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Rangeland Assessment

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ABSTRACT

This public rangeland/livestock grazing assessment includes a post-1905 history of livestock use on 10 National Forests of the Sierra Nevada and Modoc Plateau, a compilation of plant species indicators of livestock grazing effects, an assessment of grazing effects on sagebrush-steppe and mountain meadow rangelands, and a case study on correlation of meadow and riparian conditions in the Sierra Nevada.

While this assessment spans 5 decades of monitoring, it is important to recognize that although substantial reductions in livestock grazing intensity have occurred, most ranges were stocked above carrying capacity until very recently. A key indicator of improved condition that we have observed is an increase in native perennial grass composition on some upland sagebrush-steppe rangelands. A key indicator of declining condition is the continued cheatgrass invasion of many uplands. Based on the historical evidence of abuse of California mountain meadows during the post-Gold Rush Era, the recolonization by native plants, low abundance of non-native weeds, and the soil protection being provided by herbaceous vegetation as indicated by 4-5 decades of range monitoring data is significant. Considering past heavy grazing in northeastern California, the eastern Sierra in the Carson City and Tahoe environs, and lands of the Mother Lode nearest Sacramento, it is not surprising that the Modoc, Plumas, Tahoe, Eldorado and Toiyabe Forests are continuing to lag a bit in recovery since their meadows were probably most impacted during the early days following settlement. The declining abundance of grass species on mountain meadows of the Sierra National Forest and the low abundance of grass species on mountain meadows of the Sequoia National Forest during the 4-5 decade monitoring period is a biodiversity concern.

In a case study we investigated the potential for using long-term condition and trend monitoring data to indicate nearby riparian stream functionality. Using aggregated Parker transect data to the genus level, the lifeform categories of grasses, legumes, sedges, rushes, and forbs, and the raw data of bare soil exposure, litter and non-native species present currently and over the last 5 decades, we were able to predict 11-12 of 13 functioning-at-risk riparian/stream trend directions correctly. As used in the assessments developed here, variable dynamics indicating sedge to grass ratio changes without compensation of rushes, invasion or retreat of weedy forbs, reductions in abundance of late seral grasses such as <u>Deschampsia</u> and <u>Glyceria</u> species, radical fluctuation in clover composition, and 'red-flag' indicators like more than 7-10% bare soil exposure sometime in the meadow's 40-50 year history, were adequate to make the predictions.

Keywords: forage, grasses and grasslands, history, livestock, meadows, rangelands, riparian vegetation, communities, grazing, livestock management, range management, restoration, indicator plant species

INTRODUCTION

Rangeland ecosystem assessment includes bio-physical, ecological, managerial, and socio-economic components. As livestock grazing animals gather forage from the range vegetation, plant species are differentially affected depending on the season and the intensity of grazing, and the frequency of repeated grazing events. When plant species are differentially affected the plant community species composition changes. As the animals move from place to place they trample soils, redistribute nutrients and seeds, and modify vegetation fuel loading levels thereby affecting other processes such as forage productivity, wildfire intensity or even potential for fire occurrence, and wildlife habitat values.

Livestock and range managers have opportunities to use animal herding practices, water developments, fencing, scientifically-designed grazing systems, and many other approaches to enhance forage productivity, wildlife habitat and water quality, and reduce many of the possible negative or potentially non-sustainable grazing effects. Some members of the public have come to expect more products, watershed and aesthetic values from rangelands or at least less visible resource degradation. Therefore more cooperation between ranchers using the public land and agency land managers will be required to alleviate these problems where possible with reasonable effort. Cooperation here refers to ranchers and agency managers doing their best to understand undesirable grazing impacts and jointly having a commitment to stopping them wherever feasible. It does not mean a continuation of trust with no penalties for poor performance on either side.

Implementation of sustainable stewardship programs takes time, costs money and must have an educational component. It takes a commitment to collect and use existing knowledge. Unlike many problems facing society, adequate knowledge and skills exist to assess rangeland site specific problems and prescribe solutions. However, local land managers and rancher permittees may not possess the necessary information to make sustainable rangeland management decisions. The key point is that they must acquire this information and then cooperate as defined above. We feel there is a major realignment of responsibility needed in agencies and Land Grant Universities to develop, extend and use new or newly acquired but applicable old information. Within land management agencies this is a call for coordination between those closest to the ground with their place-based knowledge and those higher up in the bureaucracy with their systems-based knowledge.

Unlike other resource uses of public lands, rancher permittees annually use designated grazing allotments as part of their business enterprises under 10-year renewable grazing permits. These contractual arrangements have existed for many decades in most cases, and unlike timber sales or mining claims they are not expected to end or be periodic unless non-sustainable resource impacts occur that cannot be managed. Since the determination of non-sustainability is difficult where a use causes small but cumulative degradative effects over many years, it behooves both parties to use many sensitive indicators of problems to alleviate them before they become irreversible impacts. The purpose of this rangeland assessment is to determine whether, where, how and why non-sustainable ecological impacts are occurring. There is a further temporal aspect to this assessment, that is, if non-sustainable impacts have occurred, when did they occur or are they on-going?

We know that the Sierra Nevada and Modoc Plateau rangelands were abusively grazed and impacted by non-sustainable livestock grazing prior to 1905 (Kinney's report on past conditions of rangelands in another Sierra Nevada Ecosystem Project report). Later in this assessment we review the post-1905 grazing history of Sierra Nevada and Modoc Plateau rangelands since the establishment of public land management agencies; much overgrazing has occurred since 1905 as well. Knowledge needed to judge what is sustainable rangeland management has increased greatly over the past 50 years and especially over the last 20 years. The guidelines or standards by which managers should judge sustainability of range management activities are relatively well understood.

Beginning on the eastern edge of the Sacramento and San Joaquin valleys, low elevation Sierra foothill annual grasslands, blue oak/foothill pine savannas, and interior liveoak/blue oak woodlands, which are largely in private ownership, produce forages utilized by livestock and many wildlife animals. These areas are also where some of the most rapidly developing housing subdivisions in the state of California continue to occur. Where available, fall and spring acorn mast and browse forage production from oak trees and shrubs complement diets of herbivores. As nutritional quality of annual herbaceous forages from grasses and forbs decline in late spring each year, migratory wildlife animals and livestock benefit from moving up in elevation, using forage plants with later phenological development, typically on public lands.

Grazing permits on public and private mountain rangeland provide high protein, green forage during summer that is critical to the seasonal forage supply for rancher permittees. Recreational pack-and-saddle stock also use high elevation subalpine and alpine meadow and riparian areas in summer. In fall, big game hunters, often with pack animals, use mountain rangelands to harvest mule deer, black bear, and limited numbers of bighorn sheep. High-elevation summer range is critical habitat for these game species and other wildlife, especially for mule deer rearing young on nutritious foods in close proximity to riparian vegetation which provides fawn hiding cover from predators and humans.

The status of blue oak/foothill pine savannas and blue oak/interior liveoak woodlands is assessed in a separate report (by Standiford in this Sierra Nevada Ecosystem Project document). For nearly 10 years resource managers, scientists and the public have been concerned about inadequate oak tree regeneration in this foothill region of the Sierra. Unhealthy age-class structures, indicated by poor recruitment of seedlings, have been well studied. The combination of mortality factors including land development, fuelwood cutting, livestock grazing, competition from exotic annual grasses for soil water, fire, and other causes have led to many concerns. Much progress has been made in management policies to maintain the oak component in these foothill woodlands, but housing development continues to reduce the contribution of oak trees to foothill ecosystem function.

