Assessing rangelands : a comparison of two current methods
by Sonja Nehring Skovlin

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Range Science
Montana State University

Abstract:
Effective monitoring methods are needed to assess rangeland ecosystems. This study evaluated how similar two methods assessed rangelands. Ten transects were sampled in 1998 on two ecological sites in southwestern Montana to compare the outcomes of the NRCS Similarity Index (SI) method and the Land EKG® monitoring method under two management objectives. Calculating the SI formula attained percent similarity to the Historical Climax Plant Community for each ecological site. Land EKG® outcomes were determined by evaluating ecosystem attribute criteria, as influenced by management objectives. With the exception of one case, paired t-tests revealed that the outcomes were significantly different ($p < 0.10$) between the NRCS SI method and the Land EKG® method at both sites for two management objectives. Comparing the NRCS SI outcome to the desired plant abundance attribute outcome of the Land EKG® method is the most relevant comparison because the NRCS SI method only evaluates species composition. The Land EKG® method took significantly less time to apply ($p \leq 0.10$). Difference in outcomes was attributed to management objectives and evaluation criteria. The Land EKG® method should be used separately from the NRCS SI method due to fundamental differences in the kind of information each method produces and because the outcomes are interpreted differently for the NRCS SI method and the Land EKG® method.

ASSESSING RANGELANDS: A COMPARISON OF TWO CURRENT METHODS

by

Sonja Nehring Skovlin

A thesis submitted in partial fulfillment
of the requirements for the degree
of
Master of Science
in
Range Science

MONTANA STATE UNIVERSITY-BOZEMAN
Bozeman, Montana

January 2000

APPROVAL

of a thesis submitted by

Sonja Nehring Skovlin

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

Clayton Marlow Clayton B. Marlow 14 Jan 00

Approved for the Department of Animal and Range Sciences

Peter Burfening Peter J. Burfening 1-14-00

Approved for the College of Graduate Studies

Bruce McLeod Bruce R. McLeod 1-14-00

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a master's degree at Montana State University-Bozeman, I agree that the Library shall make it available to borrowers under rules of the Library.

If I have indicated my intention to copyright this thesis by including a copyright notice page, copying is allowable only for scholarly purposes, consistent with "fair use" as prescribed in the U.S. Copyright law. Requests for permission for extended quotation from or reproduction of this thesis in whole or in parts may be granted only by the copyright holder.

Signature Sonja Skovlin

Date 1/14/00

ACKNOWLEDGMENTS

I thank Sue Noggles, Bob Leinard, and Tony Rolfus of the NRCS for promptly providing ecological site descriptions and soils information for my study sites. Circle S Seeds of Logan, Montana gave access to their land. Ray Hagney of the Montana Fish, Wildlife and Parks granted permission to use land at the Madison Buffalo State Park. I thank Charley Orchard for teaching me how to use the Land EKG® rangeland health monitoring system. Thanks to my committee members – Drs. Clayton Marlow, Jeff Mosley, Bret Olson, and Cliff Montagne - for their expertise and patience. Deepest thanks to Jay Skovlin for unending support.

TABLE OF CONTENTS

TABLE OF CONTENTS—Continued

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Effective monitoring methods are needed to assess rangeland ecosystems. This study evaluated how similar two methods assessed rangelands. Ten transects were sampled in 1998 on two ecological sites in southwestern Montana to compare the outcomes of the NRCS Similarity Index (SI) method and the Land EKG® monitoring method under two management objectives. Calculating the SI formula attained percent similarity to the Historical Climax Plant Community for each ecological site. Land EKG® outcomes were determined by evaluating ecosystem attribute criteria, as influenced by management objectives. With the exception of one case, paired t-tests revealed that the outcomes were significantly different ($p \leq 0.10$) between the NRCS SI method and the Land EKG® method at both sites for two management objectives. Comparing the NRCS SI outcome to the desired plant abundance attribute outcome of the Land EKG® method is the most relevant comparison because the NRCS SI method only evaluates species composition. The Land EKG® method took significantly less time to apply ($p \leq 0.10$). Difference in outcomes was attributed to management objectives and evaluation criteria. The Land EKG® method should be used separately from the NRCS SI method due to fundamental differences in the kind of information each method produces and because the outcomes are interpreted differently for the NRCS SI method and the Land EKG® method.

