Rangeland Monitoring and the Parker 3-Step Method: Overview, Perspectives and Current Applications

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Introduction

E.J. Dyksterhuis, in 1951 said "applicable information from pure science must be translated into terms of action and repackaged for a specific consumer with a specific need." Dyksterhuis wrote this in response to a question posed as part of the 1950 Ecological Society of America annual meeting: "How can we best translate into helpful terms, suited to action on the range, the indispensable knowledge we obtain from pure sciences, particularly ecology?" This question is as relevant today as it was in 1950. Now we have large amounts of ecological data, unprecedented analytical technology, and more people than ever interested in how rangelands are managed. How to appropriately interpret and apply historical data sets in light of current ecological concepts for a variety of ecological services is a critical consideration for resource managers.

Quantitative monitoring to detect trends in achieving resource management objectives is the foundation for the adaptive management process. Trend is the direction of change in an attribute as observed over time (SRM 1998) so by definition requires repeated measures over time. Kenneth Parker recognized that ecologic knowledge has been useful to the range manager in the estimation of resource trends to evaluate management practices (Parker 1954). Parker developed the Parker 3-step method to provide a means for obtaining and interpreting data records of vegetation and soil factors on designated grazing allotments within National Forest system lands. These are the longest term monitoring data sets recording plant and soil dynamics on rangelands in the Southwestern Region of the Forest Service.

The challenge today is how to reconcile current ecological monitoring and concepts with those of the past to maintain the value of historical data sets. This paper discusses the Parker 3-step Method and suggests potential application for interpretation and analysis in conjunction with current rangeland ecological analyses. It will briefly present the historical development of the method, an overview and perspectives on the use of the data, and discuss current applications for the data.

Background

Fundamental information useful for management planning of rangelands include inventory and monitoring data on climate, soils and vegetation. These data are essential to properly interpret current and desired resource conditions and when analyzing alternative management proposals. For proper analysis a clear distinction must be made between the concepts of inventory and monitoring.

Inventory as defined by the USDA Forest Service is "To survey an area or entity for determination of such data as contents, condition, or value, for specific purposes such as planning, evaluation, or management." (USDA Forest Service 2009).

Monitoring as defined by the USDA Forest Service is "The collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a resource or management objective." (USDA Forest Service 2009). Rangeland monitoring means to make repeated measurements or observations over time in order to document change over time in vegetation or other rangeland resources. The emphasis on change is what distinguishes monitoring from rangeland inventories.

Rangeland assessment is the process of interpreting data and making value judgments about it. Making rangeland assessment interpretations requires knowledge about site capability from a climate, soil and plant community perspective. Knowledge of disturbance processes and regimes, and the relationship of ground cover to soil erosion rates, are also important when making rangeland assessments. Assessments are often made with inventory data and can be compared over time.

Perhaps the earliest and most widespread rangeland management monitoring effort was the development and establishment of the Parker 3-step Method on U. S. Forest Service rangelands, beginning in 1948 (Parker 1950). This method collected both quantitative and qualitative data and provided a "scoring" technique for determining resource conditions.

The method has weaknesses but none-the-less comprises the longest term monitoring data sets for most grazing allotments in the Southwestern Region of the Forest Service (Region 3) (Cook et al. 1992 and Stohlgren 1998). Range condition has been the focus of most analyses and the data collected on vegetation attributes and soil coverage has had limited use in making trend determinations in part due to the infrequency of measurements. Because the method included data collection over time on several soil and vegetation attributes Parker data can be summarized and reinterpreted to help evaluate vegetation trends and current conditions.

This discussion of the Parker 3-Step Method of measuring rangeland trend (Parker 1950, 1951) describes the background and development of the Method, and suggest ways to summarize the ecological attributes collected on Parker transects, specifically based on trends in plant species abundance, composition and soil cover.

