FSH 2209.21 – RANGELAND ECOSYSTEM ANALYSIS AND MONITORING HANDBOOK
CHAPTER 20 – RANGELAND INVENTORY AND ANALYSIS

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20.0 Chapter Overview

20.1 Scope

Inventory and monitoring provide a useful framework for understanding the environment: where and what environments can be found on the landscape, how much of each type can be tallied, and how all this changes over time. This chapter covers inventory and monitoring of the current condition of rangelands. For changes over time (trend), see Chapter 40.

Classification and inventory are separate parts of the range assessment process. Classification is basically "what" environments are found on the landscape. Refer to direction in the Terrestrial Ecological Unit Inventory technical guide (Winthers et al. 2004) for classification guidance; it is not detailed in this handbook, although information on available potential vegetation classifications can be found in Section 24.22 that follows.

Inventory is the quantity of the classification units (or other attributes of interest) on the landscape. Often we are also interested in their location as well, and so we map.

"Location" refers to mapping and is covered in Sections 24.2 and 24.3. The quantity of ecosystems—the "how much" is inventory. Quantity is usually expressed in acres of each vegetation or ecological type.

Monitoring is a sampling process used to determine the state or condition of a resource or area. Monitoring in the Forest Service has conventionally been organized as implementation, effectiveness, or validation monitoring. Implementation verifies whether treatments were completed or not. Effectiveness monitoring assesses whether the treatment accomplished (or is accomplishing) the intended objective. Validation monitoring asks fundamental questions about how ecosystems work, and is akin to research. Another way to look at validation is that it questions the objective itself.

As an example of these three, consider a project where cattle are used to reduce fire risk by removing vegetation through grazing. If we go out and check whether cattle were indeed put on the area, that is implementation monitoring. If our standard was that a certain stubble height was necessary before fire risk was reduced, and we collected field data to check this, that is effectiveness monitoring. If we are testing to see if removing vegetation through grazing really has any effect on reducing fire risk, that is validation monitoring.

Many different aspects of ecosystem structure, function, and composition can be monitored. Indeed, the list is essentially endless. To facilitate a practical, effective monitoring program, we have organized the methods with four important concepts providing the framework:

1) Time. Range conditions can be measured at a single point in time (status), or at intervals over time (trend). This chapter focuses on status and Chapter 40 focuses on

trend. Trend monitoring should be considered imperative to support a decision to change management.

2) Space. A fundamental paradigm shift inland management over the past 30 years is a recognition that ecosystem processes operate differently with spatial scale, and that these difference have profound effects on management. For example, a badly overgrazed allotment of a few hundred acres may have much or little effect on the landscape as a whole, depending on whether it is an upland or a riparian site. Paying attention to scale allows us to set priorities and capture important resource concerns that would otherwise be lost. For this reason, we have organized methods by local to mid- and broad (landscape) scales.

3) Intensity. A variety of methods have been developed for monitoring changes in range vegetation. We have grouped them by level of sampling intensity to meet varying levels of management need for concise information. Generally speaking, the more accurate and precise a method the more time and money it will cost to use. Bearing in mind that resources to sample rangelands are likely to be very limited for the foreseeable future, we emphasize using indicators of rangeland health (for uplands) and proper functioning condition (for riparian areas) methodology, assessment methods that are not overly data intensive. For upland assessments, anything exceeding moderate or greater departure from expected conditions should be considered for additional monitoring. Likewise, with proper functioning condition (riparian areas), anything rating as “functioning at risk” warrants further monitoring, particularly for the attributes causing the “at risk” rating.

4) Upland vs. Riparian. Because of the often great differences between upland and riparian ecosystems, we outline methods for sampling each.

In this chapter we first outline some basic concepts of the rangeland ecological setting, then define the scale and intensity of monitoring. Methods for each scale and level of intensity are documented. Because of a long history of tested rangeland monitoring methods, this document does not go into specific details of monitoring methods, but rather refers the reader to the accepted, peer-reviewed methodology as appropriate. The intent of this guidebook, based on extensive review and consultation, is to indicate the best method for a set of circumstances. In this way more effective, standardized monitoring and inventory throughout the Region should result.

20.2 Ecological Setting

Effective rangeland monitoring and analysis cannot be conducted without a firm grasp of the ecological setting of the area. The Terrestrial Ecological Unit Inventory (TEUI) Guide (Winthers et al. 2004) is highly useful in this regard, and has been specifically designed to provide the ecological context for integrated management at multiple scales.

Following is a brief synopsis of the key ecological concepts range managers should employ in designing monitoring and analysis, with sections cited in the TEUI guide for further explanation:

1. Multiple scales. Ecosystems function at multiple scales, from broad regions of the country to physiographic subregions to landtype associations (Smith 2001) to individual phases of ecological types covering a few acres. Processes at each scale vary and are driven by different factors. For example, broad regions are shaped by climate and geology, while at fine scale soils and vegetation become more important. Identifying the appropriate scale to address a management question is therefore of utmost importance.

2. Integrated factors. Climate, geology, geomorphology, soils, and vegetation all interact, often in complex ways. Taking an integrated approach leads to better management decisions, because the environment is more accurately understood. For example, the subalpine fir/grouse whortleberry plant association covers a wide area with different ecological factors, and thus vegetation response to disturbance on this plant association varies greatly. If this vegetation information is coupled with specific soils information, however, vegetation response may be predicted accurately.

3. The role and function of disturbance. Understanding ecosystem disturbances such as fire, wind, insects and disease, flooding, and soil movement is critical for any sound resource management. Indeed, many egregious management decisions have been made because disturbance, an integral part of landscape function, was ignored or misunderstood. Disturbance regime defined by type, frequency, intensity, duration, scale, and probability is a necessary factor to consider in landscape assessments.

4. Understanding the historical or natural range of variation and its use as a benchmark for determining sustainability. Sustainable landscapes featured a range of composition in seral stages and a disturbance regime with a range of those defining characters, including frequency and intensity or severity. Estimates of these values provide us with a set of reference conditions. Describing the current, or perhaps near future, range of variation in reference conditions would be ideal. These, however, have generally not yet been modeled or described. We therefore compare actual current conditions to historic conditions to get a sense of the departure of landscape structure, function, and composition from sustainable conditions .. In the Pacific Northwest, the 400 years prior to 1850 (the approximate point of significant European settlement) is typically used as the reference time period.

