A comparison of Range Condition Analysis and Ecodata to evaluate seral stages
by Susan Rae Winslow

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

Abstract:
Thirty plots were sampled in 1990 on 10 range sites in southwestern Montana to compare successional scores and condition classifications of Range Condition Analysis and Ecodata sampling methods. Range condition scores (RCS) and range condition classes (RCC) were derived from the traditional Soil Conservation Service's Range Condition Analysis method, with the exception that only major decreaser and increaser graminoids and shrubs were individually clipped and bagged. Minor decreaser and increaser grasses and forb species were each combined into separate vegetation classes. Ecological status scores (ESS) and ecological condition classes (ECC) were determined by the United States Forest Service's Ecodata method.

Wilcoxon's signed ranks test revealed that RCS were 17.5% greater ($p<.05$) than ESS and RCS was higher on 22 of the 30 plots. Analysis of variance determined that there were no differences ($p>.95$) between RCS and ESS within range sites. Mean RCS were higher than mean ESS on nine out of 10 range sites. Chi-Square analysis indicated that RCC and ECC were not different ($p>.99$). Twenty two of the 30 plots were classified the same. Productivity affected differences ($p<.05$) between RCS and ESS. Lower producing sites had higher RCS than ESS. Higher producing sites had greater ESS than RCS. The range site and habitat type concepts of potential natural communities probably did not contribute to the differences between scores. Differences were more likely attributed to the two different bases of measurements, RCA's species composition by weight and Ecodata's percent canopy cover. Management objectives of determining successional status should realize that the two methods provide different results and that condition classes are similar. Obtaining RCS was much less cumbersome than ESS values, however, RCS results are restricted to forage production management goals.

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5-31-95
Date

Bob Sowell
Chairperson, Graduate Committee

Approved for the Major Department

5/31/95
Date

J. R. Patterson
Head, Major Department

Approved for the College of Graduate Studies

9/23/95
Date

R. L. Brown
Graduate Dean

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Thirty plots were sampled in 1990 on 10 range sites in southwestern Montana to compare successional scores and condition classifications of Range Condition Analysis and Ecodata sampling methods. Range condition scores (RCS) and range condition classes (RCC) were derived from the traditional Soil Conservation Service's Range Condition Analysis method, with the exception that only major decreaser and increaser graminoids and shrubs were individually clipped and bagged. Minor decreaser and increaser grasses and forb species were each combined into separate vegetation classes. Ecological status scores (ESS) and ecological condition classes (ECC) were determined by the United States Forest Service's Ecodata method. Wilcoxon's signed ranks test revealed that RCS were 17.5% greater ($p<.05$) than ESS and RCS was higher on 22 of the 30 plots. Analysis of variance determined that there were no differences ($p>.95$) between RCS and ESS within range sites. Mean RCS were higher than mean ESS on nine out of 10 range sites. Chi-Square analysis indicated that RCC and ECC were not different ($p>.99$). Twenty two of the 30 plots were classified the same. Productivity affected differences ($p<.05$) between RCS and ESS. Lower producing sites had higher RCS than ESS. Higher producing sites had greater ESS than RCS. The range site and habitat type concepts of potential natural communities probably did not contribute to the differences between scores. Differences were more likely attributed to the two different bases of measurements, RCA's species composition by weight and Ecodata's percent canopy cover. Management objectives of determining successional status should realize that the two methods provide different results and that condition classes are similar. Obtaining RCS was much less cumbersome than ESS values, however, RCS results are restricted to forage production management goals.

INTRODUCTION

Livestock grazing has been the historic use on 109 million hectares of federally managed rangelands. Rangeland managers focused on forage as a commercial resource and Range Condition Analysis (RCA) was developed to monitor forage productivity and to evaluate grazing effects on plant communities. Range Condition Analysis became the standard range survey technique for the Soil Conservation Service (SCS) in the 1950s, and the method generated more than 40 years of range condition and vegetation trend data across the United States. In the 1960s, federal agencies were mandated to conduct inventories for rangeland analysis and ecosystem assessment. Inventory results were used to develop standards and guidelines for livestock grazing on public allotments and monitor rangeland resources for ecological integrity. The changes in land management policy prompted development of agency-specific methods to monitor vegetation condition and trend.

In 1987, the Northern Region of the United States Forest Service (USFS) adopted Ecodata as the standard approach for environmental analysis and plant community classification. The agency had used a variety of methodologies in the past to determine range condition and

is now in transition to the Ecodata method. The Northern Region proposes to manage three million hectares of public grazing allotments based on Ecodata similarity analysis. The relationship of Ecodata to standard range condition methods has not been established and a lack of continuity exists in information gathered with different methods. A comparison of the Ecodata method to the standard RCA would provide managers a basis for understanding Ecodata's evaluation of ecological condition.

The goal of this project was to compare the successional scores of RCA and Ecodata on a variety of range sites. The objectives were (1) to determine if the range condition scores and ecological status scores were different, (2) to determine if range condition classes and ecological condition classes were different, and (3) to determine which environmental parameters affect the differences between the range condition and ecological status scores.

LITERATURE REVIEW

History of Range Use

The federal government encouraged development of the western United States in the 19th century. Government incentives included the grant and sale of large tracts of land and access to natural resources on public domain (Evans 1979). Vast reserves of wildlife, minerals, forests, and forage lured pioneers in large numbers and economic gain governed the harvest of natural commodities (Schmautz 1979). Much of the land was unsuitable for cultivation and often the only appropriate agricultural pursuit was grazing of livestock on western rangelands. Rangeland ecosystems were characterized by grasses, grass-like plants, forbs, and shrubs and by a landscape that exhibited extremes in moisture availability (Box 1979). Early estimates of the forage resource, and the carrying capacity of the range, were often based on previous experience in more humid environments. The result was overstocking on native rangeland. From 1850-1900, six million cattle and 72.7 million sheep grazed on 470 million hectares of western range (Stoddart and Smith 1943).

High numbers of livestock were not adjusted before

the grass was completely utilized and extensive over-grazing of western rangelands damaged soil, water, and native vegetation (Powell 1879). Domestic livestock competed with wildlife for food and water and degraded fish and bird habitat. Ultimately, thousands of cattle, sheep, and native wildlife died from starvation throughout the West (Smith 1896). Thorough investigations on the effects of livestock grazing on public and private rangelands became necessary to avert catastrophic deterioration of a basic natural resource (Martin 1979).

Federal Lands and Environmental Legislation

At the beginning of the 20th century, many believed that the country would be better served if certain kinds of land were held in public ownership (Evans 1979). Forest reserves and special-use areas were placed in public domain and, in 1897, the Organic Administration Act regulated use on those lands. In 1905, the Transfer Act placed the Forest Preserves under the United States Department of Agriculture (USDA), and these lands were to be managed by the newly created United States Forest Service (USFS). The Forest Service inherited rangeland in poor condition (due to excessive grazing in the 1800s) and set out to inventory and assess the extent of the damage (Powell 1879, Smith 1896). Initial attempts employed descriptive observations to assess

soil and vegetative conditions and estimate bare ground, species composition, plant height, and canopy cover. The Taylor Grazing Act of 1934 designated the United States Department of Interior (USDI) Grazing Service, later to become the Bureau of Land Management (BLM), to regulate grazing on the remaining 32.4 million hectares of public domain (Stoddart and Smith 1943). The BLM was mandated to prevent overgrazing and soil deterioration, and improve and develop rangelands to support and stabilize the livestock industry (National Research Council 1994). The interagency range survey technique (1937) was used to determine grazing capacities although this technique did not address rangeland potential from an ecological or ecosystem perspective.

In 1935, the Soil Conservation Service (SCS) was created to assist private landowners in the control and prevention of soil erosion (USDA 1947). The devastating effects of the Dustbowl of the 1930s precipitated the need to gather soil, vegetation, and watershed data on nonfederal land and the SCS developed a system to aid conservation planning efforts (Renner 1948). Range site classification and range condition analysis (Dyksterhuis 1949) formed the basis for all SCS range work. In 1936, Resolution 289 (U.S. Congress, Senate, 1936) requested a report summarizing information on western rangeland and the results were based on range condition classification techniques. Although there were no methods for assessing range condition on a

larger scale, the report represented the opinions of range scientists on the preferred method for characterizing rangelands. After World War II societal awareness identified a need for increased conservation and improvement of the environment, and a subsequent wave of legislation began to set policy for managing natural resources (Joyce 1989).

The Multiple-Use and Sustained Yield Act of 1960 was enacted to insure that Forest Service management recognize multiple resources and uses in their planning process. Multiple use included clean water supply for urban areas and fisheries, native plant seed source, recreation activities, timber and firewood harvest, and forage production for wildlife and livestock. In 1964, the Wilderness Act was passed, and with the creation of the National Wilderness Preservation System, large tracts of land were set aside for protection from road construction, timber harvest, and grazing of livestock. A need to examine potential impacts of land management activities on the environment resulted in the passage of the National Environmental Policy Act (NEPA) in 1969. The law stated that environmental assessments address the nature and importance of the physical, biological, social, and ecomomic effects of a proposed action and its reasonable alternatives (USDA 1993c). Considerations for issuing grazing permits included water quality issues, livestock competition with wildlife,

biodiversity, and contributions to producer's livelihoods.

In 1973, the Endangered Species Act required that federal management must not jeopardize the existence of endangered animal or plant species. Grazing allotments must be inventoried and mapped for sensitive plant species and grazing activities curtailed in areas occupied by endangered species. The Resources Planning Act and the Forest and Rangeland Renewable Resource Planning Act of 1974, and the Federal Land Policy and Management Act and National Forest Management Act (NFMA) of 1976 acknowledged the need for an accountable planning process on National Forest and BLM lands. The planning process required that a detailed resource inventory be conducted every 10 years and that a current comprehensive survey and analysis of present and future conditions for forests and rangelands be maintained. Goals and objectives developed for managing renewable resources would be based on data supplied in the inventories and surveys; economic optimization was not to be considered a goal.

Legislation directing the approach agencies used to inventory nonfederal lands was passed in 1977 with the enactment of the Soil and Water Resources Conservation Act. The SCS was required, on a periodic basis, to inventory soil, water, wildlife habitat, vegetative cover, and related resources on private land. The National Resource Inventory (NRI) called for assessments of range condition based on the

range condition analysis method (Dyksterhuis 1958). The 1992 NRI data indicated a decrease of four million hectares of Montana rangeland, a 2.4 percent decline from 1982 (USDA 1994a).

In 1978, the Public Rangelands Improvement Act directly addressed the issue of rangeland condition on USFS and BLM lands. The policy included a federal commitment to inventory and identify current condition and trend, and to manage, maintain, and improve rangeland condition so as to be as productive as possible for all rangeland values. The 1985 Food Security Act was passed to address the issue of conservation problems on nonfederal land. The Conservation Reserve Program (CRP) and the sodbuster and swampbuster provisions have compliance requirements for receiving price-support payments. In Montana, highly erodible soils on 1.1 million hectares have been seeded to permanent grass cover under CRP (USDA 1994b) and may not be hayed or grazed in years with average growing conditions.

In 1992, the USDI began to encourage stewardship via methods that were designed to improve rangelands on grazing districts of the BLM. Rangeland Reform '94 (USDI 1994) was the final Environmental Impact Statement (EIS), as directed by NEPA, and proposed administrative changes in policies and regulations within rangeland management programs of the BLM and USFS. The preferred alternative set forth in the EIS would improve and restore rangeland ecosystems, and improve

and/or maintain biodiversity. Sustainable development, reformulation of grazing fees, and implementation of an ecosystem approach to rangeland management were also proposed.

Ecosystem Management

The National Forest Management Act of 1976 mandated the Forest Service to develop long-range plans that describe the planning process for meeting the requirements of the 1960 Multiple-Use Sustained-Yield Act (National Research Council 1994). Forest plans for each national forest outlined proposed management activities for watersheds, timber harvest units, and grazing allotments for 73.7 million hectares of land (Joyce 1989). The goal was to sustain biodiversity and productivity for multiple uses on public lands and to evaluate resultant changes on all ecosystems. Recognition of the complex biological and physical interactions of ecosystems (Robertson 1992) led to the adoption of an environmental policy based on ecological guidelines (USDA 1991). The purposes of the ecosystem management policy were to provide integrated ecosystem classifications, support unifying ecosystem frameworks for resource management, and develop an ecologically based information system to improve multiple use management (National Research Council 1994).

The Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (USDA 1994d), recently examined ecosystem management from the perspective of watershed function. Soil, water, animals, plants, and air (SWAPA) were considered the quality criteria for managing the environment and a planning procedures guide (USDA 1993a) was developed for ecosystem-based technical assistance. Rangeland resource quality must be evaluated in terms of ecosystem function, biodiversity, and disturbance effects. The range condition analysis method based only on forage productivity must now be replaced by analysis that integrates ecological, economic, and social elements to maintain and enhance the environment.

The fundamental approach for ecosystem management in the Forest Service brought together a wealth of disciplines to solve complex problems involving people, natural resources, and lands (Kessler 1993). Central to the principles of ecosystem management were the study of landscape spatial and temporal patterns and multiscaled levels of ecological organization (Bougeron and Jensen 1993). Issues of ecological theory considered for ecosystem management were biotic and abiotic components and their relationships, ecosystem properties, and variability over spatial scales (Bourgeron, Humphries, and DeValice 1993).

Incorporation of ecosystem principles and adaptive management procedures, determination of appropriate analysis

responsibilities, coordination of data collection and management, and recognition of the limitations of natural ecosystems for commodity production were considered prior to implementing ecosystem management (Kaufmann et al. 1994). Research needs included development of ecological risk assessments and process models, studies of native species extirpation and exotic species replacement, development of methodologies for determining historical conditions, and evaluation of existing databases for inventorying and monitoring natural variability in ecosystems (Bailey et al. 1993). Methods that characterized the variability of composition, structure, and function were developed by the Northern Region of the Forest Service (Swanson et al. 1993). The ecological concepts embodied in ecosystem management have not generally been accepted by range scientists for managing rangeland. These concepts may examine rangeland dynamics and spatial variation more realistically than earlier ecological theories based on linear plant community succession (Walker 1993).

Ecological Theory

Secondary Succession

Plant ecologists in the late 19th century were divided in their beliefs about vegetative responses to human and environmental disturbance (McIntosh 1985). Descriptive

methods listed, catalogued, and classified plant species over large areas and proponents of this classification system believed that vegetation communities were static and unchanging (Joyce 1993). These early plant classifications served to inventory the stores of forests and forage, with little consideration given to the processes of vegetation change and ecosystem structure and function (Wellner 1989). Dynamic vegetation ecologists (Clements 1905) rejected the static plant community theory because three modes of vegetation change had become apparent in the early studies of plant community development (Mueller-Dombois and Ellenberg 1974).

