Learning Natural Resource Assessment Protocols: Elements for Success and Lessons From an International Workshop in Inner Mongolia, China

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Natural resource assessment and monitoring protocols, including rangeland health protocols,[1,2] have been widely adopted in the United States. International interest in adapting and applying these and related protocols is growing rapidly, as illustrated by the numerous requests for assistance from countries throughout the world as well as independent Spanish, Chinese, and Mongolian translations.[3]

This high level of interest is driven in part by an increased recognition of the value of indicators that reflect ecosystem processes on which multiple ecosystem services depend, rather than focusing on one particular ecosystem service.[4–6] A similar trend is occurring in other fields, including soil science, in which "soil quality" indicators are increasingly being used to complement more traditional indicators tied to individual crop requirements.[7] In the United States, this has led to the development of a new effort to inventory dynamic soil properties at the national level.[8]

The relationships between the indicators and the ecosystem properties and processes they reflect are often difficult to document. These relationships vary with soils, climate, and vegetation. One of the strengths of qualitative protocols, such as "Interpreting Indicators of Rangeland Health," is that they require consideration of these different factors while the evaluation is being made in the field. Completing assessments in the context of an understanding of soil–climate–vegetation relationships helps increase the accuracy of assessments (how close they are to "true"). In contrast, data from quantitative protocols are more useful for monitoring because they are more precise (more reproducible). Precision is necessary to detect relatively small changes over short periods of time (monitoring); it is less important for assessments, where accuracy is key. Assessments based on quantitative protocols are often difficult due to the lack of reference data required to make interpretations in the context of site-specific variability.[9]

The complexity of considering these relationships in the field and the diversity of the indicators make learning qualitative assessment protocols more challenging than learning quantitative techniques. Although quantitative methods can be easily taught using training videos and manuals with explicit instructions,[3] we have found that multiday, participatory workshops are virtually essential to learn how to apply qualitative assessment protocols.

Since 1996 more than 1,500 individuals in the United States, Canada, Mexico, and Mongolia have participated in more than 40 workshops on rangeland health assessment. During these workshops, classroom sessions are used to introduce participants to general concepts, including ecological sites (a potential-based land classification system based on soils), models of soil–vegetation and related dynamics (e.g., state-and-transition), and indicator relationships to ecosystem properties and processes. Field exercises include ecological site identification, measurements of supplementary quantitative indicators, and the evaluation of rangeland health using the qualitative assessment protocol described in "Interpreting Indicators of Rangeland Health."[1,10] Seventeen indicators are used to evaluate three attributes: soil and site stability, hydrologic function, and biotic integrity.

In this article we identify and discuss eight elements that we have found lead to a successful international workshop. These elements were selected based on previous workshops and university courses in China, Mongolia, and North America, as well as conversations with individuals who have taught other natural resource assessment protocols. The elements have evolved during the last decade based in response to both formal postworkshop evaluations and subsequent informal suggestions from workshop participants.

We illustrate these elements with data and experiences from a recent workshop held in June 2008 in association with the XXI International Grassland Congress and the VIII International Rangeland Congress. The workshop was held in Keshiketeng Banner (county), Inner Mongolia, China, approximately 360 km (225 miles) north of Beijing. Keshiketeng covers 20,673 km^2 (7,982 square miles), most of which is grazing land. Most of the 247,600 inhabitants depend on these grazing lands either directly or indirectly (according to the 2007 Inner Mongolia Map Committee). In addition to Chinese students and professors, participants included citizens of Germany, Japan, Mongolia, Uganda, and the United States. They represented a broad variety of disciplines, including animal science, rangeland ecology, soil science, and community development. They included both academics and land managers.

Methods

The workshop integrated each of the eight elements described below into classroom and field sessions. Classroom sessions introduced basic principles necessary to complete a rangeland health assessment, including stratification based on ecological potential, state and transition models, and an introduction to the indicators used in the "Interpreting Indicators of Rangeland Health" qualitative assessment protocol. They also included an introduction to related quantitative measurements used to support assessments and to provide a baseline for monitoring. Field activities included a tour of representative ecological sites in the region, an ecological site mapping and stratification exercise, a qualitative assessment of three different locations, and a brief introduction to quantitative methods.