This concept was used as a framework in the Interior Columbia Basin assessment, and is the heart of Fire Regime Condition Class (FRCC). The latter could have been named "Disturbance Regime Condition Class," since the concept applies to all disturbances, not only fire.

Until good estimates of ecosystem parameters for the current sustainable range of variation are available, assessments will most likely use the historic range. Bear in mind, however, that the historic range typically used in the Pacific Northwest (late 1500s to about 1850) coincides with the Little Ice Age, and that significant European settlement coincided with a warming and relatively wet climate, followed by a continued warming and drying climate. Sustainable condition pre-1850 may have been different than sustainable conditions today as a function of climate change as well as settlement and management. In all cases, use the current science on this topic as it evolves and becomes available.

5. Understanding the relationships between historic, existing, and potential vegetation. This understanding is a fundamental tool in managing ecosystems. Historic vegetation is that characteristic of the disturbance regime and climate prior to European settlement, existing vegetation refers to its current state, and potential vegetation reflects the land's capability to generate a certain ecosystem. Potential vegetation can be defined as constrained by climate (as in most plant association classifications in the Pacific Northwest), or constrained by disturbance. The latter is sometimes referred to as a "dysclimax" seral development, limited by fire, fluvial processes, soil movement, or wind. Because the latter emphasizes the role of disturbance, it is used in FRCC. A classic work using the dysclimax approach is Kuchler 1964. Climatic and disturbance potential vegetation can be cross-referenced to each other.

6. Related to both disturbance and vegetation concepts are state and transition models. Seral stages are seen as states that can transition to multiple possible pathways depending on disturbance. This is in contrast to the classic Clementsian view where seral stages proceed along a single path to a climax state. This Clementsian view is simply inadequate as a framework for understanding the complex processes and successional pathways in arid and semi-arid ecosystems (West 1979, Westoby, at al. 1989, Tausch et al. 1993, Stringham et al. 2003). Non-equilibrium state-and-transition models incorporating concepts of multiple successional pathways, irreversible states, multiple steady states, and thresholds better describe range ecosystems (Archer 1989, Stringham 1996, West 1999, Stringham 2003). In recent years state and transition concepts have become a fundamental tool to understanding range ecosystems, and we embrace it in this handbook.

   State and transition concepts contribute greatly to range management by providing a framework to understand disturbances—both natural and human-caused—and ecosystem responses to those disturbances (Stringham et al 2003). These concepts of state, disturbance, response, and new state are inherent, for example, in Fire Regime Condition Class (FRCC) and other modeling to predict ecosystem sustainability. Also inherent in most state and transition modeling is the concept of thresholds—ecosystem conditions that indicate ecosystem functions may be at risk. For example, changes in plant composition may indicate conditions favorable for severe fire or an infestation of an invasive plant. This is obviously of great management interest.

Familiarity with basic plant ecology is essential to determine resource values and potentials, ecological status of the range, and the establishment of the desired future condition goals. At a minimum, one team member must be familiar with the vegetation of the area and be able to identify the plant species. Type potential can best be determined from prepared ecological scorecards and through examination of protected areas which have not been recently affected by a disturbance agent, for example, livestock grazing.

Sources of information for developing range inventory and analyses:

a. Potential vegetation and existing vegetation maps
b. Forest Land and Resource Management Plan.
c. Old range inventory maps and records.
d. Old allotment management plans.
e. Timber inventory, ecological site (NRCS) data, soil inventory, and soil-vegetation maps.
f. Range inspections, range readiness guides, utilization reports, allotment inspection reports.
g. Knowledge of permittees, State wildlife agency personnel, volunteers, Forest users, and interested public groups.
h. Aerial photography.
i. Wildlife use, census, and habitat analysis and trend records.
j. Land adjustment and status records.
k. County records for land ownership.
l. Area Ecology Plot data

20.3 Setting Priorities

Rangeland analysis should be done where there is a need for information to meet Forest Plan standards, for rangeland allotment decisions, for management, and/or for maintenance and improvement of rangeland condition. The degree of information analyzed will depend upon the purpose of the analysis and the issues relevant to the analysis. Analysis is strongly affected by scale and intensity, and is closely tied to the management objectives for an area. Scale involves both space (geographic area) and time (temporal scale). This chapter covers the range of spatial scales but focuses only on the present and near future (a “snapshot” of current conditions). Monitoring changes over time is covered in Chapter 40.

Priorities can vary by Forest and subregion, but the following are generally high monitoring priorities throughout the rangeland portions of the Region:

1. Allotment condition and trend
2. Relative abundance and value of allotments
3. Overall trend of range conditions
4. Relative abundance of range types, and relative value of each.
5. Landscape departure from historic or natural range

The Forest Supervisor, in consultation with staff, shall establish priorities for analysis. Carefully consider information needs at both broad (sub-regional and Forest Plan) and local (project or allotment) scales. Analyze at the proper scale and intensity for the question of interest, based on guidance in Section 21.0. For example, intense monitoring of utilization at allotment scale would be appropriate when considering allowable cattle grazing pressure, but would have little use at understanding the landscape viability of rangeland ecosystems. For broad scale needs, close coordination with the Regional Office is encouraged.

As used in this handbook, "assessment" at the local scale refers to the process of using indicators of rangeland health (for uplands, Pellant et al. 2000) and proper functioning condition (for riparian zones, Prichard et al. 1998). At landscape scale it refers to departure from the historic or natural range of conditions. "Inventory" refers to the amount of each range type across the landscape. Potential and existing vegetation mapping efforts (Winthers et al. 2003, Brohman and Bryant 2004) are used as the framework for range inventory. (See Inventory section later in this chapter.) "Analysis" is the interpretation and reporting of field information to answer specific questions on range sustainability, trend, abundance, condition, and suitability.