Phenological change occurred within the plant and were caused by growth and development, and influenced by the environmental factors of moisture and temperature. The second and third modes of vegetation change were based on primary and secondary plant succession, described as a sequence of vegetation change on different types of sites (Cowles 1901). Primary succession occurred on sites that had never before supported vegetation, such as sanddunes, rock islands, and lakeshores (Tansley 1920). Secondary succession examined sequential vegetation change following disturbance of established vegetation (Cowles 1910). Perturbations caused by nature and man included fire, floods, lava flows, timber harvest, and wildlife and livestock grazing. Successional development was said to

proceed under specific climatic conditions until it reached a predictable end-point, defined as a climax plant community (Cowles 1899). Secondary plant succession was supported by the concept that climax constituted a predictable vegetative endpoint and, thus, formed the basis for classification of plant communities (Clements 1905). Over the next 50 years secondary succession influenced the direction of vegetation science research (Daubenmire 1989). One of the most important theories was proposed by Clements in 1916 and became the basis for the rangeland classification model of today (Pendleton 1989).

Holistic Viewpoint. Frederic E. Clements (1916) proposed the successional climax model, monoclimax theory, and maintained that climax was the concrete expression of the climate and the essential unit of the climax was the dominant and subdominant plant species (Clements 1920). Vegetation was classified into formations with a group of species acting as an organic entity which would arise, grow, mature, and die. Each climax formation could reproduce itself, repeating the sequence of its development. All succession proceeded, in absence of disturbance, in a steady continuous fashion and converged toward a single climatic climax community. The linear process, if interrupted by stress factors, was totally reversible, with time required to re-establish the climax dependent on factors such as the

degree of disturbance, weather, longevity of seral species, and size of the disturbed area. Vegetation would progressively change back to climax no matter the nature or extent of disturbance and the end result was always predictable. Climax vegetation was considered to be pristine and in equilibrium with the climate and soil and remained stable over long periods of time. Dominant and subdominant species exhibited the universal tendency for stabilization and the number of individuals in the population pool was relatively constant. Equilibrium, the balance of the system, included the intake and release of matter and energy by the community as a whole. Productivity, decomposition, photosynthesis, and respiration remained constant in the underlying flow of the system. The climax plant community provided maximum soil protection based on increased plant height and cover, density, species diversity, and increased soil depth, differentiation and organic matter. Life-forms of the dominant and subdominant climax vegetation were able to efficiently exploit resources on a site and the climax was relatively more productive than seral communities.

At the macro-scale level, the climatic climax may be possible to accept, but at the local or regional scale, a convergence of community composition may not necessarily occur (Nichols 1917). Habitat conditions are usually non-homogenous and corresponding vegetation patterns are

diverse. A mosaic of edaphic, topographic, biotic, or ecoclimatically different communities are postulated by the polyclimax concept (Tansley 1920). Local habitats may be in dynamic equilibrium with their controlling factors and have a number of different climax communities within a climatic region. These plant communities are characterized by one or a few physiognomic dominants and express a relatively constant structure and strong stability over time. Tansley (1929) perhaps was the first to view the stable nature of the polyclimax as a temporary steady state.

Systematic Viewpoint. The floristic association system proposed by Braun-Blanquet in 1928 regarded the plant community as the basic unit of vegetation classification (Mueller-Dombois and Ellenberg 1974). Braun-Blanquet's floristic classification, releve' analysis, statistically derived plant communities based on properties of the vegetation. Plants were categorized into groups based on the floristic criteria that species were constant (always present), differential (separating), and/or character (indicator or diagnostic). Relationships were based on features of structural or compositional similarity and grouped individual stands into categories and similar stands into classes. Properties common to a group of similar stands were then abstracted to serve as a description of that class. The nature of variation within a class was not

always indicated.

Vegetation sampling for a releve' must occur in an area large enough to contain all species of the plant community, habitat should be uniform within the stand area, and plant cover should be homogenous. The size of the sampled area depended on the plant community being sampled and an empirical value for a grassland may be 50-100 square meters (Mueller-Dombois and Ellenberg 1974). The method included recording plot location and position, plot size, plant community description, tabulation of existing species, stratification of species by height and percent canopy cover, and estimates of soil or ground cover characteristics.

Vegetation was classified into associations by tabular comparison which processed all the releve's into a synthesis table and conveyed structure at four levels: species in vertical strata; species abundance in each stratum; number of species per stratum; and species by life form, such as tree, shrub, grass, forb, moss, or lichen. The releve' provided coarse, first order information based on the abstract judgement of the investigator and portrayed qualitative differences of recurring patterns or classes.

Relative similarity based on presence or absence of a species common to two stands provided quantitative comparisons of plant communities and was expressed as a coefficient (Jaccard 1912). A coefficient of 0 indicated a

complete lack of similarity between communities and a coefficient of 1 indicated complete community similarity (Ratliff 1993). Sorensen (1948) modified Jaccard's similarity index to include species quantity based on diversity, defined as the total number of species in each plot. Sorensen's index expressed the ratio of species common to two releve's to the average number of species in the two stands in percentage terms. Analysis did not require the same number of species or life forms in both areas, but the fewer the species or life forms in common, the smaller the index of similarity (Chambers and Brown 1983). The releve' synthesis table and Sorensen's equation provided the basis for plant community analysis in the Strata program of Ecopac (Keane et al. 1990).

Individualist Viewpoint. Gleason (1917) disagreed with the holistic and floristic viewpoints and applied Jaccard's similiarity index to emphasize continuity between similar stands of vegetation. Gleason's concept of individualism claimed that vegetation varied continuously in space and time, and communities were simply arbitrary isolates from the continuum (Gleason 1926). This model stated that species behaved as individuals and that they responded to the environment each in their own way. Community composition was determined by the availability of species and environmental overlap in survival requirements. Gleason

maintained that succession was not an orderly process, that change was universal and constant, and establishment of a climax community was impossible. Vegetation science has applied the hypothesis of continuum and formalized the relationship into methods of gradient analysis and ordination (Bray and Curtis 1957). Ecologists accepted the individualistic approach with the exception that evidence existed for a degree of integration of plant species in a community (Curtis 1959).

Causal Analytical Approach. Egler (1954) proposed two alternatives to Clements' succession model based on shifts or rearrangements of different species over time. Relay floristics viewed successionary replacement as the arrival and disappearance of species in groups. Initial floristic composition stated that species were already on the site at the start of the successional sequence. Vegetative propagules or seeds on the site allowed for different species to mature and come into prominence at different rates. Species replacement was related to allogenic influences and the particular pattern depended on local circumstances of dispersal constraints and seed size. Recognition of stages in secondary succession may be critical in the evaluation of ecosystem cover.

Connell and Slayter (1977) suggested three models to explain alternative mechanisms in the course of events

during secondary succession. Inhibition acted to prevent establishment of one species over another, facilitation occurred as the inhibitors created an environment which aided in gradual replacement, and tolerance was characterized by species which occupied a site and had little or no effect on other species. It has been determined that these models address disturbance in general and do not act independently of each other (Burrows 1990). The model did not deal with adaptive traits of a species persisting through a disturbance, nor did it address the periodic nature of the disturbance (Cattelino et al. 1979).

Alternative Concepts

Wilson and Tupper (1982) developed the multivariate site potential approach based on quantitative analysis of soil erosion and potential productivity. Multiple regression analysis through ordination principles (Bray and Curtis 1957) was included in the procedure to determine range condition based on vegetation change. The basic concept inventoried the land into range sites, measured a pre-determined vegetation parameter and soil attribute, and calculated a similiarity index (Wilson 1986). The creation of a simple index conveniently displayed information for land managers and land users and reflected the extent of vegetation change on a site (Hacker 1986). Problems with scale, variability between range sites, and climatic

influences on productivity were drawbacks of the approach (Tueller and Platou 1986).

The state-and-transition model proposed by Westoby et al. (1989) stated that rangeland dynamics can be described by a set of discrete vegetative states and by discrete transitions between states, which are triggered by natural or human-caused events. A catalogue of potential domains, such as a site dominated by shrubs or grasses, and pathways, such as fire or grazing, could be compiled for a particular type of rangeland. States could be distinguished if the differences represent an important change in the use of the land. This method stressed the opportunistic view of managing rangeland and did not follow any theoretical models about vegetation change (Laycock 1989).

Friedel (1991) went on to discuss the threshold concept of environmental change and suggested practical ways to identify the threshold before the critical transition phase occurred. The characteristics of a threshold define it as boundary in time and space between two states and the initial shift across the boundary was not reversible without substantial manipulation by the range manager. The use of multivariate analysis for classification and ordination (Bray and Curtis 1957) can detect the shift from one state to another. Although theoretical development has yet to support the threshold concept, it may provide a framework for a new approach in understanding rangeland dynamics

(Laycock 1991).

The application of catastrophe theory may supply the theoretical base for the state-and-transition and threshold concepts. Lockwood and Lockwood (1993) presented the mathematical formulation, which was designed to identify discontinuous phenomena in otherwise continuous systems. Rangeland ecosystems displayed the five symptoms found in catastrophe systems. The unique set of symptoms are modality, inaccessibility, sudden changes, hysteresis, and divergence. The cusp and fold expressions of catastrophe could act to model the smooth gradient of climax succession and the unpredictable dynamics in the state-and-transition concept. Data sets developed over a reasonable period of time must include state and control variables necessary to produce a particular threshold or transition.

Range Classifications

Survey Techniques

Early range condition studies attempted to assess the current vegetative productivity of a site relative to what the site was naturally capable of producing (SRM 1974). The purpose was to provide a basis for predicting the extent and direction of change in a plant community because of a specific activity or treatment (USDA 1976). Initial attempts were based on ocular surveys over a large area and

provided a written account of the existing range resource. James L. Jardine (Jardine and Anderson 1919) created the range reconnaissance method to visually determine forage availability and palatability, percent forage species, and descriptions of vegetation types. The reconnaissance method was modified over the years and the concept of measuring volumes of vegetation replaced visual estimates of cover (Standing 1933). The BLM officially standardized the method as the interagency range survey technique, and forage production, rather than the state of rangelands, was evaluated. The availability of forage reflected current weather conditions and structural aspects of a range ecosystem. Functional characteristics of soil stability, energy flow, and nutrient cycles were not considered in the reconnaissance technique (Sims 1979).

Ecological Approach

The fledgling discipline of range science began in 1910 to assess the structure and function of vegetation based on the ecological, climax approach. Sampson (1917) may have been the first individual to reference the utility of rangeland assessment and successional stages. He found that successional status of vegetation could be used to evaluate grassland productivity and predict recovery based on grazing intensity. Sampson (1919) introduced the terms decreaser and increaser to indicate responses of grasses and forbs to

grazing pressure, and invader to mean a plant not indigenous to a site. Sampson's (1923) work in the Wasatch Mountains in Utah used percent cover and palatability factors to determine forage yield and was instrumental in bringing together successional theory and practical grazing management. Clements' (1934) monographs on relic areas and the nature of vegetation (Clements 1936) provided additional data for range evaluation based on ecological succession.

Range Condition

Range condition classification was developed to measure the influence of grazing on plant community composition and production (Humphrey and Lister 1941). Six condition classes were used to arbitrarily index the percent of existing vegetation to the climax community, and values ranged from one for a complete climax vegetation, to six for total absence of climax species. Judgemental adjectives of excellent, good, fair, or poor accompanied the condition class scores (Renner 1948). Following Sampson's terminology (1919), plants which belong to a lower successional stage, increasers, may denote a deteriorating site; plants associated with a higher successional stage, decreasers, may indicate site improvement (Graham 1940). Weaver and Darland (1947) found that plant communities of a lower successional stage may persist for many years. Techniques for measuring forage production and species composition based on grazing

response focused on the present state of the range and were used to estimate carrying capacity and livestock stocking rates (Stoddard and Smith 1943). The emphasis shifted toward managing the range ecosystem for climax community, based on the assumption that the highest successional stage was also the most productive.

Site Potential Approach

Humphrey (1949) promoted a site potential approach based on primary productivity for a particular use. This method rated range condition as the potential productivity of a site in relation to the maximum potential for that site (Humphrey 1947). Under this approach forage production was the measure of range condition, and grazing selectivity on different plant species could result in different interpretations of range condition for the same site. Ellison (1949) also based condition on site potential, but ascribed to the view that soil stability was a critical component in determining range condition. Range condition on a site was determined with ocular estimates of soil indicators and relative productivity (Ellison 1949). This technique based range succession on a subjective distinction between stable and eroding soils.

Deming (1957) developed a Two-Phase method which separately rated soil surface condition and forage species. The Phase I scorecard rated vegetation on forage

characteristics and Phase II rated physical features and active erosion elements. The aggragated numerical rating represented how well the current conditions approached the ideal for the site. This method focused on plant species valuable for forage production and desirablilty for grazing and land was judged primarily in usefulness for livestock grazing (Wagner 1989). The 3-step method (Parker 1959) was developed to monitor long-term changes in vegetation based on 3/4 inch loop frequency measurements. Basal frequency data was collected along three permanent, photographed, 100 plot transects and were read repeatedly over time. A score was computed from the combination of the loop frequency and vigor data and compared to expected values for that particular range type. Parker data displayed extreme variability and must be converted to basal area before an ecological interpretation can be made (Brady et al. 1991). Although the importance of site potential was recognized as early as 1919 in relation to forest sites (Korstian 1919), assessment of range condition based on site potential was not acknowledged until development of the quantitative climax method in 1949 (Smith 1988).

Range Sites

Dyksterhuis (1949) refined the range succession model and introduced Tansley's (1920) edaphic or physiographic climaxes, referred to as range sites. A range site could be

classified by recognizing differences in climax plant community, soil type, climatic environment, topography, and potential capacity to produce forage. Shiflet (1973) stated that soil surveys provided a classification system based on properties such as color, horizon depth, pH, texture and other morphological features, and are important to classifying rangeland into range sites. Interactions between soils, different temperature and moisture regimes, slope, elevation, and aspect supported a unique climax plant community (Passey et al. 1982). Climax plant communities with significantly different potentials for annual biomass production, calculated from the weight of each species, was the key descriptor for a range site. Precipitation zones of 0-24 cm, 25-36 cm, 38-48 cm, and 50 plus cm were determined for each range site. Silty, shallow, clayey, and wet meadow are examples of range site terminology (USDA 1947).

Dyksterhuis (1958) went on to describe a quantitative approach for assessing range condition by determining the percentage of similarity of present vegetation to the climax community. Actual percent composition for each species was compared to the expected percent composition of the climax. Expected percent composition was determined from relict areas (Clements 1920), comparison of grazed and ungrazed areas, and review of historical and botanical literature. Total numerical values for a site indexed all decreaser species, that portion of the increaser climax species

allowed, and no invaders or annuals. The successional scores were divided into four arbitrary classes: 76-100% excellent; 51-75% good; 26-50% fair; and 0-25% poor (Stoddart et al. 1975). For example, a total of 30 indicated that the range could only support 30 percent of the normal climax cover (low-fair condition). Figure 1 depicts the trend of percent climax plant community as related to range condition and time in years of grazing.