Historical Development of the Parker 3-step Method

In the development of his monitoring method, Parker clearly understood the importance of the "use of ecological knowledge in answering range problems" and proposed an ecological approach to address them (Parker 1950, 1951, 1954). He believed that "one of our greatest needs in range management planning is a method for the determination of trend in range condition" (Parker 1950). So in addition to recommending the periodic collection of ecological data (plant community and soil attributes) he proposed an assessment process to interpret the field data based on the understanding of plant community dynamics at that time. Such range condition scores, based on a climax model of plant succession, are now known to be limited predictors of most of the ecological (functional) processes in support of ecosystem services across rangelands (NRC 1994, SRM Task Group on Unity in Concepts and Terminology 1995). Additionally, various assumptions and weightings associated with Range Condition ratings from Parker data alter the basic metrics collected and arguably limit their usefulness for interpreting resource trends.

Therefore, this discussion will include suggestions for reinterpretation of "range condition" assessments based on current state-and-transition models and suggest ways to evaluate Parker data relative to Terrestrial Ecosystem Unit Inventory (TEUI) information (Winthers et al. 2005). None of these recommendations are without challenges associated with numerous sources of variability. However, legacy data such as Parker 3-Step records should be incorporated into standard analysis and planning practices in the process of determining current and desired vegetation communities and soils and trends in their status. As Parker himself reiterated in 1954, "all possible clues must be considered before the final appraisal is made."

Parker began his study in July, 1948, which was brought on by the need "for the determination of trend in range condition," and was focused on a record of initial conditions and the collection of subsequent data to indicate trends in these conditions. Additionally, "how much of the change is due to current weather and how much (due) to grazing use," was a key element driving the protocol design.

The initial efforts surveyed personnel at Forest Service regions and Forest Service Experiment Stations and determined that:

1. No one method of rangeland analysis was endorsed,

2. That "in order to follow trend in (range) condition information must be obtained periodically on density1, floristic composition, vigor, litter and soil capabilities and erosion characteristics", and

3. Data should be collected to establish "benchmarks" within key areas selected on allotments and that repeated measurements be made on these plots at periodic intervals.

Parker also recognized that vegetation attributes could be measured "with a reasonable degree of accuracy" whereas plant vigor and erosion "must be recorded largely in descriptive terms." The protocol later required leaf measurements for determination of vigor, in addition to a qualitative scoring of vigor based on those measurements.

Field tests were conducted in 1949 (the Coronado National Forest was one of three forests selected for these original studies) to refine the adaptation of the line-intercept and point cover estimates, using a 100ft steel tape and a ¾ inch loop, use of the Southwestern Range Condition and Trend Score Card, and photo-transect techniques. These became the three steps in the "Parker 3-Step Method." Vegetation and soil attributes were defined, and correlations between the loop and other point-type methods were conducted, sampling error among observers was analyzed, and placement of transects in clusters was tested during the study.

Application of the Parker 3-Step Method

The application of the Parker 3-Step Method on an allotment basis included mapping range condition using the experience gained reading the Parker transects and Paced transects, and scoring the clusters in the field. Parker 3-Step analysis, along with production and utilization mapping (PU surveys) and general allotment inspections were the primary means of managing grazing allotments in Region 3 for most of the last half of the last century.

Parker envisioned that data, assessments and photographs taken over time from cluster locations would "eventually form a historical document as to changes in vegetation and soil erosion rates that may occur through the years."

[1] The term "density" was used at that time to describe vegetation cover.

Interestingly Parker recognized that range management to achieve satisfactory trends is a "cooperative undertaking" between the FS and livestock grazing permittees and both parties should "take part in the initial as well as the latter follow up record taking in order to secure a better mutual understanding of just what has occurred" (Parker 1951).

The three steps in the Parker 3-Step Method were described in the 1951 report "A method for measuring trend in range condition of National Forest ranges" written by Parker to summarize the highlights of the earlier study. The following describes the basic three steps in the procedure. Detailed field protocol and data forms may be found in Parker (1951) and the most recent detailed application of the protocol in Forest Service R3 Allotment Analysis Guide. This Guide was formally the Forest Service Allotment Analysis Handbook, FSH 2209.21 R-3 (USDA Forest Service 1988).

STEP 1 – establishment of permanently marked transects and the collection of basic field data from these transects. Included in this step were measuring site factors, nearest perennial plants, plant vigor, age and class of shrubs and estimating current erosion on 100 points along a transect using a ¾-inch loop. Additional cover and plant species composition data were collected from "paced transects" located at "points between the clusters." In Parker's mind these paced transects were an essential part of the overall allotment evaluation.

