RANGE CONDITION AND TREND ASSESSMENT IN BRITISH COLUMBIA

by

M.D. Pitt

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RANGE CONDITION AND TREND

ASSESSMENT IN BRITISH COLUMBIA

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INTRODUCTION AND METHODS

This investigation was initiated by the Range Management Branch of the British Columbia Ministry of Forests to help clarify and standardize the definition(s) and application(s) in British Columbia of the concepts pertaining to range condition and trend. These two concepts, more than any others, comprise the basic foundations upon which scientific range management practices and principles have been built. Consequently, range condition and trend are terms familiar to all members of the range management profession, and are commonly used by ranchers, range management students and scientists, and civil servants responsible for the stewardship of Crown grazing lands throughout British Columbia.

Unfortunately, perhaps partially because of this widespread, popular usage, range condition and trend have evolved different connotations and interpretations among range resource personnel. This evolution has also occurred among the professional membership of the Society for Range Management, which consequently established the Range Inventory Standardization Committee (RISC), with responsibility to evaluate and propose standard definitions of many rangeland terms, including range condition and trend. These deliberations have proceeded since 1978 with much controversy and disagreement, particularly for the terms range condition and trend. Although nearing completion of its work, RISC will unlikely resolve this terminology controversy to the satisfaction of all individuals and geographic regions.

Beginning in 1982, a Range Condition and Trend Problem Analysis Steering Committee (Appendix A) was established to review the preliminary recommendations of RISC, with particular reference to the conceptual and practical applications of range condition and trend in British Columbia. Meetings on October 22 and November 9, 1982 confirmed that popular usage and perception
of range condition and trend varied widely among individuals at the meetings. Moreover, specific applications of these two concepts to the widespread forested grazing ecosystems of British Columbia added an additional level of complexity to range condition and trend, which have been developed primarily for ecosystems of climax grassland and shrubland.

In order to better understand and assess this complexity, the current Problem Analysis presents a critical review of literature pertinent to range condition and trend in North America. Additionally, a series of interviews with resource management personnel (Appendix B) was conducted to provide a synopsis of concerns and perceptions of the interviewees regarding the use of range condition and trend in British Columbia. The initial list of interviewees, provided by the Problem Analysis Steering Committee, was expanded to include as many people as possible within the Ministries of Agriculture and Food, Environment, and Forests. Ranchers were also interviewed to obtain input from those resource users affected by Crown land management agencies. During all interviews, individuals were asked to comment on specific questions, as well as being encouraged to expound on their perceptions of the needs for, and constraints with, range condition and trend.

These interviews were used in conjunction with the literature review to:

1) develop an historical perspective of the use of range condition and trend in British Columbia,

2) define the research and management needs of range condition and trend in British Columbia, and

3) recommend strategies for development and implementation of a Range Condition and Trend Classification System in British Columbia.
OBJECTIVES OF THE PROBLEM ANALYSIS

1. Provide definitions of range condition which are applicable in the forested and non-forested rangeland ecosystems in British Columbia.

2. Discuss the significance and application of range condition and trend in range resource management and their relationship to animal utilization, with particular emphasis on range management in British Columbia.

3. Clarify the relationship between the B.C. Ministry of Forests ecological classification system and range condition classification with particular emphasis on the:
   a. Terminologies associated with each classification system;
   b. The purposes and/or objectives of each; and
   c. How the integration of the two classification systems may be achieved.

4. Provide recommendations on the appropriate level(s) of classification currently used by the B.C.M.o.F. Research Branch which should be addressed in the development of range condition and trend guidelines in British Columbia.

5. Evaluate the existing guidelines for range condition and trend assessment developed in British Columbia and in adjacent provinces and states and to make recommendations as to:
   a. The applicability of existing guidelines in major rangeland types in B.C.
   b. Over what geographic areas of B.C. can these guidelines be applied?
6. Discuss the need to develop animal specific guidelines and specifically to recommend what factors relating to the foraging habits and habitat preferences of each animal must be investigated.

7. Identify the floristic and/or other ecological factors currently used and/or required in the assessment of range condition and trend and further to describe:
   a. How each variable is to be sampled.
   b. How the field data for each variable are to be analyzed.

8. Discuss:
   a. How sample accuracy and precision of range condition and trend assessment may be determined.
   b. Identify the levels of sample accuracy and precision currently used in range condition and trend assessment.

9. Discuss how non-indigenous plant species should be treated in range condition and trend assessment in B.C.

10. Discuss how non-seeded and seeded clearcuts and community pastures should be treated in range condition and trend assessment in B.C.

11. Can and must the effects of grazing or browsing by each animal species be isolated from all other effects in the assessment of range condition and trend?

12. Provide a summary of pertinent research needs and recommendations.

13. Provide a summary of pertinent management needs and recommendations regarding the implementation of range condition guidelines and training activities required to ensure the proper implementation of range condition and trend assessment.
DEVELOPMENT OF RANGE CONDITION AND TREND CONCEPTS

In 1974, the Range Term Glossary Committee of the Society for Range Management defined range condition as "the current productivity of a range relative to what that range is naturally capable of producing". Range condition class identified "one of a series of arbitrary categories used to classify range condition... usually expressed as either excellent, good, fair or poor", while range trend expressed "the direction of change in range condition" (Society for Range Management 1974).

Although these conceptual definitions are clearly and explicitly stated, there still exists a wide disparity among range resource managers regarding site-specific application of range condition and trend. In their 1975 textbook on rangeland management, Stoddart et al. indicated that range condition relates current conditions to a potential, but that the term should not be confused with an immediate availability of forage. More specifically, range condition should be assessed primarily on the basis of secondary plant succession stages relative to climax, with refinements based upon plant production, foliar cover, litter and soil erosion to produce an aggregate range condition rating (USDA 1969). Similarly Heady (1975) described range condition classes as paralleling secondary plant successional stages, but also indicated that net (forage) productivity may be higher on regenerated ranges than on the original (pristine) range site because of managerial actions.

The Rangeland Inventory Standardization Committee (RISC) was established in 1978 by the Society for Range Management (SRM) to develop and recommend standard terminology for inventory, analysis and classification of rangelands. This committee tentatively proposed that range condition be defined as "the present state of vegetation of a range site in relation to the (?) climax (?) potential natural) plant community for the site". When condition classes are
used, the RISC further recommended that they be identified as early seral, mid seral, late seral and climax, corresponding to successional stages comprising 0-25, 26-50, 51-75, and 76-100% of the climax and/or potential natural plant community respectively. This definition of range condition contrasts with "resource production rating" which describes the "present production or value of given goods or services from a range site compared to.... the climax state" (SRM 1980).

The Range Inventory Standardization Committee recognized that range condition was "probably the most controversial of our proposed definitions" (SRM 1980). As range condition is also one of the most important terms in the inventory, classification and interpretations of rangeland ecosystems, its usage and application must be consistent throughout the profession of range management. The previous discussion however, illustrates that this consistency has not been attained. The following section provides a detailed summary of the origins and explanations for these inconsistent interpretations of range condition and trend.

**United States**

Several authors have recently reviewed the historical development of range condition and trend in North America (Tueller and Blackburn 1974, E. Lamar Smith 1978 and 1979, Quesnel 1982, Wilson and Tupper 1982). These concepts originated near the turn of the 20th century when Smith (1895) recommended that stocking rates of domestic livestock be adjusted to "improve the condition" of western rangelands. Jardine (1915) observed that overgrazing constituted the major cause of rangeland deterioration, and advocated grazing systems to improve range conditions, implicitly assessed by forage production and carrying capacity. Decreases in forage production and carrying capacity resulted primarily from grazing induced changes in vegetative cover, as less desirable
weedy plants replaced more palatable, productive forage species (Jardine 1915, Sampson 1917).

Sampson (1919) made the first successional-based contribution to range condition classification by describing four stages of grazing-induced retrogression which corresponded rather closely to current condition classes of excellent, good, fair and poor. Sampson further explained that depletion of rangelands is seldom recognized by general observations of "condition of the stock" or "luxuriance of the forage supply" until the animals grazed are in poor condition of flesh. Although Sampson (1919) recognized that forage value and carrying capacity are highest "where the cover represents a stage in close proximity to the herbaceous climax", he also concluded that "the most rational and reliable way to detect overgrazing is to recognize the replacement of one type of plant cover by another".

This dichotomy of approaches to assessing range condition is well established in rangeland management literature. The productivity-based approach rates current productivity in relation to the site potential for a particular forage use, such as cattle grazing (E. Lamar Smith 1978 and 1979). This range condition classification is based fundamentally on current forage production, relative to potential yield (Darrow 1944), such that "the more forage being produced, the better the condition of the range" (Humphrey 1947). This technique does not classify the vegetation, but rather the site upon which that vegetation is growing (Humphrey 1945). Each range site, based upon climate, soil or other factors that may effect plant production is rated to other similar sites relative to the "maximum production possible under the best practical management methods" (Humphrey 1945). To achieve consistency from one location to another, condition classes are commonly identified within the following guidelines (Humphrey 1949): Excellent, good, fair, poor and very poor ranges are those
producing 80-100%, 60-80%, 40-60%, 20-40% and less than 20% of possible forage respectively.

Albee et al. (1948) also considered range condition as synonymous with forage production: "Range or pasture condition (is) ... the relative ability of grassland to produce livestock and livestock products. It (range condition) refers to the quantity and quality of forage in relation to the highest productive capacity of the grassland." Albee et al. (1948) identified four condition classes for South Dakota grasslands as excellent, good, fair or poor based upon 90-100%, 75-90%, 50-75% and 0-50% of greatest or potential forage production, respectively. Although Albee et al. (1948) recognized botanical differences among these range condition classes, successional stages merely correlated with, rather than determined, range condition. Similarly, Humphrey (1965) indicated that forage composition, ground cover, plant vigor, litter and erosion all constituted useful recognition criteria of range condition based upon maximum potential forage production.

Humphrey (1947) indicated an approximate relationship between plant succession stages and range condition classes based upon forage production site potential: "Under most circumstances ranges classed as excellent or good will represent the higher stages.... in a given plant succession". However, exceptions to this generalization "may occur in the case of highly productive annual grass and weed ranges, or lands reseeded to perennial grasses other than those... (of) climax". In these cases, non-climax plant communities "may be classed as in good or even excellent condition" (Humphrey 1947).

Humphrey's (1947) conclusion contrasts to the evaluation of range condition first quantified by Dyksterhuis (1949). This condition rating, based on successional stage, places no inherent judgement on the absolute value of vegetation relative to stocking rates or forage production, but rather assumes
that climax vegetation represents stability and provides adequate soil protection (E. Lamar Smith 1978 and 1979). Species are grouped and identified, based upon response to grazing, as decreasers, increasers and invaders. Decreasers are highly palatable perennial climax forage plants that decrease under prolonged grazing. Increasers are less palatable perennials which initially increase with moderate grazing, but then decline with greater overuse. Invader plant species are those unpalatable annual and perennial plants which increase in percent foliar cover throughout all levels of grazing use.

These plant groupings are then graphed to show relative percent foliar coverage of each plant species. Only decreasers and increasers (up to and including their contribution prior to increase) are counted as contributing to the four categories of range condition classified as excellent, good, fair and poor. These categories are arbitrarily defined as supporting 76-100%, 51-75%, 26-50% and less than 25% respectively, of desirable plant species, relative to climax, as determined by response to years of grazing pressure.

Dyksterhuis (1949) observed that as each of these four categories actually represents "a class of conditions, the term range condition class is appropriate". This classification distinguishes between forage production correlated with range condition, compared to forage production as a basis for range condition classification. Although range condition and forage production are generally related, Dyksterhuis (1949) concluded that range condition determined by the subsere or stage in plant succession provided a more useful assessment of the state of range health, as influenced by grazing animals.

Several other authors have used Dyksterhuis' successional approach as a basis for assessing range condition, particularly as a barometer of range health. Parker (1951 and 1954a) developed a similar procedure incorporating plant succession, but also included plant density, composition of vegetation grouped
according to desirable, intermediate and undesirable for grazing use, plus vigor
of the desirable forage species. Parker also utilized soil factors to evaluate
range health, including litter coverage, current erosion and site stability as
indicated by relative amounts of living and dead soil cover.

Ellison et al. (1951) further promoted site stability as a key ingredient of
assessing range condition, as a decline in the physical characteristics of the soil
surface is the most serious manifestation of a decline in range condition because
of long-lasting impact on production attributes. Ellison et al. (1951) always
considered range condition to be unsatisfactory unless the soil is stable. Forage
value was evaluated only secondarily, and then only when site stability became
assured. This interpretation, at even a more basic level, supports Dyksterhuis'
conclusion that forage production may be a purpose for, but not the basis of
range condition as a state of range health.

Quesnel (1982) indicated that most investigations of range condition
classification have relied upon a wide variety of measurement units to assess
range health. Talbot (1937) enumerated weakened vitality of principal forage
plants, close grazing of inferior forage species, thinning ground cover, replace-
ment of good forage plants by poor ones and accelerating soil erosion as
indicators of deteriorating range conditions in the southwestern United States.
Costello and Turner (1944) judged range condition on the central great plains as
excellent, good, fair or poor utilizing the following criteria: proportion of
ground cover, presence or absence of taller grasses and soil condition. Allred
(1950) listed inherent site potential, proportion of climax and invading plant
species, extent of erosion plus quantity and grazing value of important range
plants as determinants of range condition in Texas, while Crane (1950), on the
eastern slopes of the Sierra Nevada Mountains, defined range condition classes
based upon plant density, percent foliar composition of palatable grasses and
weeds, amount of litter cover and degree of soil erosion.
This wide variety in assessing range health reflects the backgrounds of range management workers throughout the developing years of the profession. This background generally included a strong ethic towards range conservation, while continuing to utilize the grazing potential associated with rangelands. Successional and production measures are both required to satisfy these two primary, sometimes conflicting objectives. These two management objectives have necessarily directed the means by which range condition classification has been determined in the United States.

**Alberta**

Similar objectives have also directed the activities of range condition classification in western Canada. Hanson (1951), working on mountain ranges of southwestern Alberta, developed four condition classes denoted as good, fair, poor and depleted. Each class was characterized in terms of litter, soil compaction and degree of erosion. These measurements intended to integrate soil condition based upon stability and permeability. Additionally, each condition class was characterized relative to successional plant composition and plant density of desirable forage species. Hanson's approach was based upon work by Ellison and Croft (1944) and Reid and Pickford (1946), who were also concerned with protecting long term stability of western mountain/sub-alpine rangelands.

Smoliak et al. (1976) and Wroe et al. (1981) have developed more detailed guides for assessing range condition throughout Alberta. Utilizing the approach recommended by Dyksterhuis (1949), range condition is determined by the relative foliar composition of decreaser, increaser and invader plant species. Smoliak et al. (1975) and Johnston et al. (1981) also developed range condition guidelines for Alberta, but defined excellent, good, fair and poor categories as relative forage yields of the decreaser, increaser and invader plant species.
These two approaches may be quite compatible in Alberta, where relative forage production and successional stage are relatively closely linked (Smoliak et al. 1976; Wroe et al. 1981). Even Dyksterhuis (1949) noted that "relative foliage production... of air dry weight might prove to be more satisfactory" as a classification guideline than relative foliar cover. Although Johnston et al. (1981) and Maduram (1978) included descriptions of plant litter, plant vigor and erosion for each range condition class, Smoliak et al. (1976) and Wroe et al. (1981) observed that these units were not reliable for determining specific range condition classification.

**British Columbia**

Domestic livestock grazing in British Columbia occurs primarily within forested ecosystems of the following biogeoclimatic zones: Boreal White and Black Spruce (*Picea glauca* and *P. mariana*), Engelmann Spruce-Subalpine Fir (*Picea engelmannii*-Abies lasiocarpa), Interior Cedar-Hemlock (*Thuja plicata*-Tsuga heterophylla), Interior Douglas-fir (*Pseudotsuga menziesii*), Montane Spruce (*Picea engelmannii* and *P. engelmannii* x *P. glauca*), Ponderosa Pine-Bunchgrass (*Pinus ponderosa*), Spruce-Willow-Birch (*Picea glauca*-Salix-Betula), Sub-boreal Spruce (*Picea engelmannii* x *P. glauca* and *P. glauca*) and the Alpine Tundra (Wikeem 1983). Unfortunately, the impacts of livestock grazing on range condition within these forested ecosystems remain unquantified. Although Tisdale (1950) provided a summary of the grazing potentials and problems associated with the Interior Douglas-fir biogeoclimatic zone, he gave no indication of condition assessment techniques. Grazing values however, were certainly diminished with advancing stages of natural forest succession following disturbances such as fires, logging and outbreaks of forest insects (*Dendroctinus* spp., * Ips* spp.).
Tisdale and McLean (1957) further subdivided the Interior Douglas-fir biogeoclimatic zone into four associations based upon seral communities of lodgepole pine (Pinus contorta) and aspen (Populus tremuloides). Each of these seral communities, depending upon site potential and stand density, supported varying amounts and composition of herbaceous and woody ground cover potentially suitable for use by grazing animals.