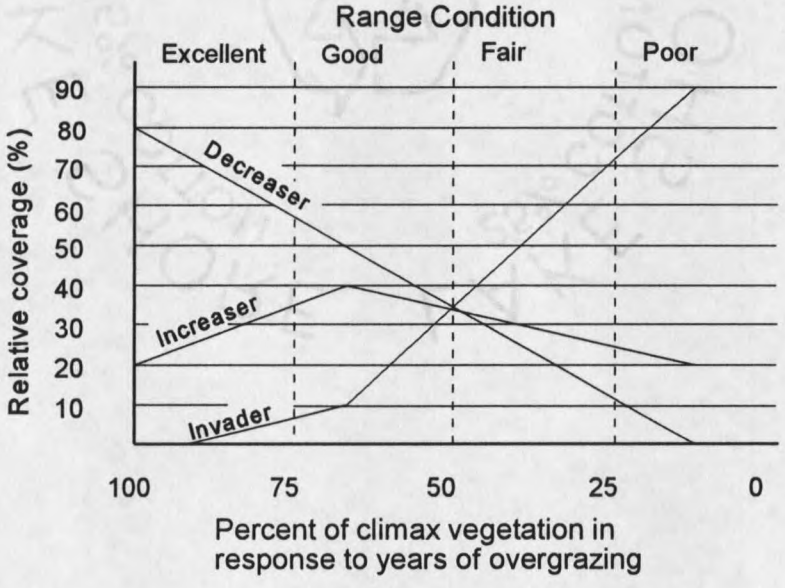

Fig. 1. Range condition as determined by percent composition of decreasers, increasers, and invaders.

Range site classification and range condition analysis provided a means for determining how much vegetation change occurred on a site. Dyksterhuis' method was adopted for use by the SCS, and the BLM and USFS modified the method for

their own purpose (Deming 1957, Parker 1959, USDI 1979). Despite development of ecological concepts, evidence of complex ecological processes, and federal mandates to manage for multiple uses, this quantitative climax model became standardized in federal rangeland policy (Svejcar and Brown 1991).

Federal transitions

Environmental legislation mandated that federal and nonfederal land management agencies conduct inventories and assessments, and monitor, maintain, and protect natural resources. To meet this requirement, federal agencies developed hierarchical systems for classifying vegetation (Daubenmire 1968, Mueggler & Stewart 1980, Pfister et al 1977) and defined specific terminology based on the climax model of species dominance and site potential (Smith 1989).

The USFS substituted the term ecological type for range site and the BLM chose ecological site as the descriptive term for a basic unit of land (Moir 1989). The ecological approach suggested a site classification that could be used to organize management knowledge and research results not necessarily based on land use (National Research Council 1994). The potential natural community replaced the climax community in the USFS manual and composition considerations allowed naturalized non-natives, where the SCS counted only native species. The BLM and Society for Range Management

(SRM) stressed desired plant communities and defined that community as the one that has been identified through a management plan to best meet the plan's objectives for the site (Borman and Pyke 1994). Ecological status came to replace range condition in the USFS and low seral, moderate, high, and very high seral were used to describe the stages of secondary succession. These terms replaced the value judgements associated with the condition classes poor, fair, good, and excellent (Laycock 1989). The NRCS drafted a National Range Handbook in 1994 and adopted most of the terminology mentioned above (personal communication, S. Burnworth, NRCS Resource Conservationist, Feb.13, 1995). All agencies intend to assign a resource value rating to vegetation based on suitability for a specific use (West et al. 1994).

Ecodata

Ecological studies and inventories rarely collected data in a standardized format and commonly cannot be shared across studies (Pfister 1989) and resource disciplines (Bastedo and Theberge 1983, Chalk et al. 1984, Hann 1989). Recognizing the need for a standardized method for the inventory and monitoring of vegetation, the Northern Region of the USFS developed Ecodata and Ecopac (USDA 1987a, 1987b). Due to the complex nature of Ecodata and Ecopac, only the portions of the system pertinent to this study will

be discussed.

The term Ecodata described all aspects of ecological data collection, entry, and storage. The primary objective of Ecodata was to provide a standardized system for description of basic ecosystem information at the plot level. A secondary objective was to promote the integrated use of vegetation data by all types of resource managers (Keane et al. 1990). Ecodata applications included vegetation and soil mapping, vegetation community classification, environmental impact assessment, wildlife habitat evaluation, and rangeland condition estimation. The Ecodata system included: sampling methods for collecting macroplot vegetation and environmental data; plot forms and codes for recording data; data entry programs; and relational database systems.

Sampling Methods. Ecodata vegetation classification methods follow the Braun-Blanquet releve' method and reflect the hierarchical system based on floristic similarities (Mueller-Dombois and Ellenberg 1974). The sampling entity, macroplots, were subjectively located without preconceived bias of potential vegetation setting in a representative portion of a stand. The general sampling method recorded plot identification and location, environmental features, vegetation structure and production, and animal history and use (Jensen et al. 1993). This method provided information

for most ecosystem description and analysis purposes, acted as a link to all other sampling methods, and bridged data to the relational databases. The non-replicated ocular method provided an indepth description of vegetation on a macroplot and was used when dominant species and indicator species were required to describe the ecosystem. Visual estimates of plant canopy cover, mean plant height, and synecological information were noted on the plant composition form, along with a complete list of species names.

Ecodata methods have been used by the National Park Service, Bureau of Land Management, Nature Conservancy, and private consulting firms and 15,000-20,000 plots have been established in Montana, Idaho, North Dakota, and South Dakota (Keane et al. 1990). Mueggler and Stewart (1980) sampled 580 relatively undisturbed grassland and shrubland stands in western Montana. Data on plant species and environmental features were analyzed and potential natural vegetation for 29 habitat types occurring in 13 climax series were defined. The macroplots were entered onto the Ecodata system to provide a basis of comparison for determining ecological succession with the Strata program. Ecological status, defined as the floristic similarity of current vegetation compared to potential natural vegetation, may be determined in Strata with vegetation and site type classifications, based on species canopy cover and floristic similarity (USDA 1993b).

Ecopac. The Ecopac analysis packages were developed as a collection of computer programs and models linked to the Ecodata databases. The utility module checks for data errors, writes hard-copy reports of summarized plot-scale information, and performs plant community analysis of plant synecological data in the Strata program. Species abundance and average cover by plot and strata are summarized in a releve' constancy-average cover table. Similarity analysis in Strata compared species cover across plots and strata and computed a similarity index based on Sorensen's equation (Sorensen 1948). Scores of 0-25, 26-50, 51-75, and 76-100 are interpreted as low, moderate, high, and very high similarity to the potential natural community, which are represented by the macroplot data of Mueggler and Stewart (1980). Successional community classifications within habitat or potential vegetation types may be refined by examining differences of site variables (e.g. aspect, elevation, slope).

Current Implications

Concerns over the condition of public rangeland due to livestock grazing, conservation efforts to preserve natural resources, economic outcries against grazing subsidies, and growing social and economic importance of other resources

(Marston 1994, National Research Council 1994, USDI 1994) have forced federal agencies to restructure rangeland management programs. Vital economic and environmental interests are at stake with the management of 14.9 million hectares of rangeland and 1.4 million hectares of pastureland in Montana (USDA 1994a). Forest Service grazing allotments across the United States generated receipts of $614 million in 1992 from approximately 2.2 million domestic animals (USDA 1993). Cow-calf operations in Montana generated receipts of $804 million in 1993 (Montana Agricultural Statistics 1994) and approximately $16 million yielded from grazing on land administered by the USFS. Forest Service allotments could experience 15-20% stocking rate reductions, based on results from rangeland assessments conducted with Ecodata (Peck 1994), which represents a potential loss of $1.5 million to the Montana livestock industry.

The proposed use of Ecodata for evaluating range condition presents social, economic, and biological challenges for rangeland managers. Managers must understand the limitations and implications associated with Ecodata assessment results and this will occur only when the method has been compared to the familiar RCA standard. This study will contribute to a better understanding of the measurements of ecological status when compared to range condition.

METHODS

Study Objectives

The purpose of this study was to compare successional scores and condition classes derived from Range Condition Analysis (RCA) and Ecodata sampling methods. Thirty plots were used to test differences between the two techniques determined on the same plot. The objectives were (1) to determine if range condition scores (RCS) and ecological status scores (ESS) are different, (2) to determine if range condition classes (RCC) and ecological condition classes (ECC) were different, and (3) to determine which environmental parameters affect the differences between range condition and ecological status scores.

Study Area

The study was conducted on the Flying D Ranch, approximately 16 km southwest of Bozeman, Montana, in Gallatin and Madison counties. The 60,700 hectare ranch borders the Spanish Peaks Wilderness of the Gallatin National Forest. Significant wildlife populations, cultural resources, and sensitive plants exist on the ranch and were

documented by Lessica in 1990 (as cited by Westech 1991). The Gallatin and Madison Rivers drain the ranch, which is characterized by intermontane valleys at 1280-2300 m elevations. The majority of the ranch receives 38-48 cm of annual precipitation, experiences an average annual temperature of 4.4^0 C, and a frost-free period of 75 days.

Bridger, Cryaquollis, Earcree, Hanson, Orofino-Poin, and Poin-Sebud soil complexes with sandy, silty, and clay loam textures dominated the study area and were frequently modified by gravel, cobble, or stone fragments (USDA 1989, 1994c). Potential natural communities (PNC) varied with range site and average production values ranged from 300 to 1200 kg/ha (USDA 1989). Dominant plant species across range sites included big sagebrush (*Artemesia tridentata* Nutt.), bluebunch wheatgrass (*Agropyron spicata* Pursh), Idaho fescue (*Festuca idahoensis* Elmer), lupine (*Lupinus spp.* L.), needleandthread (*Stipa comata* Trin. and Rupr.), prairie Junegrass (*Koeleria macrantha* (Ledeb.) J.A. Schultes), western needlegrass (*Stipa occidentalis* Thurb. ex S. Wats.), and western wheatgrass (*Agropyron smithii* Rydb.)(Ross and Hunter 1976). Flying D Ranch activities included beef and crop production, big game and timber harvest, and mineral extraction. Small numbers of livestock were present at the time of the survey. Free-roaming bison are currently being produced on the ranch

for meat production. Ranch vicinity and conceptual plot location are depicted in Figure 2.

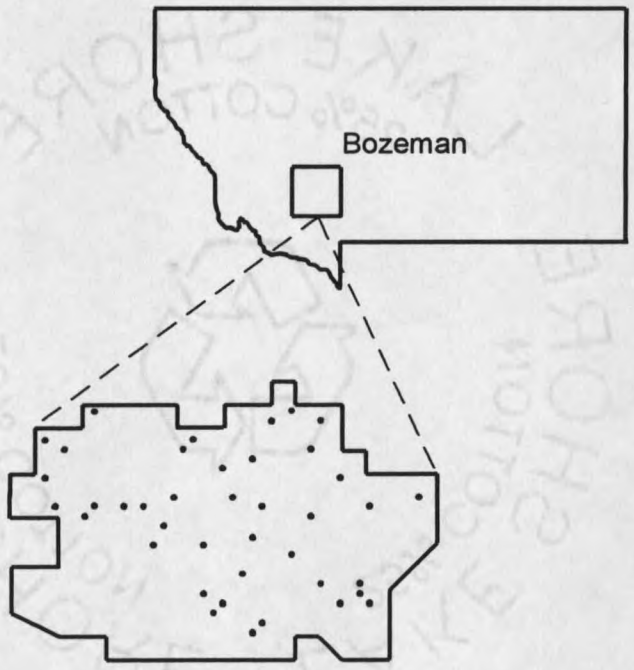

Fig. 2. Flying D Ranch vicinity and plot location map.

Plot Location

Forty permanent Ecodata macroplots were established on the ranch as part of a baseline range condition inventory in 1990. Sampling was concentrated in grassland and shrub steppe rangeland to evaluate a variety of range sites (Westech 1991). Ecodata macroplots were established in major range sites and location was based on vegetation

composition, soils, and precipitation information (Appendix Table 1). Site selection in riparian corridors was minimal due to significant modification of lowland vegetation from livestock grazing and apparent poor condition. Upland areas were sampled more intensively to determine the extent of fair to excellent condition range sites and a number of range sites were sampled at several locations. Range condition and ecological status were to be compared on range sites/habitat types that have species composition data available for similarity analysis. Ten macroplots were excluded from analysis because PNC species composition data was not available for similarity analysis on Ecodata.

Macroplots were established in a representative, homogenous range site/habitat type and permanently located with a 1.6-cm diameter capped rebar pin, exposed 10 to 40 cm above ground, at the center of the plot. Macroplot location was recorded as an azimuth from a tan fiberglass fencepost placed outside the plot and 35mm photographs were taken to aid future monitoring efforts. The fiberglass fencepost was 3.8-cm diameter and exposed 1.4 m above ground. Exact site locations and landmark descriptions are reported in Westech (1991).

Plot Sampling

Forty plots were sampled in August 1990 according to the

Ecodata ocular method, as outlined in Chapter 4 of the Ecosystem Classification Handbook (USDA 1987a). The handbook provided detailed coding instructions for each field form used in the sampling process. The circular macroplot had a 11.3 m radius and an area of 0.04 ha and the perimeter was temporarily marked with pin flags prior to data collection. Macroplot identification and location were recorded in fields 1-31 of the General Plot Data Form 3 (Appendix Figure 3) and a key identification code for data entry purposes was assigned to the plot. Environmental features of the macroplot were noted in fields 32-51. Potential natural community (habitat type) were determined with classification systems developed by Hansen et al. 1988, Mueggler and Stewart 1980, and Pfister et al. 1977. Range site was determined using Soil Conservation Service (SCS) soil survey maps (USDA 1989 and 1994c). Site parameters described included soil type, plot position on the landscape, parent material, aspect, elevation, percent slope, and ground cover characteristics. Vegetation structure and production for the macroplot were recorded in fields 52-76. Identification of dominant species (height x canopy cover) by vertical layer and estimation of total percent vegetative cover by life-form were determined.

The standard Ecodata ocular method of estimating macroplot production was deemed inadequate for subsequent determination of range condition. In this study, the actual

harvested biomass of certain vegetation classes was determined to be a more appropriate measure of production. Plant species identified as major decreaser graminoids, major increaser graminoids, or shrubs were individually clipped and bagged (USDA 1981). Plant species identified as minor decreaser grasses, minor increaser grasses, perennial forbs, annual/biennial forbs, or annual grasses were combined into separate classes. Actual production was determined by randomly placing three, 0.5 x 1.0 m microplots within an Ecodata macroplot. Current year above-ground herbaceous biomass for each class of vegetation was clipped to ground level and bagged. Production samples were oven-dried at 70° C until constant weight was achieved (48-96 hrs). Biomass weights (kg/ha) for each class, in each microplot, were totalled and averaged for the macroplot. Actual total biomass was not collected for macroplots 20, 34, 37, and 40. Mean production estimates for the habitat type listed in Mueggler and Stewart (1980) were used as production values for those macroplots. Animal use and disturbance history were noted in fields 77-80.