In mid-elevation west-slope mixed conifer forests, livestock foraging areas are limited to 'stringer meadows', riparian areas, brushfields, and 'transitional range' where even-age forest management activities or wildfires have produced temporary (7-15 years) forage resources in clearcuts, burned areas, or along roadsides seeded with grasses. Plantation grazing by cattle or sheep is sometimes used to reduce grass and shrub competition with conifer seedlings. Recreational pack-and-saddle stock use of foothill and mid-elevation rangeland is low because vistas are limited, temperatures in summer are often unfavorably hot, and the attractive elements of lakes and streams are infrequent in closed-canopy mixed conifer forest. Private land ownership limits access to much of the foothill oak woodland and annual grassland savanna rangelands.

East-side pine forests, pinyon/juniper, and sagebrush-steppe and bitterbrush upland ranges, especially common on the Modoc Plateau and east slope Sierra, provide open vistas but distances from metropolitan centers often limit pack-and-saddle stock use in these areas. Many of these rangelands are administered by the Bureau of Land Management (BLM) and provide critical mule deer and pronghorn antelope winter range, sage grouse habitats, important wetland and waterfowl habitat, as well as complementary spring and fall livestock grazing. In general, pack-and-saddle stock use increases with elevation and scenic quality and is greatest in subalpine and alpine wilderness areas on National Forest and National Park lands in the southern Sierra. 'Primary range' for livestock grazing in the Sierra Nevada and Warner Mountains occurs mainly on wet and mesic subalpine and alpine meadows on public lands including many wilderness areas, and developed meadows/irrigated pastures on private lands.

Much is known about pre-1905 changes in land, vegetation and herbivore use of Sierra and Modoc Plateau rangelands, but little information has been collated and summarized previously. This task has now been done in the report by Kinney. Some past vegetative changes, including sagebrush density increases and cheatgrass (Bromus tectorum) invasion, have led to conditions that are very resistant to restoration, while other situations such as damaged riparian systems present great opportunities for aquatic habitat restoration. By identifying these diverse situations and their likelihood for rehabilitation, society can choose policies for future public rangeland management and encourage improved land stewardship. Where possible in this assessment we will identify research, technology, and manager/rancher training needs.

Since the early to mid-1950's the Forest Service has been gathering a range condition and trend database (Parker C&T transect) to help determine changes in range plant communities and soil stability (Table 1). As part of this assessment we have collated much of this data for 10 National Forests including the Modoc, Lassen, Plumas, Eldorado, Tahoe, Toiyabe, Stanislaus, Sierra, Sequoia, and Inyo National Forests. Most of the transects for Meadow and Sagebrush range types (Table 2) which had been read multiple times were put into a database (Oracle) to facilitate summarization and analysis. These two range types are the most important to assess change since they provide the primary range forage source on Sierran and Modoc Plateau grazing allotments and are less likely to be confounded by plant successional processes unrelated to grazing. For example, range trends in Conifer range types may be solely due to tree growth and development (natural succession) and not grazing. Additionally, only the Meadow and Sagebrush range types have enough readings in recent decades to make strong trend interpretations.

The general decline in number of readings per decade (Table 1) is primarily a reflection of a Forest Service-wide decision to not continue to use the Parker Three-Step Range Condition and Trend monitoring method while searching for another method. Problems with interpretation of frequency data in the small 3/4-inch loop sampling frame, and lack of a direct relationship between frequency and canopy cover by species led to its abandonment. Experience from Forest Service Region 4 was brought to Region 5 in a training exercise in the mid-1980s. During this meeting replacement of the Parker Method by frequency sampling in larger quadrats was suggested for range trend monitoring. Since that time the Region 5 Range Handbook never got revised and a new range condition monitoring method was not adopted or promoted. Inadequate budgets also limited monitoring efforts. A further problem has been that recent hires have not been range trained and thus there has been few personnel to facilitate adequate monitoring. For lack of an alternative, on some Forests with experienced range conservationists, Parker transects have been re-read more regularly. Long-term continunity in the collection of monitoring data is critical. Without documentation of patterns of long-term changes, management decisions are much less certain to be the best for good land stewardship.

Alternative monitoring methods such as the Toe-Point Method have been used for years to supplement Parker transects in order to monitor range types not typically included in the permanent Parker transects such as annual grassland, oak woodlands and transitory range, or on key areas of allotments which did not have Parker transects. Many range conservationists have used the Toe-Point Method to estimate carrying capacity. Newer methods, such as nested-rooted frequency analysis (Region 4 approach) have been shown to be more sensitive to range condition trend but, again, inadequate formal adoption has led to a large gap in range condition monitoring information for the Sierra Nevada and Modoc Plateau rangelands. Since these other methods have had variable application by National Forests and do not cover a long period, we used the older condition and trend data.

Two National Forests in northern California, the Modoc and Klamath, have used the Region 1 ECODATA computer programs and collection of vegetation sampling methods which were developed from an ecosystem approach. These procedures were originally designed to aid in vegetation classification, but secondary uses to relate ecological status to carrying capacity and range condition trend may be a primary value. Since plant communities are the primary unit of vegetation, description of the plant species canopy cover is necessary to classify units of range vegetation. Frequency data alone does not allow classification. Without a range vegetation classification, it is impossible to define desired future condition or potential natural plant communities. A critical need is to get range vegetation classified on all allotments. Secondly, a range condition monitoring method needs to be adopted and training needs to begin as soon as possible. We recommend that a concerted effort be made to link past range condition monitoring data to whatever new method is chosen. Superimposing some of the new plots on top of some of the Parker Transects is one way make this linkage. This is being done already on the Klamath National Forest.

We re-read 24 Meadow Parker transects on 7 National Forests in summer 1995 in cooperation with local National Forest range specialists to strengthen the database and test for correlations with nearby riparian and stream conditions. As will be described in more detail below, we evaluated stream riparian conditions near these 24 transects and conducted multivariate canonical correspondence analysis (Jongman et al. 1987) of the paired stream/riparian data with the 1995 Parker transect data. If the transect data were correlated with the stream/riparian condition data it would be possible to estimate riparian conditions more widely in the Sierra and Modoc Plateau on grazing allotments using the Forest Service Parker Transect database which we have compiled. This analysis also allowed us to evaluate recent changes in livestock management and various riparian restoration efforts in 24 site-specific cases since that information was also gathered for the analysis. We include one extensive Appendix table summarizing the transect data for these 24 sites so readers of this report can make their own interpretation of the data if they desire.

To summarize, this assessment includes a history of livestock grazing on 10 National Forests with a focus on numbers of livestock grazed since 1905 or the establishment of the Forest Service (covering the period following the Kinney report to the present). We have gathered together an extensive database of Forest Service condition and trend data for Meadow and Sagebrush range types for permanent transects that have been repeatedly read over the last 5 decades on 10 National Forests. We are using a small sample of this database in conjunction with data we collected in summer 1995 on 24 grazing allotments or units on 7 National Forests to determine whether correlations exist between meadow status and stream/riparian functionality.