Transects were delineated using a 100ft steel tape and a ¾-inch loop placed at ground level at 1 foot intervals. A record was made of whatever was encountered in the loop (vegetation, litter, rock, erosion pavement, or bare soil). Plant species were recorded based on live root crown (for herbaceous species, live perennial portion of the crown for shrubs) covering over ½ the loop.

Basal cover of perennial plants was chosen as the attribute of interest rather than canopy cover because it "is a more reliable indicator of change in density (cover) than the crown spread because basal areas are not appreciably affected by differences in seasonal growth state and current grazing use" (Parker 1954).

Plant species were recorded as "desirable, undesirable or intermediate" based not just on their value as forage for livestock but also on ecological characteristics (relationship to their abundance in the so-called climax plant community) and soil protection qualities. These categories were similar but not identical to the decreaser, invader and increaser categories also used at the time (Dyksterhuis 1951).

Litter was originally defined as "any dead vegetation material, regardless of origin, and was later grouped into classes (trace, < ¼ inch, ¼- ½ inch, > ½ inch). Parker (1954) later wrote that litter ½ inch deep is "nearly as effective in its beneficial effect on infiltration rates as deeper amounts."

STEP 2 – summarize field data to determine vegetation condition and soil stability for the entire cluster. The process, to be conducted in the field, involves segregating plant species encountered in step 1 into the three groups, desirable, intermediate and undesirable as found on the plant list of the score card for classifying vegetation condition. Forage density index and composition ratings are computed from vegetation crown hits, using the appropriate score card and when added with the vigor rating constitute a condition class score. Forage density was computed from total loop hits on plants grouped as desirable. Composition was calculated based on a weighted percentage of desirable, intermediate and undesirable species loop hits.

A later addition to the Method included recording the nearest perennial species 180° in front (toward the 99.5 end of the stake) of the monitoring point if live vegetation crown is not observed in the loop. Plant species composition was then calculated by using both vegetation HITS along the transect line and DOTS that represented the nearest perennial species. These were called "near hits" in the Northern Region (Region 1) and located toward the zero end (the beginning) of the tape. It is not known exactly when this protocol was added to the Method but the purpose was to provide a "better record of composition" (USDA Forest Service 1977).

Soil stability ratings were done by combining erosion hazard scores based on ground cover hits with a current erosion rating based on qualitative soil movement criteria. Current trend (apparent trend) was then subjectively assessed for both vegetation and soil stability.

As stated previously the scoring process was to be done in the field and combined with an ocular range condition mapping procedure after experience was gained in the ratings. Forest Service personnel consulted all felt that it is "important to note the original intent" of using the Parker 3-Step Method coupling the permanent transects with the pace transects and scoring them in the field for "training or keying of the eye for estimating and mapping condition and trend for the entire pasture or allotment" (Kendall Brown, Coronado National Forest, pers. com. 2009). This was referred to as ocular estimate in 1988. The Forest Service used "the training obtained through items 1 and 2 above" (steps one and two as described here) to provide "the bulk of the condition and trend evaluation" for grazing allotments (FSH 2209.21) (USDA Forest Service 1988). Although FSH 2209.21 was removed from Forest Service Directive System in 2001, the process is discussed in the Region 3 Rangeland Analysis and Management Training Guide (1999).

Parker advocated that the ecological data provided valuable information on its own (not related to livestock grazing management) and stated that the analysis in Step 2 (scoring the data) is "quite independent" of Step 1 (Parker 1951). The score card approach was the only part of the procedure that was intended to be directly tied to forage or specific resource value for livestock grazing. Use of score cards based on very general plant species response to heavy grazing is now known to be a limited model of plant community dynamics (NRC 1994) and therefore not appropriate for general resource trend interpretation. In practice however, attribute data collected in Step-1 can and should be analyzed separately and may stand on their own for trend analysis. Efforts have been made to make Parker data more applicable for monitoring the effects of management actions. One example is work conducted by Cook et al. (1992) which provided guidance for converting Parker loop frequency data to basal area.