Although forest ecosystems provide an important, extensive summer grazing resource, virtually all range condition classification guidelines in British Columbia have been developed for climax grassland communities dominated primarily by bluebunch wheatgrass (Agropyron spicatum), rough fescue (Festuca scabrella) and Idaho fescue (Festuca idahoensis). McLean and Marchand (1958) indicated that range condition of these grasslands defined a state or health of a range in relation to its potential. Based upon Dyksterhuis (1949), plants were classified as decreasers, increasers or invaders in response to grazing animals. Excellent, good, fair and poor range supported forage comprised of greater than 75%, 50-75%, 25-50% and less than 25% decreaser plant species respectively. Associated cover values for decreaser plant species equaled 60% (excellent), 40-60% (good), 20-40% (fair) and 0-20% (poor) for each range condition class. Plant vigor, litter and degree of soil erosion were considered important range health characteristics, particularly for determining trends in range condition.

Summary of Range Condition and Trend Concepts

The previous discussions indicate that the concepts relating to range condition have been treated similarly by authors in both western Canada and the United States. In their summary article, Wilson and Tupper (1982) concluded that these authors generally used range condition to denote changes in vegetation composition, forage production and site stability as a function of grazing animals, primarily livestock. Specific range condition assessments have served
to guide and inform range managers regarding the improvement or decline (trend) in long-term productivity of the land base.

Despite general agreement on these concepts, considerable differences of opinion still persist regarding how range condition should be measured. One major approach is successationally based, while the second is based upon forage production. As a primary interest in condition classification centers on forage production, such production methods have naturally developed. Alternatively, successationally based methods are often regarded as more fundamental expressions of inherent range condition, and less subject to extraneous variability in total forage production. In this alternative, forage production is correlated with vegetation change, but not necessarily directly related (Gates 1979, Smith 1979, Wilson and Tupper 1982).

To address each of these two primary objectives, many authors and management personnel have incorporated both production and successional criteria for evaluation and descriptions of range condition classification, "depending upon background, training, facilities for work, and extent of territory under supervision" (Costello 1956). Costello further indicated that this lack of uniformity in approach required mutual discussions by advocates of different methods so that more consistent techniques could be developed in the future.

Costello's admonition in 1956 appears equally pertinent in 1984 in British Columbia. Consistent guidelines for judging condition of grazing lands, both forested and non-forested, remain to be developed. Moreover, traditional range condition assessments are now recognized to be imperfect for many managed grazing ecosystems (Smith 1979, Wilson and Tupper 1982):

1) Total forage production can be affected by factors other than grazing animals.
2) Excellent or good range condition may not be the goal of range management, which, if true, introduces needless confusion.

3) Defining plant composition at climax may be quite difficult or impossible.

4) Successionally based condition classification must be modified to accommodate introduced plant species.

5) Measures of vegetation change may not reflect accurately changes in erosion rate, a more serious implication for future range resource production potentials.
RELATIONSHIP OF RANGE CONDITION TO MANAGEMENT OBJECTIVES

Solutions to the problems summarized in the previous section require a more detailed investigation of the relationships between range condition classification and specific management objectives. This investigation will document those management objectives that are being serviced well by current condition classification techniques, as well as those objectives that are not being addressed adequately.

Grazing Management

The early work by Sampson (1919) described overgrazing as the primary cause of declining range condition, whether measured as lower successional stages or lowered forage production. Consequently, improved grazing management is expected to provide an upward trend in productivity, plus a successional stage closer to climax, or excellent range condition. Most grazing management systems, including the various combinations of deferred, rest and rotational grazing, are designed specifically to either prevent continued range deterioration or to promote improved range condition. Hormay (1956) indicated that these grazing systems, for a given livestock species, consist of manipulating only four factors: Stocking rate, season of grazing, livestock distribution and frequency of grazing.

Practical success with these grazing systems requires at least tacit acceptance by livestock grazers. "To a stockman, the main objectives of a range livestock enterprise is sustained maximum livestock production and sustained maximum dollar income" (Hormay 1956). These objectives are implicitly best achieved with range condition and associated productivity classified as good or excellent.
Such relationships, however, do not invariably materialize, as excellent range condition may be impractical to achieve with economically viable stocking rates and grazing systems. Therefore, excellent range condition may not even represent a management objective, which often seeks to retain lower successional stages through optimal forage utilization by grazing animals.

Moreover, where introduced plants occur, whether accidental or with range seeding, successional based excellent range condition may be impossible to achieve. Dyksterhuis (1949) suggested that ranges dominated by such introduced species may be managed quite productively, but would still be classified as much lower than excellent range condition. Similarly, Vallentine (1962) stated that a range in fair condition may or may not be acceptable, depending on management objectives. A range in fair condition in stable trend may be satisfactory if watershed values are not adversely affected. Even a range in poor condition will not require major changes in management, as long as an upward trend is evident.

Wilson and Tupper (1982) illustrated that management may be directed toward good or even fair range condition in those instances where increased forage production results from conversion of climax shrubland to more seral grassland. Moreover, Smith (1979) concluded that differing management objectives may be achieved best under different classification categories, even further reducing the utility of descriptive terms such as excellent, good, fair and poor. This reduced utility creates confusion among professionals and laity alike, which often leads to a complete misunderstanding of the measurement and value of range condition classification. Psychologically, it is desirable to strive towards excellent resource management, which may be obscured by terminology which equates fair range condition with management goals.

Although qualitative terms such as excellent, good, fair and poor can be misleading, the successional stages upon which they are based retain managerial usefulness. McLean and Tisdale (1972) quantified years of recovery to excellent
range condition, as a function of current condition rating. Those range sites in lower condition classes improved more slowly than those in higher condition classes, perhaps because of the competitive advantages of desirable forage plants more prominent at later successional stages (Vallentine 1971). Therefore, specific grazing management proposals, including complete rest, must always consider current successional status as well as the desired time frame for improved range condition. Allred (1950) and Dyksterhuis (1958) supported this conclusion, as both alluded to the importance of range condition class as a seral stage useful for evaluating range improvement alternatives.

Successionally based range condition classifications are therefore generally useful for assessing management success at manipulating successional stages with the use of grazing animals. However, the current terminology may obscure that management success with misleading, qualitative adjectives such as excellent, good, fair and poor range condition. Moreover, these successional categories are relatively ambiguous when applied to range management objectives other than controlling plant succession.

**Forage Production**

Present forage production, compared with the maximum forage production possible under the best practical management, represents the primary alternative to successional methods for determining range condition. As such, forage production and range condition become synonymous, and are therefore perfectly correlated.

Several authors however, have indicated that range condition measurements should assess ecological health of range sites, and that forage production is only indirectly related to this ecological health (Gates 1979). Dyksterhuis (1949) summarized the following weaknesses of using forage production to evaluate range condition classes:
1) There is often as much difference in forage production on one site from year to year, as there are differences between sites in the same year.

2) Foliar species composition (presumably in relation to factors other than grazing management) fluctuates less from year to year than does annual forage production.

3) Range plant communities which differ floristically at climax may produce the same amount of forage per unit area.

4) During inventory programs, field personnel are usually not able to classify ranges with respect to potential production, other than judged by relative plant coverage.

Based upon these observations, Dyksterhuis (1949) argued that differences in range condition must be recognized by comparing present vegetation with climax vegetation. Differences in forage production are valuable primarily for recommending appropriate stocking rates.

These conclusions notwithstanding, most authors recognize a relationship between successional stage and forage production (Humphrey and Lister 1941, Humphrey 1947, Anderson 1951, Murray 1962, McLean and Marchand 1968, Gates 1979). Dyksterhuis (1958) pointed out that the further the departure of range vegetation from climax, the greater the potential for site deterioration and loss of forage productivity. Dyksterhuis (1958) therefore concluded that range managers need to evaluate the impact of the grazing animal on the basis of both kinds and amounts of forage produced. This conclusion is also supported by Allred (1950), Costello (1956) and Rumsey (1971).

Alternatively, Houston (1966) indicated that in some cases total forage production of western wheatgrass (*Agropyron smithii*) declined with removal of
livestock and increasing condition classes (IN: Gates 1979). Similarly, Cook et al. (1965) found that poor condition sheep summer ranges in Utah produced more total herbage than good condition ranges, as assessed by successional stage. However, the good condition ranges produced more total grass than those in poor condition, although utilization of grasses was heavier on poor condition ranges. Such conclusions illustrate that even though forage production is proposed as a managerially practical assessment of range condition class, there still exists a variety of grazing management objectives that remain unanswered by total forage production measurements.

Launchbaugh (1969), working in Kansas, found that range condition classification based upon the methods of Dyksterhuis was closely related to yield proportions of dominant herbaceous species where true invaders played a minor role. These yield ratios served as good indicators of grazing management when based upon only those plant species influenced most by grazing treatment, and least by yearly weather differences. This modification of production estimates to evaluate range condition addresses the first two concerns summarized by Dyksterhuis (1949), that production varies as much between years as it does between range sites and even condition classes (Ellison 1959). Even Humphrey (1949) cautioned against relying upon variable annual forage production to assess range condition, which he believed should not be used to reclassify ranges each year based solely upon recent growing conditions.

It is apparent from literature that a relationship exists between forage production and plant succession. Even so, many exceptions to this generalization have been demonstrated (Houston 1954). Moreover, the values and products desired from rangelands may be more attainable in a seral stage. Even where it may be desirable to alter range condition classification by changing grazing intensity, this may not be possible from a practical standpoint (Pickford and Reid 1942b, Launchbaugh 1969, Gates 1979). Therefore it seems valid to retain forage production and range condition classification as separate concepts, utilizing each for its own purposes in range management planning.
Plant Density and Plant Vigor

In addition to forage production, plant density and vigor have also been recommended as useful indicators of range condition (Pickford and Reid 1942b, Parker 1951, Costello 1956, Gates 1979). However, Hanson (1951) illustrated that density varied so greatly among rough fescue sites that no boundaries were established for the upper two condition classes. Moreover, plant density did not decrease appreciably with deterioration to the 3rd or poor condition rating, but then declined considerably as ranges become depleted, in the 4th condition class. Similarly, Arnold (1955) concluded that density as an index to range condition tells little because desirable species are often replaced by undesirable species as rapidly as the former die. Goebell and Cook (1960) even found some instances where density was higher on poor condition ranges than on good condition ranges. This was particularly true when invading plants were primarily annuals.

Parker (1954a) indicated that changes in plant vigor are forewarnings of later events to come. As such, plant vigor may be of vital importance for determining range trends, but of little importance or even misleading in determining range condition (Gates 1979). For example, McConnell and Smith (1971) found that percent dead crown of bitterbush (Purshia tridentata) did not differ significantly on sites browsed heavily and moderately by cattle. Although average crown diameter did differ between the two sites at the 5 percent level of significance, age of shrubs accounted for 74 and 70 percent of total variation in average crown diameter on the heavily and moderately grazed sites respectively. McConnell and Smith (1971) therefore concluded that changes in crown cover, as a measure of plant vigor, "may not be quite as sensitive to changes in grazing as managers often assume."

Inconclusive relationships among grazing and plant vigor measurements have also been observed by other authors. Hickey (1961) studied the growth form of crested wheatgrass (Agropyron desertorum), and concluded that grazing
reduced leaf length and basal area, but did not affect culm length. Alternatively, Cole and Wilkins (1958) found that grazing by elk and cattle lowered leaf height, but did not affect basal area of rough fescue plants compared to areas grazed by elk only. Although rough fescue plants grazed by both elk and cattle displayed a greater incidence of hollow centers and clumped edge growth patterns, Cole and Wilkins (1958) cautioned that bluebunch wheatgrass plants, even when ungrazed, also produced similar hollow centers and clumped growth patterns prior to dying from old age.

All of these observations suggest that the use of plant vigor to assess range condition is tenuous, and must first differentiate among a variety of influences, including impact of current and previous grazing, plant maturity, site potential and variable species response. Indeed, Humphrey (1949) concluded that plant vigor was the least dependable criterion on which to base range condition, and that ecological principles became obscured when plant vigor comprised a part of the evaluation procedure.

Parker (1954a) summarized three major objections to the use of plant vigor to assess range condition:

1) Vigor may be modified by the effects of current weather.

2) Vigor is difficult to describe or measure.

3) Widely spaced perennial plants on depleted ranges may be more vigorous than at climax, particularly after a short respite from grazing pressure.

Although Parker (1951) believed that these objections had been overcome with procedures developed by the U.S. Forest Service, Gates (1979) concluded that these procedures utilized plant vigor primarily as an indication of range trend. Range condition and trend are certainly related, although condition refers
to a point on a seral scale, while trend refers to the direction of change in range condition from that point.

Short and Woolfolk (1956) provided data which showed a correlation between plant height and range condition on the northern Great Plains of Montana. Once again however, Gates (1979) believed that the discussion provided by Short and Woolfolk indicated plant vigor was useful more for range trend than range condition. Similarly, Bjugstad and Whitman (1970), working in southwestern North Dakota, concluded that plant vigor as measured by leaf height was most indicative of the initial stages of range deterioration, while only small differences existed between the average leaf heights on good and fair condition ranges, as measured by botanical composition. Thus, while plant vigor is a valid criterion for evaluating range trend, range condition classification is related to, but can not be determined directly by plant vigor at any specific point in time.

Forage Quality

The value of rangelands as a feed source is a primary concern to range managers seeking to optimize production of grazing animals, domestic or wild. The effects of removal of photosynthetic tissue constitute a major challenge to devising grazing systems that are consistent with the requirements of plants and animals (Gates 1979).

Goebel and Cook (1960) investigated the relationship between range condition and chemical composition of forage plants in the salt deserts of Utah, dominated by shrubby *Artemisia* and *Atriplex* species. Results of this study indicated that improvement in range condition, as determined by the relative proportion of desirable plant species, does not always result in higher nutritive content of that forage. When all forage classes were averaged together, forage quality was approximately equal on good and poor range condition sites. On poor
ranges, however, palatable forage species were higher than unpalatable forage species in percent total protein, ash, cellulose, other carbohydrates and phosphorus. Alternatively, on good condition ranges, palatable forage species were higher only in percent ash and cellulose. Such differences likely resulted from a change in the growth characteristics of the plants (Goebel and Cook 1960), which may indicate that chemical composition may have been related more to plant vigor than range condition per se (Gates 1979).

In related work, Cook et al. (1962) investigated the relationships between range condition and nutritive value of sheep diet on desert ranges of Utah, and concluded that nutrient content of herbage on good and poor ranges depended upon species composition. When palatable browse herbage dominated, such as on poor condition ranges, the diet was higher in protein, ash, lignin and ether extract. If palatable grass herbage dominated however, such as on good condition ranges, the diet was higher in cellulose and gross energy. As intensity of grazing use increased, content and digestibility of nutrients declined as animals were forced to utilize coarser portions of the forage species.

Similar results were obtained by Cook et al. (1965) on mountain ranges utilized by domestic sheep in northern Utah. Total protein, ash, lignin and other carbohydrates were slightly higher in forage ingested from poor condition ranges, while ether extract, cellulose and gross energy were higher in forage from good ranges. Digestibility of cellulose, other carbohydrates and gross energy declined on both range condition classes with increased utilization, while digestibility of total protein declined on poor condition ranges only with increased utilization.

Demarchi (1973), in bluebunch wheatgrass ranges of British Columbia found this plant species to be higher in percent crude protein on fair condition ranges compared to good condition ranges. This higher proportion of crude protein was postulated to result from a greater proportion of leaves on overgrazed plants (Demarchi 1973), again suggesting an association with plant vigor more than with
range condition class (Gates 1979). Although bluebunch wheatgrass on excellent condition ranges yielded more total crude protein per unit area than on fair condition ranges, needleandthread (*Stipa comata*) on fair condition ranges exceeded bluebunch wheatgrass on excellent range in terms of total crude protein per unit area.