INTRODUCTION

Rangelands comprise millions of hectares in the western United States. They provide forage and habitat for wildlife and livestock, and are used for recreational purposes. Concern for rangeland condition stemmed from early observations of extensive use of rangelands in the late 19th century (Powell 1879, Smith 1895, Jardine 1895). Development and use of inventory and monitoring methods has occurred since that time, with sustainability of rangeland resources as a fundamental land management objective. Furthermore, livestock producers have a significant economic stake in the way they manage their land in terms of sustainable productivity of forage. Federal and state agencies are accountable to the public in their management and knowledge of land for which they are responsible, thus creating a need to assess sites. Effective methods of assessing rangeland condition have been debated among scientists in land management agencies and in academia.

Range condition has been evaluated since the early 1900s (Sampson 1919). Methods and their underlying theories have been developed as range science has evolved. Range condition was assessed using the Quantitative Climax Method (Dyksterhuis 1949) for over four decades. However, many natural resource managers have been dissatisfied with the Quantitative Climax Method and the Clementsian succession model from which it was derived (Laycock 1991, Smith 1988, Westoby et al., 1989, Pieper 1994). Hence, scientists have developed alternative approaches that land managers currently use to assess rangeland. For example, the Natural Resources Conservation Service (NRCS) and the Bureau of Land Management (BLM) now recognize the state-and-transition model of plant community stability in their recently revised approaches to monitoring and inventory of rangeland.

While a variety of monitoring approaches exist, time and money often limit how thoroughly a site can be assessed and therefore play a role in the type of monitoring method to use. Quantitative methods such as the NRCS Similarity Index (SI) method provide detailed, objective measure of change in species composition from a defined vegetation community for a given site, but are time-intensive. Qualitative information from rating criteria that evaluate rangeland health provides a diagnosis of a site, is less costly to obtain, and may change management. Several rangeland health evaluations exist within agencies and the private sector. However, the question arises as to whether these qualitative evaluations can replace quantitative methods. The BLM (USDI 1999, draft) and the NRCS (USDA 1997) recommend using the Similarity Index method, trend measurements, and a rangeland health evaluation to assess a site because different information is acquired through use of each of these approaches, leading to a more thorough assessment.

The goal of this project was to compare the outcomes of the NRCS SI method (USDI 1997) to the Land EKG® rangeland health monitoring method (Orchard 1994), a qualitative method that can potentially diagnose ecosystem function relatively quickly. The objectives were to determine the extent these methods overlap in their information content, and to determine how similarly these methods rate vegetative characteristics and other environmental variables. Knowing how these methods compare to each other gives the land manager direction in terms of the appropriateness of each method for a given situation, and how much confidence the manager can place in information resulting from the use of each method. Any methods used to evaluate rangelands should provide enough information to effectively assess a site and from which to make land management decisions that promote sustainability of rangeland resources.

LITERATURE REVIEW

In separate surveys of land use in the West in the late 1800s, Jardine, Powell, and Smith observed degraded rangeland. Smith (1895) attributed the degraded rangelands to overgrazing and drought. In the late 1800s, prior to grazing being regulated, poor distribution of sheep and cattle, and poor timing of grazing resulted in heavy use of rangelands (Jardine 1919). Sampson (1919) suggested that changes in vegetation and soil caused by heavy grazing were analogous to stages in "retrogressive succession."

The contributions of early range scientists paved the way for future developments in assessing range condition. Powell (1879) suggested several ways that the arid West could be best managed, including the development of small, irrigated farms over large, dryland farms, or large grazing farms that would accommodate an appropriate number of livestock. Jardine (1919) oversaw development of a range reconnaissance system that served as a basis for range management decisions and that provided information on areas with varying degrees of forage utilization. Sampson's work brought successional theory and practical grazing management together (National Research Council 1994). Sampson (1919) believed that detailed knowledge of the successional stages of vegetation was needed to develop sound grazing plans. This insight identified the need for a successional framework that would serve as an indicator of range condition. Sampson (1919) identified four broad stages of plant succession, which resembled the range condition classes that came about later (Parker 1954), and introduced the concepts of decreaser and increaser to indicate response of forbs and grasses to grazing pressure.

Ecological theories formed the basis for range management throughout the early 1900s. Clements developed an ecological model based primarily on his observations of grasslands in the Great Plains. Within this model, succession was defined as the progression from bare areas to climax species, in a "complex, correlated development of habitat, community, and reaction" (Clements 1916). Pieper (1994), summarizing Clements' work, noted that in the linear model of succession, the climax state is relatively stable, and the stages in succession are predictable, given a certain environment. However, the Clementsian model had critics.

