet and Rill)	SSS, HF				✓	
Erosion (Gullies) if present	SSS, HF				✓	
Erosion (Wind) if present	SSS, HF					✓
Erosion (Streambank/shoreline) if present	SSS, HF					N/A
Water-flow Patterns	SSS, HF				✓	
Bare ground %	SSS, HF			✓		
Pedestals and Terracettes	SSS, HF				✓	
Litter Movement	SSS, HF				✓	
Effects of Plant Community Composition and Distribution on Infiltration and Runoff	HF				✓	
Soil Surface Loss or Degradation	SSS, HF, BI				✓	
Compaction Layer	SSS, HF, BI				✓	
Live Plant Foliar Cover (hydrologic and erosion benefits)	SSS, HF				✓	
Forage Plant Diversity	BI, LMQF		✓			
Percent Desirable Forage Plants (for identified livestock class)	LMQF		✓			
Invasive Plants	HF, BI, LMQF			✓		
Annual production	BI, LMQF			✓		
Plant Vigor with an Emphasis on Reproductive Capability of Perennial Plants	BI			✓		
Dead or Dying Plants or Plant Parts	BI			✓		
Litter Cover and Depth	HF, BI			✓		
Percent non-toxic Legumes (based on adaptability of Ecol. Site and/or what is expected stand for the site)	BI, LMQF		✓			
Uniformity of Use	HF, BI, LMQF			✓		
Grazing and Utilization	BI, SSS, HF, LMQF		✓			

E-T	M-E	M	S-M	N-S
			1	
			2	
				3
			5	
		6		
			7	
	22		8	
			10	
			11	
			12	
Soil & Site Stability Attribute Rating S-M with some M-ME concerns				
Evidence of past rills and gullies but vegetated at present. #14 community comp. shifting from bunch to sod forming grasses				

E-T	M-E	M	S-M	N-S
			1	
			2	3
		6	5	
		15	7	
		16	8	
		19	9	
		21	10	
	22		11	
			12	
Hydrologic Function Attribute Rating M				
Bare ground patches connected, grazing dist. Heavy near watering area and fencelines. Some rilling in livestock trails and along vehicle trail.				

E-T	M-E	M	S-M	N-S
			10	
			11	
	13			
		15		
		16		
		17		
		18		
		19		
	20			
		21		
	22			
Biotic Integrity Attribute Rating M with ME concerns				
Legumes' diversity reduced; dominant legume is white clover. Some Canadian thistles in overgrazed areas, and scattered Multiflora rose, diversity low. Shifting grass comp. from bunchgrasses to sodgrasses.				

E-T	M-E	M	S-M	N-S
	13	15		
	14	16		
	20			
		21		
	22			

Livestock Management Quality Factor
LQMF Rating M to ME

Notes: Salt placement by watering area. Livestock use, trails to pond and along fence lines. Forage plant diversity could be improved by controlling Undesirable weedy plants. Bunchgrasses are decreasing in stand, invasive shrubs scattered throughout pasture. SOM somewhat depleted from past cropping history and water erosion events. About 50% of Soil aggregates dispersed in water.

645.0517 Monitoring

A. Introduction

(1) Monitoring is the orderly repeated collection, analysis, and interpretation of resource information data. It can be used to make both short- and long-term management decisions (Perryman et al. 2004). Short term monitoring, for example, could be conducted to quantify the amount of forage used during a grazing event, whereas long term monitoring can be conducted to quantify the extent and direction of change within a plant community on an ecological site.

(2) Monitoring is important to evaluate changes over time in ecological process, in evaluating management actions or the effectiveness of a conservation plan. It is a part of Step 9 of the NRCS nine steps of conservation planning. Monitoring is part of a broader process in which data is used to test and refine management decisions and allow the collective knowledge of scientists and land managers to improve resource management (Herrick et al. 2009).

(3) Determining what and where to monitor are probably the most time-consuming components of developing a monitoring program (Allison et al. 1951, 1961). Some purposes to monitor can include:

(i) To determine the effectiveness of management practices.
(ii) Determining if forage supply and demand are in balance.
(iii) Documenting the effect of livestock grazing on natural resources.
(iv) Documenting effectiveness of movement toward a desired condition.
(v) Documenting reasons for range and pasture conditions.
(vi) Gaining a better understanding of resources and their management.
(vii) Using the information gathered to provide for adaptive management strategies.

(4) Some agencies have been transitioning toward implementing monitoring methods that are quantitative, repeatable, and statistically rigorous which involves training and calibrating observers (Burkett 2021). Factors that may dictate measurement of different attributes and/or different methods include vegetation type, management objectives and concerns, time and money available, qualifications of personnel, and other factors (Smith et al. 2012).

B. Uses on all grazing lands

(1) The Monitoring Manual for Grassland, Shrubland and Savannah Ecosystems, Core Methods Volume 1 Second edition and Design, supplementary methods and interpretations Volume 2 (Herrick et al. 2017) will be used as the standard reference for inventory and monitoring methods on rangeland, pastureland and grazed forestland which are also used in the NRCS National Resources Inventory (NRI). https://jornada.nmsu.edu/monit-assess/manuals/monitoring.

(2) The Utilization Studies and Residual Measurements, Interagency Technical Reference 1999, is a guide to provide the basis for consistent, uniform, and standard utilization studies and residual measurements that are economical, repeatable, statistically reliable, and technically adequate. https://www.blm.gov/sites/blm.gov/files/documents/files/Library_BLMTechnicalReference1734-03.pdf.

(3) *Riparian Area Management-Multiple Indicator Monitoring (MIM) of Stream Channels and Streamside Vegetation* (Technical Reference 1737-23) is a reference to provide information necessary for land managers to adaptively manage riparian resources. The MIM protocol is designed to be objective, efficient and effective for monitoring streambanks, stream channels, and streamside riparian vegetation primarily from impacts of livestock and other large herbivores on wadable streams. MIM protocol integrates annual grazing use and long-term trend indicators allowing for evaluation of livestock grazing management, with the long-term indicators being useful for monitoring changes occurring on the streambank and in the channel as a result of management activities other

than grazing. For more information see https://www.blm.gov/documents/national-office/blm-library/technical-reference/multiple-indicator-monitoring-mim-stream.

(4) Some of the remote sensing resources listed in this subpart [NRPH Subpart E 645.0501 D (4)] can be used for monitoring purposes. They can be used in combination with on-site vegetation measurements to provide perspective and context for rangeland monitoring across entire grazing units or ranches. Examination of trends in vegetation on watershed, county, or landscape scales is relatively easy with the remote sensing products that have recently become widely accessible. Remote sensing can be used to monitor and evaluate the effects of current or past disturbances and management practices.

When incorporating remote sensing into monitoring plans, remember that:

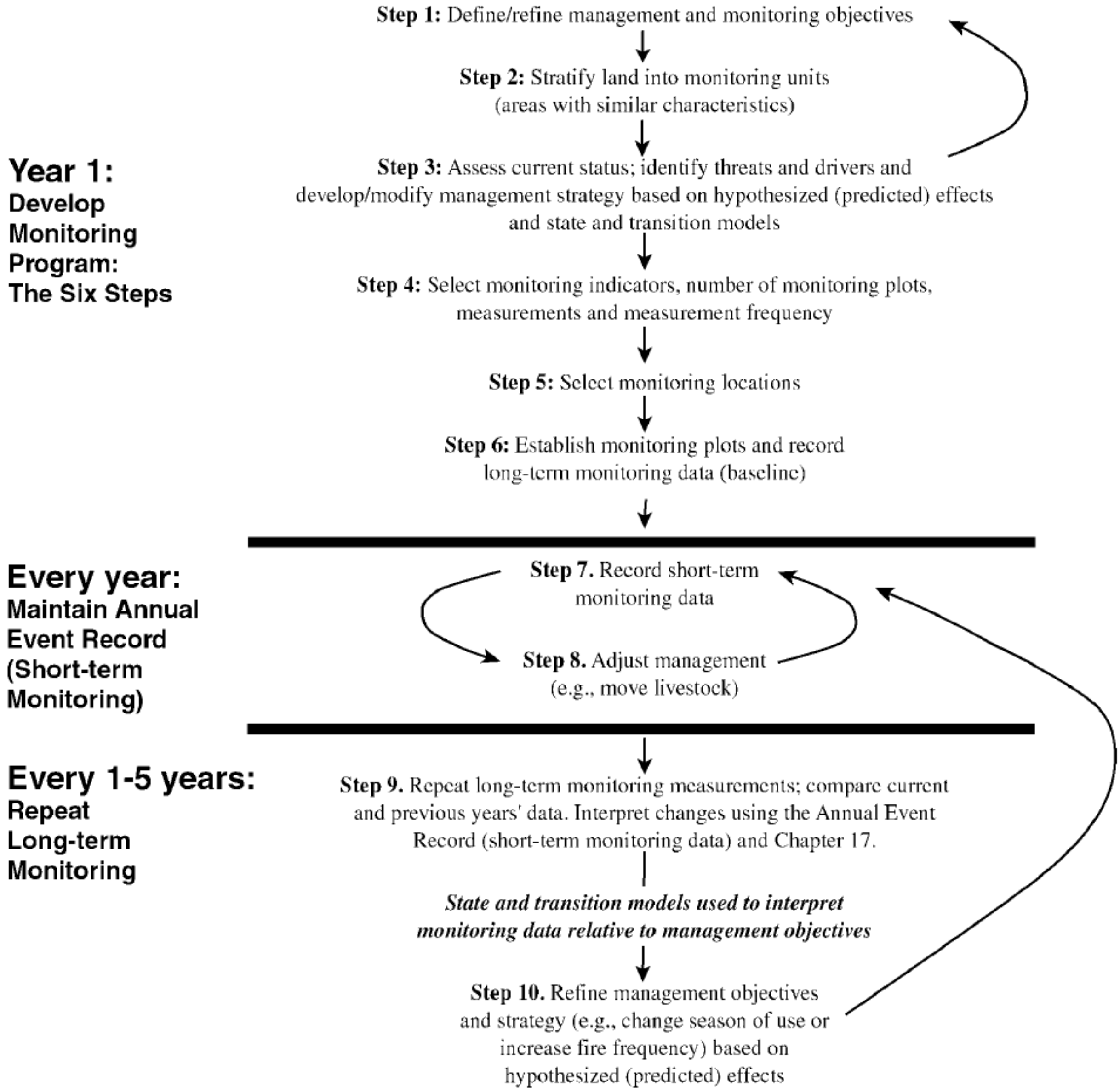
- Remote sensing does not identify plant species, only plant groups (i.e., perennial grasses and forbs, annuals, shrubs, trees, etc.).
- The trends shown by remote sensing are reliable, even though absolute values of percent cover or reported production may not always be accurate.
- Remote sensing is very effective for displaying the spatial variability of cover and production across a grazing unit, which is very useful when interpreting and extrapolating on-site vegetation measurements.

C. Developing a Monitoring Program—The Six Steps

Six steps are generally needed to design and implement a long-term ecosystem-based monitoring program. Each of the six steps are illustrated in the flow chart (figure E-57) and listed in their own chapters in Volume II of the Monitoring Manual (Herrick 2017). The steps are listed in the order they are normally completed, but because there is no single way to design a monitoring program, revisiting earlier steps is often helpful.

For example, the assessments completed in Step 3 often reveal issues that lead to new management and monitoring objectives (Step 1). State-and-transition models can be helpful here by focusing attention on areas that are at risk or have a high potential for recovery. It is also helpful to redefine management and monitoring objectives (Step 1).

Figure E-57. Gullies in a field monitoring program design and implementation (Steps 1–6) and integration with management (Steps 7–10) (Herrick et al. 2005).



645.0518 Monitoring Methods

Several materials, procedure, and calculation instructions for the methods listed in this section are described in the *Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems, Volumes I and II* (Herrick et al. 2005). Follow the recommendations in the manual for plot size, sampling size, transect length and shape, and data interpretations if one of these methods are selected. Sampling sites should be geospatially located and mapped on the conservation plan map.

(i) Line-Point Intercept:

- Line-point intercept is a rapid, accurate method for quantifying soil cover, including vegetation, litter, rocks and biological crusts. See tables E-62 and E-63 for the Line-Point Intercept Data Sheet and Data Sheet Example. These measurements are related to wind and water erosion, water infiltration, and the ability of the site to resist and recover from disturbance. Line-point intercept can be measured together with vegetation height, which describes vertical vegetation structure.
- Line-point intercept is a common method used in monitoring so the instructions on using the Line-point intercept are found here (tables E-38, E-39, E-40, E-41, and figures E-58, E-59, E-61) but full instructions with helpful tips can be found in Jornada Core Methods Volume 1, 2nd edition 2017 publication at: https://jornada.nmsu.edu/files/Core_Methods.pdf.
- Materials

  – Measuring tape (length of transect). If using a tape measure in feet, use one marked in tenths of feet.

  – Two steel stakes for anchoring tape.

  – One pointer – a straight piece of wire or rod, such as a long pin flag, at least 75 cm (2.5 ft) long and 1 mm (0.04 in) or less in diameter.

  – Electronic device for paperless data collection (preferred) OR clipboard, Line-point Intercept Data Sheet and pencil(s).

(ii) Gap intercept

Gap intercept measurements provide information about the proportion of the line covered by large gaps between plants (Herrick et al. 2005). The size and frequency of gaps in plant canopies (canopy gap intercept) reflects the potential for wind erosion on a site. Basal gap intercept measures the gaps between plant bases. The higher the proportion of a plot in large basal gaps, the greater the risk of water erosion. Larger gaps also correlate to a higher risk of invasion by weeds or woody species. Gap intercept and vegetation height together can be used to characterize vegetation.

(iii) Photograph Monitoring

- Use photo points to qualitatively monitor how vegetation changes over time. Permanent photographs of a landscape are useful for detecting changes in vegetation structure and for visually documenting measured changes.
- The Sampling Vegetative Attributes Interagency Technical Reference includes a section on how to conduct photo monitoring. That procedure is included here:

  – General description-photographs and videotapes can be valuable sources of information in portraying resource values and conditions. Therefore, pictures should be taken of all study areas when feasible. Both photographs and videos can be taken at photo plots or photo points. A photo point is a panoramic view landscape photo of the study area where a phot plot is a closeup photograph of a permanently marked plot on the ground. Use close-up and/or general view pictures with all of the study methods. Comparing pictures of the same site taken over a period of years furnishes visual evidence of vegetation and soil changes. In some situations, photo points could be the primary monitoring tool. All pictures should be in color, regardless of whether they are the primary or secondary monitoring tool (ITR 1734-4).

– Equipment—The following equipment is suggested for the establishment of photo plots:

- Study Location and Documentation Data form (see ITR Appendix A)
  -- Photo Identification Label (see ITR Appendix C)
  -- Frame to delineate the 3- x 3-foot, 5- x 5-foot, or 1- x 1-meter photo plots (see Illustrations 1 and 2)
  -- Four rods to divide the 3- x 3-foot and 1- x 1-meter photo plot into nine square segments
  -- Stakes of 3/4- or 1-inch angle iron not less than 16 inches long (request approval from client before placing angle iron on private land)
  -- Hammer
  -- 35-mm camera with a 28-mm wide-angle lens and film
  -- Small step ladder (for 5- x 5-foot photo plots)
  -- Felt tip pen with waterproof ink
- Study Identification Number studies for proper identification to ensure that the data collected can be positively associated with specific studies on the ground (see ITR Appendix B).
- Close-up Pictures Close-up pictures show the soil surface characteristics and the amount of ground surface covered by vegetation and litter. Close-up pictures are generally taken of permanently located photo plots.
- The location of photo plots is determined at the time the studies are established. Document the location of photo plots on the Study Location and Documentation Data form to expedite relocation (see ITR Appendix A).
- Generally, a 3 x 3-foot square frame is used for photo plots; however, a different size and shape frame may be used. Where new studies are being established, a 1-meter x 1-meter photo plot is recommended. Frames can be made of PVC pipe, steel rods, or any similar material. Illustration 1 of the Interagency Technical Reference shows a diagram of a typical photo plot frame constructed of steel rod.
- Angle iron stakes are driven into the ground at two diagonal corners of the frame to permanently mark a photo plot (see ITR Illustration 3). Paint the stakes with bright-colored permanent spray paint (yellow or orange) to aid in relocation. Repaint these stakes when subsequent pictures are taken.
- The Photo ID Label is placed flat on the ground immediately adjacent to the photo frame. Photo label should include date, location (pasture), name of ranch, and study site number.
- The camera point, or the location from which the close-up picture is taken should be on the north side of the phot plot so that repeat pictures can be taken at any time during the day without casting a shadow across the plot.
- To take the close-up pictures, stand over the photo plot with toes touching the edge of the frame.
- A step ladder may be needed to take close up pictures of plots larger than 3 x 3 feet.
- General View Pictures. General view pictures are photo points and present a broad view of a study site. These pictures are often helpful in relocating study sites.

– If a linear design is used, general view pictures may be taken from either or both ends of the transect. The points from which these pictures are taken are determined at the time the studies are established. Document the location of these points on the Study Location and Documentation Data form to expedite relocation (see ITR Appendix C).

– The Photo Identification Label is placed in an upright position so that it will appear in the foreground of the photograph (see ITR Appendix C).

– To take general view pictures, stand at the selected points and include the photo label, a general view of the site, and some sky in the pictures.

  - A picture of a study site taken from the nearest road at the time of establishment of the study facilitates relocation.
- Photo Points. General view photographs taken from a permanent reference point are often adequate to visually portray dominant landscape vegetation. It is important that the photo point location be documented in writing and that the photo include a reference point in the foreground (fencepost, fence line, etc.), along with a distinct landmark on the skyline. Photographs taken from photo points should be brought to the field to assist in finding the photo point and to ensure that the same photograph (bearing, amount of skyline, etc.) is retaken. The photograph should be taken at roughly the same time each year to assist in interpreting changes in vegetation. As always, recording field notes to supplement the photographs is a good idea. See figure E-64.
- Video Images. Video cameras (i.e., camcorders) are able to record multiple images of landscapes for monitoring. While video images provide ways to record landscape images, limitations in their use should also be considered. Video tapes, especially the quality of the image, may begin to deteriorate within 5 years. These images can be protected by conversion to digital computer images or rerecording the original tape onto a new blank tape. Comparing repeat video images is difficult, especially if the same landscape sequences are not repeated in the same way on subsequent video recordings. Advantages and disadvantages of video cameras should be carefully considered prior to implementing a video monitoring system.
- Repeat Pictures. When repeat pictures are taken, follow the same process used in taking the initial pictures. Include the same area and landmarks in the repeat general view pictures that were included in the initial pictures. Take repeat pictures at approximately the same time of year as the original pictures.
- General Observations. General observations concerning the sites on which photographs are taken can be important in interpreting the photos. Such factors as rodent use, insect infestation, animal concentration, fire, vandalism, and other site uses can have considerable impact on vegetation and soil resources. This information can be recorded on note paper or on study method forms themselves if the photographs are taken while collecting other monitoring data.
- The Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems Second Edition, Volume 1 Core Methods also provides instructions for setting up and conducting photo monitoring.

Table E-38. Line-point intercept (rule set).