20.4 Analysis Procedure Outline

In any compilation of range and other ecological information, there should be a strong emphasis on using legacy (existing) information. For one thing, these data obviously cannot be replaced, and we have an obligation to future generations to preserve data that may be of significant value. Legacy data also provide information on past condition, so by comparing present conditions to them we can get a good sense of trend.

1. Identify location and purpose for analysis, including a description of desired conditions.

2. Identify issues relevant to the analysis.

3. Determine makeup of interdisciplinary team and intensity of analysis.

4. Compile base information about the resources and issues identified for analysis.

   Document historic condition of area based on records (e.g., 2210 allotment file), photos, interviews and other information sources.

   a. Locate existing maps or create GIS maps from digital ortho-quads, digital raster graphics, satellite imagery, or aerial photos. Append associated tabular data from corporate databases. Consider the following map layers for inclusion if warranted by issues:

   (1) Land area, ownership, and rangeland management unit boundaries.

   (2) Vegetation cover types, community types, and complexes. Layers may include historic, existing, and potential descriptions. (Surrogates may be appropriate if these are not available)

(3) Ecological unit inventory, soil types and geology at appropriate mapping scales.

(4) Streams, lakes, ponds, seeps and springs, wells, or other water resources.

(5) Biological resources including threatened, endangered, and sensitive species or habitat, and known wildlife grazing.

(6) Cultural or heritage resources.

(7) Recreation areas and uses, including roads, trails, gates, campgrounds, and so forth.

(8) Monitoring sites.

b. Compile other documentation relevant to the analysis area, including but no limited to Forest Plan guidance, previous environmental analyses, watershed assessments, allotment management plans, annual operating instructions, permits, resource assessments and inventories, monitoring reports, and photos.

c. Range mapping should follow national and regional standards, and be seen as an integral part of existing vegetation map layers, not a separate effort. Mapping should be prioritized based on leadership direction, management issues, and planning needs. Typically, not all areas will be mapped to the same intensity, and not all areas will be kept current. Contact Regional Office vegetation mapping and inventory specialists for assistance in producing vegetation maps. Mapping is best done with regional or subregional oversight, to ensure consistency and cost efficiency, coupled with local expertise and map production, to ensure ownership and accuracy of the maps. Local expertise in vegetation is needed to produce these maps. Current vegetation maps can be compared with old digitized site analysis maps and the early 1910 and 1920 allotment maps for long term trend determinations.

5. For each rangeland vegetation type within the analysis area:

Verify mapped information, for example, present plant community or vegetative cover types.

a. Describe current conditions.

b. Describe potential vegetation for the type.

c. Interpret information for functionality and trend. Map interpreted information as needed, for example, area’s functional rating and trend, desired condition descriptive elements or attributes, areas meeting or not meeting Forest Plan Guidelines, and management alternatives.

The following optional elements can be added to the above basic monitoring requirements and are helpful in determining the impacts of and opportunities for management and use of the land area and its resources. The degree of information added to and analyzed with the basic information will depend upon the amount of cooperation, conflicts, and problems that exist over the analysis area.

1. Monitoring Studies.

    a. Use Studies.
        Proper use determinations.
        Utilization mapping.
    b. Allotment management grazing system adequacy.
    c. Big game herd unit information needs.

2. Desired future condition descriptive elements.

3. Range Inspections.

4. Inventory of planned range improvements.

21.0 Scale and Intensity of Monitoring

Identify the proper scale and intensity of rangeland analysis, as organized in the following Table. These are intended only for the current state of range conditions; for changes over time (range trend), see Chapter 40.

1. Intensity of monitoring and analysis should be seen in two phases:

    a. An extensive phase aimed at collecting more general information across areas, in order to assess general ecosystem function, or identify problem areas for more intensive monitoring and analysis. The vast majority of monitoring is expected to be extensive.

    b. A more intensive data collecting effort for relatively few problem areas identified during the extensive phase. Wherever possible, baseline data on non-problem areas is also desirable, in order to verify the quality of these areas, and so that a future data collection can show trend.

2. Allotment-scale priorities include (not necessarily in this order):

    a. Rangelands placement on the Allotment NEPA Rescission Act Schedule (P.L. 104-19).

    b. Rangelands with anadromous fisheries; Threatened, Endangered or Sensitive plants; or wildlife or plant designated critical habitat subject to consultation.

    c. Rangelands not in desired condition. For example, rangelands with water quality limited segments identified on State Total Maximum Daily Loads (TMDL) lists.

Table. Recommended Monitoring Methods for Scale and Intensity of Range Analysis

	Fine- to Mid-Scale		Broad Scale		Handbook C	
Application	Extensive	Intensive	Extensive	Intensive	Extensive	
Range Status (Present Condition)	Indicators of rangeland health (upland) or proper functioning condition attributes (riparian), Photo monitoring	Cover frequency, Nested frequency, Riparian methods (see Chap.4)	Not applicable (N/A)	Not applicable	20	
Allotment utilization	Proper Use Report , Photo Monitoring	BLM Utilization Studies	Photo monitoring	N/A	30	
Range Trend (Change Over Time)	Photo Monitoring	Cover frequency, Nested frequency, Riparian methods (see Chap.4)	Fire Regime Condition Class (FRCC), Remote sensing	Not usually applied.	40	
Landscape Assessment (Departure from Historical or Natural Range)	Remote sensing (photos or satellite imagery)	N/A	FRCC, Remote sensing	N/A	40	

d. Rangelands needing to meet Forest Plan direction (standards and guidelines).

e. Rangelands with wild horse or burro and livestock conflicts.

f. Rangelands with controversial issues.

3. Fine- to Mid-scale priorities

a. Landscape assessment for Forest plan revision.

b. Assessment of range condition trend.

c. Relative abundance and condition of range types, both upland and riparian, across the landscape.

d. Use of Fire Regime Condition Class as a measure of departure from sustainable conditions.