Gleason (1917) proposed the "individualistic" concept of the plant association, and stressed the importance of chance in the development of plant communities. Gleason argued that the rigid organization of the Clementsian model didn't reflect reality (Pieper 1994). Yet others, like Sampson, and later Dyksterhuis, Albertson, and Stoddart pushed the Clementsian model of succession into the mainstream of rangeland management (National Research Council 1994). Clements' ideas took hold among range managers, who were seeking an ecological approach to managing the large tracts of public land in the West (Smith 1988).

Developing Range Condition Theories and Methods

Several approaches to assessing range condition were developed in the 1940s. The challenge of inventorying and monitoring vast expanses of rangeland drove scientists to develop techniques that could quickly evaluate vegetation and forage quality (Smith 1944). Many scientists from the fields of forestry, botany, and agronomy helped to develop ecological theories that would become the foundation of range science and management (Parker 1954, Smith 1988). Early evaluation methods were largely qualitative because of the need to rapidly inventory large acreages. Because vigor was recognized as a key attribute of plant "health" (Weaver and Darland 1947), numerous visual indicators were defined, and some were correlated to range condition (Short and Woolfolk 1956). Vigor potentially could reflect initial changes made in intensity of grazing use, with subsequent changes in plant density, composition, and soil stability (Parker 1954). Visual estimates of plant life forms that prevailed on a range site could indicate herbage yields, abundance of mulch, plant vigor, and soil erosion (Arnold 1955).

Two popular theories emerged during the 1940s. Humphrey (1949) promoted the range potential approach to monitoring, in which the current forage production was compared to the potential production for a site. Forage production would be classified as either poor, fair, good, or excellent, based on its relationship to the potential.

Dyksterhuis (1949), drawing from Clements' successional theory, developed the Quantitative Climax Method, an ecological approach to assess range condition that gained popularity over Humphrey's productivity approach. Dyksterhuis defined a range site as one that supports a unique climax community, based on the soil and climatic environment. He further stressed the importance of identifying multiple climaxes that could coexist on a site. Slight differences in topography, geography, or stages of soil development could influence plant composition (Dyksterhuis 1949). In the Quantitative

Climax Method, the vegetational composition of an area would be compared to the climax community described for a given range site, similar to Humphrey's approach (1949) of comparing to a benchmark. The percent similarity determined whether the site would be classified as poor, fair, good, or excellent (Dyksterhuis 1949). Vegetation, measured in percent composition by weight, was separated into categories of decreasers, increasers, or invaders (Dyksterhuis 1949).

This approach assumed that the climax or near climax composition represented the ultimate in biological productivity of the system and soil conservation (Smith 1988). Late successional stages were more stable and productive plant communities, and were able to compete against weeds and inferior species (Dyksterhuis 1958, Weaver and Darland 1947). Establishing successional models gave the rangeland ecologist a basis for measuring changes from known plant communities (Westoby et al. 1989). The Soil Conservation Service embraced the ecological theory underlying the Quantitative Climax Method, and used the method for over 40 years (Pendleton 1989). The Bureau of Land Management also adopted this method (Smith 1988).

Although widely accepted, the Quantitative Climax Method only determined vegetative composition, and did not consider factors such as plant vigor, soil erosion, and plant reproduction, ecosystem attributes that several scientists deemed important (Bailey 1949, Ellison 1949, Parker 1954). Dyksterhuis (1949, 1958) proposed a dependent relation between plant succession and soil development, and that change in vegetation would reflect change in soil stability. Bailey (1949), Ellison (1949), and Parker (1954) of the U.S. Forest Service maintained that soil stability should be assessed separately because different considerations were involved in determining soil stability and that soil deterioration was more serious than retrogression of vegetation communities. The unresolved conflict divided the NRCS and the U.S. Forest Service in their approaches to assessing rangelands.

Limitations of the Quantitative Climax Method

Since the late 1970s, the Quantitative Climax Method has been challenged both on theoretical and practical grounds for its effectiveness in adequately assessing range sites. Many recent ecologists have challenged the idea that retrogression can be reversed in a linear, predictable fashion by lessening the amount of disturbance (Laycock 1989, 1991, 1994, Smith 1988, Friedel 1991, Westoby et al. 1989, Llorens 1995). Late-succession communities have been confused with early succession communities due to misinterpretation of the site potential (Laycock 1989). Furthermore, the climax vegetation was not always the vegetation desired by natural resource managers (Smith 1988). This problem was sometimes compounded by the use of the terms poor, fair, good, and excellent because these terms specified value judgments which may or may not be accurate for a given land use (Laycock 1989). In addition, the Quantitative Climax Method requires using techniques that are time-intensive.