1.	Pull out the tape and anchor each end with a steel stake.
	Keep the measuring tape taut and straight.
	Keep the measuring tape as close to the ground as possible (thread under shrubs using a steel stake or PVC pipe as a “needle” being careful to not disturb the soil surface or natural lay of the vegetation).
	In shrubby areas, it may be helpful to reverse-string the tape by anchoring the reel at the endpoint and working backwards toward the “0” end of the tape.
2.	As you move from one end of the tape to the other, always stand on the same side (the south side for NRI) of the transect for all methods and measurements. Move to the first point (0 mark) on the tape.
3.	Drop a pin flag to the ground from a standard height next to the tape.
3.1	Keep the pin vertical.
3.2	Make a “controlled drop” of the pin from the same height each time. Position the pin so its lower end is several centimeters above the vegetation, release it and allow it to slip through the hand until it hits the ground. A low drop height minimizes “bounces” off of vegetation but increases the possibility for bias.
3.3	Do not guide the pin all the way to the ground. It is more important for the pin to fall freely to the ground than to fall precisely on the transect tape mark.
3.4	A laser with a bubble level can be used instead of the pin. This tool is useful in ecosystems where plant layers may be above eye level.
4.	Once the pin flag is flush with the ground, record every plant species it intercepts (table E-39 and figure E-60).
4.1	Record the species of the uppermost or first stem, leaf or plant base intercepted in the “Top layer” column, using the PLANTS Database species code (https://plants.usda.gov), a code based on the first two letters of the genus and species, or the common name.
4.2	If no leaf, stem or plant base is intercepted or touches the pin, record “N” for none in the “Top layer” column.
4.3	Record all additional species intercepted by the pin, in the order that they are intercepted, from top to bottom.
4.4	Record herbaceous litter as “HL,” if present. Herbaceous litter is defined as detached stems, roots, leaves, haybales, and dung. Record “WL” for detached woody or succulent litter that is greater than 5 mm (or ~1/4 in) in diameter. Record “NL” for non-vegetative litter (e.g., plastic, metal, decomposing animal matter).
4.5	Record each plant species only once, the first time it is intercepted, even if it is intercepted several times.
4.6	If a plant species is not known, use the following codes, adding sequential numbers as necessary: AF# = Annual forb (also includes biennials).
	If necessary, collect a sample of unknown plants off the transect for later identification (see page 14 of the Monitoring Manual, 2nd edition for voucher specimen collection protocols).
4.7	If the genus is known, but not the species, either use the PLANTS Database genus code (https://plants.usda.gov) or record an unknown plant code as described above and note the genus at the bottom of the data sheet.
4.8	Foliage can be live or dead (see figures E-59 and E-60), but only record each species once at each pin drop. If both live and dead canopy for the same species is hit on the same point, record the live canopy.
4.9	Record vagrant lichen as “VL” or by its species in the lower layer columns.
4.10	In environments where deposited soil over a plant base occurs push the pin below the soil surface. Gently move the pin from side to side to feel for buried plant bases. If resistance from the plant base is encountered, record deposited soil as “DS” in the lower canopy and record the species basal hit in the “Soil Surface” column.
5.	Record a species code (if the pin flag intercepts a plant base, figure E-60) or another soil surface code in the “Soil surface” column).
5.1	For unidentified plant bases, use the codes listed under Rule 4.6.
5.2	An intercept with a plant base is defined as when the end of the pin rests either on, or immediately adjacent to and touching, living or dead plant material that is rooted in the soil. Carefully scrutinize if the pin rests either on, or immediately adjacent to and touching, living or dead plant material that is rooted in the soil. Carefully scrutinize if the pin is touching small, single-stemmed plants. See figure E-60.
6.0	Optional: Add more specific soil surface categories.

6.1	Record "CY" or dark cyanobacterial crust.
6.2	If mosses and lichens are identified to species, record the species code in the "Soil surface" column.
7.	Repeat Steps 3–6 at regular intervals along the transect.
	R = Rock (> 5 mm or ~1/4 inch in diameter) (a category for coarse fragments functionally resistant to movement raindrop impact).

The following specific size classes be used in place of "R". This is required where data will be used to develop classification systems, such as ecological sites.

GR = Gravel (5 – 76 mm)
CB = Cobble (> 76 – 250 mm)
ST = Stone (> 250 – 600 mm)
BY = Boulder (> 600 mm)
BR = Bedrock
D = Duff
M = Moss
LC = Visible lichen on soil crust (do not record if it is attached to a rock substrate)
W = Water
S = Soil that is visibly unprotected by any of the above

PF# = Perennial forb
AG#= Annual graminoid
PG#= Perennial graminoid
SH#= Shrub
TR#= Tree

Figure E-58. Correct Pin flag position dropping on bare soil (N/S reading) (Herrick et al. 2005).

Figure E-59. Recording Dead vs. Live.

RECORDING DEAD VS. LIVE

Distinguishing dead vs. live plant parts is important for many objectives. A pin intercept is a standing dead hit if the pin touches a dead plant part.

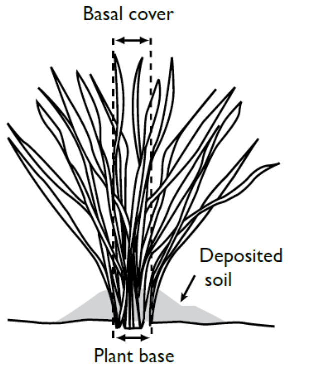
- Vegetation which grew in the current growing season is alive while rooted vegetation from the previous growing season is dead.
- Perennial and woody plant parts which support live vegetation are alive.
- Points where only dead plants or plant parts are intercepted can be recorded on paper by circling the species on paper data sheets, or electronically (by using the optional checkbox in the DIMA Line-point intercept form (https://jornada.nmsu.edu/monit-assess/).

Table E-39. A list of columns that can be populated as part of Line-point intercept, along with a list of permitted options for each Column. Following these protocols facilitates simple calculations on paper data sheets, and consistent calculations with Electronically recorded data.

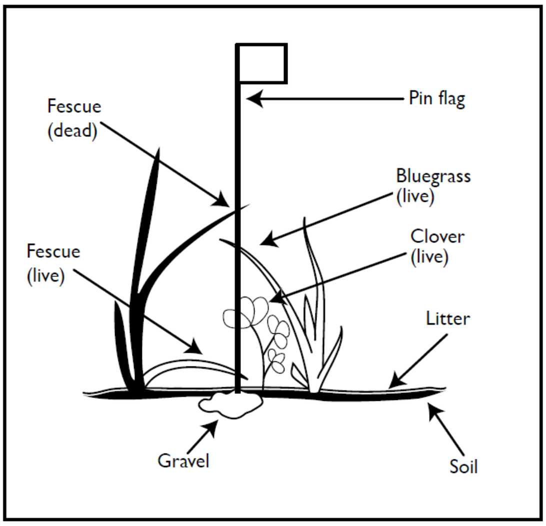
LPI COLUMN		PERMITTED OPTIONS	SOURCE/CODE		DESCRIPTION
Top layer codes		N			Indicates no foliar cover.
		Plant code	From PLANTS Database		Foliar cover.
		Unknown plant code	User assigned code		
Lower codes		Plant code	From PLANTS Database		Foliar cover.
		Unknown plant code	User assigned code		
		Litter	L or HL - herbaceous litter (including dung and haybales)		Litter cannot be entered above the first plant code or in the Top layer.
			WL - woody or succulent litter > 5 mm diameter		
			NL - other litter such as plastic, metal, and decomposing animal matter		
				Otherwise record:	
	Optional	Deposited soil	DS	S on Soil surface	Soil deposition overlying a plant base.
	Optional	Water	W	W on Soil surface	Water or ice present at the time of measurement. May be permanent or ephemeral.
	Optional	Vagrant lichen	VL	Litter	Lichens that are loose, never attached to any substrate.
	Optional	Rock fragment	GR - gravel	GR or R on soil sur face	Rock fragments 5 - 76 mm, but only when overlying a buried plant base.
	Optional		CB - cobble	CB or R on soil surface	Rock fragments 76 - 250 mm, but only when overlying a buried plant base.
	Optional		ST- stone	ST or R on soil surface	Rock fragments 250 - 600 mm, but only when overlying a buried plant base.
Soil surface codes		Plant code	From PLANTS Database		Indicates pin on hit a plant base. Plant bases have no minimum height, record a foliar hit of the same species above any plant basal hit even when no apparent pin contact is made with a leaf or stem.
		Unknown plant	User assigned code		
		Soil	S		Indicates bare soil, mineral soil, or soil with no detectable biological crust.
		Lichen	LC (or species code if known*)		Visible lichen crust attached to soil surface. Record if attached to soil, but not if on rock.
		Moss	M (or species code if known*)		
		Duff	D		Partially decomposed plant litter with no recognizable plant parts.
		Water	W		Permanent water
		Rock fragment	R		All rock fragments > 5 mm (do not use GR,CB, ST, or BY because R represents all of these).
				Otherwise, record:	
	Optional	Cyanobacteria	CY	S	For consistency with NRI bare ground calculations, both "N/S" and "N/CY" pin hits constitute bare ground.
	Optional	Embedded litter	EL	L in lower canopy and S on the Soil surface	Embedded woody litter > 5 mm in diameter
	Optional		GR - gravel	R	Rock fragments 5 - 76 mm.
	Optional		CB - cobble	R	Rock fragments 76 - 250 mm.
	Optional		ST - stone	R	Rock fragments 250 - 600 mm.
	Optional		BY- boulder	R	Rock fragments > 600 mm.
	Optional		BR - bedrock	R	

Figure E-60. Sample data sheet for examples illustrated below. Points 1 and 2 show the first two points on a transect. In Point 1, the pin flag is touching dead fescue (FERU2), live bluegrass (POPR). Clover (TRRE3), live fescue, litter, and a rock. Record fescue only once, even though it intercepts the pin twice. In Point 2, the flag touches fescue, then touches litter, and finally the fescue plant base.

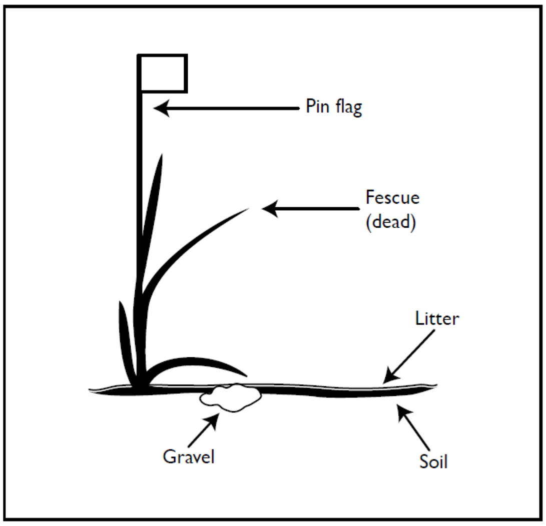
PT.	TOP LAYER	LOWER LAYERS			SOIL SURFACE
		CODE 1	CODE 2	CODE 3	
1	FERU2	POPR	TRRE3	HL	R
2	FERU2	HL			FERU2
3	FERU2	HL			S
4	N				S
etc.					



Area defined as plant base and included as basal cover.



Point 1



Point 2

Table E-40. Quality Assurance.

Quality Assurance

☐	Each data sheet is complete. All points, observer, recorder, date, line, and plot name are recorded. Scan every entry to make sure they are legible.
☐	Each pin drop is made as close to vertical as possible, and observers avoid leaning too far over the line in either direction in order to avoid parallax. Parallax issues can increase variability year-to-year because different amounts of plant canopy are measured among years.
☐	Every Top layer and Soil surface cell has an entry. Each species may occur a maximum of once in the first four columns.
☐	Fill every cell with its appropriate data; do not draw vertical lines down through multiple cells or columns to indicate repeating values.
☐	% bare ground + % foliar cover + % between plant ground cover = 100%.
☐	Cover values are consistent with plot observations.

Table E-41. Line-Point Intercept Indicator Calculations.

	Foliar cover (as calculated here) does not include bare spaces within a plant's canopy.
1.	Percent foliar cover.
1.1	Count the total number of plant intercepts in the "Top layer" column and record this number in the blank provided.
1.2	Plant intercepts include all points where a plant is recorded in the "Top layer" column. Do not include points that have a "N" in the "Top layer" column.
1.3	Divide the number of plant intercepts by the total number of pin drops and record % foliar cover in the blank provided.
2.	Percent bare ground.
2.1	Count the total number of points along the line that have bare ground and record this number in the blank provided.
2.2	Bare ground occurs only when:
	A. There are no plant intercepts (N is recorded in the "Top layer" column).
	B. There are no litter intercepts ("Lower layers" columns are empty).
	C. The pin only intercepts bare soil ("S" recorded in the "Soil surface" column).
2.3	Divide the total number of bare ground hits by the total number of pin drops and record % bare ground in the blank provided.
3.	Percent basal cover.
3.1	Count the total number of plant basal intercepts in the "Soil surface" column and record this number in the blank provided.
3.2	Plant basal intercepts occur anytime the pin intercepts a live or dead plant base (species code recorded in "Soil surface").
3.3	Divide the total number of basal intercepts by the total number of pin drops and record % basal cover in the blank column) provided.
4.	Vegetation composition.
4.1	Count the total number of intercepts where rooted vegetation occurs in at least one layer (Top, Lower, or Soil Surface layers).
4.2	Count the total number of intercepts where Species A occurs in at least one layer.
4.3	Divide the count from 4.2 by the count from.
4.1	Multiply by 100% and record this as the composition of Species A.
4.4	Repeat for Species B, C, D, N.
4.5	Sum the percent composition of each species.

Figure E-61. Line-point intercept basic interpretation.

LINE-POINT INTERCEPT BASIC INTERPRETATION

Increases in **foliar cover** are correlated with increased resistance to degradation. **Basal cover** is a more reliable long-term indicator. Basal cover is less sensitive to seasonal and annual differences in precipitation and use. Increases in **bare ground** nearly always indicate a higher risk of runoff and erosion.

Where species composition* changes may be occurring, calculate basal and foliar cover for each major species. Foliar cover usually is used for shrubs, trees and sometimes grasses. Basal cover is used for perennial grasses. When calculating foliar cover of a single species, count each time the species is intercepted, regardless of whether it is in the top or lower layer (only count it once in cases where it occurs in an upper layer and the soil surface for the same pin drop). Use these indicators together with the indicators from **Gap intercept** and **Soil stability tests** to help determine whether observed erosion changes are due to loss of cover, changes in vegetation spatial distribution, or reduced soil stability. Use these indicators together with **Plant density** data to track changes in species composition. For more information about how to interpret these indicators, please see Chapter 21, Volume II.

*Foliar cover is often used to estimate species composition. It must be recognized, however, that in dense, complex vegetation systems, foliar cover estimates of species composition based on only the first hit on each species (as described in this manual), are less strongly correlated with biomass-based species composition than estimates where multiple pin intercepts are recorded.

TYPICAL EFFECT ON EACH ATTRIBUTE OF AN INCREASE IN THE LINE-POINT INTERCEPT INDICATOR VALUE

Indicator	Attributes		
	Soil and site stability*	Hydrologic function**	Biotic integrity
Foliar cover %	↑	↑	↑
Bare ground %	↓	↓	↓
Basal cover %	↑	↑	↑

The Line-Point Intercept Data Sheet is below with an example of a correctly populated sheet.

Figure E-62. Line-point intercept data sheet (blank).

LINE-POINT INTERCEPT DATA SHEET

Page ______of______ Shaded cells for calculations

Plot: ____________________ Line: _____ Observer: ________________ Recorder: ________________

Azimuth: ______ Date: ____________ Intercept (Point) Spacing Interval: _____ ☐ cm ☐ in

PT.	TOP LAYER	LOWER LAYERS			SOIL SURFACE	PT.	TOP LAYER	LOWER LAYERS			SOIL SURFACE
		CODE 1	CODE 2	CODE 3				CODE 1	CODE 2	CODE 3	
1						26					
2						27					
3						28					
4						29					
5						30					
6						31					
7						32					
8						33					
9						34					
10						35					
11						36					
12						37					
13						38					
14						39					
15						40					
16						41					
17						42					
18						43					
19						44					
20						45					
21						46					
22						47					
23						48					
24						49					
25						50					

% foliar cover = ____ top layer pts (1st col) x 2 = _____%
% bare ground* = ____pts (w/N over S) x 2 = _____%
% basal cover = ____ plant base pts (last col) x 2 = _____%

* For NRI, bare ground occurs ONLY when Top layer = N, Lower layers are empty (no litter), and Soil surface = S or CY.

Top layer codes: Species code or N (no cover).
Lower layers codes: Species code or HL (herbaceous litter), WL (woody litter, > 5 mm (~1/4 in) diameter), NL (non-vegetative litter), VL (vagrant lichen).

UNKNOWN SPECIES CODES:
- AF#=annual forb
- PF#=perennial forb
- AG#=annual graminoid
- PG#=perennial graminoid
- SH#=shrub
- TR#=tree

SOIL SURFACE (DO NOT USE LITTER):
- R=Rock** (≥ 5 mm or ~ 1/4 in diameter)
- BR=Bedrock
- D=Duff
- M=Moss
- LC=Visible lichen on soil
- S=Soil

** Optional: use rock fragment classes in place of "R": GR (5-76 mm), CB (76-250 mm), ST (250 mm-600 mm), BY (>600 mm)

Data entry ________ Date ___________ Error check ________ Date ___________

Figure E-63. Line-point intercept data sheet (example).

LINE-POINT INTERCEPT DATA SHEET

Shaded cells for calculations

Page 1 of 1

Plot: 3 Line: 2 Observer: Jane Mendez Recorder: David Stein

Azimuth: 120 Date: 10/15/2002 Intercept (Point) Spacing Interval: 100 ☑ cm ☐ in

PT.	TOP LAYER	LOWER LAYERS			SOIL SURFACE	PT.	TOP LAYER	LOWER LAYERS			SOIL SURFACE
		CODE 1	CODE 2	CODE 3				CODE 1	CODE 2	CODE 3	
1	BOER4				BOER4	26	PRGL	BOER4			S
2	BOER4				S	27	N	HL			S
3	AFO1	BOER4			S	28	BOER4				LC
4	BOER4				S	29	AFO1	BOER4			S
5	N				S	30	YUEL	HL			S
6	BOER4				LC	31	BOER4				S
7	N	HL			S	32	N				R
8	N				S	33	BOER4	PG02			S
9	BOER4				S	34	N	HL			S
10	BOER4	HL			S	35	BOER4				S
11	BOER4	HL			S	36	BOER4	HL			BOER4
12	BOER4				S	37	BOER4	HL			S
13	N				S	38	BOER4	HL			S
14	BOER4				S	39	N				S
15	N	HL			S	40	N	HL			S
16	N				R	41	BOER4				S
17	BOER4				S	42	PRGL	AFO1			S
18	BOER4				BOER4	43	PRGL				S
19	N				R	44	AFO1				S
20	BOER4				S	45	N				S
21	BOER4				S	46	BOER4				S
22	AFO1				S	47	BOER4				BOER4
23	BOER4	HL			S	48	BOER4	HL			S
24	N	HL			S	49	N	HL			S
25	N	HL			S	50	BOER4	GUSA			S

% foliar cover = 34 top layer pts (1st col) x 2 = 68 %
% bare ground* = 5 pts (w/N over S) x 2 = 10 %
% basal cover = 4 plant base pts (last col) x 2 = 8 %

* For NRI, bare ground occurs ONLY when Top layer = N, Lower layers are empty (no litter), and Soil surface = S or CY.

Top layer codes: Species code or N (no cover).
Lower layers codes: Species code or HL (herbaceous litter), WL (woody litter, > 5 mm (~1/4 in) diameter), NL (non-vegetative litter), VL (vagrant lichen).

UNKNOWN SPECIES CODES:

AF# = annual forb
PF# = perennial forb
AG# = annual graminoid
PG# = perennial graminoid
SH# = shrub
TR# = tree

SOIL SURFACE (DO NOT USE LITTER):

R = Rock** (≥ 5 mm or ~ 1/4 in diameter)
BR = Bedrock
D = Duff
M = Moss
LC = Visible lichen on soil
S = Soil

** Optional: use rock fragment classes in place of "R": GR (5-76 mm), CB (76-250 mm), ST (250 mm-600 mm), BY (>600 mm)

Data entry SAS **Date** 10/17/2002 **Error check** JMP **Date** 10/18/2002

Figure E-64. Photo point.

E. Other Uses of NRCS Grazing Land Inventory, Monitoring and Assessment Data

(1) Inventory, assessment, and monitoring data can be used to study conservation treatment effects, to establish the baseline data for monitoring and determine resource concerns, and for other uses including:
- (i) coordinating grazing history, stocking rate, and animal performance records in determining guides to initial stocking rates
- (ii) development of ecological site description and preparing soil survey manuscripts
- (iii) studies of conservation practice treatment effects
- (iv) analyzing wildlife habitat values
- (v) planning watershed and river basin projects
- (vi) assisting and training landowners and operators in monitoring vegetation trends and the impact of applied conservation practices and programs
- (vii) exchanging information with research institutions and agencies
- (viii) preparing guides and specifications for recreation developments, beautification, natural landscaping, roadside planting, and other developments or practices
- (ix) directing Plant Material Center program activities
- (x) developing modeling tools and identifying potential climate smart grazing practices
- (xi) helping direct policy

(2) Data collected during inventories, assessments and monitoring activities can be used for ecological site description development. However, data collected for ecological site descriptions is more extensive than data for conservation planning inventories. Ecological site development requires collection of biomass data, a review of local history related to a reference plant community and are correlated to a specific soil component. The National Ecological Site Handbook describes the tiers of data required for provisional, approved and correlated ecological site products.