STEP 3 – consists of two key photographs from the 0.0 or the 99.5-foot mark, one a general landscape photograph taken with the opposite end of the transect centered in the background, and the second photo a close-up of a 3X3 foot plot taken obliquely and from the same point as the general photo. A sketch map of the 3′ X 3′ plot photo was also drawn to identify species present in the plot as well as other items such as rocks.

Limitations of the Parker 3-Step Method

There are a number of weaknesses in Parker's method (Stohlgren et al. 1998). Some of these weaknesses are inherent in the method, such as sample size limitations, the use of a ¾ inch loop rather than point (although Parker and others chose the loop over the point and justified his choice through field comparisons) (Cook and Box 1961). Other issues such as observer differences, choice of sampling location, and species identification problems exist with all vegetation monitoring methods (Godinez-Alvarez et al. 2009). Exact relocation of the tape is of great importance for reliable data comparison over time. This can be especially challenging as cluster locations may also have been corrupted over time due to roads, trails, or some other physical alteration of the site. Other limitations are due to changes in agency application of the protocol and changes in land use over time. Placement of clusters may have originally ignored important soil or slope differences and therefore combining transect data, within clusters, as is the standard procedure, is inappropriate.

Because the original protocol only included shrubs up to 5 feet in height (this was later changed to 4.5 feet, at least in Region 3) the botanical composition (diversity) of the shrub layer is underrepresented in the sample design. Another mischaracterization of botanical composition has occurred with more recent revisions. Parker (1951) evidently counted annuals if they comprised more than ½ the area of the loop as with perennial species. Annuals were also recorded at the bottom of the form using dot tallies (Parker 1951).

After 1965, changes in the procedures included annuals no longer recorded with dot tallies. Annuals were simply ranked as to abundance (light, medium or heavy). Additional procedural changes over the years counted shrub canopy hits as live hits and ignored ground cover hits within the loop when overstory vegetation was encountered. These data can be recalculated using understory hits rather than canopy hits (Hays 2007). More procedural changes came with supplemental instruction which made provisions for recording important indicator species not encountered on the transect, but occupying the 100 -150 foot plot circumscribing the transects (Parker and Harris 1959). These instructions also provided for a frequency record of composition of the "nearest perennial" plant, when there is no perennial plant within the loop. The addition of the "frequency" dots based on nearest plant when there is no loop hit introduces further experimental error to the botanical composition calculations because the distance to the nearest plant was not recorded.

Other weaknesses of the protocol include any subjective estimates of vegetation and soils trends based on ocular observations which are difficult to appropriately interpret due to differences in personnel training and experience over time. The range condition assessments based on score cards are also inconsistent in interpretive value due to conceptual limitations in the analytical models discussed below.

Despite these, in some cases, seemingly fatal flaws, Parker data offer unparalleled historical and ecological value, especially for trend interpretations. However, interpretations should only be made based on a 'preponderance of evidence' from comparisons of data gathered in Steps 1 and 3 and other information pertinent to the particular location.

Precipitation Data

Precipitation data should be included in any analysis of vegetation data. Historical climate data for the southwestern U.S. may be obtained online from the Western Regional Climatic Center website (http://www.wrcc.dri.edu/summary/Climsmaz.html). These monthly data can be summarized by "forage year" rather than calendar year to provide a better correlation with growing conditions. Many areas within the southwestern United States exhibit a bimodal precipitation pattern. Cool season or winter precipitation is usually considered to occur from October through May, while warm season or summer precipitation occurs from June through September. May precipitation is usually low and may contribute either to spring growth or summer growth but normally has the effect of extending spring growth and usually is followed by a dry, semi-dormant period in June. October precipitation may contribute to extended summer growth or regrowth on warm season grasses, especially in the pinyon-juniper type. It may also contribute to fall growth of cool season grasses and provide soil moisture that may carry through the winter. For purposes of analysis any month or other period with less than 75% of the long-term average can be considered as a dry period (SRM 1989) and any period with 125% or more of the long-term average can be considered as wet. It is also important when possible to account for the distribution and intensity of precipitation within a specific seasonal period, which is often as or more important than the total amount.

Caution must be used in interpreting weather data. The amount of precipitation received at any given cluster location may be quite different from that received at the recording station. That is especially true for terrain influenced summer rain. Therefore, a good year at a particular recording station may not necessarily be a good year at every cluster location.