Ocular Plant Species Data Form 4 (Appendix Figure 4) was used to record characteristics of the macroplot vegetation. Species life-form, percent canopy cover class, and average mean height to the nearest foot were defined. Plants were identified to genus and species using Dorn (1984), Great Plains Flora Association (1986), Hitchcock et al. (1955-

1969), and Hitchcock and Cronquist (1973). The U.S. Forest Service species list (USDA 1987a) was used as standard nomenclature for entry into the plant composition database (Appendix Table 2).

Determination of Range Condition

Traditional range condition calculations are based on clipped, dried weight of all species identified on a sample site (USDA 1981). This approach is very time-intensive (Cook and Stubbendieck 1986) and generally impractical for extensive vegetation inventories (Blaisdell and Holmgren 1984). In this study, it was determined that certain classes of vegetation were appropriate for determining range condition. Plant species identified as major decreaser graminoids, major increaser graminoids, or shrubs were individually clipped and bagged by species. Plant species identified as minor decreaser grasses, minor increaser grasses, perennial forbs, annual/biennial forbs, or annual grasses were combined into separate classes. Regardless of class, only native perennial species were counted in the calculation of range condition.

Range condition calculations for 26 macroplots were based on actual production data and on estimated percent canopy cover for those four plots without actual production data. Range condition was determined using USDA SCS range

site technical guides (1977, 1981). Relative composition by weight for each vegetation class was determined by dividing the weight of the class by total plot production. Relative species composition was then compared to allowable percent composition listed in the technical guide and range condition was determined. Estimated percent species canopy cover served as the basis for comparison to allowable composition in the range condition calculations for plots 20, 34,37, and 40.

Determination of Ecological Status

Data collected and recorded on Form 3 and Form 4 (USDA 1987a) for each of the 40 macroplots were entered into the Ecodata general form and plant composition data bases (Data General System 1985). The databases were linked to the Ecopac analysis system (USDA 1987b) and the software programs utilized were Errorcheck, Plotid and Strata (USDA 1992). Strata was chosen to inspect for the differences between the existing 30 macroplot communities and the PNCs of Mueggler and Stewart (1980). All plots were error checked and the Plotid program was used to group 30 of the 40 macroplots for entry into the Strata program. Macroplots 9, 10, 11, 16, 17, 19, 23, 27, 38, and 39 had forest or riparian shrub habitat types (PNC). Those ten macroplots were excluded from analysis because PNC species composition

data was not available for similarity analysis on Ecodata. A species synthesis table and a constancy-average table for the 30 macroplots and 159 Mueggler and Stewart (1980) plots were generated in Strata to allow selection of plants common to both groups. Composition was limited to 88 species to reduce variation in the similarity analysis. The 159 Mueggler and Stewart (1980) plots were then regrouped into their original habitat types. Each individual study macroplot was compared to all five habitat types by plot-to-strata similarity analysis in the Strata program. The PNCs were *Agropyron spicatum/Poa sandbergii* (Agrspi/Poasan), *Artemisia tridentata/Festuca idahoensis* (Arttri/Fesida), *Festuca idahoensis/Agropyron caninum/Geranium viscosissimum* phase (Fesida/Agrcan/Gervis), *Festuca idahoensis/Agropyron smithii* (Fesida/Agrsmi), and *Festuca idahoensis/Agropyron spicatum* (Fesida/Agrspi). Macroplot ecological status was calculated as degrees of similarity to PNC using Sorensen's coefficient, K=100 (2c/a+b) (Gauch 1982).

Statistical Procedures

Differences between the mean range condition analysis scores and ecological status scores were compared using the non-parametric, two-tailed Wilcoxon's signed rank test (Steel and Torrie 1980). This was considered to be a more

conservative approach than either the paired t-test or analysis of variance since the sampling methods were not collected independently. The Wilcoxon's signed rank test only assumes data can be ranked and there are very few ties when ranking values. No other assumptions of independent sampling or normally distributed differences are necessary. There was only one tied rank in the data, therefore this was considered a valid statistical test. Plot was considered the experimental unit for this and all subsequent analysis. One-way analysis of variance (SAS 1988) was used to compare differences of RCS and ESS within range sites.

Range condition classes (RCC) were poor, fair, good, and excellent and ecological condition classes (ECC) were low, moderate, high, and very high. The four condition classes, for both methods, represented successional score percentage breaks of 0-25, 26-50, 51-75, and 76-100. Analysis of RCC and ECC was based on 28 of the 30 plots. Verbal scores were transformed into categorical form (1-4). To determine the degree of independence between RCC and ECC, Chi-Square analysis (MSUStat 1994) was used on a 2-way contingency table. Association groups were determined according to the probability of such associations occurring strictly by chance. Plots 1 and 36 were excluded because they represent single occurrences in the columns of the contingency table which render the statistical inference invalid for those columns.

Differences between RCS and ESS (RCS - ESS) for each of the 30 plots were determined. Multiple regression analysis (SAS 1988) was used to determine the influences of aspect, elevation, precipitation, production, range site, and slope. Range sites were grouped irrespective of precipitation zone.

Production was the only significant variable ($P < .05$) to emerge from this analysis so simple regression analysis (SAS 1988) was used to determine the relationship between productivity and the difference between % RCS and % ESS. Differences were considered significant at the .05 probability level unless otherwise noted.

RESULTS

A total of 10 range sites were sampled and environmental parameters used to determine range site are listed by plot in Appendix Table 1. A total of 552 vascular plant taxa were identified in the range survey and are presented in Appendix Table 2. Fifty-six woody species (10% of the total), 389 forbs (71%), and 107 grasses and grass-like species (19%) were recorded. A summary of plot numbers included within each range site used in the analysis is presented in Table 3. Production values ranged from 139 kg/ha on the Very Shallow 38-48 cm range site to 4,708 kg/ha on the Silty 50+ cm range site. Production estimates for each of the 30 plots are listed in Table 4.

Table 3. Range sites and corresponding plots.

Range Site	Plot
Silty, 25-36 cm	1
Silty, 38-48 cm	2, 3, 5, 18, 21, 24, 30
Silty, 50+ cm	4, 13, 15, 32, 33, 34
Silty Droughty, 38-48 cm	22
Shallow, 38-48 cm	6, 7, 12, 28, 31, 35
Shallow, 50+ cm	29, 37, 40
Very Shallow, 38-48 cm	14, 26
Overflow, 38-48 cm	8, 25
Clayey, 38-48 cm	20
Thin Hilly, 38-48 cm	36

Table 4. Plot similarity to potential natural community and plot production (kg/ha).

Plot Number	Range Site (PNC)	Range Condition (percent)	Condition Class	Habitat Type (PNC)	Ecological Status (percent)	Ecological Class	Production (kg/ha)
1	Silty, 25-36 cm	78	Excellent	Agrspi/Poasan/Sticom	57	High	1026
2	Silty, 38-48 cm	34	Fair	Arttri/Fesida	42	Moderate	640
3	Silty, 38-48 cm	55	Good	Fesida/Agrspi	54	High	1888
4	Silty, 50+ cm	67	Good	Arttri/Fesida	53	High	1292
5	Silty, 38-48 cm	24	Poor	Fesida/Agrsmi	12	Low	2581
6	Shallow, 38-48 cm	40	Fair	Fesida/Agrispi	48	Moderate	1904
7	Shallow, 38-48 cm	49	Fair	Fesida/Agrispi	35	Moderate	788
8	Overflow, 38-48 cm	26	Fair	Fesida/Agrcan/Gervis	34	Moderate	3078
12	Shallow, 38-48 cm	38	Fair	Fesida/Agrspi	36	Moderate	1267
13	Silty, 50+ cm	68	Good	Fesida/Agrspi/Gervis	51	High	2296
14	Very shallow, 38-48 cm	48	Fair	Fesida/Agrspi	19	Low	139
15	Silty, 50+ cm	15	Fair	Fesida/Agrcan/Gervis	36	Moderate	4708
18	Silty, 38-48 cm	55	Good	Arttri/Fesida	47	Moderate	1178
20	Clayey, 38-48 cm	40	Fair	Arttri/Fesida	32	Moderate	1700*
21	Silty, 38-48 cm	44	Fair	Fesida/Agrspi	51	High	2526
22	Silty, 38-48 cm	58	Good	Fesida/Agrspi	44	Moderate	935
24	Silty, 38-48 cm	41	Fair	Fesida/Agrspi	29	Moderate	2076
25	Overflow, 38-48 cm	22	Poor	Fesida/Agrcan/Gervis	19	Low	2882
26	Very shallow, 38-48 cm	66	Good	Fesida/Agrspi	35	Moderate	639
28	Shallow, 38-48 cm	51	Good	Fesida/Agrspi	52	High	1721
29	Shallow, 50+ cm	60	Good	Fesida/Agrspi	50	High	1645
30	Silty, 38-48 cm	42	Fair	Fesida/Agrspi	40	Moderate	2002
31	Shallow, 38-48 cm	42	Fair	Fesida/Agrspi	39	Moderate	979
32	Silty, 50+ cm	31	Fair	Fesida/Agrcan/Gervis	49	Moderate	3303
33	Silty, 50+ cm	69	Good	Arttri/Fesida	42	Moderate	1454
34	Silty, 50+ cm	71	Good	Arttri/Fesida	44	Moderate	2058*
35	Shallow, 38-48 cm	47	Fair	Arttri/Fesida	48	Moderate	1883
36	Thin hilly, 38-48 cm	80	Excellent	Fesida/Agrspi	51	High	586
37	Shallow, 50+ cm	63	Good	Arttri/Fesida	56	High	1307*
40	Shallow, 50+ cm	49	Fair	Fesida/Agrspi	47	Moderate	1307*

* Mean range site production estimates.

Range condition scores varied from 15% on a Silty 50+ cm range site to 78% on the Silty 25-36 cm range site. Poor condition occurred on 10% of the range sites, fair condition on 47% of the range sites, 37% of the range sites were found to be in good condition, and 6% in excellent condition (Table 4).

Ecological status scores varied from 12% on the Fesida/Agrsmi habitat type to 57% on the Agrspi/Poasan/Sticom habitat type. Very high similarity occurred on 3% of the PNCs, 30% of the habitat types were highly similar, 57% were moderately similar, and low similarity was found in 10% of the habitat types. Percent ecological status is summarized by plot in Table 4.

There was a 17.5% difference ($P < .05$) (RCS - ESC/ESS) between the average RCS ($\bar{x} = 49.0$) and the average ESS ($\bar{x} = 41.7$) (Table 5). Range condition scores were greater than ESS on 22 plots, while ESS was greater than RCS on 8 of 30 plots.

Table 5. Overall means for range condition score (RCS) and ecological status score (ESS), Wilcoxon's signed-ranks statistic (Z Value), and probability value.

Overall Mean		DF	Z Value	P Value
RCS	ESS			
49.0	41.7	29	2.33	0.017

There were no differences ($P > .95$) between RCS and ESS within range sites (Table 6). On 9 out of 10 range sites, mean RCS were higher than mean ESS. Ecological similarity scored higher only on the Overflow range site. Mean RCS varied from 81% on the Thin Hilly range site to 24% on the Overflow range site. Mean ESS varied from 27% on the Overflow and Very Shallow range sites to 57% on the Silty 25-36 cm range site.

Actual counts of RCC and ECC categorized 22 of 30 plots the same. Contingency table expected counts for 28 plots are listed in Table 7 and Chi-Square analysis revealed that RCC and ECC classified plots in a similar manner ($P > .95$).

Regression analysis indicated that aspect, elevation, habitat type, grouped range site, and precipitation did not affect differences between RCS and ESS (Table 8). Production was the only variable which affected ($P < 0.5$) the difference between RCS and ECS.

The difference of range condition scores and ecological status scores was affected by site productivity ($P < .05$) (Fig. 5). Analysis indicated that plots with less production had higher RCS than ESS and plots with higher production had greater ESS than RCS. The equation of the line was $y = 22.91x + .003$ ($P < .05$) and $r^2 = 0.40$.

Table 6. Least squares means (LS), difference of range condition score and ecological status score (RCS - ESS/ESS), and probability values within range site.

Range Site	n	Method	LS Mean	RCS-ESS/ESS (%)	P Value
Silty, 25-36 cm	1	RC	78	37	0.23
		ES	57		
Silty, 38-48 cm	7	RC	42	8	0.68
		ES	39		
Silty, 50+ cm	5	RC	54	17	0.28
		ES	46		
Silty Droughty, 38-48 cm	1	RC	59	34	0.41
		ES	44		
Shallow, 38-48 cm	6	RC	45	5	0.83
		ES	43		
Shallow, 50+ cm	1	RC	57	12	0.53
		ES	51		
Very Shallow, 38-48 cm	2	RC	57	111	0.02
		ES	27		
Overflow, 38-48 cm	2	RC	24	-11	0.82
		ES	27		
Clayey, 38-48 cm	1	RC	40	21	0.67
		ES	33		
Thin Hilly, 38-48 cm	1	RC	81	59	0.09
		ES	51		

Table 7. Contingency table expected counts for range condition classes (RCC) and ecological condition classes (ECC).

	RCC	1	2	3	Sum
ECC	1	0.2	1.6	1.2	3.0
	2	1.3	9.6	7.1	18.0
	3	0.5	3.8	2.8	7.0
	Sum	2.0	15.0	11.0	28.0

Chi-Sq (DF=4) = 25.71, P < .0001.

Table 8. Multiple regression statistics for the effect of 7 variables on the difference between range condition score (RCS) and ecological status score (ESS).

Source	DF	F Value	P Value
Aspect	1	0.80	0.38
Elevation	1	0.12	0.73
Grouped Range	1	2.36	0.14
Habitat Type	1	0.43	0.52
Precipitation	1	0.36	0.55
Production	1	13.45	0.01
Slope	1	0.45	0.51

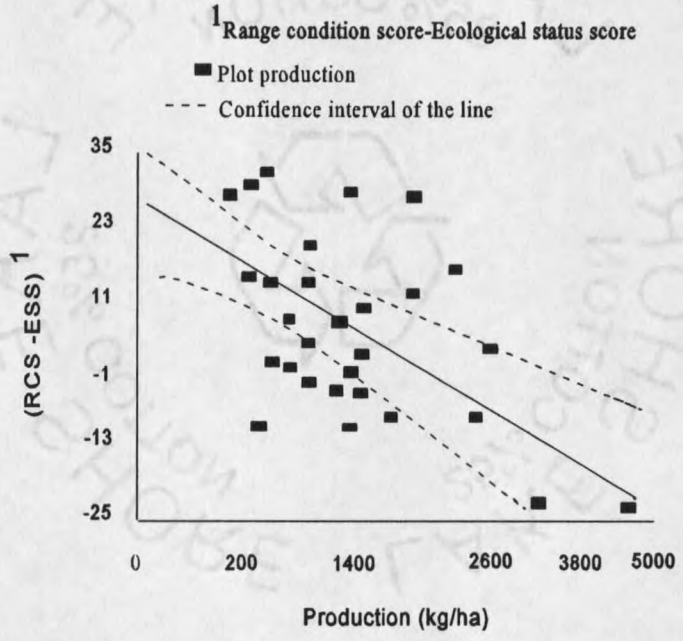

Fig. 5. Productivity effects on RCS and ESS.