(3) The Conservation Effects Assessment Project (CEAP) quantifies the environmental effects of conservation practices and programs. The process includes research, modelling, assessment, monitoring and data collection.

(4) The National Resources Inventory (NRI) Grazingland On-site Study collects and produces scientifically credible information on the status, condition, and trends of land, soil, water, and related resources on the Nation's non-federal lands in support of efforts to protect, restore, and enhance the lands and waters of the United States.

(5) Through the National Environmental Protection Act (NEPA) requirements. NRCS data is used to determine and document the environmental effects of conservation decisions through the NRCS Environmental Effects policy.
(6) Hydrologic model development is an important activity in NRCS that requires data collection from a unique set of variables including plant cover and slope. The Rangeland Hydrology and Erosion Model (RHEM) is used to assess erosion risk on rangeland.

645.0519 References

A. Aase, J. K., and J. R. Wight. 1973. Prairie sandreed (*Calamilvilfa longifolia*): water infiltration and use. Journal of Range Management 26: 212–214.

B. Abrahams, A.D., A.J. Parsons, and J. Wainwright. 1995. Effects of vegetation change on interrill runoff and erosion, Walnut Gulch, southern Arizona. Geomorphology 13: 37–48.

C. Aldon, E. F., R.E. Francis. Research Note RM-438 A Modified Utilization Gauge for Western Range Grasses. USDA Forest Service. Rocky Mountain Forest and Ragne Experiment Station. 1984.

D. Allison, C.D., Terrell T. Baker, J.C. Boren, B.D. Wright, A. Fernald. 1951, 1961. Report 53 Monitoring rangelands in New Mexico, range, riparian, erosion, water quality and wildlife. NMSU Range Improvement Task Force.

E. Allred, B.W., B.T. Bestelmeyer, C.S. Boyd, C.Brown, K.W.Davies, M.C.Duniway, L.M. Ellsworth, T.A. Erickson, S.D. Fuhlendorf, T.V. Griffiths, V. Jansen, M.O. Jones, J. Karl, A. Knight, J.D. Maestas, J.J. Maynard, S.E. McCord, D.E. Naugle, H.D. Starns, D. Twidwell, D.R. Uden. 2021. Improving Landsat predictions of rangeland fractional cover with multitask learning and uncertainty. Methods Ecol. Evol. https://doi.org/10.1111/2041-210x.13564

F. Anderson, E.W. 1974. Indicators of soil movement on range watersheds. Journal of Range Management 27: 244–247.

G. Bailey, D.W. 2004. Management strategies for optimal grazing distribution and use of arid rangelands. Journal of Animal Science 82: 147–153.

H. Barnes, R.F., C.J. Nelson, M. Collins, and K.J. Moore. 2003. Forages: An introduction to grassland agriculture (Vol. 1). Ames, IA: Iowa State University Press.

I. Bern, C., P. Block, R. Brozka, W. Doe, M. Easter, D. Jones, M. Kunze, G. Senseman & W. Sprouse. RTLA Technical Reference Manual: Ecological Monitoring on Army Lands 1–3 (2006). Fort Collins, CO; Colorado State University.

J. Blackburn, W.H. 1975. Factors influencing infiltration and sediment production of semi-arid rangelands in Nevada. *Water Resources Research* 11: 929–937.

K. Blackburn, W.H. 1984. Impacts of grazing intensity and specialized grazing systems on watershed characteristics and responses. In: Developing strategies for rangeland management. National Research Council/National Academy of Sciences. p. 927–983 Boulder. Colorado: Westview Press.

L. Blackburn, W.H. and C.M. Skau. 1974. Infiltration rates and sediment production of selected plant communities and soils of Nevada. *Journal of Range Management* 27: 476–480.

M. Blackburn, W.H., F.B. Pierson, and M.S. Seyfried. 1990. Spatial and temporal influence of soil frost on infiltration and erosion of sagebrush rangelands. Water Resources Bulletin 26: 991–997.

N. Blackburn, W.H., F.B. Pierson, C.L. Hanson, T.L. Thurow, and A.L. Hanson. 1992. The spatial and temporal influence of vegetation on surface soil factors in semiarid rangelands. Transactions of the ASAE 35: 479–486.

O. Blackburn, W.H., T.L. Thurow, and C.A. Taylor. 1986. Soil erosion on rangeland. Symposium on the use of cover, soils, and weather data in rangeland monitoring, Orlando, Florida, February 12, 1986. Texas Agr. Experiment Station TA-2119.

P. Burkett, L. 2021. *Monitoring discussion*. USDA ARS Jornada Experimental Research Station.

Q. Burton, T.A., S.J. Smith, and E.R. Cowley. 2011. Riparian area management: Multiple indicator monitoring (MIM) of stream channels and streamside vegetation. Technical Reference 1737–23. BLM/OC/ST-10/003+1737. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver, CO. 155 pp.

R. Cadaret, E.M., K.C. McGwire, and S.K. Nouwakpo. 2016a. Vegetation canopy cover effects on sediment erosion processes in the Upper Colorado River Basin Mancos Shale Formation, Price, Utah. Catena 147: 334–344.

S. Cadaret, E.M., S.K. Nouwakpo, and K.C. McGwire. 2016b. Vegetation effects on soil, sediment erosion, and salinity transport processes in the Upper Colorado River Basin Mancos Shale formation. Catena 147: 650–662.

T. Chambers, J.C. 1983. Measuring Species Diversity on Revegetated Surface Mines: An Evaluation of Techniques. United States Department of Agriculture, Forest Service, Mines and Mineral Resources. Paper 1.

U. Chambers, J.C., J.B. Maestas, D.A. Pyke, C.S. Boyd, M. Pellant, and A. Wuenschel. 2017. Using resilience and resistance concepts to manage persistent threats to sagebrush ecosystems and greater sage-grouse. Rangeland Ecology and Management 70: 149–164.

V. Chanasyk, D.S., and M.A. Naeth. 1995. Grazing impacts on bulk density and soil strength in the foothills fescue grasslands of Alberta, Canada. Canadian Journal of Soil Science: 551–557.

W. Cole, D.N. 1985. Recreational trampling effects on six habitat types in western Montana. Research Paper INT-350. U.S. Department of Agriculture, U.S. Forest Service, Intermountain Research Station, Ogden, UT.

X. Coulloudon, B., K. Eshelman, J. Gianola, N. Habich, L. Hughes, C. Johnson, M. Pellant, P. Podborny, A. Rasmussen, B. Robles, P. Shaver, Spehar, J. Willoughby. 1999. (1999). Sampling vegetation attributes*:* Interagency technical reference 1734-4. Bureau of Land Management National Business Center, Denver, CO.

Y. Coulloudon, B., K. Eshelman, J. Gianola, N. Habich, L. Hughes, C. Johnson, M. Pellant, P. Podborny, A. Rasmussen, B. Robles, P. Shaver, Spehar, J. Willoughby. 1999. Utilization studies and residual measurements-Interagency technical reference 1734-3. Bureau of Land Management National Business Center, Denver, CO.

Z. Daubenmire, R. 1968. Plant communities, a textbook of plant synecology. New York, NY: Harper & Row.

AA. Dee, R.F., T.W. Box, and E. Robertson. 1966. Influence of grass vegetation on water intake of Pullman silty clay loam. Journal of Range Management 1: 77–79.

AB. Dickard, M., M. Gonzalez, W. Elmore, S. Leonard, D. Smith, S. Smith, J. Staats, P. Summers, D. Weixelman, S. Wyman. 2015. Riparian area management: Proper functioning condition assessment for lotic areas. Technical Reference 1737-15. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver, CO.

AC. Fults, G. 2017. Ecological Sciences 190-Guidance on the use of vegetation (utilization) exclosures. Draft 06-17 NRCS West National Technology Support Center, Portland OR.

AD. Gifford, G.F. 1984. Vegetation allocation for meeting site requirements. In Developing Strategies for Rangeland Management. p. 35–116. National Research Council, National Academy of Sciences. Boulder, Colorado: Westview Press.

AE. Gifford, G.F. 1985. Cover allocation in rangeland watershed management (a review). In: Jones, E.B., Ward, T.J. (Eds.), Watershed Management in the Eighties, Proceedings of a Symposium. ASCE, pp. 23–31.

AF. Gonzalez, M.A. and S.J. Smith. 2020. Riparian area management: Proper functioning condition assessment for lentic areas. 3rd ed. Technical Reference 1737-16. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver, Colorado.

AG. Habich, E.F. 2001. Inventory and Monitoring Technical Reference 1734-7 Ecological Site Inventory. US. Dept of the Interior, Bureau of Land Management National Business Center, Denver, CO. 35–46.

AH. Hanson, C.L., A.R. Kuhlman, and J.K. Lewis. 1978. Effect of grazing intensity and range condition on hydrology of western South Dakota ranges. South Dakota State University Agr. Experiment Station. Bull. 657.

AI. Hassink, J., L.A. Bouwman, K.B. Zwart, and L. Brussaard. 1993. Relationships between habitable pore space, soil biota, and mineralization rates in grassland soils. Soil Biology and Biochemistry 25: 47–55.

AJ. Herrick, J.E., Justin W. Van Zee, K.M. Havstad, L.M. Burkett, & W.G. Whitford. 2009. Monitoring manual for grassland, shrubland, and savanna ecosystems (Vol. II). Essay, USDA - ARS Jordana Experimental Range.

AK. Hillel, D. 1998. Environmental Soil Physics. San Diego: Academic Press.

AL. Holechek, J.L., R.D. Pieper, and C.H. Herbel. 2004. Range management principles and practices. Englewood Cliffs New York: Prentice Hall.

AM. Hooper, J.F., J.P. Workman, J.B. Grumbles, and C.W. Cook. 1969. Improved livestock distribution with fertilizer: A preliminary economic evaluation. Journal of Range Management 22: 108–110.

AN. Johnson, J.W. 1976. Similarity indices I: What do they measure. BNWL-2152, NRC-1. Richland Washington, Batelle Pacific Northwest Laboratories.

AO. Johnson, C.W., and N. E. Gordon. 1988. Runoff and erosion from rainfall simulator plots on sagebrush rangeland. Transactions of the American Society of Agricultural Engineers 31: 421–427. Johnson, J.W. 1976. Similarity indices I: What do they measure. BNWL-2152, NRC-1. Richland Washington, Batelle Pacific Northwest Laboratories.

AP. Krebs, C.J. 2014. Ecological Methodology 3rd ed. San Francisco, California, Benjamin-Cummings Publishing Company.

AQ. Jones, M.O., N.P. Robinson, D.E. Naugle, J.D. Maestas, M.C. Reeves, R.W. Lankston, B.W. Allred. 2021. Annual and 16-Day Rangeland Production Estimates for the Western United States. Rangeland Ecol. Manage. 77, 112–117.

AR. Kingery, James L., C. Boyd, and Peggy E. Kingery. 1992. The Grazed-Class Method to Estimate Forage Utilization on Transitory Forest Rangelands. Station Bulletin 54 of the Idaho Forest, Wildlife and Range Experiment Station, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, Idaho 83843.

AS. Legendre, P., and L. Legendre. 2012. Numerical ecology. Elsevier, Amsterdam.

AT. Martin, S.C., and H.L. Morton. 1993. Mesquite control increases grass density and reduces soil loss in southern Arizona. Journal of Range Management 46: 170–175.

AU. Mazurak, A.P., and E.C. Conrad. 1959. Rates of water entry in three great soil groups after seven years in grasses and small grains. Agronomy Journal 51: 264–267.

AV. Mazurak, A.P., W. Kriz., and R.E. Ramig. 1960. Rates of water entry into a chernozem soil as affected by age of perennial grass sods. Agronomy Journal 52: 35–37.

AW. Moffet, C., Reuter, R., and Rogers, J, 2012. Using a Plate Meter to Measure Forage Productivity. Noble. AG News and Views Monthly Publication. 1–2.

AX. Mueller-Dombois, Dieter & Ellenberg, Heinz. (1974). Aims and methods of vegetation ecology. 10.2307/213332.

AY. Ogles, K., V. Shelton, G. Brann, B. Brazee, M. Chaney, J. Claasen, J. B. Daniel, S. Goslee, S. Morris, J. Parry, J. Pate, B. Pillsbury, K. Sonnen, R. Staff, D. Toledo, & S. Woodruff. 2020. Natural resources conservation service guide to pasture condition scoring. (K. Vance, Ed.) (2nd ed.). Natural Resources Conservation Service.

AZ. Osborn, B. 1950. Range cover tames the raindrop. A summary of range cover evaluations, 1949. Soil Conservation Service, Fort Worth, Texas.

BA. Pearse, C.K., and S B. Wooley. 1936. The influence of range plant cover on the rate of absorption of surface water by soils. Journal of Forestry 34: 844–847.

BB. Pellant, M., P.L. Shaver, D.A. Pyke, J.E. Herrick, F.E. Busby, G. Riegel, N. Lepak, E. Kachergis, B.A. Newingham, and D. Toledo. 2020. Interpreting indicators of health, Version rangeland 5. Tech 7 Ref 1734-6. Denver, CO: U.S. Department of the Interior, Bureau of Land Management, National Operations Center.

BC. Perryman, B. L., L.B. Bruce, P.T. Tueller, & S.R. Swanson. 2004. Rancher's monitoring guide educational Bulletin 06-04. University of Nevada Cooperative Extension.

BD. Phelan, P., A.P. Moloney, E.J. McGeough, J. Humphreys, J. Bertilsson, E.G. O'Riordan, and P. O'Kiely. 2015. Forage legumes for grazing and conserving in ruminant production systems. Critical Reviews in Plant Sciences 34: 281–326.

BE. Pierson, F., and C. Williams. 2016. Ecohydrologic impacts of rangeland fire on runoff and erosion: A literature synthesis. Gen. Tech. Rep. RMRS-GTR-351. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

BF. Pierson, F.B., C.J. Williams, S.P. Hardegree, and M.A. Weltz. 2011. Fire, plant invasions, and erosion events on western rangelands. Rangeland Ecology and Management 64: 439–449.

BG. Pierson, F.B., K E. Spaeth, M.A. Weltz., and D.H. Carlson. 2002. Hydrologic response of diverse western rangelands. Journal of Range Management 55: 558–570.

BH. Pyke, D.A. 1995. Population diversity with special reference to rangeland plants. pp: 21–32. In: West, N.E., ed. Biodiversity of rangelands. Natural Resources and Environmental Issues, Vol. College of Natural Resources, Utah State University, Logan, UT.

BI. Rauzi, F., C.L. Fly, and E.J. Dyksterhuis. 1968. Water intake on midcontinental rangelands as influenced by soil and plant cover. USDA Tech. Bull. No. 1390, Washington, D.C.

BJ. Renken, W. 2021. Ecological site 041XC313AZ Loamy Upland 12"–16" p.z. USDA NRCS Soil Survey: 162–173.

BK. Sanderson, M.A., R.H. Skinner, D.J. Barker, G.R. Edwards, B.F. Tracy, and D.A. Wedin. 2004. Plant species diversity and management of temperate forage and grazing land ecosystems. Crop Science 44: 1132–1144.

BL. Sanderson, M.A., S.C. Goslee, K.J. Soder, R.H. Skinner, B.F. Tracy, and A. Deak. 2007. Plant species diversity, ecosystem function, and pasture management—A perspective. Canadian Journal Plant Science 87: 479–487.

BM. Selby M.J. 1993. Hillslope Materials and Processes. Oxford: Oxford University Press.

BN. Smith, L., G. Ruyle, J. Dyess, W. Meyer, S. Barker, C.B.D. Lane, S.M. Williams, J.L. Maynard, D. Bell, D. Stewart, and A.B. Coulloudon. (2012). In guide to rangeland monitoring and assessment, basic concepts for collecting, interpreting, and use of rangeland data for management planning and decisions (pp. 1–4). introduction, Arizona Grazing Lands Conservation Association.

BO. Smith, R., Panciera, M., Probst, A. 2010. Using a grazing stick for pasture management. University of Kentucky. 1–4. Lexington, KY: Cooperative Extension.

BP. Sneath, P.H. and Sokal, R.R. (1973) Numerical Taxonomy: The Principles and Practice of Numerical Classification. 1st Edition, W. H. Freeman, San Francisco.

BQ. Society for Range Management. 1998. Glossary of terms used in range management, fourth edition. https://global rangelands.org/glossary.

BR. Spaeth, K. E., Pierson, F. B., Weltz, M. A., and J.B. Awang. 1996a. Gradient analysis of infiltration and environmental variables as related to rangeland vegetation. Transactions of the ASAE 39: 67–77.

BS. Spaeth, K.E. 2020. Soil health on the farm, ranch and in the garden. Springer Nature, Switzerland.

BT. Spaeth, K.E., F.B. Pierson, M.A. Weltz, and G. Hendricks eds. 1996b. Grazingland hydrology issues: perspectives for the 21st century. Denver, Colorado: Society for Range Management.

BU. SRM (Society for Range Management). 1999. A glossary of terms used in range management. Society for Range Management. Denver, CO.

BV. Svejcar, T., J. James, S. Hardegree, and R. Sheley. 2014. Incorporating plant mortality and recruitment into rangeland management and assessment. Rangeland Ecology and Management 67: 603–613.

BW. Swanson, S.R., and J.C. Buckhouse. 1984. Soil and nitrogen loss from Oregon lands occupied by three subspecies of big sagebrush. Journal of Range Management 37: 298–302.

BX. Synman, H.A., and W.L.J. Van Rensburg. 1986. Effect of slope and plant cover on runoff, soil loss and water use efficiency of natural veld. Grassland Society South Africa 3,4: 153–158.

BY. Thurow, T.L. 1991. Hydrology and erosion. In Grazing management: an ecological perspective, eds. R.K. Heitschmidt and J.W. Stuth. p. 141–159. Portland Oregon: Timber Press.

BZ. Thurow, T.L., W.H. Blackburn, and C.A. Taylor Jr. 1988. Infiltration and interrill erosion responses to selected livestock grazing strategies, Edwards Plateau, Texas. Journal of Range Management 296–302.

CA. Thurow, T.L., W.H. Blackburn, and C.A. Taylor, Jr. 1986. Hydrologic characteristics of vegetation types as affected by livestock grazing systems, Edwards Plateau, Texas. Journal of Range Management 39: 505–509.

CB. Toevs, G. R., J.W. Karl, J.J. Taylor, C.S. Spurrier, M.R. Bobo, & J.E. Herrick. 2011. Consistent indicators and methods and a scalable sample design to meet assessment, inventory, and monitoring information needs across scales. Rangelands, 33(4), 14–20.

CC. Toledo, D., M. Sanderson, S. Goslee, J. Herrick, and G. Fults. 2016. An integrated Grazingland assessment approach for range and pasturelands. Journal of Soil and Water Conservation 71: 450–459.

CD. USDA NRCS. 2021. National resources inventory grazing land on-site data collection, Handbook of instructions, Iowa State University of Science and Technology. https://grazingland.cssm.iastate.edu/reference-materials

CE. USDA Agricultural Research Service, University of Idaho, Bureau of Land Management, and Idaho Chapter of the Nature Conservancy, Vegetation Measurement and Monitoring, The Landscape Toolbox. Accessed August 24, 2021.

CF. USDA-NRCS. 1997. National range and pasture handbook. Washington, DC.

CG. USDA-NRCS. 2001. Pasture condition scoresheet. 2001. Grazingland Technology Institute, Ft. Worth, Texas.

CH. USDA-NRCS. 2006. Title 190 National range and pasture handbook. Washington, DC.

CI. USDA-NRCS. 2017. National Ecological Site Handbook. Washington, D.C.

CJ. USDA-NRCS. 2020 Guide to pasture condition scoring, January 2020. Washington, DC.

CK. USDA-NRCS National Grazingland Team (NGLT). 2021. Central National Technical Support Center, Fort Worth, Texas

CL. USDA-NRCS. 2020 Title 180 National planning procedures handbook (NPPH), Amend 8 Washington, DC; USDA Target Center, 23–44.