Summarization of Attribute Data, Analysis and Preponderance of Evidence

Parker data offer substantial historical and ecological value, especially for interpreting vegetation trend. The primary focus of Parker 3-Step data interpretation should be on trend analysis based on attribute data collected in Step 1 and Step 3. The value of the photographs (Step 3) is particularly important. Data should be summarized for each transect, not averaged over the entire cluster as is the common practice. Statistical analysis may be done with transects as the experimental unit, clusters as blocks and TEUI units or Ecological Sites as reference conditions (USDA, NRCS 1997). Sometimes the data are too incomplete for statistical analysis therefore a 'preponderance of evidence' of general trends approach (including weather data, actual use, professional experience and common sense) is recommended. The botanical composition estimates and soil coverage data are best used only to estimate trends, because of low sample size and varying field definitions for these attributes.

The 'preponderance of evidence' approach is suggested by the National Research Council and recommended in Rangeland Health and Proper Functioning Condition assessments (NRC 1994, Pellant et al. 2005). This means any conclusions regarding resource trends are based on the majority of indicators as well as climate, actual use and professional experience.

For example, Tables 1-3 compare Parker data collected at 6 dates over a 49 year period from a location on the Apache-Sitgreaves National Forests. These data represent only data collected in Step 1 of the Parker procedure and from only one of the three transects at the cluster. A separate tally and analysis should be done for each transect and transects averaged only if field inspection determine this appropriate.

Table 1. Percent ground cover, Parker 3-Step, T1, C1

	1957	1967	1984	1995	2001	2006
Vegetation	20	31	33	15	23	21
Rock	14	16	14	9	14	9
Litter	12	23	8	17	24	27
Bare soil	54	30	45	58	39	44

Table 2. Botanical composition (%) based on loop hits and nearest plant "frequency"

	1957	1967	1984	1995	2001	2006
Bogr2	52	64	72	47	72	80
Elel	0	0	11	24	36	3
Gusa2	8	19	3	24	10	13
Plja	12	13	3	0	2	0
Jumo	0	0	2	3	3	6
Muto2	0	3	0	0	0	0
Opun	1	1	1	2	1	1
Spcr	1	1	1	0	0	1
Spam	0	0	0	1	2	2

Table 3. Plant species abundance ranks

	1957	1967	1984	1995	2001	2006
Bogr2	1	1	1	1	1	1
Elel			2	2	2	4
Gusa2	3	2	4	2	3	2
Plja	2	3	3		5	
Jumo			5	3	4	3
Muto2		4				
Opun	4	5	6	4	6	6
Spcr	4	5	6			6
Spam				5	5	5

Table 1 presents percent ground cover for vegetation, rock, litter and bare soil and show a fairly stable trend in soil cover in all categories. Litter may have increased while bare ground decreased over this period. Inconsistencies in data collection over time add to sampling error.

Tables 2 and 3 provide information demonstrating plant species changes over time. Botanical composition, based on nearest plants recorded from loop hits, show an increase in blue grama (Bogr2) while other species have fluctuated over time. Species abundance ratings, simply a ranking of how many times a species is encountered (Table 3) show similar changes over time although Bogr2 has remained the most abundant species on this site since 1957.

Transitioning to other trend rangeland monitoring protocol

Where future vegetation trend data collection will no longer rely on Parker transect readings, a transition process is recommended to move from Parker data to other protocols. Rather than abrupt abandonment, Parker transects can be read in addition to newer vegetation trend data collection processes (Godinez-Alvaez et al. 2009). Bringing Parker data up to present, then moving forward with modern trend measurement techniques may make sense to close the loop on the historical record. If Parker locations are to be maintained for use with a newer trend protocol, it is important to make sure those locations serve the purpose of the monitoring objective. One procedure adopted by several agencies and in numerous locations in Arizona includes point data (100-600 points) for ground cover, plant species frequency and botanical composition using Dry-Weight-Rank (DWR) methods of data collection (Ruyle 1997), (Coulloudon et al. 1999). Additionally, above ground vegetation biomass (current year standing crop) data using Comparative Yield (CY) estimates can be easily added to the above protocol. Canopy cover estimates can be combined with standing crop data and periodically added to the monitoring protocol to make comparisons with data derived from TEUI and Ecological Information System (EIS) inventory data if required. The procedures for estimating canopy cover using 1/10th-acre ocular macroplots have been tested and analyzed on the Coconino and Kaibab National Forests (Hays 2006, Hays 2007, Hays et al. 2007, Hays and Russell 2008).