DISCUSSION

The difference between the RCS and ESS across all plots may be partially explained by the different units of percent measurement. The relative percent species composition by weight factor in the RCA method favors high producing forage species. For example, bunchgrasses which produce more biomass will receive a higher score under the RCA methods than lower stature, rhizomatous grasses. Value is based on plants that produce more biomass, not on root systems or foliar canopy cover that stabilize the soil surface. Plant architectural diversity which provides cover for a variety of animals, birds, and insects does not receive consideration in RCA. The percent canopy cover estimates of the Ecodata method are placed in a cover class range and then assigned a midpoint. The midpoint may be biased by extremely low or high estimates (Daubenmire 1968). The experience of the investigator may affect the estimate because plots with very low or high foliage cover are likely to be misjudged (Meuller-Dombois and Ellenberg 1974).

Another factor which may contribute to the differences in scores could be the similarity analysis calculated by Sorensen's index of similarity. The index, in general, is a function of the number of plant species found in the sampled

community versus those occurring in the reference community. The fewer the number of species in common, the smaller the index of similarity (Chambers and Brown 1983). Similarity analysis emphasizes all species equally whether they are abundant or rare (Margurran 1988). Equal emphasis, however, provides a single perspective, relatively objective analysis, and general-purpose classifications rather than special-purpose classifications (Gauch 1982). Range condition analysis has long been faulted for weighting range condition results toward forage species and being biased toward livestock grazing (Moir 1989, Smith 1989, Joyce 1993).

Differences in scores were probably not due to different concepts of PNC classification. Range site and habitat type have been found to classify land units and potential vegetation in essentially the same fashion (Hironaka 1989). Both the range site and habitat type concept are based on soil characteristics unique to a site and on differences in expected climax plant composition and production on the same site. Each site has an environment in which the combined effects of soil, climate, slope, elevation, aspect and other physical parameters produce a potential community (Hann 1989). This has been considered by some to be represented by the climax community, however, despite the similarity of the two systems, there is emerging sentiment in the United States range profession that would

prefer to discontinue classifying sites based on climax theory (National Research Council 1994).

A portion of within range site differences between RCS and ESS may be explained by the relative presence of indicator species and species diversity. Dominant and co-dominant species (such as *Agropyron smithii*, *Agropyron spicatum*, and *Festuca idahoensis*) found on the Silty 38-48 cm range site and the associated Arttri/Fesida, Fesida/Agrsmi, Fesid/Agrspi habitat types, contributed substantially to macroplot composition and ranged from 8-20% on the seven plots. Total existing species per macroplot ranged 29-58, compared to 67-105 total species for the three habitat types. This occurred on the Shallow 38-48 cm range site, with the associated Arttri/Fesida and Fesida/Agrspi habitat types. Dominant/co-dominant species varied from 7-22% and total species for the six plots were 41-52. The Very Shallow 38-48 cm range site displayed the greatest variability. The moderate dominant/co-dominant grass component (7-25%) resulted in a high RCS and reduced species diversity (35 and 49) compared to PNC (105) lowered the ESS. Differences may be explained by a small sample size (n=2). The Overflow 38-48 cm range site was the only range site where the ecological status measure was more than RCS (n=2). The RCS on the Overflow range site was reduced due to introduced grass species (80%) and high forb (30-70%) and woody species (30-50%) composition. Sites with similar potential

expressed a variety of seral stages and plant community development, which may be a function of climatic variation. Species abundance may vary widely between and within years around fluctuations in the average environment of the site (Passey et al. 1982, Blaisdell and Holmgren 1984) and single year observations do not provide an indication of range condition trend. The effect of disturbance history on secondary succession may be examined by relative percentage of annual and long-lived perennial species, and species diversity on a site. Samuel and Hart (1994) found that on mixed-grass prairie in Wyoming, sites with an abundance of annual species indicated a lower seral stage, while an abundance of perennial species on a site indicated a higher seral stage. They concluded that in the absence of disturbance, diversity of ungrazed grassland was somewhat higher than that of grazed grassland. The Flying D Ranch had a long history of livestock grazing and that may have contributed to the variation in seral stages within a range site.

There were no differences in RCC and ECC. The 17.5 % difference between RCS and ESS fell into the 25 point spread of the condition classifications. Range managers often rely on the verbal expressions of the condition classes for management purposes. Therefore, it appears that these classifications could be used interchangeably.

The effect of productivity on RCS and ESS was expected.

Habitat type and climax community classification systems are based on site productivity (Leonard and Miles 1989). Plot similarity to PNC partially based on annual production has some problems. Production on a site is dependent on annual precipitation and the RCS and ESS may simply be a function of fluctuating climatic conditions (Pieper 1978). Plants mature at different stages and time of sampling may miss the peak for certain species. The relationship of production to condition is perhaps more apparent in RCA and RCS and may reflect the variability of annual precipitation. The graph depicting the effects of productivity on the difference between RCS and ESS (Fig. 5) has implications for evaluating range condition on low and high producing sites. Generally, RCS was higher on low productivity sites and ESS was greater on higher production sites. Macroplots 14, 26, and 36 were low producing sites with the greatest difference of higher RCS than ESS. These differences might be explained by slope influences. Those three plots had production values less than 700 kg/ha on slopes greater than 30%. These sites were dominated by long-lived perennial species with fairly deep root systems and were species that counted heavily in the RCA method. Macroplots 15 and 32 were on the greater producing sites with the greatest difference where ESS tended to be higher than RCS. These two plots had greater than 3,303 and 4,708 kg/ha production represented by the Fesida/Agrcan/Gervis habitat type. This was the only

habitat type keyed to a phase level, which also corresponded to the second highest producing Mueggler and Stewart (1980) habitat type and may explain the effect.

The study found that RCS scores were higher than ESS ($P < .05$) across all plots and that RCC and ECC were the same ($P > .99$). Productivity was found to affect RCS and ESS. Range sites with lower production had greater RCS, whereas higher producing sites had greater ESS. The habitat types used in this study apply to potential natural communities found primarily in southwestern Montana. Similarity analysis based on these habitat types and applied to plant communities in other areas may not have the same results.

CONCLUSIONS

Ecological status scores (as determined by USFS's Ecodata) in this study were 17.5% ($P < .05$) lower than range condition scores (as determined by SCS's RCA). Range inventories conducted with Ecodata methods may indicate that vegetation resources have declined when the change in methods alone could account for the lower score and results may not be related to management changes. The fact that condition classes were the same may provide managers a level of confidence when reviewing Ecodata similarity analysis results.

The geographic limitations of existing habitat type classification systems present a problem for evaluating range condition based on potential natural communities. The USFS efforts to develop vegetation classification systems specific to other areas are of great importance for future studies on Ecodata similarity analysis.

The standard RCA method used as a comparison in this study has limitations. The emphasis on species forage value for grazing livestock excludes consideration of other rangeland resources. Federal agencies are mandated to manage for multiple-use and RCA assumes a goal of managing for climax plant community. Wildlife cover values,

threatened and endangered species, water quality, and soil stability are examples where managing for PNC may not adequately protect those resources. Existing vegetation, soil, site, and disturbance information collected in the Ecodata approach may be analyzed for a variety of management objectives and land use.

Public interest in this subject has increased over the last several years and questions about the present state of western rangelands have been raised. Land managers have been requested to justify management goals and objectives and methods used to determine rangeland condition are being scrutinized. There is great appeal in changing methods to improve the process, but a continued effort must be made to objectively examine proposed changes for evaluating range condition. Further comparisons between RCA and Ecodata are necessary to insure that proposed changes can be related to findings of previous studies.

The Ecodata system was introduced in 1987 and the program remains in the developmental stage. New versions of the program are updated at the regional level on a regular basis and the range manager is responsible for obtaining new copies and maintaining databases. The Ecology Staff Unit at the USFS regional office (R.O.) in Missoula, Montana responded admirably to distress calls. Considering their proximity to the problem, a multitude of complex responsibilities, and ecosystem analysis project deadlines,

the staff regularly make an effort to solving problems. The R.O. staff, however, have been unable to provide adequate, consistent, updated Ecodata training for USFS personnel. They are the only people capable of fixing errors in the software and providing answers on Ecopac analysis questions. The lack of R.O. support to system users was by far the biggest problem encountered with Ecodata.

Despite the short-comings of Ecodata, the method is much more suited to providing analysis tools necessary for solving today's ecosysytem level problems. Ecodata provides the tools for assessing a variety of existing physical and biological components on a site. Data collected with Ecodata methods may be classified and analyzed at various temporal and spatial scales. The effects of management practices on a variety of ecosystems may be described through data analysis that combines the relational databases and geographical information systems software. The Northern Region of the USFS should be commended for their efforts in developing the system, but now must move ahead to provide intensive instruction and training for all system users. Outside-agency interest will continue to grow and the USFS has a golden opportunity to promote the potential of Ecodata.

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APPENDIX

Table 1. Environmental data summary by plot.

Plot Number	Community Type (dominant species)	Soil Type	Precipitation Zone (centimeters)	Aspect (azimuth)	Elevation(meters)	Slope (percent)	Range Site
1	Bluebunch wheatgrass/prairie Junegrass	Varney clay cobbly loam 8-45%	25-36	64	1512	5	Silty
2	Big sagebrush/plains reedgrass	Orofino-Poin complex 15-45%	38-48	345	1417	20	Silty
3	Idaho fescue/bluebunch wheatgrass	Orofino-Poin complex 15-45%	38-48	122	1658	12	Silty
4	Big sagebrush/Idaho fescue	Poin-Sebud complex 8-45%	50+	121	1914	16	Silty
5	Downy brome/Kentucky bluegrass	Hanson-Rock outcrop complex 25-45%	38-48	11	1503	4	Silty
6	Idaho fescue/bluebunch wheatgrass	Orofino-Poin complex 15-45%	38-48	10	1759	8	Shallow
7	Idaho fescue/bluebunch wheatgrass	Shurley rock outcrop 25-60%	38-48	222	1733	25	Shallow
8	Woods' rose/Kentucky bluegrass	Gaylor-Burnett complex 4-15%	38-48	0	1548	19	Overflow
9	Quaking aspen	Orofino-Poin complex 15-45%	38-48	336	1622	16	Grazeable woodland
10	Willow/sedge	Bandy-Bonebasin complex 0-2%	38-48	110	1612	1	Subirrigated
11	Douglas fir/ninebark	Bangtail-Copenhaver complex 8-25%	50+	10	1792	30	Woodland
12	Rocky Mountain juniper/Idaho fescue	Catguich 25-60%	38-48	166	1719	48	Shallow
13	Idaho fescue/Richardson's needlegrass	Maryott-Cabba complex 15-45%	50+	322	1767	15	Silty
14	Rocky Mountain juniper/Douglas fir	Catguich 25-60%	38-48	233	1670	40	Very shallow shallow
15	Common timothy/Kentucky bluegrass	Bridger cobbly loam 8-35%	50+	354	1969	12	Silty
16	Sedge/tufted hairgrass	Cryaquolls 0-4%	50+	183	2109	5	Wet meadow
17	Quaking aspen	Shadow complex 15-45%	50+	104	2012	40	Grazeable woodland
18	Big sagebrush/Idaho fescue	Poin-Sebud complex 8-45%	38-48	163	2164	12	Silty
19	Cottonwood/quackgrass	Bandy-Bonebasin complex 0-2%	38-48	18	1529	1	Subirrigated
20	Big sagebrush/common timothy	Bridger cobbly clay loam 8-35%	38-48	65	1848	14	Clayey
21	Idaho fescue/bluebunch wheatgrass	Maryott-Cabba complex 8-25%	38-48	149	1750	18	Silty
22	Idaho fescue/bluebunch wheatgrass	Lap-Windham-Rock outcrop complex 35-60%	38-48	194	1763	40	Silty
23	Willow/sedge	Burnel-Ophur complex 2-8%	38-48	81	1585	8	Wet meadow
24	Idaho fescue/Kentucky bluegrass	Windham stony loam 15-35%	38-48	200	1658	13	Silty
25	Woods' rose/Kentucky bluegrass	Bridger cobbly clay loam 8-35%	38-48	353	1532	7	Overflow
26	Idaho fescue/bluebunch wheatgrass	Orofino-Poin complex 4-15%	38-48	125	1731	31	Very shallow
27	Quaking aspen	Earcree gravelly sandy loam 8-35%	50+	14	1798	12	Grazeable woodland

Plot Number	Community Type (dominant species)	Soil Type	Precipitation Zone (centimeters)	Aspect (azimuth)	Elevation(meters)	Slope (percent)	Range Site
28	Idaho fescue/bluebunch wheatgrass	Bridger cobbly clay loam 8-35%	38-48	130	1676	21	Shallow
29	Idaho fescue/bluebunch wheatgrass	Poin-Sebud complex 4-15%	50+	135	1878	7	Shallow
30	Idaho fescue/Kentucky bluegrass	Poin-Sebud complex 4-15%	38-48	200	1768	19	Silty
31	Idaho fescue/bluebunch wheatgrass	Orofino-Poin complex 15-45%	38-48	260	1683	15	Shallow
32	Big sagebrush/common timothy	Hanson-Raynesford complex 8-35%	50+	350	1847	8	Silty
33	Big sagebrush/Idaho fescue	Orofino-Poin complex 15-45%	50+	146	1951	16	Silty
34	Big sagebrush/Idaho fescue	Orofino-Poin complex 4-15%	50+	340	1987	8	Silty
35	Big sagebrush/Idaho fescue	Orofino-Poin complex 15-45%	38-48	184	1817	48	Shallow
36	Limber pine/Rocky Mountain juniper	Hanson-Rock outcrop complex 25-45%	38-48	139	1719	58	Thin hilly
37	Big sagebrush/Idaho fescue	Barbarela-Poin-Bavdark complex 4-15%	50+	188	2057	14	Shallow
38	Meadow foxtail/tufted hairgrass	Cryaquolls 0-5%	50+	148	1719	2	Subirrigated
39	Willow/sedge	Cryaquolls 0-5%	50+	134	2109	1	Wet meadow
40	Idaho fescue/bluebunch wheatgrass	Orofino-Poin complex 15-45%	50+	160	1829	16	Shallow

Table 2. Vascular plants documented at the Flying D Ranch, Madison and Gallatin Counties, 1990.