CM. USDA-NRCS. 2020. National Resources Concern List and Planning Criteria. Washington DC; USDA Target Center.

CN. USDA-NRCS. Montana. 2011 Rangeland utilization monitoring video, Montana.

CO. Wallace, L.L. 1987. Effects of clipping and soil compaction on growth, morphology and mycorrhizal colonization of *Schizachyrium scoparium*, a C4 bunchgrass. Oecologia 72: 423–428.

CP. Warren, S.D., T.L. Thurow, W.H. Blackburn, and N.E. Garza. 1986. The influence of livestock trampling under intensive rotation grazing on soil hydrologic characteristics. Journal of Range Management 39: 491–495.

CQ. Webb, R.H., and H.G. Wilshire, eds. 1983. Environmental effects of off-road vehicles: Impacts and management in arid regions. New York: Springer-Verlag.

CR. Weltz, M., and K. Spaeth. 2012. Estimating effects of targeted conservation on nonfederal rangelands. Rangelands 34: 35–40.

CS. Weltz, M.A., M.R. Kidwell, and H. Dale Fox. 1998. Influence of abiotic and biotic factors in measuring and modeling soil erosion on rangelands: State of knowledge. Soil Erosion on Rangeland. Journal of Range Management. 51:482–495.

CT. West National Technology Support Center, & Boyer, K., Stream visual assessment protocol version 31–75 (2009). Washington, DC; U.S. Dept. of Agriculture, Natural Resources Conservation Service.

CU. Whittaker, R.H. 1975. Communities and ecosystems 2nd ed. New York: Macmillan Publ. Co.

CV. Wilcox, B.P., and M.K. Wood. 1989. Factors influencing interrill erosion from semiarid slopes in New Mexico. Journal of Range Management 42: 66–70.

CW. Willat, S.T., and D.M. Pullar. 1984. Changes in soil physical properties under grazed pastures. Australian Journal of Soil Research 22: 343–348.

CX. Williams C.J., F.B. Pierson, K.E. Spaeth, J.R. Brown, O.Z. Al-Hamdan OZ, M.A. Weltz, M.A. Nearing, J.E. Herrick, J. Boll, P.R. Robichaud, D.C. Goodrich, P. Heilman, D.P. Guertin, M. Hernandez, H. Wei, S.P. Hardegree, E.K. Strand, J.D. Bates, L.J. Metz, and M.H. Nichols. 2016. Incorporating hydrologic data and ecohydrologic relationships into ecological site descriptions. Rangeland Ecology and Management 69: 4–19.

CY. Williams, C.J., F.B. Pierson, P.R. Robichaud, and J. Boll. 2014. Hydrologic and erosion responses to wildfire along the rangeland-xeric forest continuum in the western US: a review and model of hydrologic vulnerability. Int. Journal Wildland Fire 23: 155–172.

CZ. Wood, J.C., and M. Karl Wood. 1988. Infiltration and water quality on a range site at Fort Stanton, New Mexico. Water Res. Bull. 24: 317–323.

DA. Wood, M.K., and W.H. Blackburn. 1981. Grazing systems: their influence on infiltration rates in the rolling plains of Texas. Journal of Range Management 34: 331–335.

645.0520 Appendices

Appendix E-A – Forest Land Evaluations

Appendix E-B – Example Ecological Site Description

Appendix E-C – Study and Photograph Identification

Appendix E-D – NRCS Oregon Range Technical Note No. 27

APPENDIX E-A – Forest Land Evaluations

EXHIBIT E-A-1. Grazable Forest Land Evaluation

ECS-4

U.S. Department of Agriculture ECS-4
Natural Resources Conservation Service
GRAZABLE FOREST LAND EVALUATION

Date: Recorded By: Map Unit: Photo No.: Location:

Ecological Site (Habitat Type, etc.):

Soil Group: ______________________ Canopy: __________________

Slope %: 0.00%__________ Distance to Water:________

No. Roads & Trails Through: __________________ No. Water Developments: __________________

Mechanical Barriers: ______________________ Aspect: ______________________

Use History:

Weed Infestations:

Critical Erosion or Sediment Sources:

Wildlife:

TREE REGENERATION		PLOT SIZE:		
SPECIES	**DBH 0–1"**	**DBH 1–2"**	**DBH 2–3"**	**DBH 3–4"**

Ecological Status Rating: ______________________ Forage Value Rating:______________________

Initial Stocking Rate:______________________ Grazability Factor (%): 0.00%______________

Adjusted Stocking Rate:______________________

Exhibit E-A-2. Forest Land Status and Condition Record

ECS-4 Page 2
U.S. Department of Agriculture ECS-4
Natural Resources Conservation Service

SPECIES	% Composition by Weight	% Counted as Climax	GRAZING PREFERENCE C S D E			% Counted for FVR	Cover %	Average Height
			P	D	N			
GRASSES AND GRASSLIKE: (PLANT GROUP WT. %)	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
FORBS: (PLANT GROUP WT. %)	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
WOODY PLANTS: (PLANT GROUP WT. %)	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
	0.00%	0.00%				0.00%	0.00%	
Percent Composition	0.00%	0.00%				0.00%	0.00%	

EXHIBIT E-A-3. Soil-Woodland Correlation Field Data Sheet

Vigor________________________________ % Bare Soil________________________________

Topography (pick one)____________________ Horizontal Configuration______________________

Topography		Horizontal Configuration	
	1- Ridge		1- Convex (dry)
	2 Upper Slope		2 Straight
	3 Mid Slope		3 Concave (wet)
	4 Lower Slope		4 Undulating
	5 Bench or Flat		

ECS-5 page 1

U.S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

SOIL--WOODLAND CORRELATION FIELD DATA SHEET

ECS-5
08-07

N W E S

Sec. ____
Twp. ____
Rge. ____

Date __________ County __________ State ________ Location ____________________

Date By ____________________

	PLOT NUMBER				COVER TYPE NO. (SAF)	MAJOR LAND RESOURCE AREA		STATE PLANE COORDINATES		OR	SECTION, TOWN-SHIP, RANGE		ELEVATION	CARD IDENTIFICATION
	Site	Yr.	St.	Cnty		Number	Subdiv.	Zone No. / Sec.	East (X)	Town-ship	North (Y)	Range	(feet)	
LOCATION														

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

	PRECIPITATION (INCHES)		LAND-FORM	SLOPE						POSITION ON SLOPE	CARD IDENTIFICATION
	Annual	Summer	(code)	Percent	Kind (code)	Shape (code)	Micro-Relief (code)	Aspect Degr. of Azimuth	Approximate Length (feet)	(code)	
PHYSICAL											

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

	DETAILED PROFILE DESCR.	DETAILED UNDER-STORY	MENSUR. INFORM.	SOIL SERIES NAME	TEXTURE		PAST EROSION	DRAINAGE CLASS	ALTERED WATER RELA-TIONS	CARD IDENTIFICATION
	(Y or N)	(Y or N)	(Y or N)	(Print name in full)	Modifier (code)	Type (code)	(code)	(No.)		
SOIL										

SOIL PROFILE DESCRIPTION by Soil Scientist: ____________________

Hori-zon	Depth	Color		Texture	Structure	Consistence			Reac-tion	Boundary
		Dry	Moist			Dry	Moist	Dry		

NOTES:

Underlying material: ____________________

Clear Form

ECS-5 page 2

SITE	YEAR	STATE	COUNTY	PLOT NUMBER (Identification only)	0 1" 2"

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

	Scientific Plant Name Symbol	Crown Class.	Tree Origin	Tree Diameter	In. Rad. Last 10 Yr.	Rings, Pith to 1.5 in.	AGE ESTIMATION Ht. Ring Ct.	No. of Rings	Mea.Pt. Age	Total Age	Total Height	CARD IDENTIFICATION
TREE 1												
TREE 2												
TREE 3												
TREE 4												
TREE 5												
TREE 6												
TREE 7												
TREE 8												
TREE 9												
TREE 10												
TREE 11												
TREE 12												

(two woodcrops per line)	Scientific Plant Name Symbol	Number of Trees	Site Index Curve Number	Aver. Plot Site Index	Scientific Plant Name Symbol	Number of Trees	Site Index Curve Number	Aver. Plot Site Index	
INDEX									
INDEX									

	UNDERSTORY ABUNDANCE Rate Each by Code				STAND DENSITY (CANOPY)		BASAL AREA Sq. Ft. per Acre		CROWN COMPETITION FACTOR		
	Reprod.	All Woody	Grasses, Forbs	Mosses, Lichens	M. or E.	Percent	M. or E.	Sq. Ft.	(applies only to lodgepole pine)		
DENSITY											

(four species per line)	Scientific Plant Name Symbol	Percent	Scientific Plant Name Symbol	Percent	Scientific Plant Name Symbol	Percent	Scientific Plant Name Symbol	Percent	
CANOPY									
CANOPY									
CANOPY									

(four species per line)	Scientific Plant Name Symbol	Rating	Scientific Plant Name Symbol	Rating	Scientific Plant Name Symbol	Rating	Scientific Plant Name Symbol	Rating	
GROUND									
GROUND									
GROUND									

	Essential remarks only. If detailed understory or mensurational information recorded, identify the cooperating agency or plot number. Print letters between tick marks.	
REMARKS		
REMARKS		
REMARKS		

Appendix E-B. Example Ecological Site Description: Loamy Upland 12"–16" p.z. 041XC313AZ

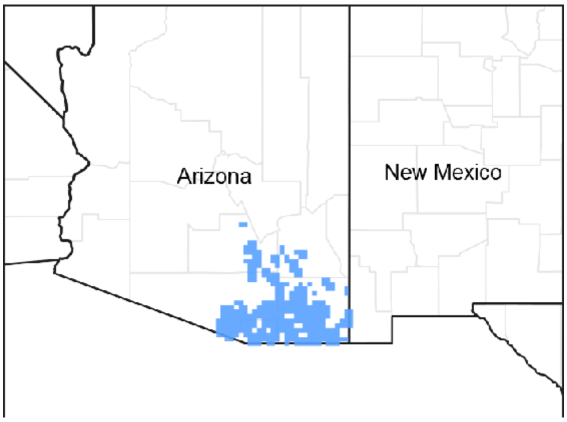
USDA

Ecological site 041XC313AZ
Loamy Upland 12"–16" p.z.
Last update: 4/12/2021
Accessed: 07/14/2021

General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state-and-transition model and enough information to identify the ecological site.

Figure E-B-1. Mapped extent.



Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 041X–Southeastern Arizona Basin and Range

Major Land Resource Area (MLRA) 41 represents the most northern extent of the Sierra Madre Occidental, or in English, the “mother mountains of the west.” The Sierra Madre Occidental is a massive, rugged mountain system that runs northwest from the Rio Grande de Santiago, in the state of Jalisco, Mexico, through the states of Sonora and Chihuahua, and ending in Arizona and New Mexico. Through Mexico, this mountain system runs parallel to the Pacific coast and, as it crosses into the United States and confronts the tectonic folding and rifting of the Basin and Range Physiographic Province, the land mass geographically breaks into smaller, isolated mountain ranges, called “sky islands.” The centralizing theme for this MLRA can be summed up as a series of inland islands extending from their mainland, the Sierra Madre Occidental, surrounded by a sea of desert grassland. To the west, the Madrean Archipelago bounds the Sonoran Basin and Range where several sky islands in southern Arizona grade into Sonoran Desert basins; to the north it bounds the contiguous mountains and geology of the Mogollon Transition area; and to the east, in New Mexico, it bounds the geology of the Rio Grande Rift. MLRA 41 is primarily a rangeland subdivision with small amounts of irrigated cropland. It encompasses approximately 13M acres.

LRU notes

Land Resource Unit 41-3, Chihuahuan – Sonoran Semidesert Grasslands. Elevations range from 3200 to 5000 feet and precipitation ranges from 12 to 16 inches per year. Vegetation includes mesquite, catclaw acacia, netleaf hackberry, palo verde, false mesquite, range ratany, fourwing saltbush, tarbush, littleleaf sumac, sideoats grama, black grama, plains lovegrass, cane beardgrass, tobosa, vine mesquite, threeawns, Arizona cottontop and bush muhly. The soil temperature regime is thermic and the soil moisture regime is ustic aridic.

Classification relationships

USDA-NRCS Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin: Western Range and Irrigated Region D; Major Land Resource Area 41, Southeastern Arizona Basin and Range; Land Resource Unit 41-3, Semi-Desert Grassland; Ecological Site Loamy Upland, 12"–16" p.z.

U.S. Environmental Protection Agency, Ecological Regions of North America: Level I, Region 12, Southern Semi-Arid Highlands; Level II, 12.1 Western Sierra Madre Piedmont, Level III, Ecoregion 79 Madrean Archipelago, 79a, Apachian Valleys and Low Hills.

USDA-USFS Ecological Subregions: Sections of the Conterminous United States: Section 321 Basin and Range; Section 321A, Basin and Range Section.

Ecological site concept

Loamy Upland, 12"–16" p.z., is found on upland landscapes with deep soils with an argillic horizon underlying loam textured soil or, when the soil above the argillic is sandy loam textured, it is less than 4" thick.

Associated sites

R041XC318AZ	Sandy Loam 12–16" p.z. Deep gently sloping areas with thicker sandy loam surface over argillic subsurface
R041XC314AZ	Loamy Slopes 12–16" p.z. adjacent slopes with deep, non-calcareous soils

Similar sites

R041XA108AZ	Loamy Upland 16–20" p.z. elevation range 4,500–6,500 ft.; precipitation zone 16–20"
R041XB210AZ	Loamy Upland 8–12" p.z. elevation range 2,600–4,500 ft.; precipitation zone 8–12"

Table E-B-1. Dominant plant species.

Tree	Not specified
Shrub	*calliandra eriophylla* *krameria erecta*
Herbaceous	*bouteloua curtipendula* *bouteloua chondrosioides*

Physiographic features

This site occurs in the middle elevations of the Madrean Basin and Range province in southeastern Arizona. It occurs on old fan terraces and old stream terraces.

Climatic features

Precipitation in this common resource area ranges from 12–16 inches yearly in the eastern part with elevations from 3600–5000 feet, and 13–17 inches in the western part where elevations are 3300–4500 feet. Winter-Summer rainfall ratios are 40–60 percent in the west and 30–70 percent in the east. Summer rains fall July-September, originate in the Gulf of Mexico and are convective, usually brief, intense thunderstorms. 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 one day. May and June are the driest months of the year. Humidity is generally very low.

Table E-B-2. Representative physiographic features.

Landforms	Fan piedmont Stream terrace Plain
Flooding frequency	None
Ponding frequency	None
Elevation	3,200–5,000 ft
Slope	1–15%
Aspect	Aspect is not a significant factor

Temperatures are mild. Freezing temperatures are common at night from December-April; however, temperatures during the day are frequently above 50°F. Occasionally in December–February, brief 0°F temperatures may be experienced some nights. During June, July and August, some days may exceed 100°F.

Cool season plants start growth in early spring and mature in early summer. Warm season plants take advantage of summer rains and are growing and nutritious July–September. Warm season grasses may remain green throughout the year.

Table E-B-3. Representative climatic features.

Frost-free period (characteristic range)	164–189 days
Freeze-free period (characteristic range)	193–213 days
Precipitation total (characteristic range)	13–15 in
Frost-free period (actual range)	163–199 days
Freeze-free period (actual range)	192–237 days
Precipitation total (actual range)	13–17 in
Frost-free period (average)	178 days
Freeze-free period (average)	207 days
Precipitation total (average)	15 in

Climate stations used

DOUGLAS [USC00022659], Douglas, AZ
TOMBSTONE [USC00028619], Tombstone, AZ
WILLCOX [USC00029334], Willcox, AZ
NOGALES 6 N [USC00025924], Rio Rico, AZ
PEARCE - SUNSITES [USC00026353], Pearce, AZ

Influencing water features

There are no water features associated with this site.

Soil features

These soils are deep soils which have formed in loamy alluvium of mixed origin. Soil surfaces range from very gravelly sandy loam to loam. Sandy loam surfaces can be no thicker than four inches (eight inches for GRV-SL) and not less than one inch. They are not calcareous in the upper 20 inches. These soils have argillic horizons near the surface. They may have calcic horizons at moderate depths (20 to 40 inches). Plant-soil moisture relationships are fair to good. Soil surfaces are dark colored. Soil series representative of this ecological site are Whitehouse and McAllister; several other series have been correlated to 41-3 Loamy Upland, 12–16” p.z., including among others, Sasabe, Wampoo, Chiricahua, Continental, and Whitehouse GrL.

Table E-B-4. Representative soil features.

Parent material	(1) Alluvium–igneous, metamorphic and sedimentary rock
Family particle size	(1) Clayey
Drainage class	Moderately well drained to well drained
Permeability class	Moderately slow to moderate
Soil depth	60 in
Surface fragment cover <=3"	5–40%
Surface fragment cover >3"	0–15%
Available water capacity (0–40in)	4.8–9.6 in
Calcium carbonate equivalent (0–40in)	1–25%
Electrical conductivity (0–40in)	0–2 mmhos/cm
Sodium adsorption ratio (0–40in)	0–2
Soil reaction (1:1 water) (0–40in)	6.6–8.4
Subsurface fragment volume <=3" (Depth not specified)	5–40%
Subsurface fragment volume >3" (Depth not specified)	0–15%

Ecological dynamics

Loamy Upland, 12"–16" p.z., ecological site is a desert grassland. Plant community variation occurs along the precipitation gradient and with depth to argillic horizon. Perennial grass composition, basal cover, and distribution are affected. At the lower end of the precipitation gradient (and with thin surface horizon over argillic), patches of short-grasses dominate over mid-grasses; while at the high end of the precipitation gradient (and with increased depth to argillic), mid-grasses dominate and bare areas diminish. Fire dynamically maintains the grassland aspect by killing seedling mesquite, other small shrubs, and half shrubs. Larger mesquite and other re-sprouting species are top-killed. Fire effects on perennial grasses will be variable with species, season of burning, and fire intensity. Alternate states arise from removal of fuel and introduction of non-native lovegrasses. Aspect is open grassland.

Land use 1 Rangeland

Rangeland uses of Loamy Upland, 12"–16" p.z., are most commonly livestock grazing, wildlife management and recreation; environmental services are many. Natural disturbances are fire, weather events, natural climatic cycling, and wildlife.

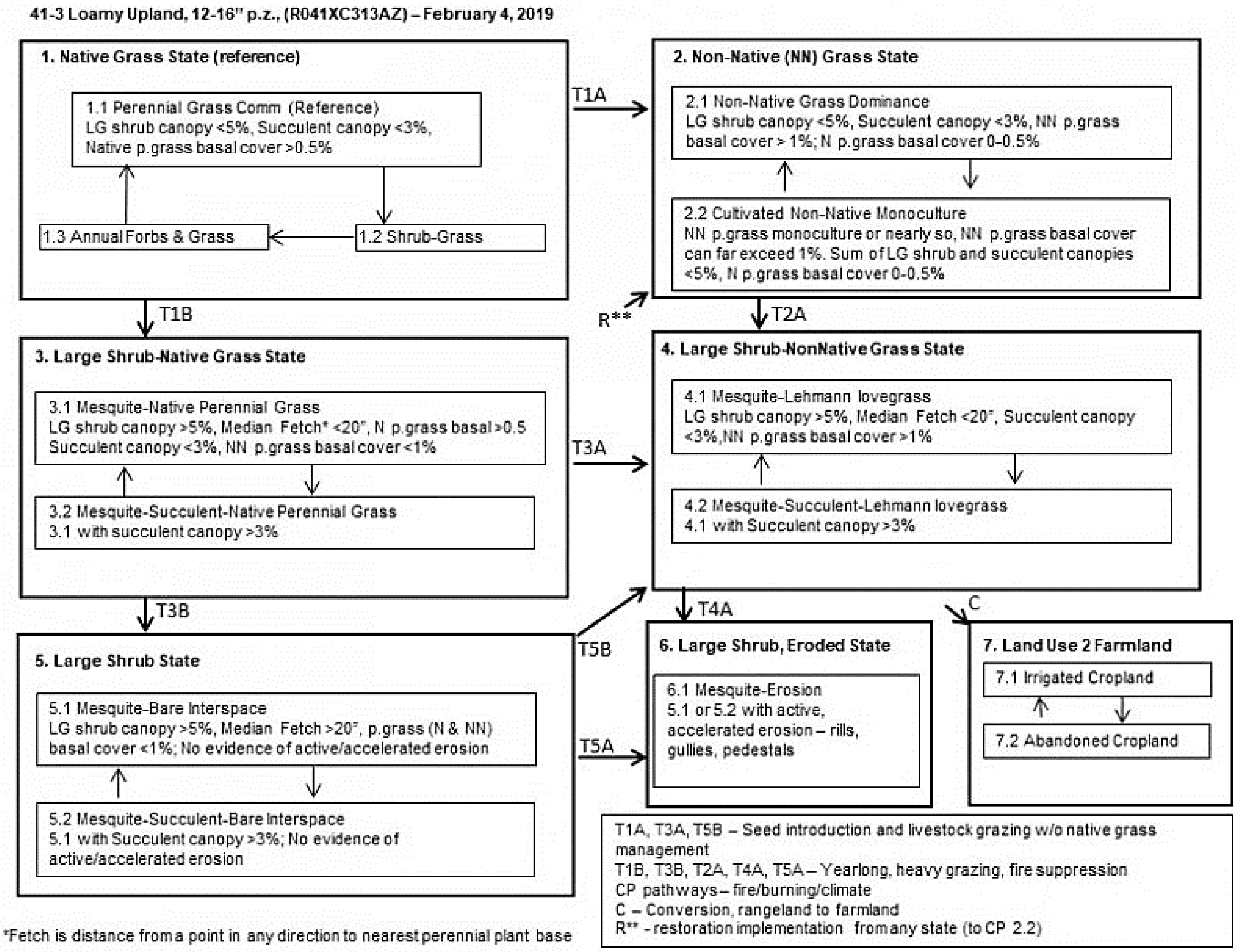
State 1.1

Native Grass (Reference)

The Native Grass (Reference) State is characterized by the open grassland aspect, with a wide variety of native perennial grasses dominating the plant community.