To address problems surfacing with the Quantitative Climax Method, the Society for Range Management formed the Revision of Inventory Standardization Committee (RISC). RISC (1983) stressed the importance of recognizing site potential to distinguish between ecological sites. RISC (1983) also recommended that the term "Potential

Natural Vegetation" take the place of "climax" to recognize past modifications to a site by human activities or natural events such as the presence of naturalized introduced species or changes in community structure caused by an altered fire history, drought, or grazing.

RISC (1983) recommended that soil condition should be evaluated separately to assess erosion rates and indicators of erosion hazard, as well as other soil variables against the "natural" erosion rate for a site. RISC (1983) suggested developing resource value ratings to express the value of the present vegetation for management objectives differing from managing for a climax community (other management objectives could include, for example, nesting cover, scenic beauty, grazing). Smith (1988) pointed out that resource value ratings were difficult to use because several ratings could be given to a site, depending on the number and types of uses identified for a site. Thus, a single management objective had to be chosen so that range condition could be reported to the public. RISC modified the Quantitative Climax Method to make it more broadly applicable, yet the theoretical underpinning of this method remained.

RISC's recommendations, though broad, did not recognize emerging ecological theories. The new ideas beginning to take hold among ecologists arose from dissatisfaction with the Quantitative Climax Method (Laycock 1991, Llorens 1995, Westoby et al. 1989). The traditional succession theory implied that once a disturbance such as grazing was removed, the plant community on a site would return to climax condition (Laycock 1994). Ecologists instead were suggesting that the direction of succession depended on the nature of the disturbance and the environmental conditions during secondary succession (Risser 1984, Friedel 1991, Smith 1988, Westoby et al. 1989). Single or combined events of weather, fire, grazing, or management action change rangelands irreversibly or in ways that don't correspond to the classic range succession model (Westoby et al. 1989). The state-and-transition model, as described by Westoby et al. (1989) recognizes steady states occurring over a period of time and space. Disturbances, either natural or management-caused, trigger a transition between steady states.

The concept of steady vegetation states addresses complex ecosystem dynamics on many ecological sites (Westoby et al. 1989), particularly those on arid and semi-arid rangelands, where episodic events can trigger transitions from one long-term stable vegetative state to another. The state-and-transition model has been applied to range sites in Australia (Westoby et. al. 1989, Friedel 1991), Argentina (Llorens 1995, Beeskow et al. 1995), and it is used by Laycock (1991, 1994) to explain changes in sagebrush – grass communities in the United States. The BLM and the NRCS have included the concepts of steady states and thresholds in their revised approaches to inventory and monitoring (USDA 1997, USDI 1999 draft). The NRCS plans to describe known stable plant communities that may occur on an ecological site and the processes of transition among them. Few of these descriptions now exist. The acceptance of the steady states concept signaled a shift away from always rating sites against a potential climax community to recognizing multiple vegetative states that contribute to the sustainability of a site.

Concepts of Rangeland Sustainability

The SRM Task Group (1995) asserted that similarity of species composition to that of the climax did not consistently relate to soil protection, nutrient cycling, value for wildlife habitat, biodiversity, or biomass productivity, any of which may be primary management goals. Whereas vegetation had been emphasized as the main indicator of rangeland condition in the Quantitative Climax Method, the SRM Task Group (1995) identified soil as the most important and basic physical resource on an ecological site, and that sustainable management of rangelands depends primarily on conservation of the soil. Others agreed that serious soil degradation, interruption of nutrient cycles, and loss of important species or seed sources could lead to irreversible changes on rangelands (Friedel 1991, National Research Council, 1994). Ellison (1949), Bailey (1949), and Parker (1954) asserted these concerns earlier.

The SRM Task Group (1995) maintained that sustainability is an unchanging priority with a sound ecological base unaffected by changing values or economic considerations. Basic vegetation and soil condition data collected should provide a record of trends in attributes even though the values placed on them may change over time (Smith, 1988). Some natural resource managers have noted that the climax vegetation is not necessary for the conservation of the site nor is it usually a management objective (SRM 1995). Vegetative characteristics of seral communities often meet the objectives of range managers as well or better than that of a climax community (Costello 1964).

Soil may be adequately protected from erosion by vegetation that has little resemblance to the climax (Miller 1994, Smith 1988).