All of these studies illustrate that the relationships among range condition and nutritive parameters are extremely complex. The range manager must recognize seasonal trends in forage quality, and understand the impacts of grazing on a wide variety of range plant species in varying stages of phenological development. Most grazing management plans try to manipulate forage quality and availability for the benefit of grazing animals without undesirable consequence for the forage resource. This objective is difficult when a single animal species is involved, but becomes even more challenging when a mixture of wild and domestic ungulates are considered within the management plan (Anderson and Scherzinger 1975). Range condition classification can be a useful guideline for this challenge. However, as summarized by Gates (1979), available literature indicates quite clearly that range condition and forage quality are not linearly related. Moreover, these two factors are also inherently confounded with utilization rates and associated plant vigor. Range condition classification therefore may not be considered as a direct assessment of forage quality, particularly on a nutrient, season, or site-specific basis.

**Forage Utilization and Stocking Rates**

Forage utilization, or the proportion of the current year's growth removed by grazing animals, is the primary cause of range trend, and ultimately range condition (Ellison et al. 1951). Heavy utilization promotes a downward trend in range condition, while light utilization encourages improved range conditions. Appropriate animal stocking rates are therefore intended to achieve desired forage utilization so as to manipulate range trend and condition. In this
sense, range condition and trend reflect "past and current stocking rates of the principal herbivore populations inhabiting the range area" (Petrides 1975).

The corollary, however, is not invariably true, regardless of whether range condition is evaluated successionally or in terms of average annual forage production. Specifically, excellent, good, fair or poor range condition per se does not necessarily indicate appropriate utilization and stocking rates. Each of these qualitative terms must be assessed locally to provide guidelines for stocking rates on a site-specific basis. Recommended stocking rates are based on research results from grazing trials, local experience, or clipped plot yields (Smoliak et al. 1976, Wroe et al. 1981). One must always acknowledge however, that forage production is only indirectly related to successionally based range condition classification, even on a site-specific basis. Consequently, appropriate stocking rates based upon this forage production are also only indirectly related to successional range condition classification.

For example, Coupland et al. (1960) investigated the relationship between forage production and range condition classification in the Canadian mixed prairie dominated by Stipa, Agropyron and Bouteloua. Range condition assessment based upon Dyksterhuis (1949) consistently overestimated actual forage yields expressed as a percentage of total yield at climax. These overestimates occurred because of the abundance at climax of increaser plant species, which also comprised the latest successional stages of range deterioration. "The higher condition ratings obtained by the Dyksterhuis method would result in overgrazing ... if applied directly as indicating the carrying capacity of pastures expressed as a percentage of the carrying capacity of the climax" (Coupland et al. 1960). Consequently, Coupland et al. (1960) recommended that range condition classification (Dyksterhuis 1949) be altered to include only decreaser plant species. This procedure produced more consistent relationships among range condition classification, forage production and subsequent suitable stocking rates.
Additionally, management objectives and constraints may also alter stocking rates within range condition classes, even on a site-specific basis. Management may not seek excellent range condition, and may therefore increase stocking rates to purposefully produce a downward trend in range condition. Stocking rates may also be affected by site characteristics that limit use of forage (Smoliak et al. 1976). Portions of the range that are rocky, distant from water, or have excessively steep slopes will not be utilized to desired levels (Anderson and Currier 1973). Under these conditions, stocking rates are often reduced to avoid overutilization of the more accessible range areas. Stoddart (1960) summarized factors that influence determination of stocking rates, including forage production, natural land features and management factors. Forage production was influenced by annual weather and prevailing climate, soil type, amount of vegetation and quality of vegetation. Natural land features included topography and distribution of water, while management factors consisted of kind of stock, management objectives, other forage users, supplement feeds, season of grazing, distribution of grazing and the use of grazing systems. Stoddart (1960) identified a final administrative factor, which evaluates the importance of livestock relative to other land uses prior to establishing appropriate stocking rates.

This list does not identify successionally based range condition as an explicit determinant of appropriate stocking rates. Moreover, forage production is only one of 14 variables contributing to stocking rates, and even this important criterion is influenced by annual weather patterns. Therefore, Humphrey (1947) argued correctly that range condition, utilization and stocking rates are distinct. An underutilized range may be in either excellent or poor range condition. The same is true of an overutilized or overstocked range. Proper utilization and stocking rates are consequently not determined solely or explicitly by range condition classification. Rather, proper utilization and stocking rates, although influenced by range condition classification, are necessarily modified by site-specific forage production potentials and managerial opportunities and constraints.
Animal Production

Ellison (1958, 1978) concluded that "the argument that livestock condition is a reflection of range condition is partly true, but the argument that it is an accurate reflection is completely false". Although animals perform better on range in good condition than poor condition, "to argue that animals are therefore a barometer to the condition of the range is to fall into a logical trap" (Ellison 1958, 1978). Under some circumstances the correlation between range condition and animal production may be strong. In other cases, such as mountainous rangelands, the correlation may be quite weak. Wilson and Tupper (1982) indicated that this correlation can even be negative in situations where increaser plant species are valuable and productive for livestock grazing.

Somewhat facetiously, Ellison (1958, 1978) asks us to "consider a range on which palatable plants have been removed by overgrazing, such that vegetation consists primarily of unpalatable plants. Are the animals going to go on a hunger strike, and quit eating?" Experience indicates that animals do not strike for preferred plants, but rather fill up with whatever plants may be available, often growing fat and productive. This ability of grazing animals to accept alternative forage is particularly characteristic of domestic livestock, which have been bred specifically to ingest large quantities of material from a wide variety of forages (Arthur Smith 1978). Moreover, it has not been demonstrated that secondary forage species are any less nutritious than those primary forage species indicative of excellent range conditions (Arthur Smith 1978). Throughout the upper levels of range condition classification, one should expect no great difference in animal response due to range condition (Arthur Smith 1978). Even at lower range condition classification levels, individual animal weight gains may still be maintained by reduced stocking rates (Arthur Smith 1978). The condition of livestock, therefore, can not be used invariably as an accurate indicator of range condition (Talbot 1937), or the appropriateness of current stocking rates (Jardine 1915).
Cattle

Nonetheless, cattle production is influenced by range condition. McCorkle and Heerwagon (1951), in the southern plains of New Mexico and Colorado, showed that ranges in good, fair and poor range conditions averaged 14.3 (16.0 kg/ha), 11.2 (12.5 kg/ha) and 8.9 (10.0 kg/ha) pounds of beef per acre respectively. Similarly, Lewis et al. (1978), in the mixed prairie region of South Dakota, described excellent, good and fair condition ranges which produced 34, 28 and 28 kg per hectare respectively for weight gains of yearling steers.

It is difficult, however, to ascribe all of this increased production to the effect of different range conditions. For example, in the study by Lewis et al. (1978), stocking rates were also highest in the pastures rated excellent (1.21 AUM/hectare), declining to 1.06 and 0.94 AUM/hectare for fair and good ranges respectively. Consequently, gain per head was highest on the good condition ranges (0.73 kg/day), and lower on the fair (0.64 kg/day) and excellent (0.68 kg/day) ranges. These conclusions support Ellison's (1978) conclusion that animal productivity is not necessarily a direct reflection of range condition. Additional years of study by Lewis et al. (1978) supported in principle the above generalizations developed from two years of grazing studies.

Sheep

Range condition classifications utilizing qualitative terms such as excellent, good, fair and poor may be misleading when evaluating that range site for use by different grazing animal species. Humphrey (1949) correctly upheld the objection of domestic sheep ranchers to classification techniques which do not properly identify ranges for sheep use with the adjectives excellent, good, fair and poor. For example, bunchgrass ranges of the Palouse Prairie are rated excellent, both in terms of herbage production and successional stage when bluebunch wheatgrass is the principal forage species. Bluebunch wheatgrass,
however, is a coarse grass, providing poor sheep feed. This range may therefore have excellent value for cattle grazing, but poor value for sheep grazing. Alternatively, if these ranges were dominated by Sandberg's bluegrass (Poa sandbergii), they may provide excellent grazing for sheep, even though range classification may be only good or fair.

Costello and Schwan (1946) provided conclusions similar to those of Humphrey (1949). On ponderosa pine sites of Colorado, a downward trend on ranges stocked with sheep was denoted first by a lack of palatable weeds, followed by disappearance of shorter, more succulent grasses and sedges. On these same sites stocked with cattle, the large, perennial bunchgrasses were the first plants to decline.

On mountainous rangelands of Utah, Cook et al. (1965) showed that wether sheep gained an average 28 pounds (12.7 kg) each for a summer grazing season on good range, but only 17 pounds (7.7 kg) each on poor ranges. This occurred even though ranges in poor condition produced slightly more herbage than good condition ranges, with daily forage intake approximately equal for sheep regardless of condition class rating.

Cook et al. (1965) provided no explanation for the weight gain differential even though a wide variety of nutritive parameters were assessed. Their data do suggest however, that relationships among weight gain and range condition are extremely complex, and are not readily explained by a single, or even a group of nutritive or production parameters.

Wildlife

Wikeem and Pitt (1979) reached similar conclusions for California bighorn sheep on bunchgrass rangelands of southern British Columbia. In this study, sheep displayed marked forage preferences among plant species that did not
differ substantially in nutritive parameters. Manipulation of plant succession and range condition to improve bighorn sheep habitat on the assumption of a definite relationship to forage quality may therefore be misleading.

Demarchi (1973) investigated the impact of range condition on California bighorn sheep, also in southern British Columbia, and concluded that climax bluebunch wheatgrass, in excellent range condition provided preferred habitat for these animals. However, this perception relates more to the value of bluebunch wheatgrass as winter forage than to range condition per se, as bighorn sheep habitat preference, as indicated by fecal group distribution, was higher in fair than in good condition ranges. Thus, "excellent range condition" for these sheep may be evaluated by availability of winter forage rather than either total forage production or successional stage.

Costello and Schwan (1946) observed that condition of game ranges on ponderosa pine sites in Colorado was related more to the amount of browse and local topography than to quantity and quality of grass. Consequently, condition classes for wildlife were based on the density of preferred browse species. Costello and Schwan (1946) further noted that the amount of browse could be reduced seriously by deer and elk, even where grass cover had increased, presumably due to improved cattle management.

Patton and Hall (1966) also assessed game range condition in New Mexico based upon good, fair or poor browse condition. Trend in this condition was determined from a scorecard summary of plant age and form class. This technique provided wildlife managers with habitat data pertinent to key areas of game ranges. Similar to Demarchi (1973), this pertinent information on "range condition" may not necessarily be evaluated by, or related to total forage production or successional stage.
Both Demarchi (1973) and Patton and Hall (1966) however, indicated condition indices based upon perceived forage preferences of the grazing or browsing animal. As such, their evaluation techniques are similar in principle to the range condition classification of Dyksterhuis, which quantifies the relative proportions of preferred plant foods. Petrides (1975) identified food preference ratings as useful tools for understanding trophic ecology and suitability of ranges as wildlife habitat. These preference ratings necessarily differ among animal species, which also indicates that habitat suitability for varying animal species differs within the same range condition classification, as determined by successional stage. Indeed, England and De Vos (1969) concluded that historic, localized overgrazing by bison, in association with trampling, rubbing and wallowing, contributed to the creation and maintenance of habitats favorable to a variety of other wildlife species.

The preceding paragraphs illustrate that range condition influences, but does not explicitly determine or explain animal productivity. Livestock weight gains per unit area are increased with improved range conditions, which allow greater stocking rates. Weight gains per animal may be maintained, assuming availability of forage, even on fair or poor condition ranges. Moreover, qualitative descriptions of range condition cannot be assumed as constant indicators for all animal species. Rather, interpretation and use of range condition classification, as value for grazing animals, must be based upon management objectives and animal-specific requirements. This value is separate, conceptually, from range condition classification based either on total forage production or successional stage.

Maintaining Range Health

Ecological classification, including range condition assessment as proposed by Dyksterhuis (1949), intends to provide an indication of range health. Theoretically, departure of current vegetation from climax or pristine conditions
corresponds directly to ill health of range sites (Ellison et al. 1951). For example, Spence (1937) studied the root systems of 50 range plants common in southwestern Idaho, and concluded that soil erosion associated with overgrazed areas resulted primarily from the replacement of climax, fibrous-rooted plants by seminal plants having taproots and semi-taproots. Spence (1937) therefore reasoned that soil erosion could be controlled by reestablishing the original grass species, or similar fibrous-rooted plants.

Rangeland ecosystem health can be indicated by a variety of factors, including both vegetation and soil. Ellison et al. (1951) and Anderson (1974) provided excellent summaries of useful indicators of range health, listing eight factors of soil stability (trampling, soil remnants, erosion pavement, lichen lines, wind-scoured depressions, aeolian deposits, alluvial deposits, and gullies and rills), amount of vegetal cover, and proportion of desirable plant species. A similar summary has been provided by Parker (1954a) who indicated that the most reliable criteria for range health (condition) included plant density, forage cover, proportion of plant species desirable for grazing, plant vigor, litter cover, current erosion and site stability as indicated by the amount of living and dead cover.

These conclusions are based upon ecological principles, supported by years of field experience and observations. Craddock and Pearse (1938), Humphrey and Lister (1941), Croft et al. (1943) and Bailey (1945) all indicated that increased grazing intensity produced declines in vegetative cover, with associated increased in soil erosion, surface runoff, plus losses in organic matter and total nitrogen (Croft et al. 1943). However, only a very few studies are available which document relationships among specific range condition classifications and these indicators of range health, particularly those indicators based on soil parameters.
Klemmedson (1956) studied two range sites in western Colorado, with the following results:

1) Plant density of desirable species decreased with a downward trend in range condition. Plant density of undesirable species increased with deteriorating range condition. A greater change in density was noted from fair to poor, than from good to fair range condition.

2) Erosion pavement, plant pedestalling, bare soil and litter cover became more evident with range deterioration. Less noticeable indicators included alluvial deposits, litter orientation, rock pedestals, and soil crusting.

3) State of health of physical soil characteristics, including infiltration rates, organic matter content, volume weight and pore size distribution, all deteriorated with declining range condition.

Murray (1962) documented the relationships among bulk density, moisture penetration, soil chemistry and range condition classification in rough fescue grasslands of western Montana. In the 0-2 inch (0-5.1 cm) soil horizon, bulk density averaged 0.71, 0.92 and 0.94 grams per cubic centimetre within excellent, fair and poor range conditions, respectively. Moisture penetrated to depths of 95.5, 77.2 and 74.8 mm in each condition class, respectively, while soil pH, total nitrogen, available phosphorus, organic matter, exchangeable sodium and potassium, and soil texture revealed no trends consistent with differences in range condition.

Leithead (1959) studied the relationship between runoff and range condition classification in western Texas, and found that infiltration rates equaled 9.5, 5.8, 4.25 and 2.75 inches/hour (24.1, 14.7, 10.8 and 7.0 cm/hour) on range sites classified as excellent, good, fair and poor, respectively. Moreover, percent soil moisture declined more rapidly from January 19 to April 7 in soils supporting
poor range conditions. This more rapid decline resulted from a threefold increase in evaporation loss in the upper 1 foot (30.5 cm) of soils on poor range condition sites.

Pendleton and Schmude (1979) summarized the relationship between soil erosion and range condition on 165.4 million hectares of rangeland in 17 western U.S. states. In nine states, where 50% or more of the rangeland was judged to be in excellent or good condition, sheet and rill erosion averaged 6.23 metric tons per hectare in 1977. In six states where 20-39% of rangeland was estimated to be in excellent or good condition, sheet and rill erosion averaged 8.33 metric tons/hectare/year. In two states, where less than 20% of investigated range areas were deemed to be excellent or good, sheet and rill erosion increased to 22.85 metric tons/hectare/year. Similar relationships existed for rate of erosion, and wind-induced sheet and rill erosion.

Belton et al. (1979) investigated the relationships among range condition, vesicular crusting and site potential of loessial soils in northern Nevada. On good condition ranges, some surface crusting occurred naturally between shrubs. With declining condition, this soil crusting increased, eventually cracking into coarse polygons. With continued deterioration, unpalatable shrubs germinated and became established in these polygon cracks of the crusted surface. As the shrubs matured, coppice mounds of structured soil material accumulated below them, obliterating the surface crusting. This situation has little chance of being reversed with natural plant succession. Surface soil crusting, as an indicator of range health or site potential must therefore be used judiciously. Rather than a direct relationship, visible soil crusting initially increases, but then declines with advancing stages of range site deterioration.

Ellison (1949) and Klemmedson (1956) similarly concluded that soil and vegetation characteristics may not be related directly to range degeneration. Greater change in soil characteristics was observed in the early stages of range
deterioration, from good to fair condition classes. Alternatively, greatest change in vegetational characteristics occurred in later stages of decline, from fair to poor range condition. Bailey (1945) noted that mountain ranges considered to be in good condition, as determined by utilization of key forage species, were actually deteriorating rapidly in terms of soil erosion. This soil erosion often progressed at such a rapid rate that forage species were reduced in vigor and density more by erosion than by grazing activities.