Range Condition

Range condition is generally thought of as the status of the range as compared to some benchmark usually associated with a theoretical "climax" or "historical" plant community. Parker's range condition ratings are primarily based on Clementsian concepts of succession, interpreting departure from climax vegetation as retrogression induced by grazing (Westoby et al. 1989). Desirable species thought to occur in the climax or "sub-climax" plant community were primarily good forage plants which also have "deep fibrous roots" and "facilitate infiltration" which combined both grazing and site protection aspects into the ratings (Parker 1954). Undesirable plants were those species considered noxious or of low forage value and "poorly adapted to holding the soil in place" (Parker 1954). The intermediate group included "species between these two extremes" and also species whose "place in succession is not definitely known" (Parker 1954). These comments acknowledge the problematic nature of interpreting successional status of vegetation and led Parker to recommend that much training is needed in "ecological perception" (Parker 1950). In application, Parker understood that present conditions may also be compared to "maximum practical condition" presumably plant communities unlikely to improve in either species composition or site protection aspects even if they are unlike historical conditions.

Many of the principles in ecological theories of vegetation dynamics during Parkers' era have been improved upon in more recent scientific publications (Noy-Moir 1975, Westoby et al. 1989, Stringham et al. 2003, Briske et al. 2006, 2008). It is now known that the traditional range condition model may incorrectly predict vegetation trajectory, resilience and resistance. Vegetation changes occur as a result of many factors other than grazing, and disturbance is a natural feature of plant communities. Grazing is not necessarily a primary driver of vegetation change and even when grazing has been the cause of vegetation change, current levels of grazing may be inconsequential and even completely removing grazing will not always result in a return to historical conditions (Westoby et al., 1989). Some, perhaps many, altered plant communities can no longer achieve what may have once been a historic condition because of lack of a current seed source, the presence of highly competitive and sometimes exotic introduced plant species and/or changes in soil characteristics limiting species adaptation to the site . These situations are considered state changes in vegetation (Bestelmeyer et al. 2004, 2009, Briske et al. 2008). And finally, if current vegetation is a result of climate and disturbance to date, it may be unrealistic to expect vegetation to return to historical conditions especially in the face of global climate change.

Reinterpreting range condition assessments from Parker data should be based on current understanding of plant community dynamics associated with state-and-transition models and site stability ratings (Task Group on Unity in Concepts and Terminology 1995, Pellant et al. 2005). Assumptions regarding plant species dynamics and reliance on subjective data weightings, as is done when assessing range condition using Parker data based on the scorecard approach of Step-2, have limited value for present day management interpretation. Rather, range condition should be considered in the contemporary view of recognizing potential state changes in vegetation composition and coupled with a site protection interpretation based in part on total ground cover. Species composition data from

Parker transects collected in Step-1 can be interpreted in terms of vegetation states, site protection, and compared to TEUI information in the following ways:

- A simple count of the species encountered (include species from areas surrounding Parker transect)
- Ranking of the most abundant to least abundant species
- Species composition calculated from nearest plant data
- Soil surface cover

This information may then be compared to similar TEUI attributes summarized in a similar fashion, providing more appropriate, site specific estimates of the similarity of current conditions to desired conditions than derived from Parker condition ratings.