Certain groups have recommended using soil attributes to assess sustainability (SRM Task Group 1995, National Research Council 1994, SRM RISC 1983). The SRM Task Group (1995) stressed defining thresholds of the rate of naturally occurring erosion for ecological sites. The kind, amount and pattern of vegetation needed on a site to prevent accelerated erosion need to be described as part of determining a soil stability threshold. The SRM Task Group (1995) suggested basal cover of perennial vegetation, community type or structure, plant spacing, plant and litter biomass as potentially good indicators of protection from erosion. While quantitative methods are desired by the BLM and the NRCS to strengthen ecological assessments, few methods are found in the newly revised handbooks of these agencies. This may be because quantitative measurements of soil surface condition vary in degree of difficulty and amount of time involved, and sometimes produce results that are ambiguous.

The Water Erosion Prediction Project (WEPP) model may provide a means of assessing naturally-occurring erosion. The WEPP model is a repeatable method of estimating sediment yield that can be used to evaluate differences between management practices to identify which are potentially sustainable (Watters et al, 1996). However, the data required to parameterize the WEPP model are considerable and costly to collect. Therefore, this model may be most appropriately applied to a site where the soil stability is in question.

Rangeland Health Evaluation

The SRM Task Group's report coincided with the National Research Council (NRC) rangeland health report (1994), which promoted approaches of evaluating sustainability of a site considered to be more thorough in than standard range condition assessment methods. The term rangeland health has been used throughout the century to define range condition (Parker 1954, Bailey 1949, Ellison 1949). The NRCS, which included a rangeland health evaluation in its revised handbook (1997) defined rangeland health as "the degree to which the integrity of the soil, the vegetation, the water, and the air as well as the ecological processes of rangeland ecosystems is balanced and sustained." This definition closely follows that used in the NRC report (1994) and the BLM rangeland evaluation handbook (USDI 1999, draft).

Similar to recommendations made earlier by Bailey (1949), Ellison (1949), and Parker (1954), the NRC report (1994) recommended that indicators of soil stability, watershed function, nutrient cycling, energy flow, and recovery mechanisms be assessed to determine the status of rangeland health. The NRC (1994) suggested the terms healthy, at-risk, and unhealthy to define states of health. Boundaries between healthy, at-risk, and unhealthy states of a rangeland ecosystem were to be distinguished based on differences between the various states in their capacity to produce commodities and satisfy values and on the reversibility of the changes between states (NRC 1994). Consequently, evaluating a site's health requires judgments on the significance of the indicators observed. The NRC report (1994) did not specify the level of knowledge or experience an individual should have to evaluate a site.

Rangeland health evaluations included in the revised NRCS (USDA 1997) and BLM (USDI 1999, draft) handbooks are meant to provide an initial, rapid assessment of ecosystem processes occurring on a site. These evaluation methods can be considered apparent trend, a point in time determination of the direction of change (USDA 1997). Similar to rangeland health assessment methods developed within agencies, the Land EKG® rangeland health evaluation (Orchard and Sindelar 1998) has the potential to rapidly diagnose functioning of ecosystem processes. Land goals are defined and site background data, including livestock use and climate records, are recorded before a site is assessed. Consistent criteria and interpretation of data are required to effectively apply the Land EKG® system to a broad spectrum of sites (Orchard and Sindelar 1998). The Land EKG® system rates indicators of soil stability, plant community function, and energy flow, and is based on a matrix of indicators identified by the rangeland health report (National Research Council 1994). A site is assessed based on accumulated data. Thresholds between zones of functioning are determined by rating the attribute criteria. This method and the NRCS and BLM rangeland health evaluations differ from time-intensive and relatively expensive methods, such as the current NRCS Similarity Index method, of clipping plots to gain knowledge of species composition and biomass (Risser, 1984).

A limitation of qualitatively assessing a site is that it can be difficult among samplers to attain consistency. Even after training, estimates deviated significantly

(Smith, 1944, Knox, 1997). Developing estimation skills takes time (Cook and Stubbendieck, 1986). Thus, RISC (1983) recommended that only experienced agency personnel should qualitatively assess a site. Land EKG®, like qualitative methods used by agencies, requires initial training to maximize consistency. Similar to the NRCS SI method, using Land EKG information to recommend management change and direction requires knowledge of the area or similar areas (Orchard and Sindelar 1998).

A rangeland health evaluation, which essentially assesses apparent trend, first could be applied to areas with higher resource values or those areas that indicate possible problems (USDI and USDA 1994). Quantitative methods may follow to gain more detailed information. Thus, a rangeland health evaluation serves as a tool to communicate the general status of rangelands between agencies, private landowners, and the public (USDI 1999). Rangeland health evaluation methods would not be used to satisfy requirements of the Federal Land Policy and Management Act for reporting on conditions of public rangelands (USDI and USDA 1994) because they are subjective.