Scientific name	Species author	Symbol	Common name
NATIVE PERENNIAL GRASSES (Cool Season)			
Agropyron caninum	(L.) Beauv.	Agrcan	bearded wheatgrass
Agropyron smithii	(Rydb.) A. Love	Agrsmi	western wheatgrass
Agropyron spicata	(Pursh) A. Love	Agrspi	bluebunch wheatgrass
Agrostis exarata	Trin.	Agrexa	spike bentgrass
Agrostis scabra	Willd.	Agrsca	rough bentgrass
Alopecurus borealis	Trin.	Aloalp	alpine foxtail
Aristida purpurea	Nutt.	Aripur	purple threeawn
Bromus anomalous	Rupr. ex Fourn.	Broano	nodding brome
Bromus carinatus	Hook. & Arn.	Brocar	mountain brome
Bromus ciliatus	L.	Brocil	fringed brome
Calamagrostis canadensis	(Michx.) Beauv.	Calmon	bluejoint reedgrass
Calamagrostis inexpansa	Gray	Caline	slimstem reedgrass
Calamagrostis montanensis	Scribn. ex Vasey	Calmon	plains reedgrass
Calamagrostis rubescens	Buckl.	Calrub	pinegrass
Carex aquatilis	Wahlenb.	Caraqu	water sedge
Carex athrostachya	Olney	Carato	slenderbeak sedge
Carex atrata	L.	Caratr	blackened sedge
Carex aurea	Nutt.	Caraur	golden sedge
Carex canescens	L.	Carcan	pale sedge
Carex disperma	Dewey	Cardis	softleaf sedge
Carex filifolia	Nutt.	Carfil	threadleaf sedge
Carex heliophila	Mackenzie	Carhel	sun sedge
Carex hoodii	Boott.	Carhoo	Hood's sedge
Carex lanuginosa	Michx.	Carlan	woolly sedge
Carex microptera	Mackenzie	Carmic	smallwing sedge
Carex nebrascensis	Dewey	Carneb	Nebraska sedge
Carex pachystachya	Cham. ex Steud.	Carpac	chamisso sedge
Carex petasata	Dewey	Carpet	Liddon sedge
Carex praegracilis	W. Boott	Carpra	clustered field sedge
Carex raynoldsii	Dewey	Carray	Raynold's sedge
Carex rossii	Boott	Carroi	Ross' sedge
Carex rostrata	Stokes	Carros	beaked sedge
Carex simulata	Mackenzie	Carsim	shortbeak sedge
Carex sprengelii	Dewey ex Spreng.	Carspe	Sprengel's sedge
Carex stenophylla	C.A. Mey.	Carste	needleleaf sedge
Carex stipata	Muhl. ex Willd.	Carsti	sawbeak sedge
Danthonia californica	Boland.	Dancal	California oatgrass
Danthonia intermedia	Vasey	Danint	timber oatgrass
Danthonia unispicata	(Thurb.) Munro ex Macoun	Danuni	onespike oatgrass
Deschampsia cespitosa	(L.) Beauv.	Desces	tufted hairgrass
Eleocharis palustris	(L.) Roemer & J.A. Schultes	Elepal	common spikesedge
Eleocharis pauciflora	(Lightf.) Link	Elepau	fewflowered spikesedge
Elymus canadensis	L.	Elycan	Canada wildrye
Elymus cinereus	Scribn. & Merr.	Elycin	basin wildrye
Elymus glaucus	Buckl.	Elygla	blue wildrye
Eriophorum chamissonis	C.A. Mey	Ericha	Chamisso's cottongrass
Eriophorum polystachion	L.	Eripol	manyspiked cootongrass
Festuca idahoensis	Elmer	Fesida	Idaho fescue
Festuca subulata	Trin.	Fessub	bearded fescue
Glyceria elata	(Nash ex Rydb.) M.E. Jones	Glyela	tall mannagrass
Glyceria grandis	S. Wats.	Glygra	American mannagrass
Glyceria striata	(Lam.) A.S. Hitchc.	Glyame	fowl mannagrass
Hordeum brachyantherum	Nevski	Horbra	meadow barley
Hordeum jubatum	L.	Horjub	foxtail barley
Juncus balticus	Willd.	Junbal	Baltic rush
Juncus confusus	Coville	Juncon	Colorado rush
Juncus ensifolius	Wikstr.	Junens	swordleaf rush
Juncus hallii	Engelm.	Junhal	Hall's rush
Juncus longistylis	Torr.	Junlon	longstyle rush

Scientific name	Species author	Symbol	Common name
NATIVE PERENNIAL GRASSES (continued)			
Koeleria macrantha	(Ledeb.) J.A. Schultes	Koecri	prairie Junegrass
Luzula campestris	(L.) DC.	Luzcam	field woodrush
Luzula parviflora	(Ehrh.) Desv.	Luzpar	smallflowered woodrush
Melica spectabilis	Scribn.	Melspe	purple oniongrass
Oryzopsis exigua	Thurb.	Oryexi	little ricegrass
Poa alpina	L.	Poaalp	alpine bluegrass
Poa interior	Rydb.	Poaalp	inland bluegrass
Poa nervosa	(Hook.) Vasey	Poaner	Wheeler's bluegrass
Poa sandbergii	Vasey	Poasan	Sandberg's bluegrass
Poa scabrella	(Thurb.) Benth. ex Vasey	Poasca	pine bluegrass
Puccinellia nuttalliana	(J.A. Schultze) A.S. Hitchc.	Pucnut	Nuttall's alkaligrass
Puccinellia pauciflora	(J. Presl) Munz.	Pucpau	weak alkaligrass
Scirpus americanus	Pers.	Sciame	American bulrush
Scirpus microcarpus	J.& K. Presl.	Scimic	panicled bulrush
Scirpus validus	Vahl	Scival	softstem bulrush
Stipa comata	Trin. & Rupr.	Sticom	needleandthread
Stipa occidentalis	Thurb. ex S. Wats.	Stiocc	western needlegrass
Stipa viridula	(Trin.) Barkworth	Stivir	green needlegrass
Trisetum wolfii	Vasey	Triwol	Wolf's trisetum
NATIVE PERENNIAL GRASSES (Warm Season)			
Andropogon scoparius	Michx.	Andsco	little bluestem
Bouteloua gracilis	(Willd. ex Kunth) Lag. ex Griffins	Bougra	blue grama
Calamovilfa longifolia	(Hook.) Scribn.	Callon	prairie sandreed
Catabrosa aquatica	(L.) Beauv.	Cataqu	brookgrass
Distichlis stricta	(Torr.) Rydb.	Disstr	alkali saltgrass
Spartina pectinata	Link	Spapec	prairie cordgrass
Sphenopholis obtusata	(Michx.) Scribn.	Sphobt	prairie wedgegrass
INTRODUCED PERENNIAL GRASSES			
Agropyron cristatum	(L.) Gaertn.	Agrcri	crested wheatgrass
Agropyron intermedium	(Host) Beauv.	Agrint	intermediate wheatgrass
Agropyron repens	(L.) Beauv.	Agrrep	quackgrass
Agrostis stolonifera	L.	Agrsto	redtop
Alopecurus pratensis	L.	Alopra	meadow foxtail
Bromis inermis	Leyss.	Broine	smooth brome
Dactylis glomerata	L.	Dacglo	orchardgrass
Festuca arundinacea	Schreb.	Fesaru	tall fescue
Festuca pratensis	Huds.	Fespra	meadow fescue
Phleum pratense	L.	Phlpra	common timothy
Poa compressa	L.	Poacom	Canada bluegrass
Poa palustris	L.	Poapal	fowl bluegrass
Poa pratensis	L.	Poapra	Kentucky bluegrass
NATIVE ANNUAL GRASSES			
Beckmannii syzigachne	(Steud.) Fern.	Becsyz	American sloughgrass
Festuca octoflora	Walt.	Fesoct	sixweeks fescue
Muhlenbergia filiformis	(Thurb. ex S. Wats.) Rydb.	Muhfil	pullup muhly
Poa annua	L.	Poaann	annual bluegrass
Bromus japonicus	Thunb. ex Murr.	Brojap	Japanese brome
Bromus mollis	L.	Bromol	soft brome
Bromus tectorum	L.	Brotec	cheatgrass
NATIVE PERENNIAL FORBS			
Achillea millifolium	L.	Achmil	common yarrow
Actaea rubra	(Ait.) Willd.	Actrub	red baneberry
Agastache urticifolia	(Benth.) Kuntze	Agaurt	nettleleaf giant hyssop
Agoseris glauca	(Pursh) Raf.	Agogla	pale agoseris

Scientific name	Species author	Symbol	Common name
NATIVE PERENNIAL FORBS (Continued)			
Agoseris lackschewitzii	D. Henderson & R. Moseley	Agolac	Mill Creek agoseris
Allium brevistylum	S. Wats.	Allbre	shortstyle onion
Allium cernuum	Roth	Allcer	nodding onion
Allium geyeri	S. Wats.	Allgey	Geyer's onion
Allium textile	A. Nels. & J.F. Macbr.	Alltex	textile onion
Anaphalis margaritacea	(L.) Benth. & Hook. f.	Anamar	pearly everlasting
Anemone cylindrica	Gray	Anecyl	candle anemone
Anemone multifida	Poir.	Anemul	pacific anemone
Anemone patens	L.	Anepat	pasqueflower
Angelica arguta	Nutt.	Angarg	sharptooth angelica
Antennaria anaphaloides	Rydb.	Antana	tall pussytoes
Antennaria corymbosa	E. Nels.	Antcom	plains pussytoes
Antennaria microphylla	Rydb.	Antmic	rosy pussytoes
Antennaria parvifolia	Nutt.	Antpar	littleleaf pussytoes
Antennaria umbrinella	Rydb.	Antumb	umber pussytoes
Apocynum androsaemifolium	L.	Apoand	spreading dogbane
Arabis drummondii	Gray	Aradru	Drummond's rockcress
Arabis nuttallii	B.L. Robins.	Aranut	Nuttall's rockcress
Arenaria congesta	Nutt.	Arecon	ballhead sandwort
Arenaria lateriflora	L.	Arelat	blunthead sandwort
Arnica chamissonis	Less.	Arncha	chamisso arnica
Arnica cordifolia	Hook.	Arncor	heartleaf arnica
Arnica fulgens	Pursh	Arnful	foothill arnica
Artemesia campestris	L.	Artcam	field sagewort
Artemesia dracunculus	L.	Artdra	falsetarragon sagewort
Artemesia ludoviciana	Nutt.	Artlud	cudweed sagewort
Artmesia michauxiana	Bess.	Artmic	Michaux sagewort
Asclepias viridiflora	Raf.	Ascvir	green milkweed
Aster chilensis	Nees.	Astchi	longleaved aster
Aster conspicuous	Lindl.	Astcon	showy aster
Aster eatonii	(Gray) T.J. Howell	Asteat	Eaton's aster
Aster falcatus	Lindl.	Astfal	creeping white prairie aster
Aster foliaceus	Lindl. ex DC.	Astfol	alpine leafybract aster
Aster hesperius	Gray	Asthes	Siskiyou aster
Aster integrifolius	Nutt.	Astint	thickstem aster
Aster modestus	Lindl.	Astmod	modest aster
Aster occidentalis	(Nutt.) Torr. & Gray	Astocc	western aster
Aster pansus	(Blake) Cronq.	Astpan	heathleaved aster
Aster subspicatus	Nees	Astsub	Douglas aster
Aster spp.	L.	Asterx	aster species
Astragalus adsurgens	Pallas	Astads	prairie milkvetch
Astragulus agrestis	Dougl. ex G. Don	Astagr	field milkvetch
Astragulus bisulcatus	(Hook.) Gray	Astbis	twogrooved milkvetch
Astragulus canadensis	L.	Astcan	Canadian milkvetch
Astragulus cibarius	Sheldon	Astcib	browse milkvetch
Astragulus crassicarpus	Nutt.	Astcra	groundplum milkvetch
Astragalus drummondii	Dougl. ex Hook.	Astdru	Drummond's milkvetch
Astragulus gilviflorus	Sheldon	Astgil	plains milkvetch
Astragulus inflexis	Doug. ex Hook.	Astinf	bent milkvetch
Astragulus microcystis	Gray	Astmic	dwarf milkvetch
Astragulus miser	Dougl.	Astmis	weedy milkvetch
Astragulus missouriensis	Nutt.	Astmis	Missouri milkvetch
Astragulus pectinatus	(Hook.) Dougl. ex G. Don	Astpec	narrowleaf milkvetch
Astragulus purshii	Dougl. ex Hook.	Astpur	woollypod milkvetch
Astragulus spp.	L.	Astrax	milkvetch species
Balsamorhiza incana	Nutt.	Balinc	hoary balsamroot
Balsamorhiza sagittata	(Pursh) Nutt.	Balsag	arrowleaf balsamroot
Besseya wyomingensis	(A.Nels.) Rydb.	Beswyo	Wyoming besseya
Brodiaea douglasii	S. Wats.	Brodou	Douglas' brodiaea
Bupleurum americanum	Coult. & Rose	Bupame	American thorow wax
Callitriche heterophylla	Pursh	Calhet	larger waterstarwort
Calochortus gunnisonii	S. Wats.	Calgun	Gunnison's mariposa