The data we have used could be considered as a pseudo-random selection of wet and mesic (moist) meadow and sagebrush-steppe sites in that we chose which transects would be used solely on the basis of the frequency of past re-reading as well as whether each transect was wholly within one plant community type. Some of the transects were inappropriately located originally and crossed two or more plant communities thereby not providing useful information--these transects were rejected from our sample if they happened to become candidates. In all cases we are using the data to help determine whether sustainable range management is occurring on public rangelands in the Sierra Nevada and Modoc Plateau. We have referenced literature where scientists have studied range condition trends and hypothesized reasons for these changes.

Finally, we have also prepared a major section on plant indicators of livestock grazing effects. We are including this section following the history section since it forms the basis for which we judge change due to livestock grazing. Some readers may want to skip over this technical section to the ecological and biophysical rangeland assessment sections which follow. From the beginning of the field of range science, range managers have used vegetation species composition and soil cover as two primary indicators of vegetation change and stability of grazed ecosystems. We believe this is the most important information range managers can use to detect short-term changes which eventually result in long-term changes and sometimes serious problems for management if undetected for an extended period of time. Botanists and ecologists alike use species presence to indicate resource use impacts. We prepared draft plant indicator material and then circulated it among agency resource specialists to refine this section of the report. Its purpose is to provide information which range managers can and should use to determine shorter term indicators of vegetation and range stability changes. One clear need arises from this effort--greater plant identification skills are essential for resource specialists doing rangeland monitoring and assessments.

POST-1905 HISTORY OF LIVESTOCK GRAZING ON NATIONAL FOREST LAND

The objective of this section of the assessment is to discuss the grazing history of the Sierra Nevada and Modoc Plateau as it relates to the condition of rangelands in the SNEP study area today. For this reason, not only are stock numbers and season of use discussed, but also changes in allotment size and number, range improvement projects and manipulation of the vegetation. In addition indirect influences on range management, such as socio-economic conditions and priorities of management, will be discussed where they have significantly affected rangeland management. Citations in this section are in the text and refer to specific National Forest unpublished documents.

Livestock were introduced into the Sierra in the mid 1700s following settlement by the Spanish. However, grazing was not a significant impact on the majority of the range until the period following the Gold Rush. It was not until the formation of the Forest Service following 1905 that livestock numbers began to be recorded. The primary sources of information used in this paper are the US Forest Service, individual Range Allotment Files (2210 files). Where available the grazing history was collected per allotment, the allotment being the unit of Forest Service land allotted to a permittee. Where this information was incomplete, grazing information at the Ranger District or Forest level was used.

Qualitative livestock stocking history is presented for six regions of the Sierra Nevada and Modoc Plateau as follows: 1) the Modoc Plateau and Warner Mountains, 2) Northern Sierra, 3) Sierra Foothills, 4) Central and Southern Sierra, 5) High Sierra, and 6) Eastern Sierra. These regions are ecologically distinct, and because of their distinct ecology and topography, ranching operations and livestock management have developed differently. This section of the assessment addresses the following points for each of these areas: 1) The change in stocking rate of livestock indicating times of highest use and reasons why, 2) changes in allotment size and number of allotments, reasons for these changes and effects, and changes in stocking rate and impacts on the land, 3) changes in type of livestock grazed and reasons for changes related to impact on the land, and 4) trends in range improvement or enhancement practices.

Fire has perhaps had the largest effect on the landscape and ecology of Sierra Nevada rangeland. As it related to livestock, fire had its greatest effect from 1880-1910 when sheepherders apparently set large brush fires every fall as they left the public lands. Miners also used fire extensively in the Sierra to expose the surface geology in looking for gold and silver. These fires opened vast areas of the western montane slopes and foothill areas for what came to be called 'transitory range' grazing. Due to the suppression of fire from 1920-present, these areas closed in with brush or denser forests thus becoming uneconomical and unproductive for livestock forage. Since wildfires still occur, transitory range continues to be created, but on a much more limited scale, never attaining the size of the areas opened to grazing as in the past. It was this human activity that led to the explosion of mule and black-tailed deer populations in the Sierra Nevada and Modoc Plateau range and forest lands.

During the World Wars I and II increased livestock use occurred on National Forests and other public lands throughout the West, often without regard to appropriate stocking rates, thus causing overuse from 1914-1920 and again from 1939-1946. During World War I the demand for wool and mutton was higher so sheep use was high, while during World War II cattle use was increased. The foot-and-mouth disease epidemic of 1924 had a severe effect on the Stanislaus National Forest grazing program, where all livestock for the 1924-25 season were slaughtered. Use was permanently reduced after that time. This event indirectly affected the surrounding forests by making use during that time go up slightly to offset this loss in capacity. This event also affected the eastern Sierra because of the closure of the Sonora Pass area to sheep, thus reducing transient use by this herbivore.

Modoc Plateau and Warner Mountains

The Modoc National Forest was established in 1903, except for 323,000 acres of the Doublehead Ranger District which was added in 1920. Until 1934 (Taylor Grazing Act) very little attention was given to grazing carrying capacity limits. From 1934-46 much information was collected about range condition and many changes were proposed to bring management more in line with range carrying capacities (i.e. sustainable use for livestock). However, significant reductions in actual use did not occur in many cases until the 1950-60 period. It was also during this time that large scale vegetation manipulation projects occurred. From 1960-70, many changes in allotment sizes took place, eliminating many of the 'uneconomical allotments' (see discussion below), and this affected overall use. It was not until the 1980s and 1990s, however, that reductions in use began to bring use into balance with forage production capacity.

The 1880-1934 period: Most livestock grazing in California was largely unregulated before the establishment of the National Forests. Prior to the establishment of the Modoc Forest in 1903, the entire area was subjected to extremely heavy use by transient cattle and sheep, in addition to the use obtained by local livestock owners. This transient use reached the point where attendant range depletion was jeopardizing the local livestock economy. Primarily for protection of the local industry, the Modoc National Forest was created. However, the ranges had been so seriously depleted by that time from a protracted series of drought years between 1917 and 1935, and by over-stocking during the war years 1916-19, they have never satisfactorily recovered. A major factor in this response has been the invasion of cheatgrass following the loss of native perennial grasses. This change in composition is discussed elsewhere in this assessment.

During this time the main emphasis of Forest Service management was to maintain the local livestock economy. There is much evidence that Forest Service personnel were aware of depleted and degenerating rangeland conditions but they would not take any action to alleviate grazing pressure if it would jeopardize a rancher's livelihood. The following quote expresses this: "The proper thing to do is to reduce the number of stock to meet forage conditions. This we have been planning to do for several years, but because of ... the precarious condition of all the stockmen concerned we feel that it is a most inopportune time to make reductions" (from the 1933 Annual Grazing Report, Modoc National Forest). More evidence that Forest Service personnel were aware of the over-use of the range are the exclosure plots set up to monitor meadow and bunchgrass types, and a quote from the 1924 Annual Grazing Report for the Modoc National Forest that states: "The meadows are too closely fed, there is not much reseeding on the range, and browse, especially in the southwestern portion of the allotment is becoming too closely fed, and some of it killed. May 1st is really too early to feed the lower part of the area ... But the demand makes it difficult to refuse stockmen the use of the range till a later date." It is clear that too little emphasis was given to animal distribution control, an option to improve management without reducing numbers.