Two days before the workshop, instructors performed traverses across the study area to preliminarily characterize ecological sites and status within sites. Based on the traverse, sampling areas were selected to reflect possible alternative states occurring on similar soils. Quantitative data were then collected at each of the three selected locations used for qualitative assessment training. Four 30-m transects were located in a spoke pattern. One transect was randomly oriented in each 90-degree quadrant. Measurements were completed along the outer 25 m of each transect to minimize correlation among the transects and disturbance effects on measurements near the center of the 60-m-diameter plot. Measurements included basal gap intercept and line-point intercept (50 points per transect or 200 points per plot) as well as both surface and subsurface soil stability (18 samples of each per plot).[2]

Element 1: Translation of Documents, Training Materials, and Presentations

Translation is an obvious but often overlooked element of any international training effort. Although English is increasingly read and spoken throughout the world, making manuals, computer-based presentations, and supplementary materials available in the local language dramatically increases comprehension and participation. Simultaneous oral translation and including English and host languages on the same slide can assist comprehension of complex concepts, particularly for individuals who have at least some comprehension of both languages. An additional benefit of the dual-language Inner Mongolia workshop (vs. previous monolingual workshops in Spanish or English) is that it required instructors to focus on key points, reducing tangential discussions that can limit understanding of core concepts.

Element 2: Integration of Site Potential–Based Land Classification System

The concept of ecological potential based on soils and climate is essential to any natural resource assessment or monitoring protocol that is to be used to help managers define current status relative to a realistic reference. A detailed soil map and ecological site classification[9] are preferred for rangeland assessments. In many cases, however, ecological sites have not been defined, and adequate soil maps do not exist. Similar types of information are available for forests and cultivated lands in many parts of the world.

We have found that a provisional ecological site classification completed during a one- to three-day period prior to the workshop is adequate for training purposes. It may also be used to teach a system for drafting ecological site classifications that participants would use later in their evaluations conducted in home locations.[11] Field traverses in which plant communities and soil profiles are rapidly observed at several locations can be aided by freely available satellite imagery (e.g., Google Earth), and global positioning system data can readily link ground observations to patterns observed in the imagery (Fig. 1). Ideally 1) at least two distinct ecological sites should be identified in the area that can be used to train participants how to distinguish sites based on soil profile differences and 2) at least three diverse training locations can be identified in at least one of the ecological sites (Tables 1 and 2; Figs. 2–4). These three locations should differ in plant community composition and soil surface conditions to provide participants experience applying the protocol to areas with different levels of degradation. The three locations should be associated with at least two different ecosystem states to allow for a discussion of the relationship between indicators and state transitions. Different communities within a state can also be used, particularly if one of the states is near a degradation threshold.

Element 3: Integration of Quantitative and Qualitative Data

It is often impossible to provide a thorough introduction to both quantitative and qualitative approaches in a

Figure 1. Preliminary ecological site delineation for the area studied during the 2008 workshop in Inner Mongolia, and an illustration of how Google Earth can be used as both a research and educational tool. The "Stops" are locations visited during the ecological site identification exercise. Stops 4–6 were selected as sites 1–3 (Tables 1, 2) for the rangeland health evaluations.

three- to four-day workshop. Instead, we believe that it is more important to focus on the more conceptually difficult qualitative assessments (which often include quantitative data) and simply provide a brief introduction to relevant quantitative methods during a half-day classroom and field session. For most of our workshops, the classroom session on quantitative data consists of a brief slide presentation focusing on the relevance of indicators derived from each method to assessment and monitoring, and on training videos[3] that provide detailed instructions. The objective is to help participants understand when quantitative data are required, how to select appropriate quantitative indicators, and how to interpret those indicators together with the qualitative indicators.

At the Inner Mongolia workshop location, for example, soil surface degradation, the development of large, unvegetated patches, and changes in species composition are important processes associated with changes in hydrology. Soil surface and near-surface degradation is addressed qualitatively with indicators 8, 9, and 11 (Table 1; Fig. 5) and quantitatively with soil stability kit data (Table 2). Qualitative evaluations of bare ground (indicator 4) and plant community composition and (spatial) distribution relative to infiltration (indicator 10) are supported by quantitative measurements of bare ground using the line-point intercept and the proportion of the soil surface covered by large gaps between plants (Table 2). Negative feedbacks between plant production, gap size, and infiltration capacity associated with soil structure degradation were inferred using the qualitative and quantitative indicators.