4. Broad scale priority information includes:

a. Assessment of the mix of rangeland ecosystems and seral stages across the analysis area
b. The relative proportion of rangelands in each condition class (functioning, functioning at risk, and not functioning)
c. The trend for these rangelands.
d. Subregional and regional assessments

5. Examples of extensive monitoring include

a. Indicators of rangeland health (for upland areas)
b. Proper functioning condition (for riparian areas)
c. Greenline riparian monitoring
d. Landscape assessment, notably FRCC

6. Examples of intensive monitoring include
a. Cover frequency data
b. Nested frequency
c. Riparian scorecard methods
d. Quantitative range utilization measures

Monitoring intensity is reflected by and defined by sampling density and effort. In general, intensive sampling is intended for answers in a relative small area (typically an ecological type or stand or community or a riparian zone) with relatively high confidence. Extensive sampling is designed for a broader scope of inference (e.g., a landscape), with more general reporting of precision.

Note again that this handbook is organized with the theme of levels of intensity to meet specific monitoring goals. We are reluctant to state one monitoring method as inherently superior to another (with the exception that new Parker 3-Step sample points should not be established). The more intense the method, the greater the accuracy and confidence in the data. But this must be balanced by the cost and time necessary to achieve that confidence. Another consideration is the inevitable loss of information when data collected with one method (e.g., cover frequency) is converted to another (e.g., nested frequency). It is therefore our recommendation that the conversion of plots collected with cover frequency methodology to nested frequency methodology be optional. New data sets should be collected with nested frequency methodology.

Sampling intensity is also affected by constraints of funding and personnel. Monitoring should therefore be designed carefully to answer the questions of interest as efficiently as possible. Choosing the right scale of analysis is therefore critical.

Photo monitoring.

Point monitoring of range sites through use of photos should be encouraged. This is a relatively inexpensive method of monitoring that is less time-consuming than most field data collection methods. It has the added value of conveying range conditions in a simple, straightforward method easily understood by all. Follow procedures in Ground-Based Photographic Monitoring (Hall 2001), and the companion Field Procedures (Hall 2002a) and Concepts and Analysis (Hall 2002b). Further details are provided in Chapter 40 of this handbook.

Proper documentation and metadata for photo monitoring is critical. Photos and slides should be provided for archiving in NRIS Terra. Use the metadata template provided in Terra documentation (available on the web at http://fsweb.sandy.wo.fs.fed.us/terra/).

Increasers and Decreasers

Regardless of the range monitoring method or intensity, indicating increasers and decreasers is a useful tool in both status and trend monitoring. Increasers are species generally unpalatable to livestock and increase with abundance as range condition deteriorates. Decreasers are the opposite—livestock seek them out because of their palatability, and hence they tend to decrease with grazing pressure. Weakened by overgrazing or other stresses, ecosystems can be vulnerable to invasive species. Thus increaser-decreaser relationships are related to invasion by undesirable plants, and can serve as indicators of thresholds when systems become vulnerable to invasives (Gayton 2003).

Much documentation, monitoring, and research on increasers and decreasers remains to be done in the Pacific Northwest. In particular, the increasers and decreasers need to be tied to specific states in state-and-transition models, as an aid to practical range management.

As a starting point, we have included an increaser/decreaser list from British Columbia (Gayton 2003) as an Appendix to this chapter. Increaser/decreaser information can also be found in plant association guides for northeast Oregon (Hall 1973, Johnson and Simon 1987, Johnson and Clausnitzer 1992).

21.1 Monitoring at Fine to Mid-Scale

A wide variety of monitoring methods are available to meet needs at a variety of scales, intensities, and timeframes. Rather than mandate one method above others, we stress a consistency of outcomes. In other words, if certain key attributes are monitored consistently, flexibility in the monitoring method is allowed.

We first outline extensive and then intensive monitoring methods. Roughly listed in order of increasing intensity, some methods for consideration are assessment (either indicators for rangeland health for uplands or proper functioning condition for riparian areas), greenline, modified greenline, Cowley and Burton (MIMS), and the riparian scorecard.

Some methods require identifying a community type. A number of resources are available for this, including plant association publications of the Region's ecology program. Most are available online at www.reo.gov/ecoshare.

21.11 Extensive Methods

Upland: Interpreting Indicators of Rangeland Health

Methods for assessing upland areas are outlined in Pellant et al. (2000), *Interpreting Indicators of Rangeland Health*. They are intended for extensive range status monitoring at fine and mid-scales. **PFC methods should not be used for range *trend* monitoring.** According to Pellant et al.(2000), they are intended for a preliminary evaluation of soil stability, hydrologic function, and ecosystem integrity at local scale. This preliminary information can be used to identify areas at risk of degradation. Action can then be taken, perhaps including more intensive monitoring. PFC does not normally identify the causes of resource problems or rangeland trends. It should only be used by knowledgeable, experienced personnel.

Indicators of rangeland health are use to identify departure from reference conditions at the local scale. (Use Fire Regime Condition Class (Hann et al. 2005) for departure defined at landscape scale.) Departure is assessed for three attributes: soil/site stability, hydrologic function, and integrity of the biotic community. These attributes are ranked from "extreme" to "none to slight" These rankings are influenced in part by field data collected on worksheets. For complete details, see the technical reference Pellant et al. 2000 (*Interpreting Indicators of Rangeland Health*). Use *Indicators* for upland areas and Proper Functioning Condition (PFC) for riparian areas.

Indicators that should be evaluated for upland assessments are listed in the Table of Contents for Pellant et al. 2000. The 18 indicators are:

1. Rills
2. Water Flow Patterns

3. Pedestals and/or Terracettes
4. Bare Ground
5. Gullies
6. Wind-Scoured, Blowouts, and/or Deposition Areas
7. Litter Movement
8. Soil Surface Resistance to Erosion
9. Soil Surface Loss or Degradation
10. Plant Community Composition and Distribution Relative to Infiltration and Runoff
11. Compaction Layer
12. Functional/Structural Groups
13. Plant Mortality/Decadence
14. Litter Amount
15. Annual Production
16. Invasive Plants
17. Reproductive Capability of Perennial Plants
18. Optional Indicators

Riparian: Proper Functioning Condition

For riparian areas, use the proper functioning condition (PFC) methods detailed in Prichard et al. 1998. **As with upland indicators of rangeland health, this method should only be used for status and not trend monitoring.** This method is more of an organized series of planning steps than an assessment of specific environmental attributes. PFC is a determination of the minimum conditions required for the area to function properly.