World War I demands for food and fiber caused use to increase from 1914 to the mid 1920s. Any reductions during this time were due to the economic climate, for example: "Probably the heaviest adjustment in livestock (both cattle and sheep) came about during the period of 1918-1923, due to over-capitalization and moving transient livestock out of the NW corner of the Forest" (from Tucker Allotment Management Plan, Doublehead Ranger District, Modoc National Forest). Also during this time allotments were large and many of them were 'community allotments' with several permittees, thus making monitoring of use more difficult, which resulted in higher use. The only limiting factor to use during this time was the lack of watering sources for stock, thus areas close to water sources were depleted while remote areas were lightly used.

The Warner Mountains are some of the most productive rangeland on the Modoc National Forest and they were not limited by water sources. Thus they were more easily exploited, and by a larger number of smaller livestock operations. Use of the Warner Mountains was not reduced during the period from 1920-1940, so as not to jeopardize the operations of these smaller ranchers. After 1924, reductions in permitted livestock outside the Warner's brought much of the range on the Modoc National Forest into better balance (Reasons for Trends in Permitted Use, 1920 report, Modoc National Forest).

The 1934-1950 period: In most cases overall livestock use was not reduced significantly until 1934 when new carrying capacities were calculated following the passage of the Taylor Grazing Act. The most drastic reductions were made from 1935-39: "Cattle were reduced 39%, and sheep 28% since 1934... Season adjustments account for about 40% of the total reduction in use, while actual cuts in numbers of stock accounted for the other 60%.". Stocking rates went up during the World War II years from 1939-46, but they were still in most cases half of the pre-1920 stocking rates. It was also during this time that many of the larger community allotments were split into smaller allotments, and many allotments changed livestock class from sheep to cattle due mostly to economic reasons (Modoc National Forest history reports).

According to the 1944, Forest Summary, Range Allotment Analysis, Modoc National Forest, many major range improvements were implemented during the 1934-1944 period, the majority being water sources for stock, making more upland areas available for grazing. There was much emphasis on expanding viable range acreage: "20,000 acres are recommended for reseeding, these include meadows, sage flats or former meadows, aspen basins etc... 15,000 acres of eroded bottom land are recommended for gully plugs, and erosion dams, ... 10,000 acres are recommended for water spreading and irrigation, ... 20,000 acres of sagebrush land are recommended for clearing, (provided current trials are successful)".

Though extensive manipulation of vegetation was proposed, Forest Service personnel were aware of the limitations of their range as indicated in the following quotation: "... in areas of extreme depletion, lower value species such as members of the Brassicaceae and Polygonum species were recommended for stabilizing soil". Sagebrush eradication was only proposed where silver sagebrush (Artemisia cana) was invading meadows or where Artemisia tridentata ssp. wyomingensis was increasing in density on bunchgrass (sagebrush-steppe) range. At the time there was no concern given to potential natural communities, thus reseeded mixtures were all exotics including: the wheatgrasses Agropyron cristatum, A. dasystachyum, A. intermedium, common timothy (Phleum pratensis), smooth brome (Bromus inermis), etc. In retrospect, this was fortunate because today we know that seeding with non-local gene pools of native species could have done more harm than seeding exotics. None of these exotic grasses have become invasive or problem species since that time. Willows and aspens were often eradicated. Economical forage production was the primary objective.

The 1950-1970 period: During this time more permanent reductions in numbers of livestock occurred on most allotments, even on the Warner Mountain Ranger District. Seasons were also reduced in most cases, and many of the 'uneconomical' allotments were abandoned. This period was also a time when many sheep allotments were being converted to cattle, thus creating more 'uneconomical' allotments, since cattle could not utilize much of the area sheep had previously used. It was also during this time that many resource enhancement projects were implemented. For example, on the Willow Creek allotment: 53 acres plowed and drilled with wheatgrasses and perennial ryegrass (Lolium perenne), 25 acres sprayed to eliminate sagebrush, 1.5 miles of water spreading ditch around the seeded area (Willow Creek Allotment Management Plan, Big Valley Ranger District, Modoc National Forest). These projects caused fluctuations in use, for example, non-use during reseeding or after a burn, and increased use after clearing of sagebrush and reseeding. At this time broadcast seeding after large burns became more economical and thus more common. In most cases, where use went up it was because of recombination of allotments, or due to enhancement projects.

The 1970-1980 period: Livestock use was mostly static during this time but many allotment boundaries changed. Many of the smaller allotments were combined or were deemed uneconomical as more ranchers quit the livestock business. It was during this time that the Forest Service began to take a more ecologically oriented approach to range management. Monitoring of range use and condition was more common. More resource protection projects such as exclosures in riparian areas, riparian pastures, and rest-rotation systems of grazing were done. However, on many allotments actual use still exceeded the carrying capacity.

The 1980-present period: Actual use began to drop again in the 1990s, due in part to reductions by the

Forest Service in numbers and season of use, more allotments being closed or placed in rest-rotation systems of grazing, and drought effects. The 'Riparian Initiative' of the Forest Service also greatly changed the current management since the riparian areas had always been the areas which received highest use. The abuse had been recognized but was not acted on until the 1980s: "General forage conditions on most ranges on the Warner Mountain and Big Valley Ranger Districts are improving slightly, or at least are remaining static. Exceptions are ... drainages, meadows, watering places and other natural concentration areas. These heavily used areas appear to continue to decline though not at an alarming rate..." (1944, Forest Summary, Range Allotment Analysis, Modoc National Forest). Since 1980, many resource protection projects were implemented, from check dams, to riparian exclosures, bank stabilization projects, etc. These have tended to immediately decrease livestock use, with the possible long-term consequences of increasing forage and thus use in the future.

Northern Sierra

The Northern Sierra area includes the montane portions of the Lassen, Plumas and Tahoe National Forests. Given that we were able to gather more information for the Lassen National Forest, many of the references will be to this Forest. These areas were established as National Forests in 1908, along with most of the Sierran Forests. Highest livestock use was prior to that time, the majority being from transient sheep grazing. Use remained high until after the 1920s. From 1928-1939, when use was lowered, allotments were made smaller, and more allotments were converted to cattle. From 1939 through the 1940s use went up again due to World War II. From 1950-1970 use was greatly reduced when many uneconomic allotments were dropped or combined. Since 1970 use has declined, partly due to a change in management focus from livestock production to resource protection.

The 1880-1928 period: As stated above this was the time of highest livestock use. The following quotation is applicable to the whole Sierra: "By 1880 there were 5,727,000 sheep in California ... after this time their numbers began to decline because of poor range conditions and later controls on the herding of sheep on public lands. Forest vegetation [primarily brush since most herbaceous forage was consumed by livestock] was affected through burning by herders and the consumption and trampling of vegetation by sheep" (The Effects of Humans on the Sierra Nevada Mixed Conifer Forest, report by Jim Johnston, Lassen National Forest). The Lassen National Forest received a large amount of transient use even after 1908, since it was a driveway for sheep to the northeast: "Driveways account for 5% of sheep grazing on this Forest, since it is located to receive travel from Nevada, northeastern California and Oregon ... Taking it along with other sheep travel it amounts to 25% of the total sheep grazing. The appraisal of 1922 gave a figure of 10,211 cow-months in excess of the current 54,150 cow-month's and 70,408 sheep-months in excess of the current 30,606 sheep-months... The feed close to water is practically gone and that in outlying districts is limited" (1909 Annual Grazing Report, Lassen National Forest). On most allotments the highest use occurred by the early 1920s, but on the whole reductions in use were not mandated by the Forest Service until 1934.