Furthermore, Klemmedson (1956) indicated that rates of trend for soil and vegetational characteristics may vary between sites. Klemmedson (1956) compared two sites which supported similar vegetation, and observed that soil deterioration was much more advanced on one site compared to the other. Klemmedson (1956) hypothesized that both sites, upon reaching a poor condition stage, attained equilibrium with the soil. However, with continued overuse, for a longer period of time, soil conditions of the former site continued to deteriorate, even though the vegetative complex remained relatively constant.

All of these conclusions illustrate that few indicators have absolute value which can be used to assess range health (Bailey 1945, Ellison et al. 1951). For example, soil movement may not become apparent until vegetative change has already occurred (Anderson 1974). Therefore, each indicator of range health must be supported by evidence from additional indicators, each of which may have a bearing on range health (Ellison et al. 1951, Anderson 1974). Importantly, the presence, or absence of these health indicators are not invariably related linearly, or even directly, to advancing declines in range condition classification.
RELATIONSHIP OF RANGE CONDITION TO ECOLOGICAL CLASSIFICATION

Range condition based upon plant successional stages as developed by Dyksterhuis (1949) is itself an ecological classification. As already discussed, this approach satisfies some, but not all managerial objectives. Poulton and Tisdale (1961) suggested that this lack of satisfaction stemmed partially from the study of rangelands as general biological complexes rather than at the basic units of ecosystems that comprise these complexes. These authors recommended that range units be classified in terms of habitat-types (Daubenmire 1952), which reflected the fundamental unit of the environment, or range site. Poulton and Tisdale (1961) hypothesized that habitat-types would differ not only in soils and climax vegetation, but also in seral vegetation which results from management activities such as grazing, prescribed burning and artificial revegetation. They further concluded that such classification, based upon sound ecological principles, should provide broad application and usefulness for the evaluation of site potential relative to a variety of managerial objectives.

Pursuing this grand notion of broadly-based utility, many land management agencies throughout North America have attempted to design such ecologically-based classification systems of use to all resource managers (Merkel and Driscoll 1982). Adoption of this common land classification would (1) aid consistent evaluation of renewable resources, (2) contribute to data collection and exchange, (3) facilitate uniform planning, and (4) promote improved application of research results (Merkel and Driscoll 1982). To achieve these objectives, a "National Land Classification System for Renewable Resource Assessments" is being developed in the United States. This classification argues that to manage land, it is essential to understand component parts in terms of inherent site potential. Therefore, components incorporated into the classification must represent relatively permanent features of the landscape, including soil, landform, climax vegetation and water (Merkel and Driscoll 1982).
Hall (1980) reviewed the application of such land classification programs in the United States Pacific Northwest. Plant communities were classified to produce a storage and retrieval system of information which could be used to (1) characterize plant communities, (2) refine predictions of how communities would respond to management, and (3) aid in development of management prescriptions to achieve desired goals. Ideally, the resultant "Area Plant Association Guidebook", based upon community type classification, average site productive potentials and current management, would be useful equally to a silviculturalist, wildlife biologist or range manager as a reference when considering options for treatment or land allocation (Hall 1980).

Although this classification can aid the resource manager, it still did not contain all the required information. Community types should therefore not be equated rigidly with habitat-type, or be based solely on species presence or absence. Rather, community types should be split or combined based upon six primary kinds of resource information (Hall 1980):

1) **Present vegetation:** cover type, old growth forest, stagnated saplings, clear cut, current volume, range condition.

2) **Land Situation:** steepness of slope, aspect, length of slope, shape of slope.

3) **Soil Taxonomy:** stability to mass movement, erodability, moisture, fertility

4) **Current Use:** wildlife winter range, livestock range, active timber sale, endangered species area, insect outbreak.

5) **Juxtaposition:** location, distance from nearest road, distance from water, ridge or bottom, kind of adjacent vegetation.
6) **Community Type:** classification, site potentials, opportunities and limitations for management, plant community response to treatment.

This list is revealing from three major perspectives. First, useful managerial parameters are not necessarily or inherently revealed by ecological classification. Information regarding erodability, stagnated forest stands and range condition must be measured during the field classification if they are to be available to the resource manager. Although range condition need not be measured directly per se, all of the data required for assessing range condition must be collected directly. It is axiomatic that no specific information can be retrieved from a classification system that is not stored in that classification system. Classification of community types based merely upon floristics does not necessarily provide information regarding range condition, whether assessed by total forage production or by successional stage.

Secondly, even if community type, forage production and successional stage are all known, information may still be inadequate for management decisions. Consequently, other factors such as steepness of slope, soil erodability, wildlife winter range, plus distance from nearest roads and water are useful, sometimes necessary information for knowledgeable range management decisions. Classifications based primarily upon generic plant and soil descriptions do not provide these kinds of information.

Thirdly, range trend, or the direction of range condition, is not provided in an ecologically based classification system based solely on soils and climax vegetation. Rather, range trend is provided by documenting changes in seral stage over time, or by assessing other characteristics such as soil erosion and plant vigor (Kinsinger 1979). These secondary characteristics are important for management decisions, and should be incorporated purposefully into any classification system intended for resource managers.
Range trend is particularly important to range managers because it provides an indication of grazing management success. Range trend documents those changes in range condition that are in response to grazing activities, as expressed through available forage production, desirable plant species or deviation from original vegetation (Noble 1979).

Not all changes in these vegetational parameters, however, can be ascribed necessarily to grazing management. Dyksterhuis (1952), Coupland et al. (1960) and Noble (1979) all indicated that temporal changes in forage production and botanical composition due to weather patterns should not be confused with changes brought about by grazing management. Jameson (1970) investigated the suitability of broom snakeweed (Gutierrezia sarothrae) as an indicator of range condition in Arizona. Over a 13 year period, changes in percent cover of broom snakeweed appeared to result from variable population oscillations rather than changes in range condition. Similarly, Launchbaugh (1969), working in Kansas, concluded that weather patterns exerted more influence on western ragweed (Ambrosia psilostachya) and western wheatgrass than did grazing intensity.

In addition to this annual variability, Heady (1973) identified other plant system dynamics resulting from daily and seasonal environmental variations, all of which are subject to long term but unpredictable changes due to immigration of species, evolution of organisms and climatic drift. Range trend therefore, whether based upon forage production or successional stage, cannot be assessed accurately unless the classification techniques first separate these other vegetational changes from those induced by grazing management. Classification systems based solely on soils, climax or even current vegetation do not inherently possess this facility for separation.

Ecological classification in British Columbia has objectives similar to those described by Poulton and Tisdale (1961), Hall (1980) and Merkel and Driscoll (1982): "to provide resource managers with some of the tools to meet the goal
(forest management), by developing a permanent, land-based, ecological classification to organize our knowledge of ecosystems and to serve as a framework within which to manage resources" (Pojar 1983). Although several ecological classification systems are currently utilized in British Columbia, the approach recommended by the B.C. Ministry of Forests (Walmsley et al. 1980, Pojar 1983) is the dominant system. All references in this text to ecological classification in British Columbia therefore refer to this system utilized by the B.C. Ministry of Forests.

Ecological classification in British Columbia reinforces the ecosystem as the fundamental unit of ecology and management, which consists of a plant community plus the soil polypedon upon which the community occurs. An ecosystem association includes all ecosystems capable of belonging to the same plant association at climax, and as such is similar to the habitat type of Daubenmire (1952 and 1968). Ecosystem associations are characterized by climax, but may include a variety of disturbance-induced, or seral ecosystems.

Conceptually, ecological classification in British Columbia is similar to ecological classifications discussed above. Presumably, managerial applications, constraints and opportunities are therefore also similar to those generalizations summarized above. Specific differences and similarities are discussed in the section dealing with Assessing Range Condition and Trend in British Columbia.
ECOLOGICAL CONSTRAINTS TO APPLICATION OF RANGE CONDITION AND TREND CONCEPTS

The discussion thus far has centered on the use of range condition and trend as techniques for assessing (1) the value of range vegetation for use primarily by domestic livestock, and (2) the health of range sites as influenced by domestic livestock grazing. These concepts have been developed historically on natural, climax, perennial grassland communities of North America, and therefore can be expected to be most applicable in these plant communities. Alternatively, one would expect that traditional range condition concepts become less useful in communities not dominated by herbaceous cover at climax.

Grassland Ecosystems

Dyksterhuis (1949) and Voigt and Weaver (1951) classified true prairie plant species according to the manner in which they respond to grazing. Primary assumptions include:

1) The pristine, climax community is dominated by the most palatable plant species.

2) All plant species of all seral stages respond in botanical composition, either positively or negatively to grazing activities.

3) Highly palatable or useful plant species are not most prevalent in seral stages.

4) Invading plant species, which are negligible components of the pristine community, are invariably of low forage value and palatability.
These four assumptions are reasonably appropriate in the climax prairie vegetation of central North America. Floristic dominants include palatable, nutritious forage species such as Andropogon and Bouteloua. Increasing or invading plant species generally consist of low growing, less productive grasses and forbs. Climax dominants for each range site are relatively easily categorized relative to response to grazing, and nearly disappear with years of overuse. Invading plant species are typically annual forbs and grasses with low value for grazing animals (Sampson 1919, Dyksterhuis 1949, Voigt and Weaver 1951).

Other grassland communities however do not adhere so easily to these four assumptions. An extreme example is the annual grassland of California which irrevocably replaced the pristine, perennial grassland beginning in approximately 1775 (Heady 1977). This annual grassland is often more productive than the original climax community, and consists of many palatable, nutritious plant species. Moreover, desirable and undesirable plant species occur at all stages of plant succession (Heady 1956), which severely reduces the utility of equating grazing value with successional stage. Furthermore, vegetation change in the annual type is strongly influenced by annual weather patterns (Pitt and Heady 1978), such that grazing management exerts a proportionately reduced impact on plant succession (Heady and Pitt 1979, Pitt and Heady 1979).

Although the California annual grassland perhaps represents a unique contrast to climax, perennial prairie vegetation, traditional concepts of range condition and trend must be modified in all grassland ecosystems where:

1) Desirable plant species, whether native or introduced, occur prevalently in seral stages.

2) Undesirable plant species, whether native or introduced occur prevalently at the climax stage of plant succession.
3) Prevalent plant species are not easily categorized in terms of response to grazing pressure.

4) Prevalent plant species are affected significantly by factors other than grazing management.

Successionally based range condition classifications have generally considered invading plant species to be undesirable indicators of declining range conditions. Research in the California annual grassland indicates clearly that this conclusion is not always appropriate, as alien plant species are often extremely valuable, and may even be dominant at the end-point of natural plant succession (Heady 1973). Consequently, these alien species, whether accidentally or purposefully introduced, should logically be considered a naturalized component of the grassland ecosystem. As such, categorization of species according to the way in which they respond to grazing pressure applies equally pragmatically to native and naturalized forage plants.

Shrubland and Forestland Ecosystems

Those ecological constraints to the application of range condition classification in climatic climax grasslands are even more pronounced in shrubland and forestland ecosystems. In these plant communities, climax species are certainly not exclusively desirable forage plants (Humphrey 1960). Dyksterhuis (1959) recognized that successional progression on forested lands often resulted in poorer grazing values. Consequently, composition based upon increasers, increasers and invaders cannot be used to classify range condition to the exclusion of other site criteria such as density, vigor, litter and soil characteristics (Parker 1952). Parker (1952) further commented that total forage production may also be inappropriate in forestland ecosystems. For example, in open ponderosa pine (Pinus ponderosa), pine may gradually close in, crowding out or decreasing forage accessibility. Lowered forage production results, "and
although the area may not have as high value for range it may still be considered as in satisfactory condition..... from the watershed and timber" aspects (Parker 1952). Volland (1982) recommended that adjustments for such increases in tree stocking must be incorporated into range condition classification of timbered areas, "so that the effect of livestock grazing on the vegetation can be separated from the effects of tree stocking".

Costello and Schwan (1946) addressed this separation of livestock grazing from the effects of tree stocking on ponderosa pine sites in Colorado by assessing range condition only in those communities dominated by herbaceous or shrubby communities. "Invasion of the climax trees in bunchgrass ranges is an indication that forage production and value will ultimately decrease. This kind of invasion, however, usually does not indicate a deterioration in site quality", and presumably therefore does not indicate a downward trend in range condition, which was assessed by forage composition, vigor and density, plus soil cover and erosion (Costello and Schwan 1946).

Dobb (1982) reviewed range condition assessment on forested rangelands, and further emphasized that the effects of timber management must be separated from the effects of grazing management when assessing range condition. For example, Hall (1978) discussed applicability of range condition classification to forest range in the Pacific Northwest, and concluded that traditional range management concepts "do not apply well to forest-range because livestock are not the only factor affecting density and composition of vegetation". Maximum herbage production is attained without tree cover. With increasing crown cover, density of ground vegetation declines. "This decrease in density is a downward range trend not caused by livestock" (Hall 1978). Therefore, forest-range condition must incorporate successional vegetation caused by tree crown cover and livestock grazing (Hall 1978).
The respective influences of these two factors must be separated in order to retain range condition as an assessment of grazing management success. For example, in the mixed conifer/pinegrass zone of eastern Oregon and southeastern Washington, Hall (1975) observed no significant difference in proportion of decreaser plant species between ranges in poor condition due to livestock overgrazing compared to range under dense tree crown cover. Adjustments in livestock management can not improve forage values depressed primarily by such overly dense trees. However, livestock management can alter forage values and range condition within specific tree crown cover classes. Consequently, Hall (1978) recommended that range condition guides in the mixed conifer forests of the Pacific Northwest be indexed to crown cover in seral stands of each forest community. This indexing provides reference points for determining appropriate proportions of decreaser plant species at each crown cover stage. In this way, the utility of range condition classification as an assessment of grazing management success is retained.

Forestlands require not only that the impacts of grazing be separated from natural forest succession, but also that the categories of decreaser, increaser and invader plant species be re-examined. As in the California annual grassland, palatable and unpalatable forage species may be found throughout all stages of forest succession. Johnson and Reid (1964) grouped plants as "desirable", "intermediate" and "least desirable" based upon a combination of ecological and forage values. The desirable group included species present in abundance at ecological climax, which are also palatable to cattle. The intermediate group included (1) species of lower palatability and low abundance at ecological climax and (2) species of fair palatability that increase as the desirable species decline. The least desirable group included species of low palatability that sometimes become dominant as range deteriorates. A similar procedure is contained in the Range Analysis Management Handbook for Region 6 of the U.S. Forest Service, which identifies "deceasers" "palatable increasers", "unpalatable increasers" and "invaders" (USDA 1979).
Shrublands are conceptually similar to forestlands relative to application of traditional range condition classification concepts. Humphrey (1960) noted that where unpalatable shrubs such as creosote (Larrea tridentata) predominate, it is possible to have a range type classified as excellent, even when few palatable forage plants are available. Such a site may be "producing all the forage possible", relative to its potential, yet still provide virtually no grazing value.

Canfield (1948) indicated that where shrubs comprise a natural component of the ecosystem, range condition may be determined more accurately by ignoring their relative contribution to botanical composition: "Grasses bear the brunt of grazing... and therefore change more quickly than their less palatable associates. Thus the grasses record the history of past grazing use and become indicators of range condition." This better indicator value of grasses persists even when range condition is improving. Populations of relatively unpalatable deep rooted shrubs and trees are slow to change in response to improved grazing management, or even total protection from livestock (Canfield 1948).

Canfield's observations in shrublands of the U.S. southwest lend further support to the ecological constraints of range condition classification in ecosystems dominated by non-herbaceous vegetation at climax. A major objective of range condition classification, to assess the impact of grazing animals, can be achieved only by quantifying changes in plant species caused by those grazing animals.

Schmutz and Smith (1976) observed that the shrub velvet mesquite (Prosopis juliflora) increased in the absence of fire on both grazed and protected range sites of Arizona. Therefore, even though velvet mesquite acts as a decreaser plant species on sites recovering from previous heavy grazing, this species does not provide useful information relative to range condition as a function of grazing management. Such changes in range condition are quantified best with those plant species which respond to grazing management, which must
be separated from changes in forage value that are caused by factors other than grazing management.