Standardizing Range Condition Concepts and Methods

The National Research Council (1994) and the SRM Task Group (1995) emphasized the importance of standardizing monitoring methods and unifying concepts and terminology so that agencies would be able to give a common report on the status of all public rangelands. The Northern Region of the USFS developed *Ecodata* and *Ecopac* in an effort to standardize inventory and monitoring of vegetation (Winslow 1995). *Ecodata* provided a standardized system to describe ecosystem information, at the plot level, that could be analyzed for a variety of management objectives (Winslow 1995). However, *Ecopac*, the accompanying software analysis, has proven difficult for district managers to use, and training has not been adequate, resulting in limited use of this system (Winslow 1995, personal communication, Orr, Gallatin National Forest, personal communication, Clark, Gallatin National Forest, Bozeman,). While interagency efforts are underway to standardize methods and produce a national inventory of rangeland condition, federal personnel still have latitude at the local level to use the methods they desire, resulting in information that cannot necessarily be shared across agencies (personal communication, Pellant, Bureau of Land Management, Boise, Idaho, personal communication, Orr and Clark, USFS Gallatin National Forest). The BLM and the NRCS have recently revised their approaches to monitoring and inventory. While the approaches are similar, the terms and methods used by each agency are still distinct from each other, heightening the disparity in standardized approaches.

Efforts since the RISC report (1983) have accomplished little in standardizing methods. The continued lack of agreement among agencies limits the usefulness of information exchanged by agencies. The debate will likely continue over when to perform detailed, quantitative, time- and resource-intensive methods such as the NRCS SI method, versus using any of several rangeland health evaluations to collect less detailed information relatively quickly that can potentially assess a site and guide change in management. Land EKG® is a relatively new method that has the potential to quickly assess ecosystem functioning. This method has not been compared to the NRCS SI to determine the similarity in outcomes and information provided.

It is important for a land manager to know if these methods produce similar outcomes in terms of ecosystem processes at a site and if the information from each method applies to management objectives to make an informed choice as to the appropriate use of each method.

OBJECTIVE

The purpose of this study was to compare outcomes of the NRCS Similarity Index (SI) method (quantitative) to those of the Land EKG® rangeland health monitoring method (qualitative). The Land EKG® method has the potential to assess the ecological status of a site, while the NRCS SI measures the present species composition on an ecological site in relation to the species composition in a described stable vegetation state that can exist on the site (NRCS 1997). The intent was to determine whether the Land EKG® method would rate a site similarly to the NRCS SI method, an updated version of the Quantitative Climax Method used to assess range condition for over 40 years. Specific objectives were 1) to determine how similarly these two methods rate vegetative characteristics and other environmental variables at the same location, given two different management objectives, and 2) to compare amount of time used to apply each method.

PROCEDURES

Study Sites

The NRCS SI method (NRCS 1997) and the Land EKG® monitoring method (Orchard 1997) were applied at two ecological sites. One study site is a sandy, 10-14 inch Precipitation Zone (PZ) ecological site, near Logan, Montana (463,400 m E; 508,130 m N in zone 12 of the Universal Transverse Mercator (UTM) grid). The second study location is a silty,10-14 inch PZ ecological site, seven miles south of Logan (463,800 m E; 507,120 m N in zone 12 of the UTM grid). The sandy site is a grazed native grass (*Agropyron spicatum/Calamovilfa longifolia*) ecological site, with a 4–8 % slope. Grazing occurred between October and April, and was stocked at a rate of between 250 to 300 head of cattle (personal communication, McDonnell, Circle S Seeds). An unknown number of mule deer and whitetail deer browse this site year-round. The soil on this site is a moderately deep, well-drained, sandy loam. A native range community (*Agropyron spicatum/Stipa comata*) occupies the silty site. The Montana Fish, Wildlife and Parks manages this site, which has not been used for livestock grazing for several decades. Approximately 30 mule deer and whitetail deer frequent the area throughout the year (personal communication, Alt, Montana Fish, Wildlife and Parks). Soil at this site is a fine sandy loam that is also moderately deep. Both locations are in an aridic moisture regime (12-14 inches, 30-34 cm mean annual precipitation) and a frigid temperature regime (mean annual temperature is lower than 8° C with the difference between mean summer and mean winter soil temperatures greater than 6° C) (USDA 1999). Elevation of both areas is approximately 1500 m. These locations were chosen because they appeared to have native plant communities and they shared regionally similar climatic features.

Methods

Five parallel 100-m transect lines were evenly spaced at each location. A 0.5-m^2 quadrat was placed at 25-m intervals on each transect, for a total of 25 quadrats per site. Two samplers and the author collected qualitative data from all quadrats using the Version 2.5 rating criteria matrix of the Land EKG® monitoring method (Orchard 1994). They then collected quantitative data from the same quadrats, using the NRCS SI method (USDA 1997).