Characteristics and indicators. Native perennial grass basal cover ≥ 0.5 percent, large shrub (mesquite) canopy <5 percent, and succulent canopy <3 percent.

State-and-transition model



Dominant plant species

Velvet mesquite	*Prosopis velutina*	shrub
fairyduster	*Calliandra eriophylla*	shrub
ratany	*Krameria*	shrub
broom snakeweed	*Gutierrezia sarothrae*	shrub

Community 1.1.1 Native Perennial Grass (Reference)		
Blue grama	*Bouteloua gracilis*	grass
Sideoats grama	*Bouteloua curtipendula*	grass
curly-mesquite	*Hilaria belangeri*	grass

Figure E-B-3. Loamy Upland 12"–16" p.z. Dos Cabezas Cemetery.

The potential plant community on this site 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 is open grassland.

With continuous heavy grazing, palatable perennial grasses like blue, hairy, sprucetop and sideoats gramas decrease. Increasers under such circumstances include curly mesquite, threeawns and, in places, false mesquite. With severe deterioration, shrubby species increase to dominate. Loss of porous surface soil causes a reduction in the site's ability to effectively use intense summer rainfall. Natural fire was important in the development of the potential plant community. Stable areas of the site can produce effective herbaceous covers with up to 5 percent canopy cover of mesquite. In areas where half-shrubs dominate the under-story, the potential production of perennial grass is about the same as the present production of half-shrubs once they are removed from the plant community by fire or brush management.

Table E-B-5. Annual production by plant type.

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	546	850	1350
Forb	20	45	225
Shrub/Vine	53	100	210
Tree	0	5	15
Total	619	1000	1800

Table E-B-6. Soil surface cover.

Surface Cover	Percent
Tree basal cover	0–1
Shrub/vine/liana basal cover	1–5
Grass/grasslike basal cover	6–25
Forb basal cover	0–1
Non-vascular plants	0–1
Biological crusts	1–10
Litter	10–60
Surface fragments >0.25" and <=3"	5–40
Surface fragments >3"	0–15
Bedrock	0
Water	0
Bare ground	15–25

Table E-B-7. Canopy structure (percent cover).

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	1–10%	10–25%	0–5%
>0.5 <= 1	–	1–10%	10–25%	0–2%
>1 <= 2	–	0–5%	10–15%	0–2%
>2 <= 4.5	–	0–1%	1–5%	–
>4.5 <= 13	0–1%	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure E-B-4. Plant community growth curve (percent production by month). AZ4134, 41.3 12"–16" p.z. other sites. Growth begins in the spring, semi-dormancy occurs during the May through June drought, most growth occurs during the summer rains.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	5	10	0	0	30	35	15	5	0	0

Community 1.1.2

Small Shrub-Native Grass

The small shrub, decadent grass community phase occurs after several fire-free years and average or above average rainfall period. Perennial grass litter accumulates, and live basal cover may contract. Small shrub population reflects winter moisture dynamics with a flourish of germination and increase canopy cover following wet winters.

Community 1.1.3

Annual Forbs and Grasses

Annual forbs and annual grasses dominate this plant community phase while perennial grasses and half shrubs are diminished after fire or extended drought. This CP is extremely vulnerable to non-native perennial grass germination from a latent soil seedbank.

Pathway P1.1a Community 1.1.1 to 1.1.2

Disturbance free plant growth and decadence.

Pathway P1.2a Community 1.1.2 to 1.1.3

Fire

Pathway P1.3a Community 1.1.3 to 1.1.1

Post-fire regrowth

State 1.2

Non-Native Grass

Non-native lovegrass basal cover is more than 1 percent within the plant community; native perennial grass basal cover is diminished. Large shrubs are scattered with less than 5 percent canopy cover. Fire may act to increase exotic lovegrass at the expense of native perennial grasses but may allow native annual species a chance to make seed and persist in the seedbank. Some soil compaction has occurred due to livestock traffic, but hydrologic relationships have not been impaired

Characteristics and indicators. Large shrub canopy <5 percent; succulent canopy <3 percent; Non-native perennial grass basal cover >1 percent; native perennial grass basal cover 0–5 percent

Dominant plant species

Fairyduster	*Calliandra eriophylla*	shrub
littleleaf ratany	*Krameria erecta*	shrub
Lehmann lovegrass	*Eragrostis lehmanniana*	grass
weeping lovegrass	*Eragrostis curvula*	grass

Dominant resource concerns

Plant productivity and health Plant structure and composition Feed and forage imbalance
Inadequate livestock shelter
Inadequate livestock water quantity, quality, and distribution

Community 1.2.1 Lehmann Lovegrass

A suite of African lovegrasses can become entrenched on this ecological site; Lehmann lovegrass is the most common and has been seen to persist in the plant community once its basal cover exceeds 1 percent. The native perennial grasses can remain until a disturbance, such as drought, fire, yearlong or heavy growing season grazing, depletes vigor or causes perennial grass mortality. Large shrub and succulent canopy percentages are similar to State 1.

Community 1.2.2
Cultivated non-native grass monoculture

Non-native perennial grasses prevail across this LRU, with a seedbank that may or may not be readily apparent on site. A non-native perennial grass monoculture results from application several restoration practices applied to any of Loamy Upland States. Most commonly, brush management or mechanical land treatment (ripping) is applied to remove mesquite dominance and reduce erosion (from States 4 or 5, for example). While species like Lehmann, Boer, Wilman and Cochise lovegrass may be seeded, non-native perennial grasses will likely invade the site regardless because of their overwhelming presence across this LRU. With good grazing management, hydrologic relationships are good and non-native grass productivity remains high (although protein and nutrient values of LL are negligible). Treated areas typically have reduced runoff for long periods of time, depending on grazing management. Mesquite and other shrubs will re-invade these areas making brush management maintenance treatment necessary within 10–15 years.

State 1.3

Large Shrub, Native Grass

Figure E-B-5.

The open aspect is interrupted by large shrubs. The perennial grass community is diminished in diversity and basal cover.

Characteristics and indicators. Large shrub canopy >5 percent, median fetch* <20”, native perennial grass basal cover 0.5 percent, NN p. grass basal cover <1 percent; succulents may or may not be dominant, see CPs.

*Fetch is distance from a point in any direction to nearest perennial plant base

Dominant plant species

velvet mesquite	*Prosopis velutina*	shrub
blue grama	*Bouteloua gracilis*	grass
curly-mesquite	*Hilaria belangeri*	grass

Dominant resource concerns

Feed and forage imbalance

Inadequate livestock water quantity, quality, and distribution

Community 1.3.1

Mesquite, Native Perennial Grass

Mesquite increases in the absence of fire for long periods of time. Native perennial grasses maintain dominance with good grazing management; mesquite canopy levels are from 5 to 10 percent. Short gramas and curly mesquite are dominant and the site remains stable as long as their basal cover does not drop below 6 or 7 percent. Snakeweed and burroweed cycle with climate but never gain dominance. Some soil compaction has occurred due to livestock traffic, but hydrologic relationships are not impaired.

Community 1.3.2

Mesquite, Succulent, Native Perennial Grass

Succulents, once established within the plant community, expand in canopy coverage until removed by fire.

Pathway P3.1a Community 1.3.1 to 1.3.2

Fire-free period

Pathway P3.2a Community 1.3.2 to 1.3.1

Prescribed burning and prescribed grazing.

State 1.4

Large Shrub, Non-native Grass

Large shrubs and non-native lovegrasses are co-dominant. Native perennial grasses may remain intact, generally under large shrub canopies. Non-native perennial grasses include African lovegrasses (most commonly Lehmann and Cochise lovegrasses) and, at the low and high elevations of this LRU, bufflegrass and yellow bluestem, respectively. The large shrubs are resistant to fire mortality and burning will not affect their removal from the plant community. Repeated burning or heavy grazing negatively affects the perennial grasses and puts the site at risk of excessive soil erosion. In these areas, mechanical brush management will likely result in transitioning the site to State 2, with a loss of native grasses, both their productivity and diversity.

Characteristics and indicators. Large shrub canopy >5 percent, median fetch* <20”, NN p. grass basal cover >1 percent; succulent canopy fluctuates, see CPs. Native perennial grass basal cover 0–5 percent.

*Fetch is distance from a point in any direction to nearest perennial plant base

Dominant plant species

velvet mesquite	*Prosopis velutina*	shrub
Lehmann lovegrass	*Eragrostis lehmanniana*	grass
weeping lovegrass	*Eragrostis curvula*	grass
yellow bluestem	*Bothriochloa ischaemum*	grass

Community 1.4.1

Mesquite, Lehmann lovegrass

Community 1.4.2

Mesquite, Succulents, Lehmann lovegrass

State 1.5 Large Shrub

Figure E-B-6.

Mesquite and other large shrubs have increased and are dominant with canopies greater than 5 percent. Native and non-native annual forbs and grasses, both cool and warm season, dominate the under-story. Snakeweed and burroweed cycle with climate, but both remain important in the plant community. Native perennial grasses are largely gone, due to the interactions of drought, fire and continuous, heavy grazing. Areas located close to mountains usually have higher soil cover of cobbles and gravel, thus, exhibit inherent soil and site stability. Hydrologic relationships have changed to increase the amount of runoff. Loamy upland in this State is at risk to transition to State 6 (Large Shrub, Eroded).

Characteristics and indicators. Large shrub canopy >5 percent, Median Fetch* >20”, perennial grass basal cover <1 percent, no evidence of active, accelerated erosion

*Fetch is distance from a point in any direction to nearest perennial plant base

Dominant plant species

velvet mesquite	*Prosopis velutina*	shrub
burroweed	*Isocoma tenuisecta*	shrub
broom snakeweed	*Gutierrezia sarothrae*	shrub

Dominant resource concerns

Plant productivity and health Plant structure and composition Feed and forage imbalance Inadequate livestock water quantity, quality, and distribution

Community 1.5.1 Mesquite, bare interspace

The Mesquite-Bare Interspace Plant community is dominated by mesquite and other large shrubs with and understory of half-shrubs, snakeweed and burroweed; miscellaneous perennial forbs and annuals occur within the confines of the shrubs. Interspaces are open, herbaceous litter is moved by wind and water until obstructed.

Remnant perennial grasses, such as bush muhly and plains bristlegrass, may occur well within protection of shrubs and indicate a seed source. Succulents are not dominant in this community phase.

Community 1.5.2 Mesquite, succulent, bare

The Mesquite-Succulent-Bare Interspace Plant community is dominated by mesquite and other large shrubs with and understory of half-shrubs and succulents (prickly pear and cane cholla). Interspaces are open, herbaceous litter is moved by wind and water until obstructed. Remnant perennial grasses, such as bush muhly and plains bristlegrass, may occur well within protection of shrubs and indicate a seed source. Succulents will continue growth until fine fuels accumulate to carry fire, such as after extremely wet spring flourish of annual forbs.

State 1.6

Large Shrub, Eroded

The Large Shrub, Eroded State is very similar in structure to States 4 and 5 (mesquite dominated, half-shrub understory), however, the soil erosion threshold has been crossed; active, extreme soil loss (exposed argillic horizon, rills, pedestals, gullies) is occurring. Snakeweed and burroweed cycle with climate, but both remain important in the plant community. Native perennial grasses are largely gone, due to the interactions of drought, fire and continuous, heavy grazing. Remnant non-native lovegrasses may be present. Hydrologic relationships are permanently altered. Restoration practices can be applied to slow erosion rates and trap sediments; paired with prescribed grazing, non-native lovegrasses will colonize the site resulting in Plant Community 2.2, Cultivated Lehmann lovegrass Community.

Characteristics and indicators. Large shrub canopy >5 percent, Median Fetch* >20”, perennial grass basal cover <1 percent, active, accelerated erosion as indicted by water flow patterns, litter dams, and rills

*Fetch is distance from a point in any direction to nearest perennial plant base

Dominant resource concerns

Sheet and rill erosion
Plant productivity and health Plant structure and composition Feed and forage imbalance
Inadequate livestock water quantity, quality, and distribution

Community 1.6.1 Mesquite, erosion

Mesquite dominates with active soil erosion in most interspaces (rills, exposed argillic horizon, gullies). Soil surface horizon is largely absent. Annual forbs and grasses are confined to shrubs. This plant community will not produce continuous fine fuels to carry fire.

Transition T1A State 1.1 to 1.2

Seed introduction and livestock grazing w/o native grass management or spontaneous flourish of Lehmann lovegrass establishing from unknown seedbank following fire/drought.

Transition T1B State 1.1 to 1.3

Extended fire-free interval (removal of fire fuel) and community composition changes by heavy, repeated or yearlong livestock grazing.

Transition T2A State 1.2 to 1.4

Extended fire-free interval (removal of fire fuel) and community composition changes by yearlong or heavy livestock grazing.

Restoration pathway R** State 1.3 to 1.2

From any Loamy Upland State, restoration practices applied to remove large shrub dominance or arrest accelerated erosion result in non-native perennial grass (Lehmann lovegrass) dominance.

Conservation practices

Table E-B-7. Conservation practices.

Practice Name
Trails and Walkways
Brush Management
Fence
Grazing Land Mechanical Treatment
Livestock Pipeline
Livestock Use Area Protection
Pond
Pond Sealing or Lining, Bentonite Sealant
Pond Sealing or Lining, Flexible Membrane
Pond Sealing or Lining, Soil Dispersant
Prescribed Burning
Prescribed Grazing
Prescribed Grazing
Pumping Plant
Range Planting
Spring Development
Trails and Walkways
Upland Wildlife Habitat Management
Vegetated Treatment Area
Water Harvesting Catchment
Water Well
Watering Facility

Transition T3A State 1.3 to 1.4

Seed introduction and livestock grazing w/o native grass management.

Transition T4A State 1.4 to 1.6

Yearlong, heavy grazing, fire suppression

Transition T5B State 1.5 to 1.4

Seed introduction and livestock grazing w/o native grass management

Transition T5A State 1.5 to 1.6

Yearlong, heavy grazing, fire suppression

Land use 2 Cropland

Cropland includes areas used for the production of adapted crops for harvest. Two subcategories of cropland are recognized: cultivated and non-cultivated. Cultivated cropland comprises land in row crops or close-grown crops and also other cultivated cropland, for example, hay land or pastureland that is in a rotation with row or close-grown crops. Non-cultivated cropland includes permanent hay land and horticultural cropland. In this MLRA-LRU, cultivated cropland is the more common category of use; all cropland is irrigated. Several row crops and close-grown crops are grown including cotton, corn, chili, and small grains. Hay land crops, alfalfa and bermudagrass, are rotated on a 3 to 5-year cycle.

When cropping and irrigation are suspended, annual forbs and annual grasses will dominate the newly barren field. Common annuals first to come in include Russian thistle, careless weed, and brome. Over time, shrubs and sub-shrubs will establish, initially in low-lying areas and eventually may come to dominate. Native perennial grasses will be largely absent; bermudagrass patches may establish in low-lying areas. Farm field maintenance, periodic tillage, will sustain the barren field with annual forbs and grasses.

After farming, the site may be restored to an area suitable to a grazing use. However, long-lasting changes in soil structure, hydrology, and nutrient availability prevent the site from returning to the Rangeland State-and-transition model. Restoration practices may be implemented to attain achieve land use goals such as increased forage availability. A desired plant community that will persist without continued watering may seeded before cessation of irrigation.

Table E-B-8. Dominant resource concerns.

	Dominant resource concerns
	Sheet and rill erosion
	Wind erosion
	Ephemeral gully erosion
	Classic gully erosion
	Bank erosion from streams, shorelines, or water conveyance channels
	Subsidence
	Compaction
	Organic matter depletion
	Concentration of salts or other chemicals
	Aggregate instability
	Ponding and flooding
	Seasonal high water table
	Ground water depletion
	Naturally available moisture use
	Inefficient irrigation water use
	Nutrients transported to surface water
	Nutrients transported to ground water
	Pesticides transported to surface water
	Pesticides transported to ground water
	Pathogens and chemicals from manure, biosolids, or compost applications transported to surface water Pathogens and chemicals from manure, biosolids, or compost applications transported to ground water
	Salts transported to surface water
	Salts transported to ground water
	Petroleum, heavy metals, and other pollutants transported to surface water
	Petroleum, heavy metals, and other pollutants transported to ground water
	Sediment transported to surface water
	Elevated water temperature
	Emissions of particulate matter (PM) and PM precursors
	Emissions of greenhouse gases (GHGs)
	Emissions of ozone precursors
	Plant productivity and health
	Plant structure and composition
	Plant pest pressure
	Terrestrial habitat for wildlife and invertebrates
	Feed and forage imbalance
	Inadequate livestock shelter
	Inadequate livestock water quantity, quality, and distribution
	Energy efficiency of equipment and facilities
	Energy efficiency of farming/ranching practices and field operations

Conversion C Land use 1 to 2
Conversion from rangeland to cropland, requires extensive input into field and irrigation development.

Additional community tables

Table E-B-9. Community 1.1 plant community composition.