Alpine Ecosystems

Thilenius (1975) provided a review of range condition and trend assessment in alpine ecosystems of the western United States. As with other types of grazing land, condition standards are generally based on the amount of desirable plant species, plus a rating of soil stability condition class. Pickford and Reid (1942a) provided range condition standards for subalpine green fescue (Festuca viridula) grassland ranges of Oregon and Washington based upon plant succession, cover density, proportion of grasses to weeds and shrubs, and the extent to which soil had been disturbed by accelerated erosion. Although no quantitative range condition classes were provided, declines in condition were identified as departures from climax vegetation, including transitional and second weed stages of plant succession. Botanical composition of climax vegetation contained only 32.1% of weedy, herbaceous species, while transitional and second weed stages, based upon nomenclature proposed by Sampson (1919), averaged 46.4% and 65.4% weedy, herbaceous species, respectively. Pickford and Reid (1942a) recommended that upward trends in range condition could be attained with reduction in stocking rates and forage utilization. Such upward trends were documented by Strickler (1961) on green fescue grasslands of Oregon.

Judging condition of alpine rangelands can often be difficult however, because of uncertainty regarding standard references for successional stages induced by grazing animals. For example, Schwan and Costello (1951) presented botanical composition standards for alpine range condition classes which actually better described a continuum of plant communities along a moisture gradient than retrogression of a given range site in response to grazing management. Thus, Thilenius (1975) warned that authors must be very careful not to confuse successional status with the wide variety of plant associations which often occur in alpine ecosystems.
Moreover, classification of alpine plants relative to their desirability can often be misleading. Strasia et al. (1970) showed that "desirable" Deschampsia caespitosa formed a minor part of domestic sheep diet, while "least desirable" species such as Geum rossii and Polygonum bistortoides comprised major items of sheep diet on alpine ranges of Wyoming. Moreover, many alpine communities are dominated at climax by forbs. These plant species, commonly considered undesirable indicators of overgrazing in lower elevation grasslands, actually have very extensive root systems, and thereby provide excellent soil holding ability (Thilenius 1975).

Alpine geomorphology, especially congeliturbation, further complicates range condition and trend assessment of alpine rangelands. Condition and trend standards must therefore clearly distinguish between inherent range site potential and range health (Lewis 1970), particularly in relation to between and within year variation due to cryopedogenic processes (Thilenius 1975). These processes commonly produce active soil erosion, irrespective of grazing management practices, and must therefore not be confused with declining range condition. Thilenius (1975) therefore recommended that trend assessment occur at yearly intervals to interpret range trend as separate from annual variation in seasonal growth and normal erosion activity.

Thus, ecological constraints to the determination of range condition and trend in alpine ecosystems are similar to those described for ecosystems dominated by forests, shrublands or annual plant species. Successional sequences are not always controlled primarily by grazing management, and climax plant communities are not necessarily the most productive or useful for grazing animals. These relationships are exacerbated by wide variability in plant community structure, distribution and productivity due to topography, geomorphology, plus amount and duration of snow accumulation. Measures of vegetation alone are therefore not likely to "provide a suitable basis for classification (of range condition) because of the nebulous nature of alpine communities (Thilenius 1975)". 
As summarized previously, literature describing range condition assessment in British Columbia includes both the successional approach proposed by Dyksterhuis (1949) as well as the forage production potential approach of Humphrey (1947). McLean and Marchand (1968) defined range condition as "a measure of forage production in relation to the potential under ungrazed or climax vegetation or ideal management". For each of three sites (Big Sagebrush - Bluebunch Wheatgrass; Bluebunch Wheatgrass - Sandberg's Bluegrass; Bluebunch Wheatgrass - Rough Fescue), anticipated average forage production in excellent, good, fair and poor condition classes were provided. Additionally, McLean and Marchand also indicated cover values of decreaser, increaser and invader plant species associated with each condition class. A Ponderosa Pine site was also described, although condition classes included only cover values of decreaser and increaser plant species, as "productivity......in each condition class (varies) greatly depending on the density of the tree cover" (McLean and Marchand 1968).

This publication of McLean and Marchand (1968) tended to present a utilitarian approach to range condition assessment, thereby prompting a productivity orientation. McLean and Tisdale (1972) described recovery of depleted range sites inside 9 exclosures located throughout southern British Columbia. Although based upon productive potential outlined by McLean and Marchand (1968), much of the discussion of condition classification provided by McLean and Tisdale (1972) revolved around descriptions of botanical changes in climax and successional plant species. These botanical descriptions, perhaps more so than total forage production, provided useful criteria for assessing the recovery in ecological health of the 9 range sites. Such a 2- pronged approach, production and botanical composition, reconfirms that the technique utilized for assessing range condition has depended a great deal on management objectives.
Specific, published guidelines for assessing range condition in British Columbia are contained nearly exclusively to these two previous papers. Moreover, these two papers emphasized climax grassland systems, with virtually no guidelines provided for the extensive forestland grazing resource. McLean and Marchand (1968) referred to the difficulty of summarizing variable forage production beneath a ponderosa pine canopy, although Tisdale (1950) identified forage production beneath mixtures of aspen, lodgepole pine and Douglas-fir canopies:

<table>
<thead>
<tr>
<th>Palatable Forage</th>
<th>Unpalatable Forage</th>
<th>Total Forage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lbs/Acre (kg/ha)</td>
<td>Lbs/Acre (kg/ha)</td>
<td>Lbs/Acre (kg/ha)</td>
</tr>
<tr>
<td>Aspen</td>
<td>623 (698)</td>
<td>23 (26)</td>
</tr>
<tr>
<td>Lodgepole Pine</td>
<td>293 (328)</td>
<td>122 (137)</td>
</tr>
<tr>
<td>Mixed Douglas-fir, Lodgepole Pine, Aspen</td>
<td>319 (357)</td>
<td>17 (19)</td>
</tr>
<tr>
<td>Mature Douglas-fir</td>
<td>155 (174)</td>
<td>17 (19)</td>
</tr>
<tr>
<td>Young Douglas-fir</td>
<td>98 (110)</td>
<td>4 (4)</td>
</tr>
</tbody>
</table>

Dodd et al. (1972) noted that estimation of forest forage yields from ground surveys is too slow to be useful where large land areas need to be covered in a short time. These authors therefore correlated approximations of herbage production with tree crown cover, measured both on the ground and with estimates from aerial photographs. Results indicated a sufficiently close relationship between herbage production and crown cover. Similar relationships occurred whether estimates of canopy cover were obtained from the ground or from aerial photographs.
Dodd et al. (1972) concluded that aerial photographs would be very useful for initiating and updating range surveys of forage production in coniferous forests. Similar techniques in deciduous forests were believed to be less accurate. These authors further recommended that crown cover classes be divided into four categories: 0-20%, 20-35%, 35-55%, and greater than 55%. Forage production was very low beneath canopies exceeding 55% crown cover, thus minimizing the need for finer resolution in crown class estimation. Dodd et al. (1972) suggested that additional refinements could be achieved by incorporating other parameters such as slope (0-20%, 20-40%, 40-60%, greater than 60%), stand age, soil moisture, and soil nutrient status. In this respect, the recommendations of Dodd et al. (1972) are similar conceptually to those outlined by Hall (1980) for classification of forestland in Region 6 of the United States Forest Service.

Current Methods and Techniques

As in the United States, ecological classification in British Columbia seeks to provide information useful to all resource managers. This information is usually collected at the level of ecosystem association, although where appropriate, a functional sub-unit termed ecosystem association phase may be used "for better site differentiation and identification" (Pojar 1983). This improvement in identification recognizes contrasting soil or landform characteristics that may be significant to users of the classification. Examples include particle size classes, slope, aspect, parent material, soil climate and bedrock geology. Such characteristic differences "influence an ecosystem's response to external disturbances.... (and) allow more consistent prediction of ecosystem response to management treatments" (Pojar 1983).

Field sampling procedures are described in detail by Walmsley et al. (1980). Sample plots are identified selectively, and are located in climax habitats that are as uniform as possible. Heterogeneous, transitional or disturbed sites are
avoided. Plots are located to represent specific combinations of moisture and nutrients, as suggested by slope position, indicator species, relative tree growth, soil texture, seepage, and base status of parent material. Five or more plots are usually sampled for each ecosystem association (phase), although intensity of sampling varies with ecosystem extent, diversity, accessibility, and managerial importance (Walmsley et al. 1980, Pojar 1983).

At each plot a variety of information is collected which describes site, soil, vegetation, mensuration, and wildlife and range characteristics. Site, soil and vegetation information is quite detailed, and provides ecological descriptions of the ecosystem association (phase). These descriptions have value for assessing ecological status of the site from a variety of perspectives. Relative to assessing range condition as a function of grazing management, ecological classification seeks to (1) identify climax or near climax ecosystems, (2) identify successional stages of these ecosystems, (3) determine productivity of climax and successional stages, and (4) determine the degree of utilization required to maintain or improve productivity (Walmsley et al. 1980).

Walmsley et al. (1980) described range condition in terms of the relative proportions and amounts of plants in a community compared to the climax community for that site, based primarily on the work of McLean and Marchand (1968). Forage plants are classified according to their response to grazing. Similar to Hall (1980), Walmsley et al. (1980) recognized 4 classes of forage species: decreasers, palatable increasers, unpalatable increasers and invaders. Species which are not part of the climax community were categorized as invaders, regardless of forage value. Although not stated specifically, Walsmley et al. (1980) implicitly defined plant species response to grazing relative to cattle, as no indication is provided that such characterization may vary with different grazing animals.
Walmsley et al. (1980) observed that production estimates provide valuable information on the potential food base for wildlife and domestic livestock. Therefore, Walmsley et al. (1980) recommended that total annual, available, above-ground forage production be estimated or measured at each sample plot. The guidelines are unclear, however, whether these production values are collected for all forage and browse species, or are restricted to key forage species. Additionally, because of time and budgetary constraints, total above-ground forage production is currently not always estimated or measured at each sample plot. Depending upon the specific sampling project, forage production values may be provided on grassland sites, while mensuration parameters receive higher priority on forest sites (Meidinger pers. comm.).

Walmsley et al. (1980) maintained that range condition ratings are most suitable when applied to rangelands where native vegetation is predominantly grasses, grasslike plants, forbs or shrubs. For densely timbered types, "the process of comparing the existing stand to the predicted climax stand is not meaningful". The authors therefore recommended that range condition not be determined on forest sites. Following disturbance on these sites by logging, thinning or fire, Walmsley et al. (1980) suggested that successional status, productivity and utilization of key forbs be recorded, but that range condition be ignored.

Based upon the preceding paragraphs, the following generalizations emerge regarding range condition assessment in British Columbia:

1) Range condition classification incorporates both of the associated but separate concepts of successionaly based and production based approaches.

2) The use of both these approaches in British Columbia indicates the value that each has, depending upon management objectives and intended interpretations.

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3) Range condition assessment guidelines for British Columbia are available for climax grasslands, but are virtually non-existent for forest grazing lands.

4) Forage production in the forest zone declines with increasing canopy cover. This decline occurs regardless of grazing management.

5) Ecological classification in British Columbia is providing detailed information regarding attributes of ecosystem associations (phases) at climax.

6) Ecological classification in British Columbia assesses range condition only for edaphic and climatic climax grasslands, including some open forest, grass-dominated ecosystems, based on the proportion of decreaser, increaser and invader plant species. This range condition assessment occurs primarily within the Ponderosa Pine-Bunchgrass and Interior Douglas-fir biogeoclimatic zones.

7) Ecological classification in British Columbia, which selects only climax sites for sampling, does not provide enough information for assessing range condition in seral stages of plant succession, thereby precluding identification of good, fair and poor condition classes.

8) Ecological classification in British Columbia does not assess range condition on climax forest sites, as determined by the proportion of desirable plant species. This omission prevents evaluation of grazing management success, as a separate influence from increasing crown canopy.

9) Ecological classification in British Columbia recommends that estimates of forage production be provided on climax forest sites. Such estimates are necessary to assess the value of these forest sites for grazing.
10) Ecological classification in British Columbia, which identifies sample sites selectively, can not provide estimates of variability for quantitative attributes of ecosystem associations. This variability is required to determine accurately the upper and lower bounds of forage production and percent composition of decreaser, increaser and invader plant species associated with each range condition class.

11) Walmsley et al. (1980) consider all alien plant species as invaders. This conclusion reduces the value of range condition classification as a measure of grazing management success, particularly when the alien plant species provide useful forage value.

12) The impacts of wildlife and domestic livestock utilization on botanical composition of understory vegetation remain largely unquantified at the level of ecosystem association (phase) in British Columbia. This informational gap precludes accurate determination of animal specific range condition guidelines at climax and seral stages of forest succession.

Perceptions of Resource Personnel

Resource management personnel throughout British Columbia are diverse in terms of educational background and professional experience. Consequently, their respective opinions regarding any particular resource management topic will also be equally diverse. Therefore, this summary of perceptions regarding range condition and trend reflects the entire spectrum of both the historical development of these concepts, as well as the terms of reference of this Problem Analysis.

When asked for a specific definition, interviewees (Appendix B) generally indicated that range condition assessment is based upon the proportion of desirable plant species as influenced by grazing animals, usually cattle. Range
trend was identified as the change in range condition classification over time. These conclusions stem primarily from formal education in coursework pertinent to range science, and are based initially upon the work of Dyksterhuis (1949). Professional experience in British Columbia supports these conclusions, both through conversation with colleagues and information contained in the widely distributed bulletin describing range condition assessment of Kamloops grasslands (McLean and Marchand 1968).

In addition to this interpretation of range condition, most people often imply other meanings when referring to range condition. Depending upon professional background and management objectives, these additional meanings may include forage production, proper forage utilization, seral stage, forage quality, plant vigor, stocking rates (Animal Unit Months), animal productivity, soil erosion, presence of noxious weeds, or winter carrying capacity for wildlife. Such variable usage necessarily creates some uncertainty and misunderstanding of the proper interpretation and application of range condition classification in British Columbia.

Much of this uncertainty relates to assessment of range condition on sites or in vegetation with climax plant communities other than perennial grassland. Examples include forested ecosystems, wetlands and clearcuts, particularly when seeded with introduced forage species. This uncertainty increases in those situations where grazing induced vegetational changes are difficult to separate from other kinds of vegetational change, such as natural forest succession.

The perceived needs for improved guidelines for range condition assessment relate primarily to those situations summarized in the previous paragraph. Priority should be given to developing guidelines for forested grazing lands, particularly within the rangeland inventory program. Of all interviewees, inventory personnel were most concerned regarding appropriate definitions and measurement of range condition. Range resource officers and others associated
with administration and management of crown grazing lands were less concerned, yet still believed that improved guidelines would facilitate better consistency and uniformity in range condition assessment among forest districts. Although management personnel do not necessarily base grazing management decisions solely on explicit range condition assessment, improved consistency between individuals was deemed desirable for communication purposes. Once again, guidelines for forested ecosystems received higher priority than for grassland ecosystems, where continuity and consistency of assessment are better achieved.

Almost regardless of professional background, interviewees generally made the following recommendations regarding development of range condition guidelines:

1) Priority should be given to forested ecosystems rather than grassland ecosystems.

2) Guidelines should provide criteria for assessing range condition on clear-cuts and rights of way.

3) Guidelines must be practical and easy to apply in the field. Requirements for detailed, formalized measurement programs would be difficult to implement, assuming current levels of funding and resource management personnel.

4) Guidelines, for management purposes, should probably be at the ecosystem association level.

5) Within the ecosystem association level, guidelines should classify seral stages.
6) Guidelines must be specific for animal species, and provide criteria for assessing range condition relative to wildlife.

**Summary of Needs and Problems**

The preceding discussion of range condition classification illustrates the complexity of this topic, particularly in relation to variabilities in management objectives, vegetation type and conceptual framework basis. Nonetheless, many specific objectives, methodologies, problems and current needs of range classification are similar in principal, irrespective of geographic region. Such similarities are summarized by the following generalizations.

1) Range condition classification, termed excellent, good, fair and poor, has been used as a general assessment of ecological, or range site health. Specific assessment techniques have been based primarily on either forage production or successional stage, as compared to the best practical management and climax respectively.

2) Regardless of which approach is utilized, excellent range condition may not be economically feasible or even ecologically or managerially desirable. Consequently, terminology such as excellent, good, fair and poor range condition may be inappropriate, and at times misleading.

3) Forage production and successional stage are related, but not always in a linear or even direct fashion. Therefore, these two concepts should be separated, utilizing each for its unique role in range management planning.

4) Similarly, plant vigor and plant density both correspond to range condition classification, but are not always linearly or even directly related. These indicators of range health are therefore more useful for assessing the direction of trend in range condition, rather than range condition per se.
5) Forage quality includes many nutritive parameters, some of which improve, and some of which degrade with declining range condition. Classification of range condition can therefore not be considered a direct assessment of forage quality, particularly on a nutrient, site, season or animal specific basis.