Scientific name	Species author	Symbol	Common name
NATIVE PERENNIAL FORBS (Continued)			
Campanula rotundifolia	L.	Camrot	roundleaf harebell
Cardamine breweri	S. Wats.	Carbre	Brewer's bittercress
Castilleja miniata	Dougl. ex Hook.	Casmin	scarlet Indian paintbrush
Castilleja pallescens	(Gray) Greenm.	Caspal	pale Indian paintbrush
Cerastium arvense	L.	Cerarv	field chickweed
Chaenactis douglasii	(Hook.) Hook. & Arn.	Chadou	Douglas' chaenactis
Chrysopsi villosa	(Pursh) Nutt.	Chrvil	hairy goldenaster
Circuta douglasii	(DC.) Coult. & Rose	Cirdou	Douglas waterhemlock
Cirsium scariosum	Nutt.	Cirsca	elk thistle
Cirsium undulatum	(Nutt.) Spreng.	Cirund	wavyleaf thistle
Claytonia lanceolata	Pursh	Clalan	lanceleaf springbeauty
Claytonia lanceolata var. flava	(A. Nels.) C.L. Hitchc.	Clalvf	yellow springbeauty
Clematis hirsutissima	Pursh	Clehir	hairy clematis
Comandra umbellata	(L.) Nutt.	Comumb	pale bastard toadflax
Conimitella willaimsii	(D.C. Eat.) Rydb.	Conwil	conimitella
Coryphantha missouriensis	(Sweet) Britt. & Rose	Cormis	nipple coryphantha
Crepis acuminata	Nutt.	Creacu	longleaf hawksbeard
Crepis occidentalis	Nutt.	Creocc	western hawksbeard
Cymopterus bipinnatus	S. Wats.	Cymbip	fernleaf springparsley
Cymopterus terebinthinus	(Hook.) Torr. & Gray	Cymter	turpentine cymopterus
Delphinium bicolor	Nutt.	Delbic	low larkspur
Delphinium occidentale	(S. Wats.) S. Wats	Delocc	western larkspur
Disporum trachycarpum	(S. Wats.) Benth. & Hook. f.	Distra	wartberry fairybell
Dodecatheon conjugens	Green	Dodcon	slimpod shootingstar
Dodecatheon puchellum	(Raf.) Merr.	Dodpul	fewflowered shootingstar
Douglasia montanum	Gray	Doumon	Rocky Mountain douglasia
Epilobium angustifolium	L.	Epiang	fireweed
Epilobium ciliatum	Raf.	Epicil	hairy willowherb
Epilobium glaberrimum	Barbey	Epigla	smooth willowherb
Epilobium palustre	L.	Epipal	marsh willowherb
Erigeron caespitosus	Nutt.	Ericae	tufted fleabane
Erigeron compositus	Pursh	Ericom	cutleaved daisy
Erigeron glabellus	Nutt.	Erigla	smooth fleabane
Erigeron ochroleucus	Nutt.	Erioch	buff fleabane
Erigeron pumilus	Nutt.	Eripum	shaggy fleabane
Erigeron speciosus	(Lindl.) DC.	Erispe	showy fleabane
Eriogonum ovalifolium	Nutt.	Eriova	cushion buckwheat
Eriogonum umbellatum	Torr.	Eriumb	sulphur buckwheat
Erysimum inconspicuum	(S. Wats.) Macm.	Eryinc	smallflowered rocket
Erythronium grandiflorum	Pursh	Erygra	glacier lily
Evolulus nuttallianus	J.A. Schultes	Evonut	Nuttall evolulus
Fragaria vesca	L.	Fraves	woodland strawberry
Fragaria virginiana	Duchesne	Fravir	Virginia strawberry
Frasera speciosa	Dougl. ex Griseb.	Fraspe	giant frasera
Fritillaria pudica	(Pursh) Spreng.	Fripud	yellow missionbells
Gaillardia aristata	Pursh	Gaiari	blanketflower
Galium boreale	L.	Galbor	northern bedstraw
Galium trifidum	L.	Galtrf	small bedstraw
Galium triflorum	Michx.	Galtri	fragrant bedstraw
Gaura coccinea	Nutt. ex Pursh	Gaucoc	scarlet gaura
Gentiana affinis	Griseb.	Genaff	pleated gentian
Geranium richardsonii	Fisch. & Trautv.	Gerric	Richardson's geranium
Geranium viscosissimum	Fisch. & C.A. Mey. ex C.A. Mey.	Gervis	sticky geranium
Geum aleppicum	Jacq.	Geuale	yellow avens
Geum macrophyllum	Willd.	Geumac	largeleaf avens
Geum rivale	L.	Geuriv	water avens
Geum triflorum	Pursh	Geutri	prairiesmoke
Gilia spicata	Nutt.	Gilspi	spicate gilia
Glycyrrhiza lepidota	Pursh	Glylep	American licorice
Goodyera oblongifolia	Raf.	Gooobl	western ratlesnake plantain
Habenaria dilatata	(Pursh) Hook.	Habdil	white bogorchid
Habenaria saccata	Greene	Habsac	slender bogorchid

Scientific name	Species author	Symbol	Common name
NATIVE PERENNIAL FORBS (continued)			
Habenaria unalascensis	(Spreng.) S. Wats.	Habuna	Alaska reinorchid
Hackelia micrantha	(Eastw.) J.L. Gentry	Hacmic	blue stickseed
Haplopappus acualis	(Nutt.) Gray	Hapaca	cushion goldenweed
Hedeoma drummondii	Benth.	Heddru	Drummond's pennyroyal
Hedysarum boreale	Nutt.	Hedbor	northern sweetvetch
Hedysarum sulphurescens	Rydb.	Hedsul	yellow sweetvetch
Helianthella uniflora	(Nutt.) Torr. & Gray	Heluni	oneflower helianthella
Helianthus nutallii	Torr. & Gray	Helnut	Nuttall's sunflower
Heracleum lanatum	Michx.	Herlan	cowparsnip
Heuchera parvifolia	Nutt. ex Torr. & Gray	Heupar	littleleaf alumroot
Hieracium cynoglossoides	Arv.-Touv.	Hiecyn	houndstongue hawkweed
Hieracium gracile	Hook.	Hiegra	slender hawkweed
Hydrophyllum capitatum	Dougl. ex Benth.	Hydcap	ballhead waterleaf
Hymenopappus filifolius	Hook.	Hymfil	fineleaf hymenoppus
Hymenoxys acaulis	(Pursh) Parker	Hymaca	stemless hymenoxys
Hypericum formosum	Hook.	Hypfor	western St. Johnswort
Iris missouriensis	Nutt.	Irimis	Rocky Mountain iris
Kuhnia eupatorioides	L.	Kuheup	false boneset
Lactuca oblongifolia	Nutt.	Lacobl	chicory lettuce
Lemna minor	L.	Lemmin	common duckweed
Lesquerella alpina	(Nutt.) S. Wats.	Lesalp	alpine bladderpod
Lewisia rediviva	Pursh	Lewred	bitterroot
Liatris punctata	Hook.	Liapun	dotted gayfeather
Linum lewisii	Pursh.	Linlew	prairie flax
Lithophragma parviflorum	(Hook.) Nutt. ex Torr. & Gray	Litpar	smallflowered fringecup
Lithospermum incisum	Lehm.	Litinc	yellow gromwell
Lithospermum ruderale	Dougl.ex Lehm.	Litrud	western gromwell
Lomatium ambiguum	(Nutt.) Coult. & Rose	Lomamb	Wyeth biscuitroot
Lomatium cous	(S. Wats) Coult. & Rose	Lomcou	cous biscuitroot
Lomatium foeniculaceum	(Nutt.) Coult. & Rose	Lomfoe	desert biscuitroot
Lomatium macrocarpum	(Nutt. ex Torr. & Gray) Coult. & Rose	Lommac	bigseed biscuitroot
Lomatium triternatum	(Pursh) Coult. & Rose	Lomtri	nineleaf biscuitroot
Lupinus argenteus	Pursh	Luparg	silvery lupine
Lupinus leucophyllus	Dougl. ex Lindl.	Lupleu	velvet lupine
Lupinus polyphyllus	Lindl.	Luppol	bigleaf lupine
Lupinus sericeus	Pursh	Lupser	silky lupine
Lychnis drummondii	(Hook.) S. Wats.	Lycdru	Drummond campion
Lygodesmia juncea	(Pursh) D. Don ex Hook.	Lycjun	rush skeletonplant
Lysimachia ciliata	L.	Lyscil	fringed loosestrife
Mentha arvensis	L.	Menarv	wild mint
Mertensia ciliata	(James ex Torr.) G. Don	Mercil	mountain bluebell
Mertensia oblongifolia	(Nutt.) G. Don	Merobl	oblongleaf bluebells
Microseris nigrescens	Henderson	Micnig	blackhairy microseris
Microseris nutans	(Hook.) Schultz-Bip.	Micnut	nodding microseris
Mimulus guttatus	DC.	Mimgut	common monkeyflower
Mitella breweri	Gray	Mitbre	Brewer's mitrewort
Monarda fistulosa	L.	Monfis	horsemint
Musineon divaricatum	(Pursh) Raf.	Musdiv	leafy wildparsley
Myosotis sylvatica	Ehrh. ex Hoffmann	Myosyl	alpine forget me not
Myriophyllum spicatum	L.	Myrspi	spike watermilfoil
Oenothera nuttallii	Sweet	Oennut	Nuttall's eveningprimrose
Opuntia fragilis	(Nutt.) Haw.	Opufra	Brittle pricklypear
Opuntia polycantha	Haw.	Opupol	Plains pricklypear
Orobanche fasciculata	Nutt.	Orofas	clustered broomrape
Osmorhiza chilensis	Hook. & Arn.	Osmchi	sweetcicely
Osmorhiza occidentalis	(Nutt. ex Torr. & Gray) Torr.	Osmocc	sweet anise
Oxytropis campestris	(L.) DC.	Oxycam	slender locoweed
Oxytropis lagopus	Nutt.	Oxylam	haresfoot locoweed
Oxytropis sericea	Nutt.	Oxyser	silvery oxytrope
Parnassia fimbriata	Koenig	Parfim	fringed grass of Parnassus
Paronychia sessiliflora	Nutt.	Parsess	yellow nailwort
Pedicularis groenlandica	Retz.	Pedgro	elephanthead

Scientific name	Species author	Symbol	Common name
NATIVE PERENNIAL FORBS (continued)			
Penstemon albidus	Nutt.	Penalb	white penstemon
Penstemon aridus	Rydb.	Penari	stiffleaf penstemon
Penstemon erianterus	Pursh	Peneri	fuzzytongue penstemon
Penstemon nitidus	Dougl. ex Benth.	Pennit	waxleaf penstemon
Penstemon procerus	Dougl. ex Graham	Penpro	littleflower penstemon
Perideridia gairdneri	(Hook. & Arn.) Mathias	Pergai	Gairdner's yampa
Petasites sagittatus	(Banks ex Pursh) Gray	Petsag	arrowleaf coltsfoot
Phacelia hastata	Dougl. ex Lehm.	Phahas	silverleaf phacelia
Phlox albomarginata	M.E. Jones	Phlalb	whitemargined phlox
Phlox alyssifolia	Greene	Phlaly	alyssumleaf phlox
Phlox hoodii	Richards.	Phlhoo	Hood's phlox
Phlox longfolia	Nutt.	Phllon	longleaf phlox
Polygonum amphibium	L.	Polamp	water knotweed
Polygonum bistortoides	Pursh	Polbis	American bistort
Potamogeton spp.	L.	Potamo	pondweed species
Potentilla anserina	L.	Potans	commom silverweed
Potentilla arguta	Pursh	Potarg	tall cinquefoil
Potentilla diversifolia	Lehm.	Potdiv	varileaf cinquefoil
Potentilla glandulosa	Lindl.	Potgla	sticky cinquefoil
Potentilla gracilis	Dougl. ex Hook	Potgra	slender cinquefoil
Potentilla hippiana	Lehm.	Pothip	woolly cinquefoil
Potentilla pensylvanica	L.	Potpen	Pennsyvania cinquefoil
Prunella vulgaris	L.	Pruvul	common selfheal
Pyrola asarifolia	Michx.	Pyrasa	pink wintergreen
Ranunculus aquatilis	L.	Ranaqu	whitewater crowfoot
Ranunculus cymbalaria	Pursh	Rancym	alkali buttercup
Ranunculus glaberrimus	Hook.	Rangla	sagebrush buttercup
Ranunculus macounii	Britt.	Ranmac	Macoun's buttercup
Ranunculus natans	C.A. Mey.	Rannat	nodding buttercup
Ranunculus uncinatus	D. Don ex G. Don	Ranunc	hooked buttercup
Ratibida columnifera	(Nutt.) Woot. & Standl.	Ratcol	prairie coneflower
Rubus acaulis	Michx.	Rubaca	dwarf raspberry
Rudbeckia occidentalis	Nutt.	Rudocc	western coneflower
Rumex occidentalis	S. Wats.	Rumocc	western dock
Rumex paucifolius	Nutt.	Rumpau	mountain sorrel
Rumex salicifolius	Weinm.	Rumsal	willow dock
Sanicula marilandica	L.	Sanmar	Maryland sanicle
Saxifraga oregana	T.J. Howell	Saxore	Oregon saxifrage
Sedum lanceolatum	Torr.	Sedlan	lanceleaf stonecrop
Senecio canus	Hook.	Sencan	woolly groundsel
Senecio foetidus	T.J. Howell	Senfoe	water groundsel
Senecio integerrimus	Nutt.	Senint	lambstongue groundsel
Senecio pauperculus	Michx.	Senpau	balsam groundsel
Senecio pseudaureus	Rydb.	Senpse	falsegold groundsel
Senecio serra	Hook.	Senser	tall groundsel
Senecio sphaerocephalus	Greene	Sensph	ballhead groundsel
Senecio triangularis	Hook.	Sentri	arrowleaf groundsel
Silene douglasii	Hook.	Sildou	Douglas's campion
Sisyrinchium angustifolium	P. Mill.	Sisang	common blueeyed grass
Smilacina racemosa	(L.) Desf.	Smirac	feathery false Solomon's seal
Smilacina stellata	(L.) Desf.	Smiste	starry false Solomon's seal
Solidago canadensis	L.	Solcan	Canada goldenrod
Solidago gigantea	Ait.	Solgig	giant goldenrod
Solidago missouriensis	Nutt.	Solmis	Missouri goldenrod
Sparganium minimum	(C.J. Hartman) Wallr.	Spamin	small burreed
Sparganium spp.	L.	Sparga	burread species
Sphaeralcia coccinea	Nutt. Rydb.	Spacoc	scarlet globemallow
Stellaria longifolia	Muhl. ex Willd.	Stelon	longleaf starwort
Stephanomeria runcinata	Nutt.	Sterun	desert wirelettuce
Thalictrum occidentale	Gray	Thaocc	western meadowrue
Thelesperma subnudum	Gray	Thesub	slender greenthread
Thlaspi montanum	L.	Thlmon	alpine pennycress