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Dominant Mid Grasses**	**300–500**			
	sideoats grama	BOCU	*Bouteloua curtipendula*	200–500	
	plains lovegrass	ERIN	*Eragrostis intermedia*	50–200	
	cane bluestem	BOBA3	*Bothriochloa barbinodis*	50–200	
2	**Dominant Short Grasses**	**150–300**			
	blue grama	BOGR2	*Bouteloua gracilis*	50–250	
	sprucetop grama	BOCH	*Bouteloua chondrosioides*	50–100	
	black grama	BOER4	*Bouteloua eriopoda*	50–100	
	hairy grama	BOHI2	*Bouteloua hirsuta*	0–50	
	slender grama	BORE2	*Bouteloua repens*	0–50	
	common wolfstail	LYPH	*Lycurus phleoides*	0–50	
3	**Shortlived Grasses**	**20–150**			
	Rothrock’s grama	BORO2	*Bouteloua rothrockii*	10–50	
	curly-mesquite	HIBE	*Hilaria belangeri*	10–50	
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–50	
	Arizona muhly	MUAR3	*Muhlenbergia arizonica*	0–25	
4	**Subdominant Mid Grasses**	**10–150**			
	Arizona cottontop	DICA8	*Digitaria californica*	5–50	
	bush muhly	MUPO2	*Muhlenbergia porteri*	0–50	
	plains bristlegrass	SEVU2	*Setaria vulpiseta*	5–50	
	tanglehead	HECO10	*Heteropogon contortus*	0–40	
5	**Perennial Threeawns**	**50–100**			
	spidergrass	ARTE3	*Aristida ternipes*	5–50	
	spidergrass	ARTEG	*Aristida ternipes var. gentilis*	5–50	
	Fendler threeawn	ARPUL	*Aristida purpurea var. longiseta*	5–50	
	poverty threeawn	ARDI5	*Aristida divaricata*	5–30	
	purple threeawn	ARPU9	*Aristida purpurea*	0–25	
	Parish's threeawn	ARPUP5	*Aristida purpurea var. parishii*	0–25	
	Santa Rita threeawn	ARCAG	*Aristida californica var. glabrata*	0–15	
	Havard's threeawn	ARHA3	*Aristida havardii*	0–10	
	Wooton's threeawn	ARPA9	*Aristida pansa*	0–10	
	Wright's threeawn	ARPUW	*Aristida purpurea var. wrightii*	0–10	
6	**Miscellaneous Grasses**	**6–50**			
	squirreltail	ELEL5	*Elymus elymoides*	5–50	
	tobosagrass	PLMU3	*Pleuraphis mutica*	0–25	
	green sprangletop	LEDU	*Leptochloa dubia*	0–20	
	vine mesquite	PAOB	*Panicum obtusum*	0–20	
	whiplash pappusgrass	PAVA2	*Pappophorum vaginatum*	0–20	
	purple grama	BORA	*Bouteloua radicosa*	0–20	
	fall witchgrass	DICO6	*Digitaria cognata*	1–20	
	red grama	BOTR2	*Bouteloua trifida*	0–10	
	burrograss	SCBR2	*Scleropogon brevifolius*	0–10	
	spike dropseed	SPCO4	*Sporobolus contractus*	0–5	
	slim tridens	TRMU	*Tridens muticus*	0–5	
	Hall's panicgrass	PAHA	*Panicum hallii*	0–5	

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
	low woollygrass	DAPU7	*Dasyochloa pulchella*	0–5	
	nineawn pappusgrass	ENDE	*Enneapogon desvauxii*	0–5	
7	**Annual Grasses**	**10–100**			
	sixweeks threeawn	ARAD	*Aristida adscensionis*	1–50	
	feather fingergrass	CHVI4	*Chloris virgata*	0–50	
	needle grama	BOAR	*Bouteloua aristidoides*	1–50	
	Mexican panicgrass	PAHI5	*Panicum hirticaule*	0–50	
	sixweeks fescue	VUOC	*Vulpia octoflora*	1–50	
	mucronate sprangeltop	LEPAB	*Leptochloa panicea ssp. brachiata*	0–25	
	sixweeks grama	BOBA2	*Bouteloua barbata*	1–25	
	tapertip cupgrass	ERACA	*Eriochloa acuminata var. acuminata*	0–25	
	prairie threeawn	AROL	*Aristida oligantha*	1–20	
	tufted lovegrass	ERPE	*Eragrostis pectinacea*	0–20	
	desert lovegrass	ERPEM	*Eragrostis pectinacea var. miserrima*	0–20	
	Mexican sprangletop	LEFUU	*Leptochloa fusca ssp. uninervia*	0–20	
	Arizona signalgrass	URAR	*Urochloa arizonica*	0–20	
	Mexican lovegrass	ERME	*Eragrostis mexicana*	0–15	
	littleseed muhly	MUMI	*Muhlenbergia microsperma*	0–10	
	witchgrass	PACA6	*Panicum capillare*	0–10	
	Parry's grama	BOPA2	*Bouteloua parryi*	0–10	
	Arizona brome	BRAR4	*Bromus arizonicus*	0–5	
	Bigelow's bluegrass	POBI	*Poa bigelovii*	0–5	
	delicate muhly	MUFR	*Muhlenbergia fragilis*	0–5	
Forb					
8	**Perennial Forbs**	**5–75**			
	weakleaf bur ragweed	AMCO3	*Ambrosia confertiflora*	1–25	
	bluedicks	DICA14	*Dichelostemma capitatum*	1–20	
	spreading fleabane	ERDI4	*Erigeron divergens*	1–20	
	lacy tansyaster	MAPI	*Machaeranthera pinnatifida*	1–20	
	desert globemallow	SPAM2	*Sphaeralcea ambigua*	1–20	
	brownplume wirelettuce	STPA4	*Stephanomeria pauciflora*	1–20	
	New Mexico fanpetals	SINE	*Sida neomexicana*	0–10	
	Rocky Mountain zinnia	ZIGR	*Zinnia grandiflora*	1–10	
	Wright's deervetch	LOWR	*Lotus wrightii*	1–10	
	Indian rushpea	HOGL2	*Hoffmannseggia glauca*	0–10	
	slender janusia	JAGR	*Janusia gracilis*	0–10	
	wild dwarf morning-glory	EVAR	*Evolvulus arizonicus*	1–10	
	spreading snakeherb	DYSCD	*Dyschoriste schiedeana var. decumbens*	0–10	
	dense ayenia	AYMI	*Ayenia microphylla*	0–10	
	leatherweed	CRPO5	*Croton pottsii*	0–10	
	Cooley's bundleflower	DECO2	*Desmanthus cooleyi*	0–5	
	trailing windmills	ALIN	*Allionia incarnata*	0–5	
	Arizona wrightwort	CAAR7	*Carlowrightia arizonica*	0–5	

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
	hairyseed bahia	BAAB	*Bahia absinthifolia*	0–5	
	desert marigold	BAMU	*Baileya multiradiata*	0–5	
	dwarf desertpeony	ACNA2	*Acourtia nana*	0–5	
	brownfoot	ACWR5	*Acourtia wrightii*	0–5	
	fetid marigold	DYPA	*Dyssodia papposa*	0–5	
	Arizona snakecotton	FRAR2	*Froelichia arizonica*	0–5	
	beeblossom	GAURA	*Gaura*	0–5	
	small matweed	GUDE	*Guilleminea densa*	0–5	
	ragged nettlespurge	JAMA	*Jatropha macrorhiza*	0–5	
	Greene's bird's-foot trefoil	LOGR4	*Lotus greenei*	0–5	
	Gila manroot	MAGI	*Marah gilensis*	0–5	
	variableleaf bushbean	MAGI2	*Macroptilium gibbosifolium*	0–5	
	American vetch	VIAM	*Vicia americana*	0–5	
	Louisiana vetch	VILU	*Vicia ludoviciana*	0–5	
	silverleaf nightshade	SOEL	*Solanum elaeagnifolium*	0–5	
	Coulter's wrinklefruit	TECO	*Tetraclea coulteri*	0–5	
	pricklyleaf dogweed	THAC	*Thymophylla acerosa*	0–5	
	tufted evening primrose	OECA10	*Oenothera caespitosa*	0–5	
	orange fameflower	PHAU13	*Phemeranthus aurantiacus*	0–5	
	slender poreleaf	POGR5	*Porophyllum gracile*	0–5	
	velvetseed milkwort	POOB	*Polygala obscura*	0–5	
	Arizona cudweed	PSAR12	*Pseudognaphalium arizonicum*	0–5	
	Wright's cudweed	PSCAC2	*Pseudognaphalium canescens ssp. canescens*	0–5	
	twinleaf senna	SEBA3	*Senna bauhinioides*	0–5	
	Leiberg stonecrop	SELE	*Sedum leibergii*	0–5	
	Lemmon's ragwort	SELE8	*Senecio lemmonii*	0–5	
	anoda	ANODA	*Anoda*	0–5	
	tuber anemone	ANTU	*Anemone tuberosa*	0–5	
	rockcress	ARABI2	*Arabis*	0–5	
	New Mexico silverbush	ARNE2	*Argythamnia neomexicana*	0–5	
	pioneer rockcress	ARPL	*Arabis platysperma*	0–5	
	southwestern pricklypoppy	ARPL3	*Argemone pleiacantha*	0–5	
	Watson's dutchman's pipe	ARWA	*Aristolochia watsonii*	0–5	
	spiny milkwort	POSU2	*Polygala subspinosa*	0–2	
	shrubby purslane	POSU3	*Portulaca suffrutescens*	0–2	
	branched noseburn	TRRA5	*Tragia ramosa*	0–2	
	jewels of Opar	TAPA2	*Talinum paniculatum*	0–2	
	gooseberryleaf globemallow	SPGR2	*Sphaeralcea grossulariifolia*	0–2	
	canaigre dock	RUHY	*Rumex hymenosepalus*	0–2	
	rose heath	CHER2	*Chaetopappa ericoides*	0–2	
	San Felipe dogweed	ADPO	*Adenophyllum porophylloides*	0–2	
	lyreleaf greeneyes	BELY	*Berlandiera lyrata*	0–2	
	climbing wartclub	BOSC	*Boerhavia scandens*	0–2	
	fingerleaf gourd	CUDI	*Cucurbita digitata*	0–2	
	coyote gourd	CUPA	*Cucurbita palmata*	0–2	
	desert larkspur	DEPA	*Delphinium parishii*	0–1	

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
	Indian paintbrush	CASTI2	*Castilleja*	0–1	
	desert tobacco	NIOB	*Nicotiana obtusifolia*	0–1	
	copper zephyrlily	ZELO	*Zephyranthes longifolia*	0–1	
	slimflower scurfpea	PSTE5	*Psoralidium tenuiflorum*	0–1	
9	**Annual forbs**	**15–150**			
	sensitive partridge pea	CHNI2	*Chamaecrista nictitans*	1–50	
	longleaf false goldeneye	HELOA2	*Heliomeris longifolia var. annua*	1–50	
	camphorweed	HESU3	*Heterotheca subaxillaris*	0–25	
	Arizona poppy	KAGR	*Kallstroemia grandiflora*	0–25	
	slender goldenweed	MAGR10	*Machaeranthera gracilis*	1–25	
	tanseyleaf tansyaster	MATA2	*Machaeranthera tanacetifolia*	1–25	
	woolly plantain	PLPA2	*Plantago patagonica*	1–25	
	Arizona popcornflower	PLAR	*Plagiobothrys arizonicus*	1–25	
	desert Indianwheat	PLOV	*Plantago ovata*	1–20	
	hollowleaf annual lupine	LUSU3	*Lupinus succulentus*	0–20	
	crestrib morning-glory	IPCO2	*Ipomoea costellata*	1–20	
	western tansymustard	DEPI	*Descurainia pinnata*	1–20	
	lambsquarters	CHAL7	*Chenopodium album*	1–20	
	Coulter's spiderling	BOCO2	*Boerhavia coulteri*	1–20	
	carelessweed	AMPA	*Amaranthus palmeri*	1–20	
	milkvetch	ASTRA	*Astragalus*	1–20	
	wheelscale saltbush	ATEL	*Atriplex elegans*	0–15	
	New Mexico thistle	CINE	*Cirsium neomexicanum*	1–15	
	California poppy	ESCAM	*Eschscholzia californica ssp. mexicana*	0–15	
	shaggyfruit pepperweed	LELA	*Lepidium lasiocarpum*	0–15	
	foothill deervetch	LOHU2	*Lotus humistratus*	0–15	
	coastal bird's-foot trefoil	LOSAB	*Lotus salsuginosus var. brevivexillus*	0–15	
	spreading fanpetals	SIAB	*Sida abutifolia*	1–15	
	woolly tidestromia	TILA2	*Tidestromia lanuginosa*	0–10	
	purslane	PORTU	*Portulaca*	0–10	
	manybristle chinchweed	PEPA2	*Pectis papposa*	0–10	
	tepary bean	PHAC	*Phaseolus acutifolius*	0–10	
	sorrel buckwheat	ERPO4	*Eriogonum polycladon*	1–10	
	scrambled eggs	COAU2	*Corydalis aurea*	0–10	
	fringed redmaids	CACI2	*Calandrinia ciliata*	0–10	
	suncup	CAMIS	*Camissonia*	0–5	
	hoary bowlesia	BOIN3	*Bowlesia incana*	0–5	
	miner's lettuce	CLPEP	*Claytonia perfoliata ssp. perfoliata*	0–5	
	bristly fiddleneck	AMTE3	*Amsinckia tessellata*	0–5	
	New Mexico copperleaf	ACNE	*Acalypha neomexicana*	0–5	
	cryptantha	CRYPT	*Cryptantha*	0–5	
	American wild carrot	DAPU3	*Daucus pusillus*	1–5	
	Wright's prairie	DAWR	*Dalea wrightii*	0–5	

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
	clover				
	sacred thorn-apple	DAWR2	*Datura wrightii*	0–5	
	Texas stork's bill	ERTE13	*Erodium texanum*	0–5	
	wedgeleaf draba	DRCU	*Draba cuneifolia*	0–5	
	spurge	EUPHO	*Euphorbia*	0–5	
	Arizona blanketflower	GAAR2	*Gaillardia arizonica*	0–5	
	star gilia	GIST	*Gilia stellata*	0–5	
	southwestern mock vervain	GLGO	*Glandularia gooddingii*	0–5	
	pearly globe amaranth	GONI	*Gomphrena nitida*	0–5	
	Arizona gumweed	GRAR2	*Grindelia arizonica*	0–5	
	Arizona lupine	LUAR4	*Lupinus arizonicus*	0–5	
	Coulter's lupine	LUSP2	*Lupinus sparsiflorus*	0–5	
	miniature woollystar	ERDI2	*Eriastrum diffusum*	0–5	
	Thurber's morning-glory	IPTH	*Ipomoea thurberi*	0–5	
	intermediate pepperweed	LEVIM	*Lepidium virginicum var. medium*	0–5	
	Lewis flax	LILE3	*Linum lewisii*	0–5	
	whitestem blazingstar	MEAL6	*Mentzelia albicaulis*	0–5	
	Nuttall's povertyweed	MONU	*Monolepis nuttalliana*	0–5	
	combseed	PECTO	*Pectocarya*	0–5	
	phacelia	PHACE	*Phacelia*	0–5	
	phlox	PHLOX	*Phlox*	0–5	
	groundcherry	PHYSA	*Physalis*	0–5	
	desert unicorn-plant	PRAL4	*Proboscidea althaeifolia*	0–5	
	doubleclaw	PRPA2	*Proboscidea parviflora*	0–5	
	New Mexico plumeseed	RANE	*Rafinesquia neomexicana*	0–5	
	golden crownbeard	VEEN	*Verbesina encelioides*	0–5	
	sleepy silene	SIAN2	*Silene antirrhina*	0–5	
	Gordon's bladderpod	LEGO	*Lesquerella gordonii*	0–5	
	sawtooth sage	SASU7	*Salvia subincisa*	1–5	
	chia	SACO6	*Salvia columbariae*	0–2	
	Fendler's desertdandelion	MAFE	*Malacothrix fendleri*	0–2	
	warty caltrop	KAPA	*Kallstroemia parviflora*	0–2	
	redstar	IPCO3	*Ipomoea coccinea*	0–2	
	sanddune wallflower	ERCA14	*Erysimum capitatum*	0–2	
	southwestern pricklypoppy	ARPL3	*Argemone pleiacantha*	0–2	
	fewflower beggarticks	BILE	*Bidens leptocephala*	0–2	
	sego lily	CANU3	*Calochortus nuttallii*	1–2	
Shrub/Vine					
10	**Dominant Half-shrubs**	**50–100**			
	fairyduster	CAER	*Calliandra eriophylla*	20–100	
	bastardsage	ERWR	*Eriogonum wrightii*	10–50	
	littleleaf ratany	KRER	*Krameria erecta*	20–50	
	trailing krameria	KRLA	*Krameria lanceolata*	0–50	

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
	desert zinnia	ZIAC	*Zinnia acerosa*	0–50	
11	**Increaser Half-shrubs**	**1–40**			
	broom snakeweed	GUSA2	*Gutierrezia sarothrae*	1–30	
	burroweed	ISTE2	*Isocoma tenuisecta*	0–30	
	threadleaf snakeweed	GUMI	*Gutierrezia microcephala*	0–20	
	turpentine bush	ERLA12	*Ericameria laricifolia*	0–10	
12	**Miscellaneous Shrubs**	**0–20**			
	Fourwing saltbush	ATCA 2	*Atriplex canenscens*	0–10	
	velvet mesquite	PRVE	*Prosopis velutina*	0–5	
	oneseed juniper	JUMO	*Juniperus monosperma*	0–2	
	Jerusalem thorn	PAAC3	*Parkinsonia aculeata*	0–2	
	blue paloverde	PAFL6	*Parkinsonia florida*	0–2	
	spiny hackberry	CEEH	*Celtis ehrenbergiana*	0–10	
	knifeleaf condalia	COSP3	*Condalia spathulata*	0–5	
	whitethorn acacia	ACCOP9	*Acacia constricta var. paucispina*	0–5	
	catclaw acacia	ACGRG3	*Acacia greggii var. greggii*	0–5	
	rough menodora	MESC	*Menodora scabra*	0–5	
	catclaw mimosa	MIACB	*Mimosa aculeaticarpa var. biuncifera*	0–5	
	sacahuista	NOMI	*Nolina microcarpa*	0–5	
	velvetpod mimosa	MIDY	*Mimosa dysocarpa*	0–2	
	longleaf jointfir	EPTR	*Ephedra trifurca*	0–2	
	American tarwort	FLCE	*Flourensia cernua*	0–2	
	ocotillo	FOSP2	*Fouquieria splendens*	0–2	
	desert-thorn	LYCIU	*Lycium*	0–2	
	yerba de pasmo	BAPT	*Baccharis pteronioides*	0–2	
	Warnock's snakewood	COWA	*Condalia warnockii*	0–2	
	Kearney's snakewood	COWAK	*Condalia warnockii var. kearneyana*	0–2	
	whitethorn acacia	ACCO2	*Acacia constricta*	0–2	
	lotebush	ZIOB	*Ziziphus obtusifolia*	0–2	
	button brittlebush	ENFR	*Encelia frutescens*	0–1	
	whitestem paperflower	PSCO2	*Psilostrophe cooperi*	0–1	
	threadleaf ragwort	SEFL3	*Senecio flaccidus*	0–1	
13	**Succulents**	**2–50**			
	Palmer's century plant	AGPA3	*Agave palmeri*	0–5	
	beehive cactus	CORYP	*Coryphantha*	0–5	
	Christmas cactus	CYLE8	*Cylindropuntia leptocaulis*	0–5	
	walkingstick cactus	CYSP8	*Cylindropuntia spinosior*	0–5	
	staghorn cholla	CYVE3	*Cylindropuntia versicolor*	0–5	
	hedgehog cactus	ECHIN3	*Echinocereus*	0–5	
	candy barrelcactus	FEWI	*Ferocactus wislizeni*	1–5	
	globe cactus	MAMMI	*Mammillaria*	0–5	
	cactus apple	OPEN3	*Opuntia engelmannii*	1–5	
	purple pricklypear	OPMAM	*Opuntia macrocentra var. macrocentra*	0–5	
	tulip pricklypear	OPPH	*Opuntia phaeacantha*	0–5	

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
	banana yucca	YUBA	*Yucca baccata*	0–5	
	soaptree yucca	YUEL	*Yucca elata*	0–5	
	jumping cholla	CYFU10	*Cylindropuntia fulgida*	0–5	
	candle cholla	CYKL	*Cylindropuntia kleiniae*	0–2	
	Santa Rita pricklypear	OPSA	*Opuntia santa-rita*	0–2	
	Arizona pencil cholla	CYAR14	*Cylindropuntia arbuscula*	0–2	
	rainbow cactus	ECPEP	*Echinocereus pectinatus var. pectinatus*	0–1	
	spinystar	ESVI2	*Escobaria vivipara*	0–1	
Tree					
14	**Trees**	**0–15**			
	western honey mesquite	PRGLT	*Prosopis glandulosa var. torreyana*	0–5	

Animal community

With continuous heavy grazing, palatable perennial grasses like blue, hairy, sprucetop and sideoats grammas and plains lovegrass decrease. Increasers under such circumstances include curly mesquite, threeawns and, in some areas, false mesquite. With severe deterioration, shrubby species increase to dominate. Mesquite forms the over-story with snakeweed and lesser amounts of burroweed in the under-story. Cholla and prickly pear can also increase on the site. Water developments are very important to wildlife on the site. Being open grassland, this site is home to a variety of small herbivores, birds and their associated predators. With the exception of the antelope, the site is mainly a forage area for larger wildlife species.