Orchard trained the author in the use of the Land EKG® method. The author then trained two samplers how to visually estimate sampling variables used in the Land EKG® method. For the NRCS method, samplers were instructed to clip all vegetation within a designated quarter of the 0.5 m^2 frame and separate the live and dead material. They separated the live material by species, and bagged it for drying and weighing.

Land EKG® Rangeland Health Monitoring Method

Twenty-two visually-estimated variables representing ecosystem function were evaluated (Appendix, Tables 1 and 2). Samplers rated indicators of mineral cycling, water cycling, plant succession and change, and energy flow. Observing the area within the quadrat, each attribute was assessed using the criteria described in the Land EKG® matrix (Appendix A, Tables 1 and 2).

Management objectives influence the rating of ecosystem processes. Land managers, interviewed prior to data collection, articulated their management objectives related to each Land EKG® ecosystem attribute. In general, the silty site was managed for a native plant community. The sandy site was managed for sufficient livestock forage. To objectively apply the methodologies under study, both management objectives were considered when assessing each site. Based on one objective, the sites were evaluated as to how their species composition matched the Historical Climax Plant Community (HCPC) for that site. Under the second management objective, the sites were evaluated for use as winter cattle grazing pastures. The species present on each site were considered adequate for winter grazing, but their composition did not correspond to the HCPC.

Each ecosystem attribute was ranked from zero to five, with five indicating the healthiest state (Orchard and Sindelar 1998). The scores for each attribute in each frame were recorded on a scorecard (Appendix A, figure 4). Scores were tabulated for each attribute, for each of the four ecosystem processes, and then for a composite of all attributes. Each of these scores was converted to a percent so that they could be compared against an NRCS SI percent similarity. A score of 1 equaled 20 %, 2 equaled 40 %, 3 equaled 60 %, 4 equaled 80 %, and 5 equaled 100 %. The Land EKG® scores for ecosystem processes, individual attributes, and composite of attributes were averaged for each of the five transects, resulting in five transect scores for each of these outcomes.

These scores were then compared to the following categories defined by Orchard and Sindelar (1998):

functioning – 70-100 %

concern – 40-70 %

non-functioning – 0-40 %.

Quantitative Measurements

The NRCS SI method was applied to the same quadrats in which the Land EKG® method had been applied.

All vegetation was clipped from a 25 percent area within each quadrat. Present year's (green) growth was separated by species. Previous years' (standing dead) growth and litter were also collected. Present year's growth, previous years' (standing dead) growth and litter were dried at 120° F for 72 hours. These samples were then weighed and recorded.

Plant species composition within the five quadrats along each transect were averaged, resulting in five transect values for each study location. These averages were compared to the HCPC for the ecological site corresponding to each study location (NRCS 1997) (Appendix B, figures 5 and 6). The HCPCs for both ecological sites were determined by comparing vegetation to reference sites (USDA 1997). The percent similarity to the HCPC was calculated using the NRCS SI calculation.

Samplers recorded the time it took to apply each method at each quadrat. The times were averaged for each transect. Times to apply the Land EKG® method were recorded for the HCPC management objective at the silty location, and for the winter grazing management objective at the sandy location.

ANALYSIS

NRCS SI outcomes were compared to the Land EKG® composite, plant community process, and desired plants attribute outcomes with a paired t-test (Ott 1977). Times to apply each method were compared using a paired t-test (Ott 1977). Comparisons were considered significant at $p \leq 0.10$.

RESULTS AND DISCUSSION

The Land EKG® composite outcomes and plant community outcomes were in a concern zone for both sites, for management objectives. The Land EKG® desired plant abundance attribute outcomes, when managing for winter grazing, also were in concern zones for both sites, while the Land EKG® desired plant abundance attribute outcomes, when managing for the HCPC, were listed in a non-functioning zone. According to the NRCS SI, the plant community at the silty site was 18 % similar to the HCPC, while the plant community at the sandy site was 26 % similar to the HCPC. Under current NRCS procedures, rating classes (poor, fair, good, excellent) are not assigned to % similarity values. The technician suggests management actions based on the % similarity (personal communication, Bob Leinard, NRCS).