The 1928-1949 period: Use started to decrease in the mid to late 1920s, but not until 1934 did the Forest Service make significant reductions in numbers and seasons. "By 1915 the U.S.F.S. fixed the allotment lines, but major changes in the broad patterns of grazing did not occur until the early 1940s" (History of Tahoe National Forest 1840-1940: A Cultural Resources Overview History, Tahoe National Forest). "Reductions have brought the actual use down to a point near the present estimate which is a little under the 1934 grazing survey figures" (1946 Annual Report, Lassen National Forest). It was recognized that range conditions were in a degraded state: "There are 64 allotments on the Forest now, with few considered in good condition" (1946 Annual Report, Lassen National Forest). Emphasis however was still on maximizing use of rangeland. In the 1940 Statistical Report for the Lassen National Forest, the following work was proposed: recommend reseeding--620 acres; rodent control--60,000 acres; re-treatment rodent control--80,000 acres and recommended new rodent control-- 112,100 acres. Rodent control, mostly for gophers in meadows, attests to the drying and declining condition of meadows.

While in 1934 only 5,500 acres of rangeland were reported overgrazed, in 1940, 19,000 acres were reported. The lack of concern was evident in the statement: "As a whole, we do not feel greatly alarmed over our overgrazed areas as we are holding them in check in spite of most adverse weather conditions" (1934 Annual Grazing Report, Lassen National Forest). Much of the rangeland on the forests in the northern Sierra and southern Cascades is in timbered areas. With the harvesting of timber much temporary rangeland was created following 1940: "Our large reductions for the next 10 years are on account of lands that will be cut over by 1944 ... if the sheep grazing experiment turns out as satisfactorily as we feel it will, we should be able to take care of the sheep as the lands are cut over" (1934 Annual Grazing Report, Lassen National Forest). There was little clearing of brush to open areas for grazing during the 1928-1949 period. From 1941-1946 use went up due to World War II, but it was still lower than in the 1920s.

The 1950-1970 period: Both animal numbers and season of use were reduced soon after 1950 due to the realization that areas were over-stocked and to the growing encroachment of brush, both on montane slopes and in meadow areas: "A direct result of the grazing is the widespread appearance of sagebrush. Spraying was applied in the 1940s, and 1950s on sagebrush" (1946 Annual Grazing Report, Lassen National Forest). In response to this increase in brush, many clearing, burning and spraying projects were undertaken: "Considerable range improvements have been made on the Forest, but many more are needed to facilitate proper management. Fences and water development are those most required. The same is true of range resource development with the emphasis on water spreading, rodent control and some reseeding" (1946 Annual Grazing Report, Lassen National Forest). Changes were made in the allotments as a result of the vegetation changes: "In general the east side ranges are economical... A number of the west side ranges ... are considered as non-usable. Pine reproduction and brush make several other allotments marginal. Boundary changes are necessary in many cases to bring allotments to an economic size; these changes are chiefly on the west side" (1946 Annual Grazing Report, Lassen National Forest). During this period, most seasons were shortened, numbers reduced, allotments were dropped, and others were combined usually with a reduction in use.

The 1970-present period: The process of recombining and eliminating uneconomical allotments continued during this time. From 1970-80, use did not vary greatly, many sheep ranges changed to cattle or dropped out. In the 1980s use was again reduced, this time due to a change in management emphasis, which actually started in the 1970s. Concern over resource protection began to govern range use. Again, the 'Riparian Initiative' and several other Forest Service programs shifted emphasis to the protection and conservation of riparian areas. With this change in emphasis many exclosures, riparian pastures, erosion control structures, and replanting of riparian species occurred.

<u>Sierra Foothills</u>

National Forest ranges in the Sierra Foothills are primarily 'transitory ranges' on the west slope of the Sierra with limited lower-elevation annual grasslands and oak woodlands. They are primarily used during the winter months, for short periods during the spring and early summer, and sometimes in conifer plantation grazing programs. These areas, especially in the central Sierra received heavy use from 1870-1900 because of their close proximity to mining communities. They were also affected by the early sheepherders, not so much by direct grazing pressures as by the fires sheepherders set. From 1900-1930, the Forest Service continued to stock these areas at a fairly high rate. In the 1940s use on these areas decreased due to allotment closures and reduced numbers and season. From 1950 to 1970, use was again reduced and many areas were closed. In the 1980s and 1990s use was further reduced due to the cumulative effect of years of fire suppression and the resultant increase in brush and urban development.

The 1870-1900 period: These areas were first grazed in the spring and fall by sheep when the large bands numbering up to 6 million were driven from the San Joaquin Valley up to the high Sierra. Again, the sheepherders' fires impacted the foothills more than grazing. "Some herders developed the practice of setting fires to clear underbrush in order to increase forage the following year... Once a fire was set however there was no method of controlling the destruction..." (Basque 'Tramp herders' on Forbidden Ground: Early Grazing Controversies in California's National Reserves, Forest Service). The number of acres burned during this time was quite extensive: "While no records were kept...the largest percentage of the most destructive fires in the mountains of California were caused by sheepmen during the 30 years preceding the establishment of the National Forest" (Fire History-Sheepmen Fires by Thomas West 1932). Areas close to the mining towns were used for both cattle and sheep, although this use was not extensive.

The 1900-1930 period: By 1910, fires set by sheepherders were being curtailed but intensive grazing use continued. "Early historical accounts of the range in the Sierra foothills report that the land had been overgrazed to the point of being badly abused. The reason for this being the accessibility to local ranches and the closeness of the Yosemite National Park back country to livestock grazing. With the loss of their summer range in Yosemite, the local ranches of Mariposa County freely made use of the Forest Service land west of the Park" (Chowchilla Allotment Management Plan, Sierra National Forest). This high use was true throughout the western foothills of the Sierra. Livestock use peaked in most cases in the early 1920s. After this time there were some efforts to reduce use, and in the southern forests sheep use declined and some areas were not re-stocked with cattle.

The 1930-1950 period: While there was an increase in use from 1939 to 1944 due to World War II, many reductions occurred after that time. Allotments were combined, dropped and boundaries changed in order to make the allotments economical units, and most sheep allotments by 1945 changed to cattle allotments. With the suppression of fire since 1920, many areas were reverting to brush and timber and were deemed uneconomical. Even though closures took place and stocking was reduced, the area was often stocked above the carrying capacity: "This area was not excepted from the heavy use common in the Sierra early in the century. As recently as the 1960s, sheep were brought through this area enroute to higher elevation sheep allotments... No matter which period of the grazing history we discuss we will find the area was overstocked" (Chiquito Allotment Management Plan, Sierra National Forest). It was in the 1950s that many vegetation 'type-conversion' projects were proposed, but most did not take place until later.