6) Appropriate utilization, stocking rates and range condition are conceptually distinct. Site-specific managerial opportunities and constraints necessarily influence stocking rates, regardless of whether range condition is determined by forage production or successional stage.

7) Although animal production is often higher on good than on poor condition rangelands, animal productivity cannot be used as a direct assessment of range condition. Moreover, different animal species display variable forage and habitat preferences, indicating that a specific range condition classification is not "excellent" or "poor" for all animal species.

8) Ecological classifications, which are based solely on community types and successional stage, provide guidelines for management purposes. However, many specific management needs, summarized in points 1-7 above, can not be provided directly with ecological classifications that do not incorporate such information in addition to plant community floristics.

9) Ecological classification, based solely on plant communities and successional stage, is not invariably a direct assessment of ecological, or range health.

10) Successionally based range condition classifications are suited best to vegetation dominated by palatable, perennial grasses at climax. Application of these range condition classifications become more difficult in vegetation not dominated by herbaceous plants at climax.
11) Alien plant species are not inherently undesirable and can therefore be accommodated pragmatically within either a production or successional based range condition classification.

12) Livestock grazing is only one of many factors which influence botanical composition, forage production and community structure of grazing lands. These other factors, including wildlife populations and management techniques such as fertilization, prescribed burning and forest thinning, must be separated from livestock influences in order to retain range condition as an assessment of grazing management success.

13) On forested grazing land, natural forest succession exerts a primary influence on understory forage production and botanical composition. Forest succession must therefore be separated from grazing influences in order to retain range condition as an assessment of grazing management success in forested ecosystems.

Range condition assessment in British Columbia can also be described accurately by these 13 generalizations. Specific objectives, methodologies, problems and current needs differ in degree rather than in principal, and have been summarized in the section discussing range condition assessment in British Columbia. Additional recommendations and management needs have been identified throughout British Columbia. The following sections discuss terminology proposed to address all of the varied objectives, problems and needs of range condition classification, with particular emphasis for British Columbia.
PROPOSED DEFINITIONS FOR RANGE CONDITION AND TREND

The summaries provided in previous sections demonstrate quite clearly that range condition classification techniques have suffered from being overly ambitious. Whether based upon forage production, successional stage or physical site characteristics, no single variable, or group of variables, correlates directly with all other condition indices or management objectives. Debate over which index assesses range condition best only serves to obscure these management objectives. Rather, each index or site description provides management value unique to its own objectives and measurement units. Value or utility of any specific range condition index is therefore determined solely by intended management use. Each of these intended management uses represents either a specific resource value or a characterization of management potentials, constraints and success. A pragmatic, efficient range assessment program would therefore assign the appropriate index to each management objective.

Range Condition and Trend

One of the most important range management objectives is to determine the impact of grazing animals on herbaceous vegetation. The following definition (SRM 1980) addresses this objective:

"Range condition is the present state of vegetation of a range site in relation to the potential natural plant community for the site. It is an expression of the relative degree to which the kinds, proportions and amounts of plants in a plant community resemble that of the potential natural plant community. Condition classes may be four in number, corresponding to 0-25, 26-50, 51-75, and 76-100% similarity to the potential natural plant community, and should be called early seral, mid seral, late seral and climax."

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Trend is the direction of change in range condition, or any resource production value, observed over time. Trend is best measured over time, but may be deduced from a single observation of pertinent indicators. Trend in range condition should be expressed as toward potential natural vegetation, away from potential natural vegetation or not apparent.

Potential natural vegetation (PNV) is defined by the Society for Range Management (1982) as that biotic community which would become established if all successional sequences were completed without human interference under present environmental conditions. Potential natural vegetation differs from historic climax in that PNV reflects the end point of plant succession based upon current floristic, edaphic and climatic conditions. Many grazing lands have been so altered by past use and species introductions, that the historic climax plant community can not be reestablished. Potential natural vegetation is therefore a more realistic projection of steady state plant communities.

Heady (1973) observed that permanent alterations of rangeland ecosystems influence successional patterns, such that new climaxes result. Such permanent alterations must therefore be recognized as such, particularly when their removal becomes impossible in practical terms (Heady 1973). Potential Natural Vegetation describes a new climax plant community based upon these permanent alterations. Although the term climax could be retained to represent this new steady state plant community, PNV is proposed by the Society for Range Management (1982), most likely to avoid confusion with the traditional use of climax as an historic plant community.

Resource Value Ratings

Range condition based on seral stages does not invariably provide a direct assessment of the value of that range site relative to management objectives. These values must therefore be determined separately from range condition
classification. Resource Value Ratings describe the present production or value of given goods and services from a range site compared to its production or value at climax (SRM 1980).

These value ratings can be expressed as a percent of climax, and may be higher or lower than at this climax stage of plant succession. The total number of Resource Value Ratings determined for each range site varies directly with management objectives, as each rating necessarily must be related to a specific use or value. Commonly used resource value ratings may include forage production, appropriate stocking rates, beef production, suitability for wildlife habitat, site stability relative to erosion plus potential for timber regeneration and growth in forested ecosystems.

Relationship to Management Objectives

These proposals which separate range condition and trend from other resource value ratings provide improved flexibility and application compared to condition classifications that attempt to assess all values with a single, integrative index. The following discussions briefly illustrate this improved flexibility and management utility.

Grazing Management

The primary objectives of grazing management are to produce a useable animal product without impairing long-term health of the range site. Proper grazing management therefore seeks an optimal balance between these potentially conflicting goals. Such an optimal balance for many grazing animals is often attained at successional stages other than climax, as determined by potential natural vegetation. Grazing management may therefore seek to maintain plant succession in a mid or late seral stage.
The specific desired successional stage controlled by grazing management depends upon the relative values of alternative resource products, including domestic livestock. Regional priorities for these resource products suggest the appropriate successional stage, or range condition class, that should be maintained through the judicious management of grazing animals. Movement away from this successional stage, whether toward potential natural vegetation or an earlier seral stage, therefore represents undesirable grazing management.

Two primary differences exist between the proposed definition for range condition and that suggested by Dyksterhuis in 1949. First, seral stages do not have intrinsic values of excellent, good, fair and poor. Maintenance of a mid seral stage is no longer termed fair range condition when it represents desired grazing management. Similarly, management is no longer penalized philosophically for not producing "excellent" range conditions where climax vegetation is not desired. Rather, management identifies an appropriate successional stage, and gauges success by whether grazing management maintains that desired successional stage.

Secondly, the recognition of potential natural rather than historic climax vegetation allows naturalized, or alien plant species to be evaluated equally. All plant species are rated in terms of their response to grazing management as decreasers, increasers or invaders. This equal, ecological footing for native and naturalized plants permits a more accurate assessment of grazing management success. Relating relative proportions of all species to potential natural vegetation also allows management to look forward towards its goals, rather than backwards towards historic climax, which often is not known explicitly, and in many situations may be impossible to reproduce.
Animal Production

Range condition, as defined by successional stage, represents only one of many potentially useful Resource Value Ratings. Moreover, range condition, although correlated with, does not invariably describe these other Resource Value Ratings. Among the most important of these Resource Value Ratings for animal production are those relating to forage quantity and quality.

These two resource attributes may be assessed by a variety of specific ratings, including herbage, browse, available forage, useable forage, net productivity, percent crude protein, protein per unit area, digestible energy, total digestible nutrients or availability of winter wildlife habitat. Obviously, the length of this list depends upon specific management needs and objectives.

These management needs relate to the information required to establish appropriate stocking and utilization rates, based upon desired output of domestic livestock and wildlife within a specific range condition classification. While trend in range condition refers to succession away from or toward potential natural vegetation, trend in Resource Value Ratings should be expressed as up, down, or not apparent (SRM 1982). This kind of expression for trend is essential, as trends in Resource Value Ratings for several uses on the same site may be in different directions, with no necessary correlation to trend in range condition.

Although Resource Value Ratings may be expressed as percentages relative to potential natural vegetation, absolute quantification of each resource value expected at each successional stage is likely more useful to resource managers. Animal production, stocking rates and desired utilization rates are all predicated on absolute information regarding forage quantity and quality, particularly as influenced by successional stage. Range condition can then either be altered or maintained, depending upon management objectives and grazing practices.
Ecological Classification

Range condition classification, as proposed, evaluates the proportion of plant species, for each range site, in relation to potential natural vegetation. As such, range condition is an ecological classification, relating plant succession to climatic potential, as influenced by variabilities in edaphic and site characteristics. The proposed definition differs from Dyksterhuis (1949) only by the recognition of introduced plant species, and by the omission of the qualitative terms excellent, good, fair and poor. In fact both of these changes represent improvements ecologically, as (1) ecological relationships exist, regardless of a plant's origin, and (2) plant succession occurs regardless of human interpretation for value. It is doubtful that plant species adapted to early seral stages would consider succession toward potential natural vegetation as an "excellent" occurrence.

The proposed definition of range condition can not be accommodated within ecological classifications based solely on climax communities, as such classifications do not provide information regarding proportion of plant species at seral stages of plant succession. However, the proposed definition is highly desirable from a range management perspective, which requires information regarding the impact of grazing animals on botanical composition at all stages of plant succession.

Value for grazing management is further enhanced when range condition classification is supplemented with resource value ratings such as forage production. Walmsley et al. (1980) indicated that ecosystem classification included "differentiating" characteristics, "accessory" characteristics, and "accidental" characteristics. These accidental characteristics are those ecosystem attributes which may not be associated consistently with differentiating characteristics, but which may be important for other purposes, such as management considerations. This last statement is philosophically identical to
the current proposals when range condition and resource values are substituted for differentiating and accidental characteristics respectively.

The classification system summarized by Hall (1980) provided a specific example of how resource values can complement more traditional approaches to ecological classification of vegetation. Hall (1980) recommended that some resource values such as forage production or timber regeneration potentials may become part of the classification system itself, particularly when differentiating plant community types. This approach ensures that interpretive information is included directly in the classification, thereby promoting future management utility. The current proposals to assess range condition separately from resource value ratings facilitates this management utility, irrespective of whether these ratings are supplemental to ecological classification (Walmsley et al. 1980), or are components of the classification system itself (Hall 1980).

Maintaining Range Health

Although terminology alone can not provide continued health of rangeland ecosystems, the current proposals do promote an improved assessment of range health attributes. Ecologically, range health is presumed to deteriorate with departures of range condition from climax. However, consideration of range health as additional examples of resource value ratings, separate from range condition classification, requires that important characteristics such as erosion, water quality, gullyng and soil compaction all be quantified. These resource values are extremely important relative to long term site productivity, and should not be presumed as necessarily identical with range condition. Rather, these range health resource values should be rated, depending upon management needs, in association with specific range condition classes.

Although many authors have considered range health as philosophically synonymous with range condition classification, such usage is inappropriate for
two primary reasons: (1) Range health imparts no specific, quantitative information in addition to range condition class, and (2) range health attributes such as erosion, water quality and site stability are not invariably linearly related to successional stage. Just as excellent, good, fair and poor are replaced by climax, late seral, mid seral and early seral condition classes, the generic term range health should be discarded in favor of more specific, quantitative assessments of long term site productivity.
APPLICATION IN BRITISH COLUMBIA

The current proposals for separate determination of range condition and associated resource value ratings offers ecological and managerial flexibility. This flexibility is particularly valuable in British Columbia, where a broad diversity of resource values and related management objectives can no longer be addressed with a rapid, simple, all-inclusive inventory assessment. Moreover, the proposed definition of range condition applies to all biogeoclimatic zones of British Columbia, regardless of relative dominance by indigenous or introduced herbaceous or woody plant species. The following discussions illustrate these comments.

Grassland Ecosystems

McLean and Holland (1958), van Ryswyk et al. (1966), McLean (1970) and McLean et al. (1971) all discussed climax grassland communities in relation to soil and climate. These discussions summarized natural plant communities at each respective research site, and thereby provide benchmarks by which ecologically similar grassland communities throughout the southern interior of British Columbia can be described. These benchmarks are useful for (1) recognition of corresponding climax plant communities, and (2) determination of successional stages within climax plant associations. Conceptually therefore, ecological descriptions of grasslands in British Columbia already display similarities to the proposal that range condition be assessed as early seral, mid seral, late seral and climax, as based on potential natural vegetation.

Only in those discussions dealing explicitly with animal grazing do the terms excellent, good, fair and poor appear (McLean and Marchand 1968, McLean and Tisdale 1972). These qualitative terms are intended to evaluate plant succession as influenced by grazing management. However, grazing influence can be measured, with equal accuracy with the terms early seral, mid seral, late
seral and climax. Therefore, retention of the qualitative terms provides no additional information, particularly as they already depend exclusively on successional stage. Omission of the qualitative terms (excellent, good, fair, poor) would not alter how the influence of grazing on plant succession is determined in British Columbia, but rather would alter only the terminology associated with that grazing influence. Procedurally therefore, assessment of range condition, as a measure of grazing management success, remains unchanged by the current proposals.

Similarly, the proposals for resource value ratings also complement current procedures in British Columbia. McLean and Marchand (1968) and McLean (1979) both provided stocking rates and forage productions associated with climax and grazing induced seral stages. These specific resource value ratings are applicable primarily to the Kamloops grasslands, but may easily be adjusted for application in other grassland regions of British Columbia.

The most salient observation, therefore, is that existing techniques and guidelines for range condition assessment in British Columbia grasslands already closely parallel the current recommendations. Impact of grazing assessment is based on successional stage, while pertinent resource value ratings are associated with each successional stage. Adoption of the current proposals for British Columbia grasslands therefore, requires only that current procedural techniques be developed, rather than altered. These techniques, based upon McLean and Marchand (1968), are applicable primarily to the grassland ecosystem associations of the Ponderosa Pine-Bunchgrass and Interior Douglas-fir biogeoclimatic zones.

Forestland Ecosystems

The proposed definition that range condition be considered "the present state of vegetation of a range site in relation to the potential natural plant community for that site" must be modified to be applicable in forestland
ecosystems. This modification is essential in order to assess range condition as a function of grazing management. Walmsley et al. (1980) correctly indicated that range condition assessment in forested ecosystems can not be achieved by comparing existing vegetation to the predicted climax stand. To assess range condition properly in forested ecosystems, two kinds of vegetation sequences must actually be identified. One sequence, seral stage, indicates natural forest succession. The second sequence, range condition within forest successional stages, indicates impact of grazing management. The term range condition should not reflect stage of forest succession, but should be used to indicate grazing induced status of herbaceous vegetation within stages of forest succession.

Even with this modification in the definition of range condition however, implementation in British Columbia forest ecosystems is still restricted by a lack of information regarding the relative impacts of crown closure and grazing management on herbaceous vegetation. Indeed, no range condition classification guidelines are currently available for forested ecosystems in British Columbia. Nonetheless, such guidelines for range condition assessment are available for the forest zones of eastern Oregon and Washington, with direct, conceptual applicability to the forests of British Columbia (Hall 1975 and 1978, USDA 1979, Hall 1980, Volland 1982).

First, range condition must be assessed within specific crown cover classes for each forested ecosystem associated within coniferous biogeoclimatic zones. For example, the USDA (1979) identified four range condition classes, based upon proportion of decreaser plant species, within each of three crown cover classes in mixed conifer/pinegrass sites in the Pacific Northwest. The impacts of grazing management on herbaceous vegetation could then be identified separately from natural forest succession.
Second, quantification of range condition as a function of grazing management must focus on those forage plant species most affected by grazing animals. Many forestland plant species respond more to forest succession than to grazing management, and should therefore be ignored when quantifying range condition. Moreover, forage species response to grazing in forested ecosystems will likely include 4 rather than 3 categories: decreasers, palatable increasers, unpalatable increasers and invaders (USDA 1979, Walmsley et al. 1980).

Range condition could then be determined by calculating the present proportion of desirable forage species relative to ungrazed stands beneath similar crown cover classes. Guidelines developed by the USDA (1979) included 3 crown cover classes for Douglas-fir: under 40%, 41-70% and over 70%. Only decreaser plant species are counted as contributing to desired range conditions, with specific classification also influenced by the vigor and number of decreasers per sample plot.

These recommendations for Washington and Oregon are useful as general guidelines for range condition assessment in forested ecosystems. Specific recommendations, however, should be adjusted to be more appropriate for British Columbia's forest ecosystems. For example, specific crown cover classes within which range condition should be quantified remain to be determined. Additionally, decreasers plus palatable increaser forage species may both be counted as contributing to range condition, while vigor may be considered as indicative of range trend rather than range condition.