Scientific name	Species author	Symbol	Common name
NATIVE PERENNIAL FORBS (continued)			
Townsendia parryi	D.C. Eat.	Toweat	Parry's townsendia
Trifolium longipes	Nutt.	Trilon	longstalk clover
Triglochin maritimum	L.	Trimar	seaside arrowgrass
Trollius laxus	Salisb.	Trolax	American globeflower
Typha latifolia	L.	Typlat	common cattail
Urtica dioica	L.	Urtdio	stinging nettle
Valeriana edulis	Nutt. ex Torr. & Gray	Valedu	edible valerian
Valeriana sitchensis	Bong.	Valsit	Sitka valerian
Verbena bracteata	Lag. & Rodr.	Verbra	bracted verbena
Veronica americana	Schwein ex Benth.	Verame	American speedwell
Veronica serpyllifolia	L.	Verser	thymeleaf speedwell
Vicia americana	Muhl. ex Willd.	Vicame	American vetch
Viola adunca	Sm.	Vioadu	early blue violet
Viola canadensis	L.	Viocan	Canada violet
Viola macloskeyi	Lloyd.	Viomac	small white violet
Viola nephrophylla	Greene	Vionep	northern bog violet
Viola nuttallii	Pursh	Vionut	Nuttall's violet
Zigadenus venenosus	S. Wats.	Zigven	meadow deathcamas
INTRODUCED PERENNIAL FORBS			
Centaurea maculosa	DC.	Cenmac	spotted knapweed
Cerastium vulgatum	H. Gartner	Cervul	common chickweed
Chrysanthemum leucanthemum	L.	Chrleu	oxeye daisy
Cirsium arvense	(L.) Scop.	Cirarv	Canada thistle
Euphorbia esula	L.	Eupesu	leafy spurge
Knautia arvensis	(L.) Coult.	Knaarv	field scabious
Lychnis alba	P. Mill.	Lycalb	white campion
Medicago sativa	L.	Medsat	alfalfa
Nasturtium officinale	R. Br.	Nasoff	watercress
Nepeta cataria	L.	Nepcat	catnip
Plantago lanceolata	L.	Plalan	narrowleaf plantain
Rumex crispus	L.	Rumcri	curly dock
Sonchus species	L.	Sonchu	sowthistle species
Taraxacum officinale	G.H. Weber ex Wiggers	Taroff	common dandelion
Trifolium hybridum	L.	Trihyb	alsike clover
Trifolium pratense	L.	Tripra	red clover
Trifolium repens	L.	Trirep	white clover
FERNS AND ALLIES			
Cheilanthes feei	T. Moore	Chefee	Fee's lipfern
Cystopteria fragilis	L. Bernh.	Cysfra	brittle bladderfern
Equisetum arvense	L.	Equarv	common horsetail
Equisetum laevigatum	A. Braun.	Equlae	smooth horsetail
Selaginella densa	Rydb.	Selden	compact clubmoss
Woodsia oregana	D.C. Eat.	Wooore	Oregon woodsia
NATIVE ANNUAL/BIENNIAL FORBS			
Androsace filiformis	Retz.	Andfil	filiform rockjasmine
Androsace septentrionalis	L.	Andsep	pygmyflower rockjasmine
Arabis holboellii	Hornem.	Arahol	Hoelboell's rockcress
Atremesia biennis	Willd.	Artbie	biennial wormwood
Aster brachyactis	Blake	Astbra	alkali rayless aster
Atriplex patula	L.	Atrpat	spear saltbush
Barbarea orthoceras	Ledeb.	Barort	American yellowrocket
Bidens cernua	L.	Bidcer	nodding beggarticks
Chenopodium fremontii	S. Wats.	Chefre	Fremont's goosefoot
Chenopodium leptophyllum	(Moq.) Nutt. ex S. Wats.	Chelep	slimleaf goosefoot
Collinsia parviflora	Lindl.	Colpar	blue eyed Mary
Collomia linearis	Nutt.	Collin	narrowleaf collomia

Scientific name	Species author	Symbol	Common name
NATIVE ANNUAL/BIENNIAL FORBS (Continued)			
Cryptantha celosioides	(Eastw.) Payson	Crycel	buttecandle
Descurainia pinnata	(Walt.) Britt.	Despin	pinnate tansymustard
Epilobium paniculatum	Nutt. ex Torr. & Gray	Epipan	autumn willowherb
Erysimum asperum	(Nutt.) DC.	Eryasp	plains wallflower
Galium aparine	L.	Galapa	stickywilly
Grindelia squarrosa	(Pursh) Dunal	Grisqu	curlycup gumweed
Hackelia deflexa	(Wahlenb.) Opiz	Hacdef	nodding stickseed
Hackelia floribunda	(Lehm.) I.M. Johnston	Hacflo	showy stickseed
Lappula echinata	Gilib.	Lapech	bristly stickseed
Lappula redowski	(S. Wats.) Greene	Lapred	western stickseed
Linum rigidum	Pursh	Linrig	yellow flax
Madia glomerata	Hook.	Madglo	cluster tarweed
Mentzelia albicaulis	(Dougl. ex Hook.) Dougl. ex Torr. & Gray	Menalb	whitestem blazingstar
Mentzelia dispersa	S. Wats.	Mendis	bushy blazingstar
Microsteris gracilis	(Hook.) Greene	Micgra	pink microsteris
Myosurus minimus	L.	Mysmin	tiny mousetail
Nemophila breviflora	Gray	Nembre	basin nemophila
Orthocarpus luteus	Nutt.	Ortlut	yellow owlclover
Parietaria pensylvanica	Muhl. ex Willd.	Parpen	Pennsylvania pellitory
Phacelia linearis	(Pursh) Holz.	Phalin	threadleaf phacelia
Plagiobothrys scouleri	(Hook. & Arn.) I.M. Johnston	Plasco	Scouler's popcornflower
Plantago patagonica	Jacq.	Plapat	woolly plantain
Polygonum achoreum	Blake	Polach	leathery knotweed
Polygonum douglasii	Greene	Poldou	Douglas' knotweed
Ranunculus abortivus	L.	Ranabo	littleleaf buttercup
Ranuculus scerleratus	L.	Ransce	blister buttercup
Rorippa curvisiliqua	(Hook.) Bess. ex Britt.	Rorcuv	curvepod yellowcress
Sanguisorba occidentalis	Nutt.	Sanocc	western burnet
Silene antirrhina	L.	Silant	sleepy silene
INTRODUCED ANNUAL/BIENNIAL FORBS			
Alyssum alyssoides	(L.) L.	Alyaly	pale madwort
Arabis glabra	(L.) Bernh.	Aragla	tower mustard
Arctium lappa	L.	Arclap	great burdock
Arenaria serpyllifolia	L.	Areser	thymeleaf sandwort
Asperugo procumbens	L.	Asppro	madwort
Berteroa incana	(L.) DC.	Berinc	hoary false madwort
Camelina microcarpa	DC.	Cammic	littlepod falseflax
Capsella bursa-pastoris	(L.) Medik	Capbur	shepard's purse
Carduus nutans	L.	Carnut	musk thistle
Chenopodium album	L.	Chealb	lambsquarter
Cirsium vulgare	(Savi) Ten.	Cirvul	bull thistle
Conium maculatum	L.	Conmac	poison hemlock
Cynoglossum officinale	L.	Cynoff	common hound's tongue
Descurainia sophia	(L.) Webb ex Pratl	Dessop	herb sophia
Draba nemorosa	L.	Dranem	woods draba
Filago arvensis	L.	Filarv	field filago
Lactuca serriola	L.	Lacser	prickly lettuce
Lepidium campestre	(L.) Ait. f.	Lepcam	field pepperweed
Lepidium perfoliatum	L.	Lepper	clasping pepperweed
Medicago lupulina	L.	Medlup	black medic
Melilotus officinalis	(L.) Lam.	Meloff	yellow sweetclover
Myosotis micrantha	Pallas ex Lehm.	Myomic	forget me not
Sisymbrium altissimum	L.	Sisalt	tall tumblemustard
Thlaspi arvense	L.	Thlaarv	fanweed
Tragopogon dubious	Scop.	Tradub	yellow salsify
Verbascum thapsus	L.	Vertha	common mullein
Veronica arvensis	L.	Verarv	common speedwell

Scientific name	Species author	Symbol	Common name
SUBSHRUBS			
Arctostaphylos uva-ursi	(L.) Spreng.	Arcuva	kinnikinnick
Artemesia frigida	Willd.	Artfri	fringed sagewort
Berberis repens	Lindl.	Berrep	Oregongrape
Gutierrezia sarothrae	(Pursh) Britt. & Rusby	Gutsar	broom snakeweed
Rubus parviflorus	Nutt.	Rubpar	thimbleberry
Toxicondendron rydbergii	(Small ex Rydb.) Greene	Toxryd	poison ivy
SHRUBS			
Alnus sinuata	(Regel) Rydb.	Alnsin	Sitka alder
Amelanchier alnifolia	(Nutt.) Nutt. ex M. Roemer	Amealn	Saskatoon serviceberry
Artemesia cana	Pursh.	Artcan	silver sagebrush
Artemesia tridentata	Nutt.	Arttri	big sagebrush
Cecocarpus ledifolius	Nutt.	Cerled	curlleaf mountain mahogany
Chrysothamnus nauseosus	(Pallas ex Pursh) Britt.	Chrnau	rubber rabbitbrush
Chrysothamnus viscidiflorus	(Hook.) Nutt.	Chrvis	green rabbitbrush
Clematis occidentalis	(Hornem.) DC.	Cleocc	western blue virginsbower
Cornus stolonifera	Michx.	Corsto	redosier dogwood
Crataegus columbiana	T.J. Howell	Cracol	Columbia hawthorn
Juniperus communis	L.	Juncom	common juniper
Juniperus horizontalis	Moench	Junhor	horizontal juniper
Ledum glandulosum	Nutt.	Ledgla	Western Labradortea
Lonicera utahensis	S. Wats.	Lonuta	Utah honeysuckle
Physocarpus malvaceus	(Greene) Kuntze	Phymal	mallow ninebark
Potentilla fruiticosa	(Pursh) A. Love	Potfru	shrubby cinquefoil
Prunus virginiana	L.	Pruvir	common chokecherry
Rhus aromatica	Ait.	Rhuaro	skunkbush sumac
Ribes americanum	P. Mill.	Ribame	American black currant
Ribes cereum	Dougl.	Ribcer	wax currant
Ribes inerme	Rydb.	Ribine	whitestem gooseberry
Ribes setosum	Lindl.	Ribset	bristly gooseberry
Rosa acicularis	Lindl.	Rosaci	prickly rose
Rosa arkansana	Porter	Rosark	prairie rose
Rosa woodsii	Lindl.	Roswoo	Wood's rose
Rubus idaeus	L.	Rubida	red raspberry
Salix bebbiana	Sarg.	Salbeb	Bebb willow
Salix boothii	Dorn	Salboo	Booth's willow
Salix drummondiana	Barratt ex Hook.	Saldru	Drummond willow
Salix exigua	Nutt.	Salexi	sandbar willow
Salix geyeriana	Anderss.	Salgey	Geyer willow
Salix planifolia	Pursh	Salpla	planeleaf willow
Sheperdia argentea	(Pursh) Nutt.	Shearg	silver buffaloberry
Sheperdia canadensis	(L.) Nutt.	Shecan	Canada buffaloberry
Spiraea betulifolia	Pallas	Spebet	white spirea
Symphoricarpos albus	(L.) Blake	Symalb	common snowberry
Symphoricarpos occidentalis	Hook.	Symocc	western snowberry
Tetradymia canescens	DC.	Tetcan	spineless horsebrush
Vaccinium globulare	Rydb.	Vacglo	globe huckleberry
Vaccinium scoparium	Leib. ex Coville	Vacsco	grouse whortleberry
Yucca glauca	Nutt.	Yucgla	soapweed yucca
TREES			
Abies lasiocarpa	(Hook) Nutt.	Abilas	subalpine fir
Juniperus scopulorum	Sarg.	Junsco	Rocky Mountain juniper
Picea engelmannii	Parry ex Engelm.	Piceng	Engelmann spruce
Pinus contorta	Dougl. ex Loud.	Pincon	lodgepole pine
Pinus flexilis	James	Pinfle	limber pine
Populus angustifolia	James	Popang	narrowleaf cottonwood
Populus tremuloides	Michx.	Poptre	quaking aspen
Populus trichocarpa	Torr. & Gray ex Hook.	Poptri	black cottonwood

Scientific name	Species author	Symbol	Common name
TREES (Continued)			
Pseudotsuga menziesii	(Mirbel) Franco	Psemen	Douglas fir

Figure 3. General plot data - Form 3.

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GENERAL PLOT DATA — FORM 3 (FSH 2090.11, Chap. 4)

IDENTIFICATION AND LOCATION

F1 KEY_ ID Fo D P Yr E Plt ___ _ _ __ _ ____ F2 Examiner _____ F3 EDIT _

Survey Mo Day Project # Plot Types PltRL Plot W

F4 ___ F5__ F6__ F7 _____ F8 3_____ F9 ___ F10 ___

F11 Quad _____ F12 Satellite (Date/ID) _____/_____

F13 Aerial Photo (Date/ID) _____/_____ F14 Spectral ____

F15 Pl _____ F16 Legal _ ID ____T/___R/__S/_ 1/4 S/_ 1/4 of 1/4

F17 UTM _____N/_____E/__Z F18 WL _ MUStrata _____

F19 Timber Strata _____ F20 TS_ ID: CO__ SC__ ST____ Plot ___.___

F21 Range _____ Allot/ ____ MU/__ Ext F22 Ra-Ty____ F23 Cap Area _____

F24 ComPlot _____ F25 Rep _ F26 GDA __ F27 Pol# __ F28 VT_

F29 % Po__ F30 Community Size (acres) ____ F31 Community Shape ___

ENVIRONMENTAL FEATURES

F32 Eco Type (1) _ F33 Potential Natural Community (1) _____ Seral Type (1) ___

F34 Eco Type (2) _ F35 Potential Natural Community (2) _____ Seral Type (2) ___

F36 Soil Map Unit / Landtype Symbol _____ F37 Soil Taxon _____

F38 Parent Material ___ F39 Geomorphic Landform ___

F40 Plot Position _ F41 Slope Shape _ F42 Aspect ____ F43 Slope % ____

F44 Elevation _____ F45 Micro Climate _ F46 Soil Surface Status _

F47 Erosion Type _ F48 Erosion Depth ____ F49 % of Area Eroded ___

F50 Ground Cover _S+_G+_R+_L+_W+_M+_BV+_O=100% F51 SpFe ___

VEGETATION STRUCTURE AND PRODUCTION

BAF ___ * No Trees ___ = F52 Basal Area ____ F53 DBH-Dom ___ F54 Struc _ F55 Veg Change _

F56 Total Tree Cover _ F57 Pole(+) _ F58 Sapling _ F59 Seedling _

F60 Total Shrub Cover _ F61 Tall Shrub _ F62 Mid Shrub _ F63 Low Shrub _

F64 Total Graminoid Cover _ F65 Total Forb Cover _

F66 Mean Age of Dominant (> 10% canopy cover) Woody Species _____ years

F67 Mean Age of Oldest Woody Species (if different) _____ years

Production-herb + browse (DWF = dry weight factor expressed as a decimal)

Green wt. gram _____ * .___ DWF = F68 _____ lb / acre dry wt

Green wt. forb _____ * .___ DWF = F69 _____ lb / acre dry wt

Green wt. shrub _____ * .___ DWF = F70 _____ lb / acre dry wt

F71 Herb/browse production class _ F72 Fuel Loading Class ___

F73 NFDRS Fuel Model ___ F74 Duff Depth __.__ F75 Litter Depth __.__ F76 Fuel Depth __.__

ANIMAL USE AND DISTURBANCE HISTORY

F77 Animal Use _____ F78 Ground Cover Disturbance _

F79 Disturbance History (below)

DT	I	YR	S	DT	I	YR	S	DT	I	YR	S	DT	I	YR	S	DT	I	YR	S
__	_	__	_	__	_	__	_	__	_	__	_	__	_	__	_	__	_	__	_
__	_	__	_	__	_	__	_	__	_	__	_	__	_	__	_	__	_	__	_

F80 Comments on location, environment, structure, disturbance, etc. (up to 230 characters)

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Figure 4. Ocular plant species data - Form 4.

USDA-Forest Service

OCULAR PLANT SPECIES DATA — FORM 4

(FSH 2090.11, Chap. 4)

F1 KEY_ ID _____ F2 Number of Plant Species Recorded ___

	F3	F4	F5	F6	F7 Age/Size Class					F8			F9		
NO	LF	NAME	CC	MHT	1	2	3	4	5	DI	SF	PH	UT	IN	NOTES
1															
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