21.12 Intensive methods

Legacy Method

Parker loop method. Years ago the standard for collecting range vegetation composition data was the Parker loop method (sometimes referred to as "Parker Three Step" because this method involved (1) photos, (2) scorecards, and (3) vegetation measurement with ¾ inch loops. Vegetation was tallied along a transect using a small loop attached to a rod. Although this method is no longer a standard in any Forest Service Region, much legacy data remains and is an invaluable asset in understanding past range conditions. Any existing Parker loop data is valuable and should be input to electronic form. Revisiting sites monitored with this method (and making a transition to one of the newer standard methods) is also strongly recommended. For more details, see Trend monitoring in Chapter 40.

Note: Specific methodology and data entry forms for the cover frequency and nested frequency methods that follow can be found on the web at http://fsweb.ftcol.wo.fs.fed.us/frs/rangelands/inventory/index.shtml These protocols are supported by the USDA Forest Service Rangeland Management Service Center in Ft. Collins, CO and are formatted for entry into NRIS Terra.

Do not use the Parker loop method to collect new data, except when making a transition to a more current method. In that case a one-time remeasurement of the transect using both Parker and the more current method is appropriate. Subsequent remeasurements would use the more current method.

Frequency Methods (Cover Frequency and Nested Frequency)

Appropriate Uses

Cover frequency and nested frequency methods are available to monitor range vegetation. Sampling range vegetation involves an estimate of the current condition (status) and a change in conditions over time (trend). Both of these methods are acceptable when the objective is to determine the current condition of rangeland vegetation (status). Nested frequency will be the preferred method for intensive range sampling to determine trend, because it is more robust (less sensitive) to changes in cover caused by fluctuating rainfall. Canopy coverage may be used to assess successional status of rangeland vegetation where previous classification studies describe seral status in terms of canopy cover or scorecards have been developed to reflect this vegetation attribute.

Cover and nested frequency methods are detailed on pp. 37-49 and pp. 55-63 of Coulloudon et al. 1999 (the Interagency Technical Reference on Sampling Vegetation Attributes).

Colloudon et al. 1999 outline four methods involving data collected on a two-dimensional area (rather than points): Daubenmire method, pace frequency, quadrat frequency, and nested frequency. The Daubenmire method involves small rectangular frames (2 X 5 dm quadrats) arrayed along a short transect. With this method both canopy cover and frequency can be calculated. A limitation is that herbaceous canopy cover can change dramatically between years because of rainfall fluctuations. It is therefore difficult to separate management impacts to range condition from weather effects. Pace frequency is a plotless system that tallies species encountered at paced intervals along transects. (An example is employed in the greenline method, documented elsewhere in this document.) Quadrat frequency is similar to the Daubenmire method, but plot sizes and numbers can vary. Frames are generally bigger to encompass a higher proportion of the species likely to be encountered (Coulloden et al. 1999).

Nested frequency is an enhancement on the typical frequency method in that a set of nested plots is employed, with the larger plot used for species less densely encountered (such as trees and shrubs). Nested within this is another plot or plots, for species that are increasingly dense (i.e., grasses, forbs, etc.) The nested approach has the advantage of more accurately capturing the frequency of each lifeform and is more robust in accounting for the effect of year-to-year climatic fluctuations and the subsequent variation in plant canopy coverage that occurs. Because nested frequency is independent of plant canopy coverage, it can be used regardless of plant phenology as well as in areas currently grazed by livestock. On the other hand, it is also more time-consuming to collect data with this method, however.

Use the nested frequency method described in *Methodology Technical Guide: Nested Frequency Transect Protocol.* This is available on the web at the following address, and is formatted for entry into NRIS Terra.

http://fsweb.ftcol.wo.fs.fed.us/ftp/pub/staff/rangelands/docs/protocols/transects/nested_frequency/Nested_Frequency_Methodology_Tech_Guide.doc

Further details on the nested frequency method can be found on pp. 27-43 and p. 49 of Coullouden 1999. Details can also be found in Chapter 40 of this handbook.

Whatever method is used, as a minimum plant percent canopy coverage and frequency must be reported. Documentation of all the above methods are found in Coullouden et al. 1999. Additional information can be found in Hyder et al. 1963, BLM 1985, Bonham 1989, and Forest Service 1994. West (1985) discusses some of the limitations of frequency-based sampling.

Intensive riparian sampling methods

Greenline method

The Greenline method, actually a set of three methods, is designed as a more intensive follow-up to a riparian proper functioning condition assessment (Prichard et al. 1998). Greenline methods are appropriate for an intensively-sampled view of the current state of conditions, not for long-term intensive monitoring. For the latter, use the riparian scorecard methods detailed in Chapter 40.

The three sampling methods involved in Greenline are 1) the vegetation cross section composition, 2) the greenline composition, and 3) woody species regeneration (Winward 2000). The first two require some kind of vegetation community classification be available. Where a classification is not available, and an intensive method is needed, use the riparian scorecard methods in Chapter 40.

Following are brief descriptions of the three methods. For more details, see Winward 2000.

Vegetation cross-section data are collected with at least five transects placed perpendicularly to the stream. The plant species at regular stepped intervals along the transects is recorded. These can then be translated to percent composition.

Greenline composition is determined through use of transects along streams on the boundary between vegetation and eroded soil or rock. Typically this "greenline" is located several feet above bank-full stage. In addition to individual species composition, greenline composition can be used to determine percentages of plant communities present.

Woody species regeneration is tallied by evaluating a 6-ft wide belt superimposed on the greenline transect. Within this belt, woody stems are tallied and classified as sprout, young, mature, decadent, or dead.

Greenline methods provide quantitative data on the current state of vegetation and its vigor along streams. Because transects and methods are difficult to repeat with these methods, they are not recommended for monitoring changes over time.

Greenline methodology (Winward 2000) can be downloaded from the web at http://fsweb.ftcol.wo.fs.fed.us/frs/rangelands/inventory/index.shtml. This site also includes data entry forms

Pacfish/Infish Biological Opinion (PIBO) Method

This is a modified version of the greenline method and is used on BLM- and Forest Service-administered lands in the upper Columbia River Basin. Greenline methods were altered to increase precision. Species cover data rather than community type data is collected, removing the confusion and ambiguity associated with identifying community types in shifting riparian zones or where community type classifications do not exist. The Woody Regeneration method of greenline was dropped because of the variability experienced among observers (National Riparian Service Team 2004).