NRCS SI scores were significantly lower ($p \leq 0.10$) than the Land EKG® composite score and the Land EKG® plant community process score at both sites, for both management objectives associated with the Land EKG® method (figures 1a-d). Comparing the NRCS SI outcome to the Land EKG® desired plant abundance score is most relevant since the NRCS SI only rates the existing plant community. The NRCS SI rating compares more closely with the Land EKG® plant community process rating and the Land EKG® desired plant abundance attribute rating than with the Land EKG® composite score. When managing for a plant community other than one that will match the HCPC, it is not surprising that the outcomes produced by the NRCS SI and the Land

Figure 1. Comparison of NRCS SI and Land EKG mean outcomes at study sites, under two management objectives.

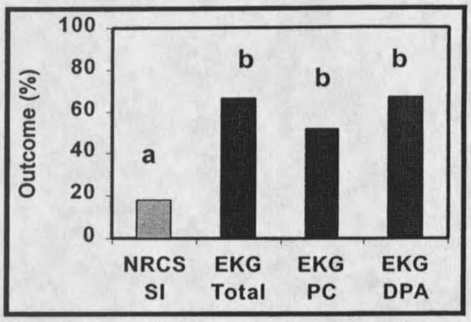

Figure 1a. Outcomes for silty site, managed for winter grazing.

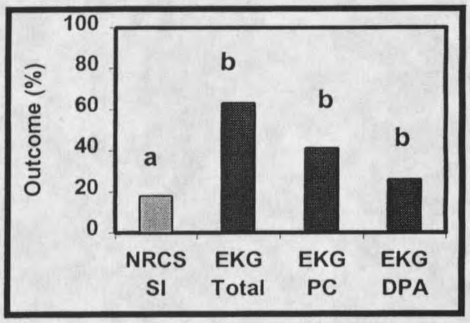

Figure 1b. Outcomes for silty site, managed for HCPC.

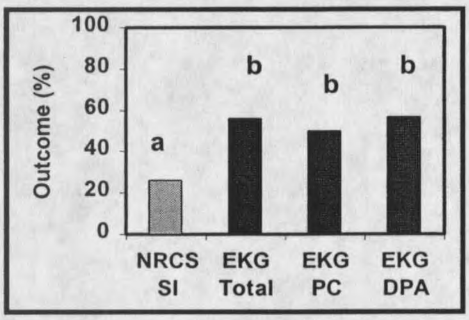

Figure 1c. Outcomes for sandy site, managed for winter grazing.

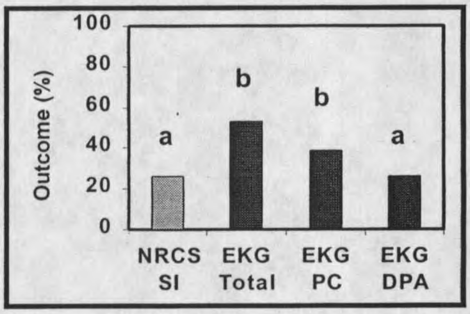

Figure 1d. Outcomes for sandy site, managed for HCPC.

Figure 1. Comparison of NRCS SI and Land EKG mean outcomes at study sites, under two management objectives. NRCS SI outcomes reflect percent similarity to HCPC; Land EKG outcomes reflect percent potential relative to management objectives.

[a,b] Land EKG outcomes with different letters than NRCS SI outcomes differ significantly at $p \leq 0.10$.

EKG® methods differ. Conversely, similar outcomes may be expected when managing for the HCPC. The NRCS SI score did not differ significantly ($p \leq 0.10$) from the Land EKG® desired plant abundance attribute score at the sandy site when managing for an HCPC for that ecological site (figure 1d). The percent similarity scores are significantly lower ($p \leq 0.10$) than the Land EKG® desired plant abundance attribute score when managing for the HCPC at the silty site, yet the mean values between the methods are close (figure 1c).

The NRCS SI accounts for kind, proportion, and amount of species present, while the Land EKG® method considers the amount of species in abundance classes. Almost no species that should dominate the plant composition matching the HCPC were present at the sandy site. Therefore, the Land EKG® desired plant attribute was rated in a non-functioning zone based on this observation. More species that are part of the HCPC for a silty site were found within the frames at the silty study site, potentially causing samplers to rate the desired plant abundance attribute higher. Since the criteria were not specifically defined in the management objectives, scores were more susceptible to sampler bias. Orchard (1994) provided multiple criteria for rating the desired plant abundance attribute. The management goal needed to be more clearly defined to meet exact criteria.

Significantly less time was required to complete the Land EKG® method than the NRCS SI method for both the silty and sandy sites (figure 2). The time it took to clip at the sandy location was significantly lower because there was less standing dead vegetation to separate (Appendix C, Table 3). The significantly different times to apply