Hydrological functions

Thin, coarse textured, soil surfaces capture some of the intense summer rainfall on the site. Natural rates of runoff are as high as 30 percent for this site. Very shallow argillic (clayey) horizons keep soil moisture high in the soil profile and available to shallow rooted plants. Rainfall simulator studies, conducted by ARS in southern Arizona, offer some insight into how the ratio of infiltration to runoff changes under different ecological conditions and with different thickness of soil surface horizon. Two inches of rain was applied to wet soils, in a one-hour time period. A site with vegetation in high ecological condition and 4 inches of A horizon, had a ratio of 27/73 percent, runoff to infiltration. A site with vegetation in fair ecological condition and 1 and 1/2 inches of A horizon, had a ratio of 44/56 percent, runoff to infiltration. And the last site with vegetation in poor ecological condition and with only 1/2 inch of A horizon had a ratio of 85/15 percent, runoff to infiltration.

Recreational uses

Hunting, hiking, horseback riding, photography, bird-watching.

Wood products

Mesquite remains shrubby on this site due to very thin soil surfaces over clayey sub-soils. Established mesquite offers little more than fuel-wood for campfires, and nothing large enough for post or stay.

Inventory data references

Range 417s include 10 in excellent condition, 15 in good condition and 15 in fair condition.

Type locality

Table E-B-10. Type localities.

Location 1: Pinal County, AZ	
Township/Range/Section	T10S R13E S2
General legal description	Tom Mix Hwy ROW
Location 2: Cochise County, AZ	
Township/Range/Section	T18S R28E S2
General legal description	Oak Ranch
Location 3: Cochise County, AZ	
Township/Range/Section	T21S R19E S17
General legal description	Un-surveyed. Ft. Huachuca
Location 4: Pima County, AZ	
Township/Range/Section	T19S R14E S16
General legal description	Enclosure # 41 on the Santa Rita Experimental Range. On the Whitehouse fan at 3575 feet elevation

Other references

Griffith, G.E., J.M. Omernik, C.B. Johnson, and D.S. Turner, 2014, Ecoregions of Arizona (poster): U.S. Geological Survey Open-File Report 2014-1141, with map, scale 1:1,325,000, https://dx.doi.org/10.3133/ofr20141141. ISSN 2331-1258 (online)

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296.

McNab, W.H.; D.T. Cleland, J.A. Freeouf, J.E. Keys, Jr., G.J. Nowacki, C.A. Carpenter, comps. 2007. Description of ecological subregions: sections of the conterminous United States [CD-ROM]. Gen. Tech. Report WO-76B. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p.

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Approval: Curtis Talbot, 4/12/2021

Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Table E-B-11.

Author(s)/participant(s)	Robinett, Carrillo, Womack, Decker, Roberts, McReynolds, Buono
Contact for lead author	3241 N Romero Rd, Tucson, AZ 85705 520-292-2999x105
Date	12/01/2007
Approved by	Curtis Talbot
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Table E-B-12. Indicators.

No.	Description
1	Number and extent of rills: None, these sites generally occur on low slopes not prone to rill formation
2	Presence of water flow patterns: They cover about 15 percent of the area, are discontinuous, sinuous, uniformly distributed and range in length from 2 to 20 feet and width is generally < 1ft
3	Number and height of erosional pedestals or terracettes: Very slight pedastalling on longer-lived plants. Terracettes are infrequent, 5 to 20 feet apart and with elevation differences of 1 – 2 in.
4	Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground): 20–25 percent bare ground (20–30 percent gravel on some soil series), bare patch size averages 1–3 ft, connectivity is very low
5	Number of gullies and erosion associated with gullies: None, these sites generally occur on low slopes not prone to gully formation
6	Extent of wind scoured, blowouts and/or depositional areas: None present
7	Amount of litter movement (describe size and distance expected to travel): Litter is all fine, herbaceous and litter movement in steeper areas is from 1 to 2 feet. Litter is not moving in flatter areas. No loss of litter from the site
8	Soil surface (top few mm) resistance to erosion (stability values are averages -- most sites will show a range of values): Soil surface is 3 to 4 inches of dark colored gravelly sandyloam over clayloam and clay. Soil surface resistance to erosion is good across the site with little variability, aggregate stability test averages > 5
9	Soil surface structure and SOM content (include type of structure and A-horizon color and thickness): Soil surface has moderate to strong fine granular structure, with common to many fine roots. Surface horizon is 3 to 4 inches thick and dark colored and OM present throughout site
10	Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff: Perennial mid-grasses have a canopy of 30 percent, half-shrubs a canopy of 5 percent, shor grasses a canopy of 5 percent, and large shrubs and succulents a canopy of 2 percent. All species are uniformly dispersed with no reduction in basal area affecting infiltration and runoff (basal area: >12–15 percent)
11	Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site): No surface soil compaction. Soil surface is loose as you walk across it in some areas. An abrupt textural change at 3 to 4 inches from sandyloam to heavy clayloam or clay has the feel of being compacted but is not.
12	Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):
	Dominant: Warm season perennial mid-grasses >> half-shrubs > warm season perennial short grasses = annual forbs > perennial forbs = succulents > large shrubs and trees
	Sub-dominant: Other:
	Additional:
13	Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence): Good age class distribution of dominant perennial grasses. Some mortality and loss of live basal meristem during severe drought conditions. Litter and senescent vegetation comprise a large amount of the total biomass
14	Average percent litter cover (percent) and depth (in): Litter is roughly 20–25 percent of ground cover (predominantly from mid-grasses) and is uniformly distributed throughout site, depth (1/8 to 1 in)
15	Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production): Production in lbs/acre based on annual rainfall: High- >1150 lbs/ac, Norm- >1040 lbs/ac, Low- >930 lbs/ac
16	Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site: Mesquite, whitethorn, burroweed, prickly pear, Lehmann lovegrass
17	Perennial plant reproductive capability: Not impaired in any way; good age class distribution of perennial grasses, recruitment is evident throughout site

APPENDIX E-C. Study and Photograph Identification

A. Numbering Studies—Studies should be numbered to assure positive identification. These numbers can also be used to identify photographs. Following are three alternative schemes for numbering studies

(1) Number Scheme 1. Consecutive numbers may be assigned to study within an allotment. For example, Mooncreek #1 and Mooncreek #2 would be studies Number 1 and 2 within the Mooncreek Allotment. A disadvantage to using the name of allotments in a numbering scheme is that names can and often do change.

(2) Number Scheme 2 may be numbered based on their location within a township, range and section. A 10-character number can be assigned in the following manner.

(i) The first three characters are the township (03S), the second three are the range (27W), the next two are the section (08), and the last two are simply a series number assigned to a study based on the number of studies located within a section.

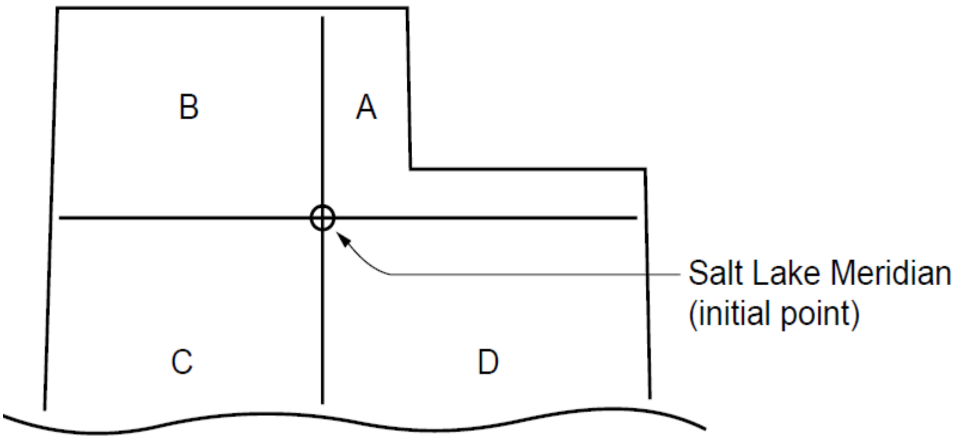
(ii) The numbers for studies located in Section 8 would be 03S-27W-08-01, 03S-27W-08-02, and so forth.

(iii) Depending on the local situation, this scheme can be modified by adding characters to the code where there are fractional townships or ranges, where there are more than 99 sections/tracts within a township, and/or where there is more than one public land survey principal meridian and baseline within the area of jurisdiction.

(3) Numbering Scheme 3. Studies may be numbered based on their location relative to the initial point of survey (principal meridian and baseline governing public land survey).

(i) Under this scheme, the first character is a letter assigned to a principal meridian and baseline quadrat. Using the initial point of the survey as the center point, the northeast quadrat (townships located to the north and east of the initial point) is coded “A.” The northwest, southwest, and southeast quadrats are coded “B,” “C,” and “D,” respectively. For Example:

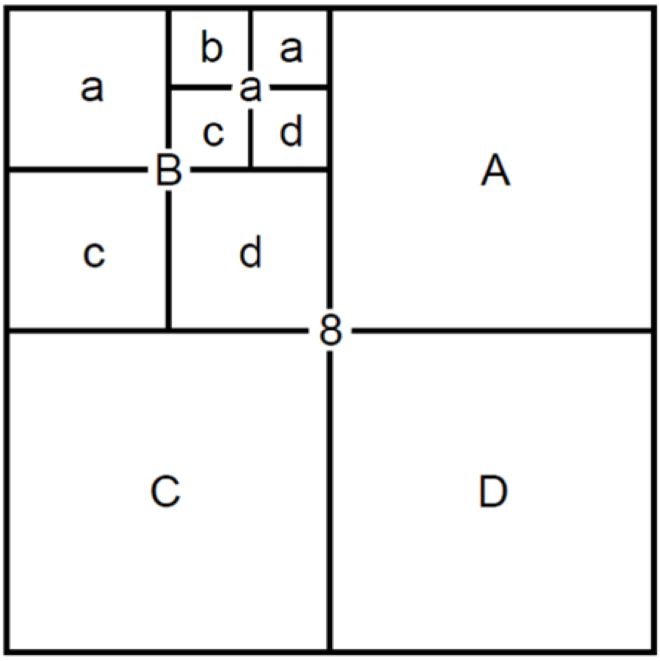
Figure E-C-1.



(ii) The next characters are the township number (3.16, etc. followed by the range number (7, 32, etc.) and the section number (8, 21, etc.)).

(iii) The next three characters are used to identify the subdivisions within a section (down to 10 acres) in which a study is located. These subdivisions have letter designations as follows:

Figure E-C-2. Numbering Scheme.



(iv) The last character(s) is (are) simply a series of numbers (1,2,3 etc.) assigned to a study based on the number of studies located within the smallest subdivision.
(v) For example, Studies 1 and 2 located in the SE1/4NE1/4NW1/4 of Section 8, T3S, R21E would be numbered (D-3-21)8Bad-1 and (D-3-21)8Bad-2.
(vi) Depending on the local situation, this scheme can be modified by adding characters to the code where there are fractional townships or ranges, where there are more than 99 sections/tracts within a township. And/or where there is more than one public land survey principal meridian and baseline within the area of jurisdiction.

B. Identifying Photographs—In most cases, the number that has been assigned to a study is the number used to identify the photographs associated with that study. Following is a description of the three labels that can be used to include the study number in the photographs:

(1) Label 1 The Photo Identification Label below can be copied and used to identify photographs. This label provides space for documenting the date, number, and location (Resource Area, allotment, and pasture) of study. A large black felt tip marking pen should be used to print the information on the label.
(2) Label 2 A common white board with dry erase markers can be used as a inexpensive label. The whiteboard should be large enough to have all specific identifying information at a scale that is readable in the photo (1½" lettering). After one photo site is complete, the white board can be wiped clean and the whiteboard reused for the next photo site. Caution must be used with markers that are not dark enough to be clearly visible (black is recommended) and the white board should be placed at an angle that prevents sunlight glare.

Photo Identification Label

DATE:____________
No._______________
R.A.______________
Allot._____________
Pasture:____________

APPENDIX E-D. – NRCS Oregon Range Technical Note No. 27

TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE
PORTLAND, OREGON JULY 2014

RANGE TECHNICAL NOTE NO. 27

Dry Weight Percentages of Selected Oregon Grasses, Grass-likes, Forbs, Vines, Shrubs, and Trees

This technical note is based on information contained in a WNTSC technical note.

INTRODUCTION:

The green weight of field clipped vegetation needs to be converted to air-dry weight for immediate stocking recommendations, Ecological Site Descriptions, and Forage Suitability Groups.

Air-dry weight in pounds per acre (lbs./acre) or in kilograms per hectare (kg/ha) differentiate Ecological Site Description's characteristic vegetation of the reference state, the plant association tables, and the production data found in Forage Suitability Groups. The field green-weight must be converted to air-dry weight. Air-dry weight can be determined by using these conversion tables based on species and phenological stage of growth. The air-dry weight of all plant species are documented and inventoried during the conservation planning process and development of Ecological Site Descriptions.

The relationship of green weight to air-dry weight varies according to such factors as exposure, amount of shading, time since last rain, unseasonable dry periods, and the phenological stage of the plant. Thus, ranges of dry-weight are common in the tables.

Prescribed Grazing (528) requires a Forage-Animal Balance developed for the grazing plan. This balance ensures forage produced or available meets forage demand of livestock and/or wildlife. Air-dry forage consumed in one month is estimated to be 912.5 pounds per 1.000 pounds of grazing animal equivalent. This amount is known as an Animal Unit Month (AUM).

Usable production is a method of determining stocking rates based on measuring the total amount of forage (standing crop) per acre and converting green weight to air dry weights and into AUM's. The only production to be considered in determining stocking rate is the current year's forage growth below 4.5 feet vertical height. Forage from plant species that are undesirable, non-consumed, or toxic to the kind and class of livestock intended to graze the area should be excluded. The air dry weight is summarized for the entire area to be grazed after any necessary adjustments are made. Read Chapter 5 Management of Grazing Lands in the National Range and Pasture Handbook for information on adjustments.

HOW TO USE THE TABLES:

The tables contain the Plant Code; Phenological Stage Classification (occurrence of natural events in their annual cycle). The phenological classifications for grasses, forbs, and tree/shrubs are described separately; the present Scientific Name; Historic or Archived Scientific Name; Common Name, and a Notes column.

Example 1: During a high precipitation year, Russian wildrye is clipped while in stage 3. The field measured green weight is 200 pounds/acre.

PSJU3 = 200 pounds X .40 = 80 pounds air-dry weight.

Example 2: During a low precipitation year, Russian wildrye is clipped while in stage 3. The field measured green weight is 125 pounds/acre.

PSJU3 = 125 pounds X .50 = 62.5 air-dry pounds/acre.

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Dry Weight Percentages of Selected Oregon Grasses, Grasslikes, Forbs, Shrubs, and Trees

GRASS AND GRASSLIKES

GRASS PHENOLOGICAL STAGE CLASSIFICATION:

1 -GREEN LEAVES BEFORE BOOT
2- BOOT STAGE
3- SEED SOFT DOUGH TO RIPE
4- SEED DISSEMINATION
5- WINTER DORMANCY CURED

INTRODUCED COOL-SEASON PERENNIAL GRASS

PLANT CODE	1	2	3	4	5	PRESENT SCIENTIFIC NAME	HISTORIC SCIENTIFIC NAME	COMMON NAME	NOTES
AGCR	25-30	40-45	50-55	60	75-90	Agropyron cristatum	Agropyron cristatum	Fairway crested wheatgras	
AGDE2	25-30	40-45	50-55	60	75-90	Agropyron desertorum	Agropyron desertorum	Standard crested wheatgra	
AGCRxAGDE2	25-30	40-45	50-55	60	75-90	A. cristatum x A. desertorum		Crested wheatgrass cross	
AGFR	25-30	40-45	50-55	60-65	75-90	Agropyron fragile	Agropyron sibiricum	Siberian wheatgrass	
ALAR	25	35-40	45-50	55-60	70	Alopecurus arundinaceus	Alopecurus arundinaceus	Creeping foxtail	strong rhizomes
ARELE	25	35-40	40-45	50-55	65-85	Arrhenatherum elatius var. elatius	Arrhenatherum elatius	Tall oatgrass	
BRER3	20-25	35-40	40-45	50-55	75-85	Bromus erectus	Bromus riparius	Meadow brome	short rhizomes
BRIN2	20-25	35-40	40-45	50-55	75-85	Bromus inermis	Bromus inermis	Smooth brome	sod-forming
DAGL	20-25	30-35	40-45	50-55	60-80	Dactylis glomerata	Dactylus glomerata	Orchardgrass	
FEBR7	25-35	40-45	45-50	55-60	75-85	Festuca brevipila	Festuca ovina duriuscula	Hard fescue	
FEOV	25-35	40-45	45-50	55-60	75-85	Festuca ovina	Festuca ovina	Sheep fescue	
LOPE	25-30	40-45	45-55	55-60	70-85	Lolium perenne	Lolium perenne	Perennial ryegrass	
PHAR3	25	40-45	50-55	60	75	Phalaris arundinacea	Phalaris arundinacea	Reed canarygrass	sod- forming
PHPR3	25	35-40	45-55	55-65	70-90	Phleum pratensis	Phleum pratensis	Timothy	
POPR	20-25	35-40	45-50	55-60	65-70+	Poa pratensis	Poa pratensis	Kentucky bluegrass	sod-forming
SCAR7	25	35-40	45-50	55-60	70	Schedonorus arundinaceus	Festuca arundinacea	Tall fescue	
THIN6	25	40-45	45-50	55-60	75-85	Thinopyrum intermedium	Agropyron intermedium	Intermediate wheatgrass	short rhizomes
THIN6	25-30	38-43	45-50	55-60	70-85	Thinopyrum intermedium	Agropyron trichophorum	Pubescent wheatgrass	short rhizomes
THPO7	25	40-45	48-55	55-65	80-90	Thinopyrum ponticum	Agropyron elongatum	Tall wheatgrass	
PSJU3	25	35-40	40-50	55-65	70-85	Psathyrostachys juncea	Elymus junceus	Russian wildrye	

Developed from WNTSC Technical Note

Prepared by Bob Gillaspy, 6/30/201

Dry Weight Percentages of Selected Oregon Grasses, Grasslikes, Forbs, Shrubs, and Trees

GRASS PHENOLOGICAL STAGE CLASSIFICATION:
1 -GREEN LEAVES BEFORE BOOT
2- BOOT STAGE
3- SEED SOFT DOUGH TO RIPE
4- SEED DISSEMINATION
5- WINTER DORMANCY CURED