Cowley and Burton Method

This method, sometimes referred to as "MIMS" (Multiple Indicator Monitoring System), is a variation of the greenline technique and offers some assessment of riparian bank condition and stability. Placement of the sampling plots is less subjective than the greenline method. Its use is acceptable, provided the same data attributes as with the greenline technique are collected. Information on the Cowley and Burton method can be found at www.id.blm.gov/techbuls/index.htm. Cowley and Burton (2005) can be used for both status and trend monitoring of the relationship of grazing use to attainment of desired conditions.

Riparian scorecard

An intensive riparian sampling method involving vegetation classification, vegetation sampling, and soil sampling has been developed by Zamudio (2005) and others of the Central Oregon Ecology Service Team. This method is the most intensive of those listed, and should be seen as a long-term investment in monitoring, and be reserved for only those areas of great management interest or controversy. Because the primary purpose with this method is comparing sites to a classified type, and for long-term trend monitoring, it is more fully described in Chapter 40. Weixelmann et al. (1997) also provides more details on the method.

21.2 Monitoring at Broad Scale

Monitor of landscapes at broad scale using maps and assessment tools is strongly recommended. When personnel and financial resources are limited, relying on maps and remote sensing is an effective and cost-efficient way to monitor landscapes. The Regional standard Interagency Mapping and Assessment Process (IMAP) is designed to provide existing vegetation maps, historic vegetation maps, and modeled future conditions based on the current management scenario (DeMeo et al. 2005). Use of the Fire Regime Condition Class method (Hann et al. 2005) is appropriate for landscape assessment, including implications beyond fire management. A combination of IMAP products and FRCC methods should meet most rangeland monitoring needs at broad scale. LANDFIRE maps, prepared for a national scope, may also be of use, particularly in comparing areas with across Forest Service Regions.

22.0 Rangeland Inventory

22.1 Overview

Rangeland inventory answers the question of "how much" of the resource is present: acres of ecological types, tons of forage, etc. Ecological unit inventory will be used as the standard for spatial (mapping) aspects of rangeland inventory.

22.2 Ecological Unit Inventory

Ecological unit inventory is the agency standard for mapping the environment. Integrated units representing climate, geology, geomorphology, soils, and potential vegetation are mapped at multiple scales. Refer to the Terrestrial Ecological Unit Inventory (TEUI) guide for details on mapping procedures (Winthers et al. 2003).

For rangelands, landtype associations (LTAs) are the appropriate scale for landscape assessment, such as used in Forest plan revisions. For more local applications, such as allotments landtypes or landtype phases cover the appropriate areas.

Landtype associations can be mapped relatively quickly and cheaply, and are available for many areas in the Region. In contrast, proper mapping of landtypes and (especially) landtype phases is expensive and time-consuming, and will in practice be used only for areas of the greatest ecological, economic, or social interest.

Where potential vegetation or soils maps are available at fine scale, these may be used as a surrogate for ecological unit maps.

22.21Standards

Follow standards for ecological unit inventory maps in Winthers et al. 2003. Where potential vegetation or soil maps are used as a surrogate, note they must still follow applicable standards in the national TEUI guide. All mapping must conform with TEUI and rangeland data standards in NRIS Terra. (See Section 25.0.)

22.3 - Identifying Ecological Types. Reference the Terrestrial Ecological Unit Technical Guide (Winthers et al. 2003), and Section 23.3 in this Handbook for further discussions on identifying and naming ecological types. Use TEUI ecological types if available. If not, use surrogate such as plant association. Differences in the kind, proportion, and production of plants are in large measure the result of differences in soil, topography, climate, and other environmental factors. Variations in soil texture, depth, and topographic position usually result in pronounced differences in plant communities. Environmental conditions associated with a specific ecological type can be used to identify the type in the absence of the potential natural vegetation.

Distinguishing between ecological types along ecotones is difficult. Type differentiation may not be readily apparent until the cumulative environmental impact on vegetation is examined over a broad area. Ecological type differences may be reflected in production or in the kinds and proportion of the plant species making up the core of the plant community, or both. Of necessity, boundaries between ecological types along a gradient of closely related soils and a gradually changing climate may be somewhat arbitrary and, therefore, may be mapped as a composite.

The criteria used to differentiate one ecological type from another are:

1. Significant differences in the kind and proportion of species groups in the plant community.
2. Significant differences in soil properties, slope, and topographic position reflecting different use potentials and hazards that are not reflected in the community.

Any differences in criteria, either singly or in combination, great enough to indicate a different use potential or to require different management are bases for establishing an ecological type. (This is the reason we do it.)

22.4 - Naming Ecological Types. Ecological types are named using a two-part, abiotic and biotic name. The abiotic portion is based on readily recognized permanent physical features such as landform or soil family. The biotic name shall consist of two (sometimes three) scientific names of characteristic, diagnostic, or prominent species. Where one layer of vegetation exists, one or two names shall be chosen, e.g., Agropyron smithii/Stipa viridula. Where more than one vegetation layer exists, names shall come from both (or three) layers. For example, Pinus ponderosa/Purshia tridentata/Festuca idahoensis. An example of a complete ecological type name might be Pinus ponderosa/Purshia tridentata/Festuca idahoensis--Typic Cryoborolls, fine-loamy mixed ecological site, or a Artemisia tridentata/Purshia tridentata/Festuca idahoensis--Typic Cryoborolls, fine-loamy, mixed.

Ecological types are correlated on the basis of species frequency, composition, cover, or production of the potential natural communities (PNC's), and soils or landform. Sometimes it is necessary to extrapolate frequency, composition, cover and plant production data from one soil to describe the plant community on a similar soil for which no data are available. The delineation of two distinct soil or landform taxonomic units does not automatically require recognition of two ecological types. Likewise, some soil or landform taxonomic units occur over broad environmental gradients and thus may support more than one distinctive PNC because of changes in an environmental component such as average annual precipitation or temperature. Where this occurs the soil or landform taxonomic unit should be phrased to reflect the different potential plant community.