Element 4: Diversity of Participants

Many natural resource assessment protocols, including "Interpreting Indicators of Rangeland Health," emphasize the importance of multidisciplinary knowledge. Therefore, workshop participant diversity is necessary to increase the quality of discussions and make the field exercises as realistic as possible. One of the lessons learned from the Inner Mongolia workshop was that a diversity of cultural perspectives can also be beneficial as cultural perceptions of the land serve as important filters during indicator evaluations. It is often easier to see how others' filters are affecting their evaluations, and this understanding can help us to better understand our own. The workshop in Inner Mongolia supported the assertion that one of the benefits of globalization for ecology is the synergy and creativity stimulated by international interactions in field-based activities.[12]

Element 5: Participant Commitment to the Training Process

Participant commitment to the training process is essential to any workshop, but is particularly important for qualitative assessments because of the importance of learning relatively subtle observational skills. Although the disciplinary, national, cultural, and linguistic diversity of the participants in the Inner Mongolia workshop ultimately enhanced the quality of the workshop, it also presented a number of challenges. Additionally, only two participants had previous experience completing qualitative evaluations of rangeland health. Despite these limitations and a very challenging set of training locations, the participants' ratings of the indicators were as close as we have had in virtually any of the other workshops we have led (Table 1). As found in a previous study (D. A. Pyke, J. E. Herrick, P. L. Shaver, and M. Pellant, unpublished data, 2003–2005), consistency tended to increase with experience (sites 2 and 3 vs. site 1), and attribute ratings were more consistent among groups than

Table 1. Interpreting Indicators of Rangeland Health (IIRH) indicator and attribute ratings for the instructors and three groups for each of the three Inner Mongolia training sites

	Site 1					Site 2					Site 3				
	43.36108°N 116.73536°E					N43.36108 °N 116.73536°E					43.36014°N 116.73335°E				
	ET	ME	M	SM	NS	ET	ME	M	SM	NS	ET	ME	M	SM	NS
Indicators															
1 Rills				I	++++				+I	+++			+	++I	+
2 Water-flow patterns	+	+++I							++++I			+++I		+	
3 Pedestals and/or terracettes		+++	+I					+	+++I				+	+++	I
4 Bare ground	+++	+I							++	++I		+++	I	+	
5 Gullies		+			+++I					++++I					++++I
6 Wind scour and/or deposition	+	++I	+					+	++	+I			++I	++	
7 Litter movement	++I	+			+			+	++	+I		+	+	++I	
8 Soil surface resistance to erosion		++++I*								++++I			++++I		
9 Soil surface loss or degradation	+++I	+							+I	+++		+++I	+		
10 Plant community composition relative to infiltration	+	++I	+						++	++I		+	+++I		
11 Compaction layer	+	+I	++						+++I	+		++	++I		
12 Functional/structural groups	+I	+++							+++	+I		+I	+++		
13 Plant mortality/ decadence	+		++I		+				++	++I		+	+++	I	
14 Litter amount	++++I								++++	I		+	+++I		
15 Annual production	+++	I	+						++	++I		+	+++I		
16 Invasive plants					++++I					++++I					++++I
17 Reproductive capability of perennial plants		++	+I	+					++	++I			++	++I	
Attributes															
Soil and site stability	+	+++I							++++I			+	++I	+	
Hydrologic function	+	+++I							++++I			+	+++I		
Biotic integrity	+	+++I							++	++I		+	+++I		

Note: ET=Extreme to Total departure from expected for the site; ME=Moderate to Extreme; M=Moderate; SM=Slight to Moderate; NS=None to Slight. Each + represents the rating of one participant group (total of four groups of five to eight individuals). I is the Instructor group rating. Instructors had access to quantitative vegetation data (Table 2); groups relied on ocular estimates or step point. All sites were in different pastures, separated by barbed wire fences.
*To save time, groups were provided with soil stability kit values and recommended rating indicator 8 at site 1. For sites 2 and 3, they received values only. Normally, they would complete this test themselves.

Table 2. Quantitative indicators for the three sites that can help inform interpretation of the qualitative indicators and be used to monitor				
	Site 1	**Site 2**	**Site 3**	**Most closely related IIRH indicator(s)**
Bare ground	69	40	10	4
Litter (including under plants)	7	28	57	14
Functional/structural groups				10, 12
C4 Rhiz. grass (e.g., *Phragmites* sp.)	2	32	3	
C3 Tallgrass (*Acantherum* sp.)	0	0	46	
C3 Bunchgrass (*Puccinellia* sp.)	1	1	4	
Shrubs	23	8	3	
Other	2	23	30	
Soil surface covered by gaps (%)				10
50–200 cm	12	21	41	
>200 cm	81	60	24	
Soil stability (1–6 scale with 6 most stable)				
Surface (0–3 mm)	2.9	3.1	4.8	8
Subsurface (~25 mm)	2.3	1.7	5.3	9

Note: Soil stability is a 1–6 scale with 6 most stable (Herrick et al. 2005). The "Most closely related IIRH indicator(s)" refer to indicator numbers listed in the first column of Table 1. IIRH = Interpreting Indicators of Rangeland Health. For additional quantitative indicator relationships, see table 2 and appendix 6 in Pellant et al. (2005).[1]

individual indicator ratings (Table 1). Most of the more divergent ratings were explained by a lack of understanding of a particular indicator or failure to confirm ocular estimates with a pace transect (e.g., the Slight–Moderate bare ground indicator rating and soil and site stability attribute rating for site 3).