Hall (1978) indicated that seral stage is not synonymous with grazing management success in forestland ecosystems. Forest seral stage represents a subjectively defined successional unit. Success or failure of grazing management is not equated rigidly with that seral stage, but rather is determined by whether grazing management is maintaining desired resource value ratings correlated with that seral stage and associated crown closure status.
Resource value ratings may include proportion of desirable forage plant species indicative of desired grazing management, levels of forage production, soil compaction, potential stocking rates, or any other resource values pertinent to local resource managers. Therefore, in a mature forest, successional stage may be climax, forage production may be low (Humphrey 1949), stocking rates may be low, and proportion of desirable, herbaceous plant species may indicate excellent grazing management. The only major difference between grassland and forestland grazing systems is that seral stage and associated grazing resource values are more closely related in the former.

This difference however, is one of degree rather than principle. Adoption of the current proposals for British Columbia forestlands therefore, requires only improved documentation of the relationships among seral stages, crown closure, herbaceous and woody understory, impacts of grazing animals and associated resource value ratings. These recommendations are appropriate for all forested ecosystem associations where livestock grazing occurs, including the Boreal White and Black Spruce, Engelmann Spruce-Subalpine Fir, Interior Cedar-Hemlock, Interior Douglas-fir, Ponderosa Pine-Bunchgrass, Spruce-Willow-Birch and Sub-boreal Spruce biogeoclimatic zones.

Clearcuts

Following clearcut logging, successional stage is classified as early seral. Other resource value ratings such as forage production and stocking rates may be quite high, particularly in relation to pre-logging values. As natural forest succession proceeds however, total forage production and animal stocking rates likely decline.

Grazing management success, as defined by the proportion of desirable forage plant species, may remain constant during all seral stages once the compounding factors of canopy cover have been removed from consideration.
Thus, clearcuts represent only a specific example of range condition assessment in forestland ecosystems. Conceptually however, clearcuts can be evaluated similarly to any other seral stage, even though artificially induced.

Alpine and Wetland Ecosystems

Very little direct information currently exists regarding range condition assessment of either alpine or wetland ecosystems in British Columbia. Selby (1980) provided qualitative interpretations of cattle grazing influences of alpine/subalpine communities of the southern Chilcotin Mountains, although detailed records of grazing use were not available for explicit conclusions. Morrison (1972) investigated food habits of cattle on subalpine grasslands in the Ashnola Region of southern British Columbia, but provided no recommendations regarding range condition classifications.

Recent wetland classifications proposed by Runka and Lewis (1981) and Moon and Selby (1983) both sought to provide information necessary to resolve potential resource use conflicts. Although each classification discussed management alternatives and implications, neither provided direct guidelines for range condition classes or assessment techniques suitable for wetlands. Similarly, no range assessment guidelines are available for wetlands in regions other than British Columbia. Although some information exists for alpine areas, these guidelines are inconclusive (Thilenius 1975), and certainly not directly applicable to British Columbia.

Implementation of the current recommendations is therefore restricted by a lack of direct information regarding the impacts of animal grazing in alpine and wetland ecosystems. Conceptually however, appropriate range condition assessment techniques for alpine and wetland range sites are consistent with those recommended for grassland and forestland ecosystems. Range condition classification must still identify the relationships among seral stages, forage
production, impacts of grazing animals and associated resource value ratings. Although these relationships often vary tremendously within small geographic areas in both alpine and wetland ecosystems, such habitat variability does not alter the successional foundation upon which range condition must be based.

Alpine and wetland ecosystems constitute an important grazing resource in many regions of British Columbia. For example, organic wetlands support more than 50% of the Animal Unit Months on Crown Range in the Chilcotin. Consequently, range condition guidelines must be developed to facilitate improved grazing management and desired levels of forage utilization on wetland and alpine grazing lands of British Columbia. Such guidelines should be developed at the ecosystem association level in those biogeoclimatic zones where grazing occurs in wetlands, and for those ecosystem associations where grazing occurs in the Alpine Tundra biogeoclimatic zone.

**Introduced Plant Species**

Smoliak et al. (1976) indicated that "the principles used in determining condition of rangeland do not apply to pastures seeded to introduced grasses and legumes; therefore, range condition cannot be determined." This statement is true if range condition is assessed relative to traditional methods proposed by Dyksterhuis (1989). However, the statement is not true if range condition is assessed by the current proposals, based upon potential natural vegetation.

Introduced plant species all display relative adaptation to differing stages of plant succession. Crested wheatgrass (*Agropyron desertorum*) may persist indefinitely in many arid zones of British Columbia, and therefore can be considered as a climax component of the potential natural vegetation. Alternatively, some varieties of alfalfa (*Medicago sativa*) may not be as well adapted to these same zones, and therefore should be considered as negligible components of the climax potential natural vegetation.
The implications of this perspective are quite obvious. Seral stage, or range condition, of grassland ecosystems can be evaluated regardless of native or introduced plant species. Similarly, other resource values can also be evaluated, regardless of native or introduced plant species. Indeed, a primary reason for seeding introduced plant species is to increase such resource values, particularly forage production and stocking rates. These introduced plant species may merely complement existing resource value ratings of native plant species within a successional stage, or they may completely substitute for resource values of these native plant species within similar or altered successional stages of potential natural vegetation.

Even though range condition can be evaluated with introduced plant species, there is no imperative to do so in all cases. In the situation described by Smoliak et al. (1976) range condition may not be of any managerial or ecological interest. The seeded pasture may be managed purely for forage production, with little concern for successional stage. Consequently, only resource value ratings such as forage production and associated animal unit months may be quantified.

Clearcuts seeded to domestic forage species provide a similar example. Grazing management may intend to utilize completely the newly created forage resource, with correspondingly reduced concern for range condition within stages of advancing forest succession. Range condition quantification may therefore be ignored. Alternatively, other resource values such as forage production, soil compaction or coniferous tree regeneration may be of greater importance.

These examples illustrate that introduced plant species can be treated as ecological equivalents to native plant species relative to range condition classification and associated resource value ratings. Which of these particular parameters are assessed on a site-specific basis depends upon management objectives and needs, regardless of whether plant species are native or introduced.
RECOMMENDATIONS FOR IMPLEMENTATION IN BRITISH COLUMBIA

Appropriate strategies for development and implementation of a range condition and trend classification system in British Columbia should consider the following criteria: (1) Priority should be given to developing range condition guidelines for forested ecosystems, (2) Range condition guidelines should be developed at the ecosystem association level within biogeoclimatic zones, (3) Range condition guidelines should document seral stages within each ecosystem association, (4) Range condition guidelines in forested ecosystems must distinguish between the separate influences of grazing activities and forest succession, particularly in relation to crown cover class, (5) Range condition guidelines should document the relationships among seral stage, forage production and appropriate stocking rates, particularly within forested ecosystems, and (6) Range condition guidelines must be specific for animal species, as each grazing animal exerts differing impacts on vegetation.

Efficient implementation of these recommendations for range condition assessment in British Columbia requires coordination among resource management agencies and cooperation of resource management personnel. This cooperation can be achieved only with mutual support for data collection parameters, procedures and objectives. The following sections discuss appropriate sample parameters, sampling procedures, research programs and extension activities proposed to attain this mutual support.

Appropriate Measurement Parameters

Wilson and Tupper (1982) provided an excellent summary regarding the appropriate parameters by which to measure range condition. A basic premise of their review is that range condition must be measured in terms of vegetation, as "a change in vegetation is the first symptom of a change in condition....and is the primary factor which leads to a change in other attributes such as erosion and reduced secondary productivity".
As each unit of measure emphasizes different characteristics of the vegetation, appropriate floristic and ecological parameters must be chosen with reference to specific range inventory and condition assessment objectives. For example, species frequency may be the most appropriate measure for assessing the presence of rare species, while forage production and species composition may be more appropriate for determining suitable stocking rates and impact of grazing animals (Wilson and Tupper 1982).

The choice of suitable units of measure must relate not only to these ecological relationships, but also to the needs of local resource management personnel. These needs have already been summarized, and relate specifically to (1) development of clear, consistent definitions of range condition, and (2) requirements for information necessary to practice good range management. This information must be useful at the operational level and consists primarily of impact of grazing animals on production and botanical composition of forage plants, particularly in forested ecosystems.

The preceding discussions indicate that consistent definitions of range condition require separation of indices relating to plant succession and associated resource value ratings. The proposed definition for range condition identifies seral stage based upon the kinds, proportions and amounts of plants in a community relative to the potential natural vegetation. Therefore, the range condition assessment program must document, as a minimum requirement, relative percent composition and total biomass contribution of these plant species within each successional stage.

These two parameters satisfy many immediate needs of resource management personnel including ecological descriptions (kinds of plant species), a measure of grazing management success (seral stage in grasslands; proportion of decreasers, increasers and invaders of herbaceous understory in forestlands), plus a foundation for establishment of animal stocking rates and appropriate utilization rates (biomass of preferred plant species).
Many forest districts throughout British Columbia rely upon utilization estimates of preferred plant species to assess the validity of existing stocking rates. Therefore, measures of biomass contribution of those forage species within each seral stage are necessary to refine and complement existing management practices. Demarchi and Harcombe (1982) recommended that forage production be rated at a minimum of 2 stages of forest succession: (1) following tree removal by fire or logging, coincident with maximum forage production, and (2) at rotation age, or maturity of the forest stand. To provide additional information regarding forage availability, Demarchi and Harcombe (1982) further suggested that forage production potential be rated at all stages of forest succession.

The two parameters of percent composition and biomass of plant species within successional stages represent minimum requirements for range condition inventory programs in British Columbia. Other pertinent resource value ratings may include soil stability, potential erosion, winter wildlife habitat, and opportunity for coniferous tree regeneration. Which resource value ratings, and therefore which additional floristic and ecological parameters should be quantified in the inventory program, depends upon government policy, regional management objectives, plus availability of funds and personnel. Vigor of preferred, decreaser forage species should also be recorded at each sample plot so that trend in range condition can be assessed.

Sampling for Range Condition and Resource Value Ratings

Sampling procedures and data analysis for seral stage, forage production and other pertinent resource value ratings should be consistent with the constraints and objectives of current classification and rangeland inventory programs. It would be both redundant and economically inefficient for this document to encourage a new, separate sampling scheme specifically and exclusively for range condition assessment. Nonetheless, the following discus-
sion summarizes criteria that should be considered within current and future rangeland sampling programs.

Accuracy and Precision

McQuisten and Gebhart (1983) reviewed the importance of inventory data relative to the decision making process in resource management. These authors stressed, that although inventory data can be quite useful, they can also be misleading, depending upon how the data are generated and interpreted. For example, data can be inaccurate and imprecise, having both random and systematic errors; they can be precise but inaccurate, having systematic errors; and they can be both accurate and precise having neither random nor systematic errors.

If land management decisions are to be based upon these inventory data, then decision makers must be provided with an explicit level of statistical confidence in the reliability associated with the data. Without such confidence and reliability, the data may very likely be misinterpreted, or may be ascribed greater weight in the decision making process than actually warranted.

Theoretically, inventory data can be both accurate and precise. However, this theoretical ideal is seldom possible for extensive inventory programs. Therefore, it is necessary to define an acceptable level of confidence in the data. McQuisten and Gebhart (1983) suggested that 95% confidence is required for litigation purposes, while 85% is suitable for land management decisions. Reports based on data with 75% confidence should contain qualifications, while information providing less than 75% confidence is either discarded or used for general information only.

Although appropriate levels of confidence may differ from those suggested by McQuisten and Gebhart (1983), their request for stated levels of accuracy,
precision and confidence for inventory data should be heeded. Land managers, in our increasingly technical society, "must be assured of credibility and integrity of the number generated for the decision making process" (McQuisten and Gebhart 1983).

Sampling precision and accuracy are direct functions of sampling intensity and population variability. Because inventory samples usually display high variability, high precision is usually extremely costly. Based upon this cost of sampling plus the risk of an incorrect interpretation of data, Eckert (IN: SRM 1980) recommended that a precision of ±20% about the mean with a probability of 80% is acceptable for most range condition inventory techniques. For example, a decrease in precision and probability from ±10% at 95%, to ±20% at 95%, to ±20% at 90%, to ±20% at 80% reduced the number of plots needed to sample density of bluebunch wheatgrass from 174, to 44, to 29 to 18 plots respectively.

Range condition is based upon four condition classes, climax, late seral, mid seral and early seral. Therefore each class must have a confidence interval of only ±12.5 percent. For example, if the climax stage contains greater than 75-100% of the potential natural vegetation, then the mean of 87.5 must be estimated within 12.5 percent at the desired level of probability. Hall (pers. comm.) indicates that community types which represent greater than 5% of the land area usually require 10 or more estimates of range condition to classify correctly within one of four condition classes.

Although a statistical measure of sampling precision is very desirable, it is rarely feasible for all sampled parameters at each sample location. Feasibility depends not only on sample variability, but also on management objectives within the constraints of time and budgets. General suggestions regarding appropriate sample accuracy and precision therefore have minimal value for particular management units from one inventory sequence to the next. In order to reduce
the chance of reaching incorrect or inappropriate conclusions from range inventory data however, each sampled parameter must have an estimate of variability and stated confidence interval associated with that estimate.

Accuracy relates not only to statistical objectives, but also to collecting data which do indeed provide the desired information, free from other potentially confounding factors. Range condition refers to changes in vegetation induced by grazing, which are separate from variation arising from season and amount of rainfall, and changes in cover and biomass resulting from recent livestock utilization. Similarly, total forage production also varies tremendously, both annually and seasonally within a single growing season. Sampling programs must therefore be structured so that these confounding sources of variability can be distinguished.

Accuracy and precision are most often compromised in rangeland inventory programs because of the requirements for assessment over wide areas of land in a minimum amount of time. Wilson and Tupper (1982) therefore recommended that inventory programs should incorporate both measurement and estimation of the sample parameters. For example, Anderson and Kothmann (1982) determined standing crop of herbaceous vegetation by first estimating foliar cover per unit area, and then obtaining a regression between foliar cover and harvested standing crop. This method permitted rapid estimates of standing crop (forage production) while minimizing the time spent on actual harvesting. Moreover, standing crop of both major and minor forage species was estimated adequately without over sampling major species or under sampling minor species (Anderson and Kothmann 1982).

This double sampling approach utilizes visual estimates from extensive surveys, which are then calibrated and refined with periodic, rigorous measurement. These visual estimates of sample parameters, however, must still retain verified indices of accuracy and precision in order to optimize managerial utility (Anderson and Kothmann 1982).
Lamacraft (1978) indicated that lack of equal precision and accuracy among several observers providing visual estimates results from four primary reasons: (1) heterogeneity of variance within observer, (2) observer bias, (3) non-linearity of estimates within observer, and (4) unstable calibration, where observer accuracy varies with factors such as fatigue or inexperience in new geographic locations. Consequently, observers must be well trained and repeatedly spot-checked to ensure that double sampling techniques will provide useful, managerial information (Lamacraft 1978). Rangeland inventory in British Columbia currently utilizes such double sampling techniques for estimates of forage production, and should therefore take care to ensure that inventory personnel receive adequate training.

Accuracy and precision are also influenced by the sampling and assessment techniques utilized to collect information. Hacker (1979) showed that indices of range condition based upon Dyksterhuis (1949) varied with each of eight alternative indices chosen to measure vegetative change. One must therefore select carefully among the various techniques proposed to assess range condition, including the Parker loop (Parker 1951, 1954a, 1954b) macro plots (Poulton and Tisdale 1961), rated microplots (Morris 1973) line intercept (Hyder and Sneva 1960), discriminant analysis (Jameson et al. 1970) and points (Clarke et al. 1942).

Eckert (IN: SRM 1982) reviewed this literature, and concluded that cover or density measurement techniques are not appropriate for extensive monitoring programs for range trend. This conclusion related to the sampling intensity required to obtain the statistical reliability needed to detect changes in vegetation over time. Eckert (IN: SRM 1982) reported his belief that sampling intensity to achieve accuracy within 10% of the true value with a 95% level of confidence would be beyond the funding commitments of most resource management agencies. This problem of statistical unreliability would be further intensified if relatively untrained seasonal employees participated in the data collection process.
Of range trend assessment techniques currently in use, Eckert (IN: SRM 1982) believed frequency of occurrence to be the only methods that combined the "simplicity, objectivity, statistical reliability and cost characteristics required of an extensive monitoring program". The frequency technique utilized most commonly for assessment of rangelands is the 3/4" (1.9 cm) loop, first recommended by Parker (1951). Sharp (1954) evaluated this technique in the shrublands of southern Idaho, and found close agreement in vegetation measurements among 3 different observers. Moreover, Reppert and Francis (1973) outlined procedural rules for interpreting trends in range condition based upon the Parker loop, and concluded that this technique provided statistically reliable information, when utilized by experienced field personnel.