Comparing Current Conditions with Site Potential from TEUI and ESD's

Because of the limited sample size and other issues, it is preferable to collect additional data "on top" of Parker clusters such as point data for ground cover and basal area as well as canopy cover ocular estimates in 1/10th acre plots, and use these data to establish current conditions for comparisons with TEUI and data from Ecological Site descriptions (ESDs) (USDA, NRCS 1997). Measuring methods, such as Parker 3-step transects or newer methods applied to cluster locations, can be designed, installed and maintained for the purpose of obtaining long term trends to evaluate achievement of Land Management Plan and specific grazing allotment desired conditions and objectives. The plan-to-project matrix established in Forest Service Grazing Permit Administration Handbook, Chapter 90, R3-2209.13-2007-1, assists in the documentation of existing condition and the determination of desired conditions. The matrix, when used at the local level can be modified to meet site-specific needs as was done by John Hays, University of Arizona and Mike Hannemann, Kaibab National Forest (Hays 2007). Hays and Hannemann present vegetation, wildlife and soil data in a matrix that allows quick comparison of potential, desired condition and existing condition within particular TEUI ecological units. Hays and Hannemann also created a site specific decision tree regarding the interpretation of data collected during future monitoring visits. The decision tree identifies likely causes in vegetation changes and provides possible adaptive management actions which could be taken. The use of the matrix, combined with the use of the decision tree provides a good foundation to understanding the ecological dynamics of the specific landscape being managed and provides rationale for adaptive management actions (Hays 2007).

Where current species composition varies greatly from that predicted in TEUI, an interpretation of whether the current plant community state has shifted or whether the site is an inclusion or otherwise variant of the mapped TEUI unit is in order. In either case, the photographic record and soil cover data should be considered in addition to current vegetation composition and abundance. For example, woody plant increases and/or the establishment of a highly competitive herbaceous species such as a solid stand of blue grama may indicate a state change where transitions to other states are unlikely. In other words changes in current livestock grazing management, even complete removal of livestock, will not necessarily result in desirable plant community shifts (Westoby et al. 1989). In those cases, site protection interpretations may be a better indication of range conditions than a calculation of plant species similarity for ecological status. For example, a blue grama dominated site with little potential to change may provide adequate site protection and be judged in satisfactory condition. Additional scale considerations may be warranted to properly assess floristic diversity at an allotment level. As Parker clusters were usually located in grassland vegetation or openings in woodlands or savannahs, comparison to TEUI botanical composition will often result in under-representation of the woody species component of a site. Where this is obvious, a comparison of just the herbaceous species may be the appropriate lifeform to analyze. Additionally, an effort should be made to list species occurrence over a larger area than the Parker cluster sample location.

Another situation where current vegetation may not well represent TEUI estimations was encountered by Hays (2007) where one or more of the dominant grasses listed in the TEUI were not present at the sampling locations. However, total soil coverage, and basal and canopy cover of plant species present exceeded TEUI levels and species present were those that would not be thought to occur in any abundance on a degraded site (Table 4). In such cases

Table 4. Natural and current soil surface conditions (percent cover) as depicted on TES Map Unit 453.1 (Terrestrial Ecosystem Survey of the Coconino National Forest) compared to Paced Quadrat Frequency monitoring plots sampled in 2001 and 2006 (Hays 2007).

	TES Natural	TES Current	2001	2006
Vegetation	15	10	18	36
Rock	30	30	17	19
Litter	20	5	26	15
Bare soil	35	55	39	30

current conditions may be meeting or exceeding TEUI levels even though species composition similarity is low. Typically these situations reflect transitional (and less frequently, state) changes in plant communities due to land uses or fire frequency related to woody species removal or invasion. Other factors may include historical land use (dry land farming for example) or mapping inclusions that are of limited extent within TEUI mapping units.

Because each monitoring location is unique and soil-vegetation classifications such as TEUI or Ecological Site Inventory (USDA,NRCS 1997) are constructs of human interpretation, potential or desired conditions require a great deal of professional judgment and should be used for general guidance only. Monitoring data acquired at site specific locations, regardless of the data collection method, should be interpreted using current ecological concepts. The legacy data that exist from Parker 3-Step cluster locations can be used to interpret vegetation trends and existing conditions and represent an invaluable information source for resource managers.

Conclusion

Below are some important points to consider when reviewing Parker Cluster data and transitioning to other methods.

- Analyze appropriateness of cluster location in terms of current management issues and appropriateness of the site it is meant to represent.
- Always compare trends with precipitation data.
- Rely on photographs to verify any interpretation.
- Trends should be compared transect by transect rather than averaged by cluster
- Attributes of primary interest are soil surface cover, plant species abundance, diversity and botanical composition.

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