The 1950-1970 period: It was during this time that many vegetation 'type conversion' projects took place. These involved burning, mechanical clearing, and herbicide spraying of brush then reseeding with annual or perennial grasses. There was also much reseeding on burned areas, and following reseeding areas were often heavily stocked by either cattle or sheep. This practice was significant since the burned acreage was extensive. The following quote is indicative of this vegetation management practice: "... steadily decreased use due to brush encroachment and diversion of livestock to the other units. In 1920-30 there were several large fires that opened up previously timbered or brush covered land. From 1960-64, 274 acres of land were 'cleared and converted' to perennial and annual grassland, clearing and reseeding again occurred in 1979" (Hyde Mill Allotment Management Plan, Sequoia National Forest). Even with these projects most allotments were becoming uneconomical not only due to reversion to brush and timber, but also due to encroaching housing development and resultant impacts: "... 1944-because of mining and agricultural settlement, this is just a place to put small herds of cattle for a short period. It is my opinion that this area will not be grazable much longer as people are the disturbing factor" (Otter Creek Allotment Management Plan, Eldorado National Forest).

The 1970-1990 period: As previously stated it was not until the late 1970s and early 1980s that resource protection became a greater emphasis relative to forage resource production. At this time many Sierra transitory range-based allotments were already closed. Those that were open were often put in rest-rotation systems of grazing thus decreasing their use. In areas where fire destabilized soil, revegetation projects were implemented. Where gully erosion occurred from grazing, fire or logging, check dams were installed. The overall trend in use was toward shorter seasons and lower numbers. It became accepted policy that these more marginal transitory ranges were not suitable as permanent range.

Central and Southern Sierra

The Central and Southern Sierra area includes the upper montane areas of the Lake Tahoe Basin, Eldorado, Stanislaus, Sierra, and Sequoia National Forests, and parts of Yosemite and Sequoia National Parks before they were closed to grazing. This area includes the Mother Lode Gold Rush area, is highly accessible, and has extensive water sources. These factors contributed to higher early use by both cattle and sheep than many areas of the Sierra. Access and location relative to valley urban areas later contributed to a reduction in grazing due to increased recreational use and development. Highest use occurred before the National Forests were established in 1908: "Use was heavy in the 1920s, decreased during the drought years of the 1930s, increased greatly during the 1940-1946 war years, decreased slightly from 1948-1952, and has remained constant to date (1960)" (Haskell Allotment Management Plan, Sierra National Forest).

The 1870-1900 period: There were several areas that received particularly high use by transient sheep grazing during this period, both the Lake Tahoe Basin and Sonora Pass area of the Stanislaus National Forest. By 1900 the number of transient sheep bands were significantly reduced throughout the Sierra.

The 1908-1930 period: Once the National Forest took over management, transient sheep use was gradually brought under control, and it was further reduced by a disease outbreak. In 1925, there was an outbreak of foot-and-mouth disease on the Stanislaus National Forest which resulted in all of the livestock being slaughtered. After this time numbers were reduced to 66% of previous stocking, which also forced some sheep operations to change to cattle. Movement of sheep over the Sonora Pass onto the eastern Sierra ranges effectively stopped thus eliminating the driveway use on the Stanislaus National Forest. Permitted use on the allotments was still high, but there was an awareness of degraded and deteriorating conditions: "It can safely be stated that all grasslands in the Forest are decreasing in food value annually. This circumstance is due to several causes. First, consumption of the grass before it re-seeds. Second, trampling of cattle on the wet meadows. Third, the general practice which is now being remedied, the over-stocking of the range. Fourth, improper handling of cattle on the range" (1910 Annual Grazing Report, Eldorado National Forest). Improvements were recommended but few reductions in numbers or season of use were made: "The only remedy in any case, seems to be a large reduction of stock and, after determining by experiments the character of grasses that will grow the best in certain localities, reseed the areas and exterminate the marmots by poison" (1910 Annual Grazing Report, Eldorado National Forest).

Use began to decline by the mid 1920s: "Livestock numbers and total animal months during the early years of record, 1912-1916, must have undoubtedly been partially responsible for conditions existing on the range today. During this period numbers exceeded 14,000 AUMs. This stocking rate is 3-4 times the amount permitted under present management. By 1930, use had declined by 66% ... Over 90% of the primary and more than 75% of total suitable range is in poor condition. The present management, though not the best, has shown some improvement over past years" (1970s Breckenridge Allotment Management Plan, Sequoia National Forest).

The 1930-1950 period: As the previous quote indicates use began to decline in the 1930s. During World War II permitted use again went up, but only to a fraction of the pre-1920 use. In some cases the actual use did not go up: "In 1942 through the World War II period use dropped approximately 1,000 head. Stockmen were receiving good prices and they concentrated on feedlot management where possible. The lack of man-power for range riding and cost of transportation was high" (Letter to Tuolumne County Supervisor from Stanislaus Forest Supervisor, 1965). The montane areas and foothill ranges were rapidly reverting to brush and timber types due to fire suppression. The previous practice of using a lower elevation allotment in conjunction with a higher elevation allotment became less feasible with the decrease in productivity of transitory ranges, and with the lack of man power after World War II many permittees dropped out all together.

An effort was made to make ranching on Forest Service land economical by combining the less economical allotments, splitting of the large community allotments and clearing of brush and reseeding. This practice met with little success as timbered areas closed in with thickening timber stands, and there was less burned area and shrub browse for livestock. "The timbered type is not good range, and will be less in demand when the present old-time users drop out of business" (Functional Inspection, Stanislaus National Forest, 1949). By 1950, use was significantly lower over the region.

The 1950-1970 period: Reductions in livestock numbers continued through the 1970s, again due to uneconomical operations: "1953--a sizable number of larger operations dropped out voluntarily ... From 1948-1963, 32 permits representing 7,217 cattle were voluntarily dropped. 5 permittees dropped their numbers ... Also during this time the Forest Service administratively reduced the carrying capacity on 8 ranges" (Letter to Tuolumne County Supervisor from Stanislaus Forest Supervisor, 1965). There are some references to increased use on the central and southern Sierra Forests due to loss of adjacent ranges to development, overgrazing, and allotment closures. This augmented stocking of livestock does not appear to have been long lasting, however. Again during this time many resource enhancement projects were undertaken in an effort to increase productivity of rangeland: "In 1963, brush was cleared and burned and grasses were seeded, and later spraying of brush occurred. Through 1965, 434 acres were cleared" (Sugarloaf Allotment Management Plan, Sierra National Forest).

The 1970-1990 period: Though poor range condition was recognized prior to this time, it was not until the late 1970s and 1980s that management began to focus on resource protection: "This range sustained a high rate of grazing use under National Forest administration for at least 45 years and unrestricted use for several decades before that, due to accessibility. Since much of the range is in a depleted state, the ultimate objective should be to retire it completely from grazing use. Important key areas will be of prime importance for recreation ..." (1963 Stanislaus Meadow Allotment Management Plan, Stanislaus National Forest). Most actual reductions in use were made in the 1980s and 1990s. Also due to the focus on riparian areas in the 1980s, projects were applied to these areas including willow plantings, riparian pastures, exclosures, and in-stream structures (Meadow Inventory Study, Eldorado National Forest, 1994). Most plantings used native willow and dogwood species. In most cases reduction in livestock use was made in project areas, at least on a temporary basis.

High Sierra

According to all accounts the high elevations received the greatest grazing abuse by bands of sheep than any area of the Sierra or Modoc Plateau (Kinney report). After establishment of National Forests, use decreased immediately but was still high until the 1920s. From the 1920s until the mid 1940s use decreased and fluctuated. By 1946, most of the highest elevation areas were ungrazed by cattle and sheep. Recreational packstock impacts have increased since that time. Other areas of the high Sierra have reduced numbers and have gradually converted to cattle.