Each Forest may devise a numerical coding scheme for their ecological type names for use on photos, maps, and GIS systems. Ecological type names, however, should be correlated, and a master list maintained and stewarded at the Regional level, consistent with NRIS standards.

It is permissible to use community type names for ecological type names if ecological classifications, type keys, or names are not available. A key or notes should be kept with the analysis to describe these communities.

Acceptable surrogates: SRI, vegetation cover map, plant association maps, ecological sites, NRCS maps

22.5 - Available Classifications and References. Some of the rangeland ecosystems in the Pacific Northwest Region have ecological classifications. For a list of those maintained electronically, see the "Publications" page on the website at www.reo.gov/ecoshare. This website also has links to other related documents.

22.6 Existing Vegetation Mapping

Existing vegetation maps are of course a critical part of understanding the current condition of rangelands. They should be maintained at mid-scale and are highly desirable at fine scale. Follow national (Brohman and Bryant 2004) and regional (USDA Forest Service 2004) standards.

DeMeo et al. 2005 shows the 2005 state of existing vegetation maps in the Region. It also outlines a strategy for bringing areas up to standard. The document provides direction for mapping priorities in the Region. Subsequent leadership direction led to combining this effort with the Hemstrom landscape assessment method.

The regional existing vegetation mapping strategy is now known as the Interagency Mapping and Assessment Process (IMAP). Mapping formally commenced in Fiscal Year 2006. For the first iteration mapping of rangeland portions of the landscape (where consistent, widely-collected ground data are generally not available), The Nature Conservancy's ReGap maps will be used.

Use IMAP products as a source of existing vegetation maps. LANDFIRE and its associate, the Rapid Assessment, will also be providing vegetation maps in 2006 and beyond. Forests are strongly discouraged from producing maps deviating from National and Regional standards. For more details on IMAP, visit www.reo.gov/ecoshare, under "Existing Vegetation Mapping Strategy."

22.7 Updating Rangeland Inventories. Rangeland inventories shall be updated whenever basic information in an analysis proves inadequate for use in current land and resource management planning and for making rangeland management decisions. To provide continuity of data and verification of trend, measurement transects should be read as determined in the allotment management plan monitoring section. In all cases there should be a thorough review of existing information and relevant remote sensing technology before any field data are collected.

22.8 - Review Procedures. Review existing analysis to determine if it contains the necessary ingredients for making management decisions. Some of the questions a current analysis should answer:

1. Are stocking rates proper for the existing management situation?

2. Are resource conflicts identifiable?

3. Are coordination measures necessary to minimize conflicts spelled out?

4. From the information available, can an effective management plan be developed or revised?

5. Can suitable progress be determined in meeting management objectives as specified in the allotment management plan?

6. Is information available to detect need for change of direction or emphasis for subsequent annual operating plans or refinement and update of the allotment management plan?

7. Is information available to see if the Forest Plan Standards and Guides, the grazing permit, the Allotment Management Plan, and the Annual Operating Plan are being complied with?

8. Is information available to meet range resource information needs from the base level inventory as described in Section 21.21c-2?

If the answer to the majority of these questions is not affirmative, then perhaps an updated inventory and analysis is needed. Answering these questions adequately also means sufficient implementation and effectiveness monitoring will be necessary.

23.0 Rangeland Data Management

26.1 Data Standards

Design all field data collection with the goal of entering or migrating data to NRIS Terra. Use methodologies and formats compatible with NRIS Terra formats. Data formats can be found at http://fsweb.ftcol.wo.fs.fed.us/frs/rangelands/inventory/index.shtml. Additionally, national and regional vegetation standards (Brohman and Bryant 2004, USDA Forest Service 2004) must be adhered to.

For the monitoring purposes and objectives stated in this manual, do not use methods other than those included in this document.

26.2 Use of Data Recorders

Use of electronic field data recorders is encouraged. (These are sometimes referred to as portable data recorders, or PDRs.) Recording field data directly in an electronic format saves time and resources and reduces errors. Guidance for use of PDRs has been developed by NRIS, in cooperation with the Forest Service Rangeland Management Service Center. Follow their recommendations. These can be found on the web at http://fsweb.ftcol.wo.fs.fed.us/frs/rangelands/.

NRIS Terra has facilitated considerable work with PDRs. Use the tools they have developed in this regard.

26.3 Migrating Legacy Data

Legacy data (information previously collected) should be inventoried and prioritized for migration (moving data from its current form into appropriate current formats). Priorities must be set, since adequate financial and personnel resources to migrate all possible data is unlikely.

Legacy data useful for establishing trend should be the highest priority. Much of this was collected using the Parker "3 step" method. With these data on rangelands from 30 years ago or more, we can compare current conditions and make an invaluable quantitative assessment of trend.

Although some datasets will be low priorities for migration, paper or electronic data on older media (tapes) should never be discarded. The relative value of datasets can change over time.

Data should be migrated to NRIS Terra wherever practical. If it is temporarily migrated to an MS Access template (or the agency's database standard software, should this change over time), it must still follow all existing data standards. An example would be Parker 3-Step data, which currently does not have formats available in Terra. Using the Access database developed by the easternWashington ecology area program offers an interim solution.

26.4 Maintaining Data

Each Forest or subregion (group of Forests) should identify a range data steward. Responsibilities of this individual include documenting datasets, writing methodology (metadata), and facilitating the migration of appropriate datasets to an electronic setting.