NATIVE COOL-SEASON PERENNIAL GRASS

PLANT CODE	1	2	3	4	5	PRESENT SCIENTIFIC NAME	HISTORIC SCIENTIFIC NAME	COMMON NAME	NOTES
ACHY	30-35	45-50	50-55	60-75	80	Achnatherum hymenoides	Oryzopsis hymenoides	Indian ricegrass	
ACLE9	25-30	40-45	50-55	60-65	70+	Achnatherum lettermanii	Stipa lettermani	Letterman needlegrass	
ACNEN2	25-30	40-45	50	55-60	75+	Achnatherum nelsonii ssp. nelsonii	Stipa columbiana	Columbia needlegrass	
ACNEN2	25-30	40-45	50	55-60	70+	Achnatherum nelsonii ssp. nelsonii	Stipa williamsi	Williams needlegrass	
ACTH7	25-30	40-45	50-55	60-65	80+	Achnatherum thurberianum	Stipa thurberiana	Thurber needlegrass	
BRMA4	20-25	35-40	40-45	50-75	65-85	Bromus marginatus	Bromus marginatus	Mountain brome	short-lived
BRVU		44				Bromus vulgaris	Bromus vulgaris	Columbia brome	
ELEL5	25-35	45-50	55-60	65-70	85-90	Elymus elymoides	Sitanion hystrix	Bottlebrush squirreltail	
ELGL	25	35	40	75	75-85	Elymus glaucus	Elymus glaucus	Blue wildrye	short-lived
ELLA3	25-30	45-50	53-56	60-65	80-90	Elymus lanceolatus ssp. lanceolatus	Agropyron riparium	Streambank wheatgrass	rhizomatous
ELLAL	25	45-50	55-60	60-65	85-90	Elymus lanceolatus ssp. lanceolatus	Agropyron dasystachyum	Thickspike wheatgrass	rhizomes
ELTRT	25-30	40-45	50-55	60-65	75-90	Elymus trachycaulus ssp. trachycaulus	Agropyron trachycaulum	Slender wheatgrass	short-lived
ELWA2	25-30	40-50	50-55	55-65	80-90	Elymus wawawaiensis	Agropyron spicatum	Snake River wheatgrass	
FEID	25-35	40	45-50	50-60	75-85	Festuca idahoensis	Festuca idahoensis	Idaho fescue	
HECO26	25-35	40-50	50-55	60-65	70+	Hesperostipa comata	Stipa comata	Needle & Thread	
KOMA	20-35	38-50	50-55	60-65	75-85	Koeleria macrantha	Koeleria cristata	Prairie junegrass	
LECI4	25-30	45-50	50-55	60-65	65-80	Leymus cinereus	Elymus cinereus	Basin wildrye	
MEBU	20-30	40-45	45-50	50-55	80-85	Melica bulbosa	Melica bulbosa	Oniongrass	
PASM	25-35	45-55	53-58	60-65	70-90	Pascopyrum smithii	Agropyron smithii	Western wheatgrass	rhizomes
POFE	25-35	45		50-60	90-95	Poa fendleriana	Poa fendleriana	Muttongrass	
POSE	25-30	38-45	50-55	60-65	70+	Poa secunda	Poa ampla	Sandberg (big) bluegrass	
POSE	20-30	38-50	50-55	60-65	70+	Poa secunda	Poa nevadensis	Sandberg (Nevada) bluegrass	
POSE		69			63	Poa secunda	Poa sandbergii	Sandberg bluegrass	
POSE	25-30	40-45	50-55	55-60	65-90	Poa secunda	Poa secunda	Sandberg bluegrass	
PSSPI	25-30	35-40	45	50-60	80-90	Pseudoroegneria spicata spp.inermis	Agropyron inerme	Beardless wheatgrass	strong tillers
PSSPS	25-30	40-50	50-55	55-65	80-90	Pseudoroegneria spicata ssp. spicata	Agropyron spicatum	Bluebunch wheatgrass	

Dry Weight Percentages of Selected Oregon Grasses, Grasslikes, Forbs, Shrubs, and Trees

GRASS PHENOLOGICAL STAGE CLASSIFICATION:
1 -GREEN LEAVES BEFORE BOOT
2- BOOT STAGE
3- SEED SOFT DOUGH TO RIPE
4- SEED DISSEMINATION
5- WINTER DORMANCY CURED

NATIVE WARM-SEASON PERENNIAL GRASS

PLANT CODE	1	2	3	4	5	PRESENT SCIENTIFIC NAME	HISTORIC SCIENTIFIC NAME	COMMON NAME	NOTES
ARPUL	28-35	40-45	50-55	60-65	85-90	Aristida purpurea var. longiseta	Aristida longiseta	Red threeawn	
CARU	25-30	35-40	40-45	45-50		Calamagrostis rubescens	Calamagrostis rubescens	Pinegrass	rhizomatous
SPCR	30-45	40-50	50	60-70	90	Sporobolus cryptandrus	Sporobolus cryptandrus	Sand dropseed	
SPAI	30-40	45-60	55	65	80	Sporobolus airoides	Sporobolus airoides	Alkali sacaton	

INTRODUCED COOL-SEASON ANNUAL GRASS

PLANT CODE	1	2	3	4	5	PRESENT SCIENTIFIC NAME	HISTORIC SCIENTIFIC NAME	COMMON NAME	NOTES
BRAR5				56		Bromus arvensis	Bromus japonicus	Japanese brome	tillers
BRRU2				70		Bromus rubens	Bromus rubrum	Red brome	
BRTE	20-30	35-50	50-55	60-65	85-90	Bromus tectorum	Bromus tectorum	Cheatgrass	

NATIVE COOL-SEASON ANNUAL GRASS

PLANT CODE	1	2	3	4	5	PRESENT SCIENTIFIC NAME	HISTORIC SCIENTIFIC NAME	COMMON NAME	NOTES
VUOCG				80		Vulpia octoflora	Festuca octoflora	Sixweeks fescue	

GRASSLIKE

PLANT CODE	1	2	3	4	5	PRESENT SCIENTIFIC NAME	HISTORIC SCIENTIFIC NAME	COMMON NAME	NOTES
CAFI	30	49	55	60-67	80	Carex filifolia	Carex filifolia	Threadleaf sedge	
CAGE2	40	50	55	60	75	Carex geyeri	Carex geyeri	Elk sedge	rhizomatus
ELEOC				38		Eleocharis sp.	Eleocharis sp.	Spikerush	
JUNCO	20	40-45	55-60			Juncus balticus	Juncus spp	Wiregrass, Baltic rush	

Dry Weight Percentages of Selected Oregon Grasses, Grasslikes, Forbs, Shrubs, and Trees

FORBS and VINES

FORB PHENOLOGICAL STAGE CLASSIFICATION:

1- GREEN BEFORE FLOWERING
2 - FULL BLOOM PETALS FALLING
3 - FRUIT RIPENING
4 - FRUIT RIPE OR FALL DORMANCY
5 - SEED DISSEMINATION OR WINTER DORMANCY

NATIVE PERENNIAL FORBS

PLANT CODE	1	2	3	4	5	PRESENT SCIENTIFIC NAME	HISTORIC SCIENTIFIC NAME	COMMON NAME	NOTES
ACMI2		31-49				Achillea millefolium	Achillea millefolium	Common yarrow	
AGUR	25	30-40	45			Agastache urticifolia	Agastache urticifolia	Horsemint/hyssop	rhizomatous
AGGL	17-20	45				Agoseris glauca	Agoseris pumila	Mountain dandelion	
ALAC4	15	20-40		70	70-90	Allium acuminatum	Allium acuminatum	Onion	
ANRO2	35	55		85		Antennaria rosea	Antennaria rosea	Pussytoes	
ARLU	18			43-45	65+	Artemisia ludoviciana	Artemisia ludoviciana	Louisiana sagewort & cudweed	rhizomatous
ASCO9			47			Astragalus columbianus	Astragalus columbia	Columbia vetch	
ASSP4	31					Astragalus spaldingii	Astrogalus spaldingii	Milkvetch, spalding's	
BASA3	17-32	27-36	35-45	45-50	65+	Balsamorhiza sagittata	Balsamorhiza sagittata	Arrowleaf balsamroot	
CAAN7		27	30	35	50+	Castilleja angustifolia	Castilleja spp.	Indian paintbrush	
COUMP	20	50				Comandra umbellata ssp. pallida	Comandra palida	Bastard toadflax	
CRCA2	20-25	30-40	35	40	50	Crepis acuminata	Crepis acuminata	Tapertip hawksbeard	
DEOC	22	28	30	35	50	Delphinium ×occidentale	Delphinium spp.	Tall larkspur	
DENU2	25	30	35	40	50	Delphinium nuttallianum	Delphinium spp.	Low larkspur	
DICA14				70		Dichelostemma capitatum	Dicheloatemma spp	Bluedicks	corm
ERCH4					60-100	Erigeron chrysopsidis	Erigeron chrysopsidis	Dwarf yellow fleabane	
ERSP4	22	25	33	35	55	Erigeron speciosus	Erigeron speciosus	Daisies	
ERHE2	45-50		67-70	90		Eriogonum heracleoides	Erigonum heraculoides	Wyeth buckwheat	
ERUM	20-25	30-40	46	50-55	65+	Eriogonum umbellatum	Eriogonum umbellatum	Sulphur-flower buckwheat	
FRSP		20	20			Frasera speciosa	Fraseria speciosa	Elkweed	
GABO2	17-20			45-50	85	Galium boreale	Galium boreale	Bedstraw	
GEMA4	20					Geum macrophyllum	Geum macrophyllum	Largeleaf avens	
GETR		39				Geum triflorum	Geum triflorum	Old Man's Whiskers	
HEUN	20	30-35	38-45	50-55	65+	Helianthella uniflora	Helianthella uniflora	Oneflower sunflower	
HEMA80	20	20	20	22	30	Heracleum maximum	Heracleum lanatum	Cow parsnip	
HECH	40					Heuchera chlorantha	Heuchera spp.	Alumroot	
HISCA	15-20	25-30		35-40	65+	Hieracium scouleri var. albertinum	Hieracium albertinum	Hawkweed	
LIPU11				60		Leptodactylon pungens	Leptodactylon pungens	Granite gilia	
LUARM4					57	Lupinus arbustus	Lupinus laxiflorus	Spur Lupine	

Developed from WNTSC Technical Note

Prepared by Bob Gillaspy, 6/30/2014

Dry Weight Percentages of Selected Oregon Grasses, Grasslikes, Forbs, Shrubs, and Trees

FORB PHENOLOGICAL STAGE CLASSIFICATION:
1- GREEN BEFORE FLOWERING
2 - FULL BLOOM PETALS FALLING
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4 - FRUIT RIPE OR FALL DORMANCY
5 - SEED DISSEMINATION OR WINTER DORMANCY

NATIVE PERENNIAL FORBS continued

PLANT CODE	1	2	3	4	5	PRESENT SCIENTIFIC NAME	HISTORIC SCIENTIFIC NAME	COMMON NAME	NOTES
LUSE4			32		39	Lupinus sericeus	Lupinus sericeus	Silky Lupine	
LUPIN	18-25	25-30	30-35	40-45	50-90	Lupinus	Lupinus spp.	Lupine	
MEAR6	15-18	20-25	22	30	50-75	Mertensia arizonica	Mertensia leonardi	Bluebells	
OSOC	15-18	21	25	30	50-70	Osmorhiza occidentalis	Osmorhiza occidentalis	Sweet anise	
PABR			30-38	40		Paeonia brownii	Paeonia brownii	Peony	
PHHO	35	50		75		Phlox hoodii	Phlox hoodii	Hoods phlox	
PHLO2	20-25	35-40	50		70-80	Phlox longifolia	Phlox longifolia	Longleaf phlox	
POAR7	50					Potentilla arguta	Potentilla arguta	Galley cinquefoil	
POGR9	44	50				Potentilla gracilis	Potentilla gracilis	Northwest cinquefoil	
POTEN	15-20	25	30-35	38-45	55+	Potentilla	Potentilla spp.	Cinquefoil	
RUOC2	20	25-35		30-40	55-70	Rudbeckia occidentalis	Rudbeckia occidentalis	Coneflower	
PACA15		24				Packera cana	Senecio canus	Wooly groundsel	
SESE2	15-20	25-30	35	40	55+	Senecio serra	Senecio serre	Butterweed	
SOMI2	30					Solidago Missouriensis	Solidago Missouriensis	Missouri goldenrod	
PSJA2	23	25	30	31	90	Pseudostellaria jamesiana	Stellaria jamesiana	Starwort	
TAOF	20	25				Taraxacum officinale	Taraxacum officinale	Dandelion	
THFE	23	30	36	40	70	Thalictrum fendleri	Thalictrum fendleri	Meadow rue	
VAOC2		20		25		Valeriana occidentalis	Valeriana occidentalis	Valerian	
VIOLA	15-20	20-25	30	38		Viola	Viola spp.	Violet	
WYAM	20-25	25-30	35	40	55+	Wyethia amplexicaulis	Wyethia amplexicaulis	Mulesear	
LESQU				65		Lesquerella	Lesquerella spp	Tallow weed	
ARCA12	30-35	65		80-85		Artemisia campestris ssp. borealis	Artemisia spp.	Sageworts	biennial
CHAL7	29					Chenopodium album	Chenopodium spp	Lambsquarters	
CRSE11	50					Croton setigerus	Croton spp	Dove seed	
GEVI2	20	38	30-35	40-45	55-70	Geranium viscosissimum	Geranium viscosissimum	Sticky geranium	
HEAN3	25	50		95		Helianthus annuus	Helianthus annuus	Annual sunflower	
LAOCO	25	45		95		Lappula occidentalis var. occidentalis	Lappula redowskii	Stickseed	biennial
ORLU2	15	20	25	35	45+	Orthocarpus luteus	Orthocarpus spp.	Owl-clover	
PODO4	25	40		85		Polygonum douglasi	Polygonum douglasi	Knotweed	
SEIN2	15-20	23-30	30-40	40-45	55+	Senecio integerrimus	Senecio integerrimus	Lambstongue	biennial
SOAM	20					Solanum americanum	Solanum nigrum	Black nightshade	
SPCO	40-45	55		80-90		Sphaeralcea coccinea	Sphaeralcea coccinea	Scarlet globemallow	biennial
THIN			50			Thelypodium integrifolium	thelypodium integrifolium	Entire leaved thelypod	biennia
AMRE		20				Amaranthus retroflexus	Amaranthus spp	Red root	
AMTE3				80		Amsinckia tessellata	Amsinckia spp	Fiddle neck	
LAPPU				85		Lappula	Lappula spp	Stick seed	biennial
PLOV				75		Plantago ovata	Plantago spp	Indian wheat	

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Developed from WNTSC Technical Note

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FORB PHENOLOGICAL STAGE CLASSIFICATION:
1- GREEN BEFORE FLOWERING
2 - FULL BLOOM PETALS FALLING
3 - FRUIT RIPENING
4 - FRUIT RIPE OR FALL DORMANCY
5 - SEED DISSEMINATION OR WINTER DORMANCY

NATIVE VINE

PLANT CODE	1	2	3	4	5	PRESENT SCIENTIFIC NAME	HISTORIC SCIENTIFIC NAME	COMMON NAME	NOTES
LABR	15-20		25-40		50-80	Lathyrus brachycalyx	Lathyrus spp.	Peavine, Bonneville pea	
VIAM	20	25-30		75		Vicia americana	Vicia americana	American vetch	rhizomatous
HULU	30			80		Humulus lupulus	Humulus spp	Hop	

INTRODUCED FORBS/VINE

PLANT CODE	1	2	3	4	5	PRESENT SCIENTIFIC NAME	HISTORIC SCIENTIFIC NAME	COMMON NAME	NOTES
COAR4		35				Convolvulus arvensis	Convolvulus spp	Field bindweed	perennial, vine
CYOF	20	35		90		Cynoglossum officinale	Cynoglossum officinale	Houndstonque	biennial
SAKA	30	50		100		Salsola kali	Salsola kali	Russian thistle	annual
SATR12	25	30	45	50	65	Salsola tragus	Salsola tenuifolia	Prickly Russian thistle	annual
TRDU	33					Tragopogon dubius	Tragopogon dubius	Salsify	annual/biennial
TRLA30	30	50		75		Tragopogon lamottei	Tragopogon pratensis	Goatsbeard	biennial
ASCI4	20	30				Astragalus cicer	Astragalus cicer	Cicer milkvetch	perennial
ERCI6		40		60		Erodium cicutarium	Erodium spp	Alfilaria	annual/biennial
MESA	20	30		39-42		Medicago sativa	Medicago sativa	Alfalfa	annual/perennial
MELIL	20	30				Melilotus	Melilotus spp.	Sweetclover	biennial
ONVI	20	30				Onobrychis sativa	Onobrychis sativa	Sainfoin	perennial, forb

Dry Weight Percentages of Selected Oregon Grasses, Grasslikes, Forbs, Shrubs, and Trees

TREE/SHRUB/SUBSHRUB

SHRUB PHENOLOGICAL STAGE CLASSIFICATION:
1 - GREEN LEAVES ONLY OR FULL LEAF STAGE
2 - FLOWERS IN BUD, GREEN FLOWERING STAGE
3 - FLOWERS OPEN OR FRUIT DROP
4 - SEED MATURITY OR FALL DORMANCY * = GREEN FRUIT WT
5 - WINTER DORMANCY OR CURED LEAVES ** = DRY FRUIT WEIGHT

NATIVE TREE/SHRUB

PLANT CODE	1	2	3	4	5	PRESENT SCIENTIFIC NAME	HISTORIC SCIENTIFIC NAME	COMMON NAME	NOTES
ACGL	30					Acer glabrum	Acer glabrum	Rocky Mtn. maple	
AMAL2	35	45	85	30*	85**	Amelanchier alnifolia	Amelanchier alnifolia	Serviceberry	
ARTR2	35-55	40-65	50	55-75	60-90	Artemisia tridentata	Artemisia tridentata	Big sagebrush	
CEVE	35	45	50	65		Ceanothus velutinus	Ceanothus velutinus	Snowbrush	thicket forming
JUOS			58			Juniperus osteosperma	Juniperus osteosperma	Utah Juniper	single stem
JUSC2	45	55	60	35*	85**	Juniperus scopulorum	Juniperus scopulorum	Juniper	stoloniferous
POTR5	20	20	37-50	52-56		Populus tremuloides	Populus tremuloides	Quaking aspen	single stem
PREM			43	69		Prunus emarginata	Prunus emarginata	Bitter-cherry	thicket forming
PRVI	30	40-46	65	40*	90**	Prunus virginiana	Prunus virginiana	Chokecherry	
SALIX		30				Salix	Salix spp.	Willow	
SANIC6	15	45	60	30*	80**	Sambucus cerulea	Sambucus cerulea	Elderberry	

Dry Weight Percentages of Selected Oregon Grasses, Grasslikes, Forbs, Shrubs, and Trees

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NATIVE SHRUB

PLANT CODE	1	2	3	4	5	PRESENT SCIENTIFIC NAME	HISTORIC SCIENTIFIC NAME	COMMON NAME	NOTES
ARPA6				60		Arctostaphylos patula	Arctostaphylos spp	Greenleaf manzanita	
ARAR8	45	60	54-70	60-75		Artemisia arbuscula	Artemisia arbuscula	Low sagebrush	single stem
ARNO4	40	55	50-75	60-75		Artemisia nova	Artemisia nova	Black sagebrush	
ARTR4	40		38-50			Artemisia tripartita	Artemisia tripartita	Threetip sagebrush	
ARCA13	35	50	70			Artemisia cana	Artemisia cana	Silver sagebrush	rhizomatous
ATCA2	58			60		Atriplex canescens	Atriplex canescens	Fourwing saltbush	
ATCO	40	60	75			Atriplex confertifolia	Atriplex confertifolia	Shadscale	
ATCO				40		Atriplex confertifolia	Atriplex jonesii	Mound saltbush	
MARE11		37-67				Mahonia repens	Berberis repens	Oregongrape	stoloniferous
MATR3	50	65				Mahonia trifoliolata	Berberis spp	Algerita	
CEGR				70		Ceanothus greggii	Ceanothus greggii	Buckbrush	
ERNAO	30-40	45-50	55-60	65	70+	Ericameria nauseosa ssp. consimilis	Chrysothamnus nauseosus	Rubber rabbitbrush	
CHVI8	30	37-45	50-60	65	70+	Chrysothamnus viscidiflorus	Chrysothamnus viscidiflorus	Green rabbitbrush	
EPVI	10			55		Ephedra viridis	Ephedra spp	Mormontea	
KRLA2	20-25	60-67	65			Krascheninnikovia lanata	Eurotia lanata	Winterfat	
GUSA2	30	50	75			Gutierrezia sarothrae	Gutierrezia sarothrae	Broom snakeweed	
HODI	50					Holodiscus discolor	Holodiscus discolor	Oceanspray	
OPUNT				30		Opuntia	Opuntia spp	Pricklypear (fruit only)	succulent
OPUNT	10	15	13-20	10*	70**	Opuntia	Opuntia spp.	Pricklypear	succulent
PHLE4	33					Philadelphus lewisii	Philadelphus lewisii	Mockorange	
PHMA5				74		Physocarpus malvaceus	Physocarpus malvaceus	Ninebark	
PUTR2	30-35	40-45	55-65	65		Purshia tridentata	Purshia tridentata	Bitterbrush	
RHTR				50		Rhus trilobata	Rhus trilobata	Skunkbush sumac, Squaw	rhizomatous
RIBES			45			Ribes	Ribes	Currant	
ROWO	20-25	35	35-50	50*	85**	Rosa woodsii	Rosa spp.	Rose	rhizomatous
SAVE4	35	38-45	60			Sarcobatus vermiculatus	Sarcobatus vermiculatus	Greasewood	
SEFLF				20*		Senecio flaccidus	Senecio longilobus	Woolly groundsel	
SYAL	25-30	35-40	65	30-40*	85**	Symphoricarpos albus	Symphoricarpos spp	Snowberry	rhizomatus
TECA2			55	70		Tetradymia canescens	Tetradymia canescens	Horsebrush	