The 1870-1908 period: High Sierran meadows were the destination point for summer sheep grazing during this time period. While forage and water were abundant, there were also extremely sensitive areas which were degraded rapidly given the granitic parent material and young geologic age of the Sierra Mountain Range. The entire high Sierra range appears to have been intensely overgrazed for decades, beginning in the early 1860s (Vankat 1970, Ratliff 1985). When the National Forests and National Parks were established, sheep grazing was greatly curtailed: "About 1900, sheep grazing was practically banned from the Forests because of heavy damage in high meadows. In 1958, we had 3 sheep permittees with a total of approximately 4,600 sheep. One of these dropped out because of economics. Another has taken 5 years non-use. Active sheep are now 2,550 in number" (Letter to Tuolumne County Supervisor from Forest Supervisor, Stanislaus National Forest 1965).

The 1908-1946 period: During this period grazing was allowed in the high Sierra on National Forest land, but only by local ranchers or ranchers holding 'base property' according to the Taylor Grazing Act. Controls on transient use greatly reduced the numbers of sheep. Use was still high and did not allow regeneration of many of the meadow areas. In the National Parks, packstock replaced livestock use as soon as the Parks were created. In Yosemite National Park packstock immediately had significant impacts; in Sequoia National Park use was low until the 1940s.

The 1946-1970 period: Packstock use increased everywhere after World War II due to increased road access and the public having more leisure time and money for recreation. Many more allotments became vacated due to conflict with recreation and range productivity declines with packstock use: "Recovery will be slow at such elevations (9,000-10,000 ft.), in fact it may be 10-20 years ... The Forest officers propose to remove all cattle and sheep from the high country, as soon as practicable ... to allow nature to heal..." (Functional Inspection, Stanislaus National Forest, 1949). This pattern of closure of livestock allotments continued; some sheep were still stocked on some of the higher allotments but cattle replaced sheep on most allotments that still allowed livestock.

Many areas still received high use and were not brought into accordance to their carrying capacity. Management of the Mulkey Allotment, Inyo National Forest, typifies this: "A large % of this allotment is in the Golden Trout Wilderness. Few records were kept before 1906. For the whole Kern Plateau 200,000 sheep were trailed across. Mulkey Meadows was used as a staging area in the fall. By 1900, cattle were becoming the dominant livestock. From 1906 to 1961, the Templeton common area (which was composed of Templeton and Mulkey Allotments) sustained 6,000 animal months (AMs). In 1962, Mulkey was separated out and stocked with 450 AMs. In 1967, range analysis was done and the acres were calculated to be 1,051 suitable acres and deemed capable of supporting 318 AMs. But it was still stocked with 450 AMs until 1971. In 1971, though carrying capacity was estimated to be 335 AMs, stocking rate was still at 450 AMs, also in 1975, 255 AMs were added. In 1981, 701 AMs were permitted. Pack stock use in 1983 was 1,175 stock nights, it was increased in 1988 to 4,401 stock nights" (Mulkey Allotment Management Plan, Inyo National Forest).

The 1970-1990 period: Reductions continued through the 1970s and no doubt the degraded range conditions influenced management decisions: "Permitted grazing continued in the Pecks-Dillon areas somewhat longer, 40 head were grazed until 1970, after that it was closed to commercial grazing. Several factors led to the reduction and eventual elimination of the permit. Conflicts with recreation, wildlife, and the National Park Service, plus deteriorating range condition, led to its closure" (Kern Allotment Management Plan, 1970s, Sequoia National Forest). It was not until the 1980s and 1990s that a serious movement towards resource protection was taken. This change was prompted by the writing of wilderness management plans. Very little monitoring of range impacts due to packstock use has been done. Monitoring is increasingly important since packstock use is now the primary impact of the high Sierra.

Eastern Sierra

This area includes the east slope of the Inyo National Forest and the Bridgeport and Carson Ranger Districts of the Toiyabe National Forest. The area was settled somewhat later than the west slope of the Sierra. It also received high use by sheep but not until 1880, when the sheep, being banned from some areas on the western Sierra, came over Sonora Pass to the east. After 1908, when the National Forests were established, transient sheep grazing was curtailed and in 1924, with the outbreak of foot-and-mouth disease, sheep were not allowed over Sonora Pass again. Sheep, however, still continued to be driven in by way of the Mojave Desert until the 1940s. Cattle and sheep use was high through the 1920s and 1930s. In the late 1940s, use was reduced through shorter seasons and fewer numbers when many of the large community allotments were split and converted to cattle. Livestock use declined gradually in the 1970s, especially on the higher elevation allotments as mentioned above in the High Sierra section. In the 1980s and 1990s, use was further reduced.

The 1880-1912 period: It was during this time that large bands of sheep grazed this area: "In the 1880s, the 'California' sheep began to come in large numbers and were able to go in and clean up uncontrolled range so thoroughly that there would be no feed left for cattle. This forced many small cattle ranches into the sheep business ... The California sheep came in by two routes. One route, part of which is still used, was from Bakersfield, California in the spring, through the Mojave Desert and along the foothills of the Sierra. They traveled north and reached the higher elevations of the Walker River, Mono Basin and Owens River for the summer and continued back to the west side of the Sierra via Sonora Pass by fall. The second route went over the Sonora Pass very early in the spring, into the Walker Range. 200,000 sheep are estimated to have grazed in the E & W Walker country, including the Bodie Hills ... The sheep migration still continued to some extent through the Mojave Desert (1946)" (Ranger District Management Plan (1947), Bridgeport Ranger District, Toiyabe National Forest).

Since the Carson City community supported many people, there were many small local ranches there. The following is a description of the early livestock use in the Carson City area: "During 1865-1895 due to the mining and logging populations, the meadows in the Carson Valley area were used for dairy herds. In 1893 the first large herds of sheep started coming in from southern California. It is said that the migration was due to the West side grazing ranges being included in the National Forests so that their grazing there was curtailed and they turned to the East side. Local ranchers were pleased when the National Forest was established in 1912. In 1915-1931 there was a gradual decrease in the numbers of cattle and a corresponding increase in the numbers of sheep. After 1931, the trend was reversed" (Alpine (Carson) Ranger District Report (1947), Toiyabe National Forest). Some sheep were also brought into the area through the Tahoe Basin, but this is not well documented.

The 1912-1945 period: With the elimination of large roaming sheep bands on National Forest Lands actual use went down considerably, but many small operators converted to sheep in the early 1900s. Increases again occurred in the 1930s and 1940s. Sheep use tended to deplete the slopes more than cattle since sheep could access and thus use more areas. Few changes were made during this time to reduce use. Use was extremely high during the World War I years: "the main concern was to use all 'available forage' ... 1918, most of the ranges appeared grazed to their full capacity. Any material increase would, in many cases, force the permittee to leave for want of forage" (Alpine (Carson) Ranger District Report (1947), Toiyabe National Forest). Use was reduced somewhat after that, more due to economics than a conscious conservation effort. Also during this time, many changes were made to make allotments more economically feasible, these changes included splitting large community allotments, initiation of resource enhancement projects, dual use of rangeland by cattle and sheep etc. The following quote represents the general management of rangelands during this time: "Shortly after the formation of the National Forests the numbers of livestock were sharply reduced and until very recently, there has not been a major change... In 1930-35 sheep ranges were increased by allowing the sheep to go to the cattle ranges in the fall after cattle were removed ... In general, management by the National Forest Service has consisted of the following: Setting allotment lines, setting opening and closing dates, and setting permitted numbers. Allotment lines have often been overlapped between sheep and cattle allotments, opening dates have in general been from one to two weeks too early, closing dates as much as a month too late, and numbers often above safe capacity" (Ranger District Management Plan (1947), Bridgeport Ranger District, Toiyabe National Forest). Use during World War II was in most cases increased but never as high as pre-1920.