Appendix. Interim List of Increasers and Decreasers for the Pacific Northwest

(adapted from a British Columbia list (Gayton 2003))

Explanation of Abbreviations Used

NDE Native Decreaser
NMR Native Mixed Response
NIN Native Increaser
NIV Native Invader
IIV Introduced Invader

NDE Native species cover values decrease as grazing pressure increases

NMR Native species cover values may increase or decrease depending on grazing regime or local site conditions

NIN Native species cover values increase as grazing pressure increases

NIV Native species associated with disturbed ground and early seral situations (includes "pioneer" species)

IIV Introduced species that invade grasslands, usually following disturbance or overgrazing

Common name	Scientific name	Category
Yarrow	*Achillea millefolium*	NIN
Columbia needlegrass	*Achnatherum nelsonii*	NDE
Stiff needlegrass	*Achnatherum occidentale*	NDE
Spreading needlegrass	*Achnatherum richardsonii*	NMR
Short-beaked agoseris	*Agoseris glauca*	NDE
Nodding onion	*Allium cernuum*	NIN
Saskatoon	*Amelanchier alnifolia*	NDE
Cut-leaved anemone	*Anemone multifida*	NIN
Prairie crocus	*Anemone patens*	NIN
White pussytoes	*Antennaria microphylla*	NIN
Field pussytoes	*Antennaria neglecta*	NIN
Rosy pussytoes	*Antennaria rosea*	NIN
Holboell’s rockcress	*Arabis holboellii*	NIV
Kinnikinnick	*Arctostaphylos uva-ursi*	NIN
Red three-awn	*Aristida purpurea*	NMR
Orange arnica	*Arnica fulgens*	NIN
Prairie sagewort	*Artemisia frigida*	NIV
Big sagebrush	*Artemisia tridentata*	NIN
Little gray aster	*Aster falcatus*	NIN
Timber milk-vetch	*Astragalus miser*	NIN
Arrow-leaved balsamroot	*Balsamorhiza sagittata*	NMR
Japanese brome	*Bromus japonicus*	IIV
Cheatgrass	*Bromus tectorum*	IIV
Pinegrass	*Calamagrostis rubescens*	NIN
Prairie sandgrass	*Calamovilfa longifolia*	NDE
Sagebrush mariposa lily	*Calochortus macrocarpus*	NDE
Littlepod	*Camelina microcarpa*	IIV
Thread-leaved sedge	*Carex filifolia*	NIN
Elk sedge	*Carex geyeri*	NDE
Sulphur paintbrush	*Castilleja sulphurea*	NMR
Thompson’s paintbrush	*Castilleja thompsonii*	NMR

Lamb's-quarters	*Chenopodium album*	IIV
Pink fairies	*Clarkia pulchella*	NMR
Narrow-leaved collomia	*Collomia linearis*	NIV
Field bindweed	*Convolvulus arvensis*	IIV
Slender hawksbeard	*Crepis atrabarba*	IIV
Timber oatgrass	*Danthonia intermedia*	NMR
Upland larkspur	*Delphinium nuttallianum*	NIN

Common name	**Scientific name**	**Category**
Thickspike wildrye	*Elymus lanceolatus*	NDE
Quackgrass	*Elymus repens*	IIV
Slender wheatgrass	*Elymus trachycaulus*	NDE
Common rabbit-brush	*Ericameria nauseosus*	NIV
Long-leaved fleabane	*Erigeron corymbosus* E	NIN
Thread-leaved fleabane	*Erigeron filifolius*	NIN
Shaggy fleabane	*Erigeron pumilus*	NIN
Parsnip-flowered buckwheat	*Eriogonum heracleoides*	NMR
Altai fescue	*Festuca altaica*	NDE
Rough fescue	*Festuca campestris*	NDE
Idaho fescue	*Festuca idahoensis*	NDE
Red fescue	*Festuca rubra*	NIV
Rocky Mountain fescue	*Festuca saximontana*	NDE
Field filago	*Filago arvensis*	IIV
Wild strawberry	*Fragaria virginiana*	NIN
Brown-eyed Susan	*Gaillardia aristata*	NMR
Northern bedstraw	*Galium boreale*	NIN
Old man's whiskers	*Geum*	NIN
Yellow hedysarum	*Hedysarum sulphurescens*	NMR
Needle-and-thread grass	*Hesperostipa comata*	NMR
Common juniper	*Juniperus communis*	NIV
Junegrass	*Koeleria macrantha*	NMR
Bristly stickseed	*Lappula squarrosa*	IIV
Prairie pepper-grass	*Lepidium densiflorum*	NIV
Giant wildrye	*Leymus cinereus*	NIN
Small-flowered woodland star	*Lithophragma parviflorum*	NIN
Lemonweed	*Lithospermum ruderale*	NIN
Nine-leaved desert-parsley	*Lomatium triternatum*	NMR
Silky lupine	*Lupinus sericeus*	NMR
Tall Oregon-grape	*Mahonia aquifolium*	NMR
Alfalfa	*Medicago falcata*	IIV
Black medic	*Medicago lupulina*	IIV
Green needlegrass	*Nassella viridula*	NDE
Silverleaf phacelia	*Phacelia hastata*	NIV
Common timothy	*Phleum pratense*	IIV

Small-flowered ricegrass	*Piptatherum micranthum*	NMR
Woolly plantain	*Plantago patagonica*	NIV
Canada bluegrass	*Poa compressa*	IIV
Kentucky bluegrass	*Poa pratensis*	IIV
Sandberg's bluegrass	*Poa secunda*	NIN
Douglas' knotweed	*Polygonum douglasii*	NIV
Trembling aspen	*Populus tremuloides*	NMR
Bluebunch wheatgrass	*Pseudoroegneria spicata*	NDE
Bitterbrush	*Purshia tridentata*	NIN
Common name	**Scientific name**	**Category**
Prairie rose	*Rosa woodsii*	NMR
Woolly groundsel	*Senecio canus*	NIN
Tall tumble-mustard	*Sisymbrium altissimum*	IIV
Canada goldenrod	*Solidago canadensis*	NIN
Perennial sow-thistle	*Sonchus arvensis*	IIV
Birch-leaved spirea	*Spirea betulifolia*	NIN
Common snowberry	*Symphoricarpus albus*	NMR
Common dandelion	*Taraxacum officinale*	IIV
Intermediate wheatgrass	*Thinopyrum intermedium*	NDE
Tall wheatgrass	*Thinopyrum ponticum*	NIN
Yellow salsify	*Tragopogon dubius*	IIV
Great mullein	*Verbascum thapsus*	IIV
American vetch	*Vicia americana*	NDE
Six-weeks grass	*Vulpia octoflora*	NIV
Meadow death-camas	*Zigadenus venenosus*	NIN