We attribute the high level of consistency among groups at this workshop to the commitment of all of the participants to fully engage in the training process, including reading the background materials prior to or during the workshop. This allowed groups to reach consensus quickly despite significant language barriers. English and Chinese were used throughout the workshop. The "English"-speaking evaluation group included two native English speakers, a Japanese, a German, and two native Mongolian speakers. The other three groups were dominated by native Chinese speakers, with several native English-speaking instructors.

Element 6: Discussion of Current and Potential Applications of the Protocol

This element, which is important in US-based workshops, is even more critical internationally because it forces workshop leaders and participants to jointly consider the local relevance of the protocols. Livestock production is the dominant land use in Mongolia and Inner Mongolia,[13] although there is a growing interest in exploring additional ecosystem services to supplement incomes of pastoralists.[14] The discussion should include both site-specific local interpretations, as well as examples of regional applications from other parts of the world.[15]

Site 3 (Table 1) provides an example of how the evaluations can be used to inform livestock management. The Soil and Site Stability and Hydrologic Function attributes were rated as a moderate departure based on the preponderance of evidence for all indicators, and the Bare Ground indicator was rated moderate to extreme by most groups, primarily because of increased patch size and connectivity. The qualitative assessment of this indicator was supported by the quantitative data (Table 2). The line point intercept method showed that although bare ground was relatively low, the proportion of the soil surface covered by large (>50 cm) gaps between plant bases was high (Table 2) and highly variable (data not shown) among the four transects.

These indicators helped focus discussion about both short- and long-term strategies for grazing management. In the short term, the objective is to simply increase ground cover by adjusting grazing duration, timing, and intensity to increase foliar cover and litter production. In this region, intensity of use can be adjusted by reducing livestock numbers, altering class of livestock (cattle, sheep, horses, or

Figure 2. Inner Mongolia workshop evaluation site 1. See Tables 1 and 2 for evaluations and data.

goats), and controlling use of the target area through herding. Because there was a large volume of standing dead biomass available, grazing intensity could be increased, and time of grazing decreased as a method of temporarily increasing litter cover. This might be accomplished by a large herd of livestock utilizing the area for a short period of time to trample standing plant material.

Figure 4. Inner Mongolia workshop evaluation site 3. See Tables 1 and 2 for evaluations and data.

In the long term, basal cover and overall production need to be increased, particularly in the larger gaps, although this may be difficult if gaps have crossed soil degradation thresholds (Fig. 5). Again, the basic tools of timing, intensity and frequency can be applied during successive years to promote grass establishment and production.

Element 7: Connection to Decision Makers

A clearly defined connection to individuals responsible for land management in the region increases the probability that the protocols will be locally adapted and applied. It also helps participants from outside the region to begin to think about how the protocols might be applied in their own area. The Inner Mongolia workshop experienced these benefits

Fiigure 3. Inner Mongolia workshop evaluation site 2. See Tables 1 and 2 for evaluations and data.

Figure 5. Soil surface structure in vegetated (left) and unvegetated (right) soil showing soil degradation (indicator 9) and compaction (indicator 11). The loss of soil organic matter reflected in the color change is reflected in lower soil surface aggregate stability values (indicator 8).

Figure 6. Concluding meeting of workshop representatives with the governor of Keshiketeng Banner, Inner Mongolia.

via the participation of local government officials. Social events and a closing discussion with the banner (county) governor provided additional opportunities to communicate the importance of implementing a systematic approach to assessment and monitoring (Fig. 6).

Element 8: Proximity of Lodging, Classroom, and Field Training Locations

The final element is mundane but important. Minimizing travel time maximizes training time.

Summary

Learning to apply qualitative indicators of rangeland health requires hands-on training. There are at least eight elements of a successful international workshop: translation, integration of a site potential–based land classification system, integration of quantitative and qualitative data, participant diversity, participant commitment to the training process, discussion of applications, connection to decision makers, and proximity of field and classroom locations. Success in transferring knowledge is seen via consistent, positive course evaluations by participants, but the ultimate success of these types of workshops will be reflected in the participants' use of the information in future decision making. The conclusions presented here are based on the authors' collective experiences and both postworkshop evaluations and subsequent feedback from participants who are applying the methods. Future investigation of the relative importance of the eight elements presented here should include more formal evaluations one or more years following the workshops.

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