In contrast however, Hutchings and Holmgren (1959) reported that the 3/4" (1.9 cm) loop method overestimated plant cover for species with diameters less than 6 times loop diameter, and also provided trend information for mountain brome (Bromus carinatus) opposite to actual changes in basal area as determined by pantographic data recorded on quadrat charts. Morris (1973) recommended that loop frequency data could be improved with rated microplots, either circular or rectangular, which included estimates of plant cover within the plot.

Hironaka (pers. comm.) indicates that federal agencies in the United States are currently adopting frequency plot methods to monitor vegetational change, as "no other single methodology appears to have the objectivity, speed and statistical sensitivity to detect vegetational change". Nonetheless, Eckert (IN: SRM 1982) noted that frequency data may not be appropriate in all vegetation types, and recommended that each vegetation type should be evaluated with methods that best provided statistical reliability at accepted standards.

Eckert (IN: SRM 1982) also recommended that range condition may be determined better by the relative composition, by weight, of each plant species, as this method provided statistical consistency and repeatability of data. If
these production data are to be used in conjunction with visual estimates of forage production in a double sampling program, then the sampling design must provide data at a specific, acceptable level of accuracy and precision. If this statistical confidence is not provided, then the data can not be utilized for prediction and extrapolation of forage production on unsampled range sites. Such prediction equations for forage production also require that yield estimates and measurements be adjusted for phenology, current utilization and annual variability in weather patterns.

Note that Eckert (IN: SRM 1982) proposed different measurement units for range condition and range trend. Although condition and trend are customarily associated with each other, Hall (1970) stressed that the two terms are certainly quite distinct. Trend is a measurement of vegetation change on the same site over time, while range condition is assessed by comparing current vegetation to condition guidelines based upon information averaged from several sites considered to be representative. Consequently, range condition and range trend are quite likely to be measured best by different parameters. Moreover, appropriate sampling techniques for range condition and range trend may also differ. For example, if comparisons of measured changes in vegetation over time are to be valid statistically, range trend requires sampling precision. In contrast, range condition, based upon an estimate of assumed potential natural vegetation, may not require the same degree of sample precision (Hall 1970).

The most appropriate sampling methods for assessing range condition, range trend and forage production in British Columbia should be determined after a thorough review of existing literature, supplemented with pertinent field research. The final choice should be based upon the reliability of those methods relative to cost, plus stated, prescribed levels of accuracy, precision and levels of confidence associated with the data resulting from the inventory program.
Information Priorities

Priorities regarding the kinds of information needed, how it should be collected and where it should be collected depend upon a variety of criteria, including statistical requirements, management objectives, available funding and government policies. It is beyond the scope of this paper to address all of these criteria, particularly those relating to funding, government policies, and the immediate or long term objectives of regional and district resource managers. Nonetheless, range condition and inventory programs in British Columbia must document relative percent composition and total biomass contribution of plant species within seral stages in grassland ecosystems, and within grazing induced vegetation changes of understory vegetation in forest ecosystems.

Priorities regarding additional information (resource value ratings) which should be collected during rangeland inventory programs may vary among forest districts and biogeoclimatic zones. The rangeland inventory program should assess these priorities carefully to identify the information needs shared most commonly throughout the grazing lands of British Columbia. Presumably all forest districts and biogeoclimatic zones where grazing occurs will benefit equally from the rangeland inventory program. The rangeland inventory program should therefore allocate its efforts equally among these forest districts and biogeoclimatic zones to provide a broadly-based managerial and informational return to the inventory dollar.

Relationship to Ecological Classification

Ecological classification in British Columbia (Walmsley et al. 1980) addresses some of the current proposals regarding range condition assessment and associated resource value ratings. Kinds of plant species are recorded at each plot, including percent crown cover, plus available, above-ground forage production on selected plots. Additional associated information includes vigor, for
indication of range trend (SRM 1982), plus utilization, which permits assessment of current stocking levels prior to undesirable changes in range condition (seral stage).

Nonetheless, gaps and ambiguities do exist between the current proposals and ecological classification (Walmsley et al. 1980). First, classification of plants as decreasers, increasers and invaders is misleading if applied to all grazing animals. Coding sheets must therefore indicate specifically the grazing animal relative to which plants are classified as decreasers, increasers and invaders.

Second, range condition is not documented on forest grazing lands. As suggested in the current proposals, both seral stage and range condition should be assessed in forest ecosystems. Ecological classification presently collects information applicable to seral stage, but omits descriptions of decreasers, increasers and invaders, which are necessary to assess grazing management success.

Third, classification currently locates sample plots in climax or near-climax ecosystems. Transitional or disturbed sites are avoided (Pojar 1983). Such location of sample sites reduces documentation of resource values such as forage production associated with range condition classes (seral stage). This omission is particularly important on forest grazing lands where forage production and range condition must both be determined within each stage of forest succession.

Hall (1970) concluded that range condition guides based upon modal, or typical climax community groups, are generally inappropriate because true site potential varies considerably within plant associations. Indeed, several successional sequences are possible within a single climax community, depending upon the nature of disturbance such as logging, or overutilization by cattle or deer.
Hall (1970) found range condition guidelines which excluded transitional plant communities were unable to rate condition suitably for approximately 2/3 of the land area in Oregon's Blue Mountains. Such problems intensified when condition guidelines were based upon a limited geographic region, and resulted from a lack of information regarding environmental variability.

Stevenson (1982) reviewed ecosystem classification in British Columbia, and similarly concluded that descriptions of climax vegetation only are insufficient to meet the needs of wildlife resource managers. Optimal management of forage, whether for livestock or wildlife, requires a classification system which also includes successional stages. Such a system permits, "the prediction of the floristic and structural characteristics of seral stages after forest management activities" (Stevenson 1982). These floristic predictions are also essential to quantify accurately range condition and forage production within each stage of forest and grassland succession.

Finally, selective location of sample plots precludes quantitative estimates of variability required to determine the upper and lower bounds of forage production and percent composition of plant species associated with each range condition class. This variability is essential also for providing stated levels of accuracy and precision, which are needed for expressions of confidence in inventory data.

Walmsley et al. (1980) summarized future objective of ecological classification in British Columbia, including (1) identification of successional stages of ecosystems, (2) evaluation of productivity of climax and successional stages, and (3) the degree of animal use required to maintain or improve productivity within successional stages. Such objectives address the needs of range condition classification, and should be pursued.
Research Needs

Some research is necessary if the proposed recommendations for range condition assessment are to be implemented on grazing lands throughout British Columbia. All of this research pursues applied objectives, and relates to documentation of the relationships among plant succession, range condition assessment and associated resource value ratings. The order of the following list does not imply priority, but merely summarizes information needs, as identified in earlier sections.

1) There is a need to develop range condition guidelines applicable to all grassland regions of British Columbia. This guideline should describe seral stage, forage production and appropriate stocking rates for each major grassland region. The guideline would likely be similar to those for Alberta, which present the above information for major rainfall zones of Alberta. The proposed guideline is similar conceptually to the work of McLean and Marchand (1968), but would also include information specific to grasslands of the East Kootenay, Okanagan, Similkameen, Chilcotin and Peace River regions of British Columbia.

2) There is a need to develop range condition guidelines applicable to forest ecosystems of British Columbia. Similar to the grassland, these guidelines should describe seral stage, forage production and appropriate stocking rates for different ecosystem associations in each forest zone used extensively for grazing of domestic livestock.

3) In addition to these parameters, there is also a need to document successional sequences of herbaceous understory vegetation in response to grazing animals within each stage of forest succession. This is essential for range condition to be retained as a measure of grazing management success, as separate from natural forest succession.
4) These range condition guidelines for forested zones will require much improved identification of decreaser, increaser and invader herbaceous plant species. This documentation must occur in all forest biogeoclimatic zones where grazing by livestock constitutes a significant resource use.

5) There is a need to identify forage and habitat preferences for each managerially important grazing animal. As each grazing animal displays unique forage preferences, range condition based upon decreaser, increaser and invader plant species is necessarily animal specific. Similarly, habitat values for animal species must be related to habitat needs of each animal species. Any specific grassland or forest successional stage provides varying resource values for wildlife and domestic livestock. Neither seral nor climax stages are inherently more valuable for all animal species.

6) There is a need to develop quantifiable relationships among successional stages, forage production, and appropriate animal stocking rates in both grassland and forestland ecosystems. These relationships will permit resource management personnel to make decisions based upon anticipated benefits and costs of alternative management opportunities. Such relationships develop the science aspect of range management, which too often still relies primarily upon the experiential, artistic abilities of range managers.

7) There is a need to determine the most appropriate sampling technique(s) to assess range condition and trend relative to cost plus stated levels of accuracy and precision.

Extension Needs

In 1951, Ellison et al. wrote that in order to judge condition and trend accurately, range managers have three basic needs. First, a technical foundation
of ecological principles; second, an understanding of condition and trend as they relate to management objectives; and third, a knowledge of the meanings and limitations of the indicators of range condition and trend. If these common needs are not satisfied, uniformity among resource professionals regarding range condition assessment techniques will likely remain elusively unattainable (Costello 1956).

Although approximately 30 years have passed, the warnings of Costello (1956) and Ellison et al. (1951) remain timely and cogent. Perceptions of resource managers in British Columbia represent a variety of backgrounds in ecological foundation, agency objectives and field experience. Nonetheless, a consensus does exist for a desire in uniformity and consistency regarding range condition assessment.

Extension activities should therefore capitalize on this consensus. Most resource management personnel in British Columbia possess an adequate background in ecological principles. Consequently extension should emphasize the current recommendations in relation to management objectives. Without such an emphasis, which illustrates immediate, applied utility to resource managers, probability of successful implementation will be reduced severely.

To facilitate acceptance of the recommendations, all branches of government involved in rangeland resource management and measurement must participate, with leadership provided by the Ministry of Forests, Range Management Branch. With good preparation and organization, extension activities should require no more than two days in each region, on a recurrent basis. The first day should summarize the objectives and techniques of range condition classification, while the second should illustrate these objectives and techniques in the field. With concise presentation, clearly related to management needs, acceptance by receptive field personnel can be attained relatively quickly. Concern of these field personnel regarding range condition classification revolves more around inconsistent application and interpretation, rather than philosophical alliance with mutually exclusive objectives and procedures.
SUMMARY

Detailed summaries are contained throughout the text for convenient reference regarding specific topics. The following list summarizes the most important conclusions, particularly in relation to the Problem Analysis terms of reference.

1) Range condition has been defined traditionally either with successional or forage production criteria, thereby producing inconsistent application and interpretation of range condition terminology and assessment techniques.

2) Successionally-based range condition classifications are useful primarily for assessing grazing management success at manipulating and controlling plant succession.

3) Successionally-based range condition classifications are related to, but not necessarily direct assessments of forage production, plant density and vigor, forage quality, forage utilization, appropriate stocking rates, livestock and wildlife production, and ecological health.

4) The qualitative terms excellent, good, fair and poor range condition are philosophically misleading when grazing management purposefully seeks higher resource value ratings associated with seral stages of plant succession.

5) In grassland and forested ecosystems, alien plant species, whether introduced accidentally or purposefully, can still be classified according to the way in which they respond to grazing animals.

6) Each kind of grazing animal displays inherent forage preferences. Therefore, the terms decreaser, increaser and invader plant species should always be used in conjunction with a specific grazing animal.
7) Range condition should express the relative degree to which the kinds, proportions and amounts of plants in a community resemble that of the potential natural plant community. Condition classes should be four in number, termed early seral, mid seral, late seral and climax.

8) Range condition assessment guidelines for British Columbia are available for grasslands, but are virtually non-existent for wetland, alpine and forested grazing lands.

9) Range condition classification on forest grazing lands must distinguish between the separate influences of natural forest succession and vegetation changes produced by grazing animals. This separation permits range condition to be used as a measure of grazing management success in forested ecosystems.

10) Resource value ratings should be identified for each range condition class, depending upon management objectives, needs and constraints.

11) Range health, as a generic term, should be discarded in favor of more specific, quantitative assessments of long term site productivity.

12) Range condition and associated resource value ratings may be determined for any seral stage, including areas recovering from clearcut logging.

13) Introduced plant species are considered components of potential natural vegetation, and may therefore be incorporated directly into range condition classification and associated resource value ratings.

14) Relative percent composition and total biomass contribution of forage plant species provide essential information relative to range condition and forage production. These parameters are required to assess success of
grazing management, and to determine appropriate stocking and utilization rates.

15) Ecological classification in British Columbia addresses many of the current proposals regarding range condition and resource value ratings. However, ecological classification can address these proposals better by a) assessing range condition and forage production in seral as well as climax stages, b) assessing range condition and forage production on forested grazing lands, and c) sampling for variability in species composition and forage production associated with each range condition class.

16) Appropriate sampling methods for assessing range condition, forage production and associated resource value ratings should be determined relative to prescribed levels of accuracy, precision and confidence associated with these inventory data.

17) Research should develop quantifiable relationships among range condition, forage production and animal stocking rates for major grassland regions of British Columbia. On forested grazing lands, these relationships should be quantified for grazing induced changes on herbaceous vegetation within each stage of forest succession.

18) Extension and training activities should emphasize the relationship of range condition classification to management objectives. Resource management personnel seek consistent guidelines, that are presented best in short field sessions which illustrate immediate application and utility.
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APPENDIX A

The Problem Analysis Steering Committee, which provided guidance and editorial review of this problem analysis, consisted of Mr. Don Blumenauer (Ministry of Agriculture and Food), Mr. Tom Lester (Ministry of Forests, Range Management Branch), Dr. Alastair McLean (Agriculture Canada) and Mr. Brian Wikeem (Ministry of Forests, Research Branch). The Problem Analysis Steering Committee consulted with the following people to identify the terms of reference: Dr. Ted Baker (Ministry of Forests, Research Branch), Mr. Alf Bawtree (Ministry of Agriculture and Food), Mr. Dwaine Brooke (Ministry of Forests, Range Resource Officer), Dr. Jim Dangerfield, (Ministry of Forests, Research Branch), Ms. Evelyn Hamilton (Ministry of Forests, Research Branch), Dr. Earl Jenson (Ministry of Forests, Range Management Branch), Mr. Bill McLachlan (Ministry of Forests, Range Management Branch), Mr. Del Meidinger (Ministry of Forests, Research Branch), Mr. Bob Mitchell (Ministry of Forests, Research Branch), Dr. R.V. Quenet (Ministry of Forests, Inventory Branch), Mrs. Sonya Quesnel (Ministry of Forests, Inventory Branch), Mr. Brian Radford (Ministry of Forests, Range Resource Officer), Mr. Lyle Resh (Ministry of Forests, Range Resource Officer), Mr. Rick Tucker (Ministry of Forests, Range Resource Officer), Mr. Tom Wallace (Ministry of Forests, Range Resource Officer), Mr. Walter Wiebe (Ministry of Agriculture and Food).
APPENDIX B

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APPENDIX C

GLOSSARY

Accessory Characteristics

Those attributes that are consistently associated with differentiating characteristics. Accessory characteristics are sometimes used in identifying classes when they can be observed and the differentiating characteristics can not.

Accidental Characteristics

Those attributes not consistently associated with the differentiating characteristics, but may be important for some purposes.

Climax

The state of a biotic community that is attained when population structures of all its species fluctuate rather than exhibit unidirectional change. Such a community will remain in a self-perpetuating state so long as present climatic, edaphic and biotic conditions continue.

Congeliterbation

The churning or heaving of soil by freezing and thawing.

Cryopedogenic

Caused by or associated with permanently frozen ground or intensive frost action.
Differentiating Characteristics

Those ecosystem, soil or vegetation characteristics that are selected to distinguish or set apart classes. They should have as many accessory characteristics as possible.

Potential Natural Vegetation

That biotic community which would become established if all successional sequences were completed without human interference under present environmental conditions. Potential natural vegetation (PNV) differs from traditional definitions of climax in that PNV reflects the end point of plant succession based upon current rather than historic floristic, edaphic and climatic conditions.

Range Site

A kind of rangeland, with a specific plant association and specific physical site characteristics, differing from other kinds of rangeland in its ability to produce vegetation and to respond to management.

Resource Value Rating

The present production or value of given goods or services from a range site compared to its production or value in the climax state. It may be expressed in absolute terms, or as a percentage of climax. Synonomous with Resource Production Rating (SRM 1982).

Stocking Rate

The number of specified kinds and classes of animals grazing or utilizing a unit of land for a specific period of time.
Succession

Unidirectional change that results in the partial or complete replacement of one plant community by another.

Utilization

The proportion of the current year's growth or production that is removed by grazing animals.