The 1946-1970 period: During this time, local livestock economics were changing, operations were smaller and most were converting to cattle. There was concern over depleted range conditions because of this and many changes in management occurred. Marginal allotments were closed, many larger allotments were split, most were converted to cattle with a reduction in use, and much attention was given to resource enhancement projects: "From 1941-46 there has been a significant trend from sheep to cattle. Although this trend has given some relief to the range it was not until the last 2 years that a change from sheep to cattle actually brought stocking to what appears to be true grazing capacity" (Ranger District Management Plan (1947), Bridgeport Ranger District, Toiyabe National Forest). Though the dates here are 1941-46, most of the actual conversions were later. The following is typical of the changes in allotment management: "Until 1947, this was part of Clover Patch, it then became the Wilfred Allotment and was converted to cattle. In 1967 half the allotment was sprayed and in 1969 the other half was sprayed. In 1968 the Cashbaugh unit was separated out into the Glass Mtn. Allotment" (Wilfred Allotment Management Plan (1970s), Inyo National Forest). The aforementioned spraying was to reduce sagebrush encroachment in drying meadows, many areas were then reseeded with wheatgrasses, timothy, bromegrasses and other species. "In 1948 reseeding occurred on Dry Lake. In 1951 the south end of Sweetwater was reseeded. In 1958, 59 and 60 the rest of Sweetwater was reseeded" (Sweetwater Allotment Management Plan, Bridgeport Ranger District, Toiyabe National Forest). There was also reference made to water-spreading or irrigation projects: "Great possibilities exist for water spreading on many ranges" (Ranger District Management Plan (1947), Bridgeport Ranger District, Toiyabe National Forest).

The 1970-present period: Many more allotments were combined and split in the 1970s in order to make them more economical and facilitate management. Beginning in the 1980s, management concentrated on resource protection. At this time numbers and perhaps more importantly seasons of use were reduced significantly. On the Toiyabe National Forest, especially, major new vegetation inventory projects were conducted leading to a more 'ecological' approach to livestock management. Again, riparian rehabilitation projects took place with reduced use on riparian areas, riparian exclosures, riparian pastures, and rest-rotation grazing systems were begun.

PLANT INDICATORS OF LIVESTOCK GRAZING EFFECTS

Plant species composition and bare soil exposure in wet and dry meadows and upland sagebrush-steppe and other shrublands on National Forests have been monitored periodically for up to 5 decades on permanently located Parker 3-Step transects by the U.S. Forest Service. These data are the only long-term, widespread range vegetation information available in the Sierra and Modoc Plateau. Thus analysis of these data is one key element to interpreting the sustainability of livestock grazing programs on rangelands in the Sierra Nevada Ecosystem Project study area. Given the history of reported overgrazing of the region from 1865 to the early 1900s and the time needed for recovery with improved management since that time, these data should show improving range conditions if sustainable stewardship has been occurring over the last 50 years.

A large literature exists justifying plant community composition and bare soil exposure changes as indicators of grazing impacts (NRC 1994 and Ratliff 1985). We will not review that literature here except to say that excessive defoliation and trampling, both temporally and spatially, can selectively reduce growth capacity of individual plant species thereby reducing their fitness and survival leading to plant community composition change. On the other hand, lack of herbivore (wildlife and livestock) grazing in grazing-adapted ecosystems such as grasslands, including meadows, can lead to unnatural plant compositions especially those subjected to exotic plant invasion or high litter accumulation. Over time the plant community composition reflects grazing effects. Since soil is the ultimate resource supporting terrestrial biota, changes in soil exposure to erosion indicates potential risk for soil loss and therefore sustainability. Thus reduction in bare soil on Parker transects is a second important indicator of good stewardship.

The potential underlying causal mechanisms for plant community changes are numerous, including 1) reduced rooting depth and water uptake by native plants in excessively trampled and closely grazed meadows or sagebrush-steppe, 2) shading out of small plants by large tall plants and their litter accumulation with little or no grazing in highly productive meadows and grassland, 3) lowering of water tables due to gullying thereby shifting composition to species suited to drier soil conditions, 4) inadequate reproductive success due to frequent seedhead removal, and aggressive weed competition, etc.

Permanent Parker 3-step transects are typically 100 feet in length where plant species or other soil coverage (litter, rock, moss, bare, etc.) categories are read and recorded at 1 foot intervals using a 3/4 inch loop reference area immediately above the soil surface. The method was developed to assess range condition and trend and is in all older Forest Service Range Handbooks. For the purposes of this SNEP analysis, only the raw species composition, bare ground, litter and other soil coverage information was used. There is an extensive literature criticizing range condition and trend rating systems so we chose to only use the raw data and not any of the past value-laden condition ratings (NRC 1994). We realize that many species identification problems exist in the data, but by correcting known misidentifications, and by using a lumped species to genus or other family or life-form categories many of the limitations are reduced. All data (numerous species codes and their synonyms) were entered into an Oracle database for data summarization. These databases and the Oracle programs will be made available to Forest Service Districts and others who desire them.

Since one of the potential primary negative impacts of overgrazing is to alter the water holding capacity of soils due to soil compaction or lowering of water tables due to stream downcutting, the relative abundance of grasslike and true grass species is an important indicator of this change. A large group of grasslike species are wet-site related (see below). In Sierran wet meadows, sedges (Carex spp.) are by far the most important genus of grasslike plants. Identification of Carex spp. to the species level was not common in the Parker transects which limits other more site specific interpretations, but not the major one of soil water relations change. Certain Carex species indicate alpine communities, bogs/fens, springs/seeps, streambanks, wet/moist meadows or dry meadow edges/uplands and are therefore useful indicator species for plant community classification, which is not the task here. Distinct environmental conditions and restrictions largely determine the composition and structure of these plant communities. The following sections discuss plant indicators in general for rangelands in the Sierra Nevada Mountains and Modoc Plateau. Specific findings on changes observed in the Parker transects will follow this background material.

Grasslike Plant Indicators

Much is known about some grasslike species such as Carex nebrascensis, C. scopulorum, C. aquatilis, and C. rostrata which indicate quite different environmental and grazing impacted conditions. Much of this species-specific information was developed from the collective experience of range scientists, specialists and ecologists, and from reference material including the Range Plant Handbook (USDA Forest Service 1937). A discussion of a limited number of Carices follows.

Carex nebrascensis is one of the most easily identified grasslike species and is a very widespread rhizomatous plant which can survive frequent trampling and a degree of dewatering with lowering of a water table (it was usually identified to species). This capability is supported by the fact that it is still found in grazed dry meadows. Throughout its range Nebraska sedge occurs exclusively in such wet sites as along slow streams, near springs, in shallow swampy areas, and wet meadows. In the wet meadows of the Sierra it is frequently one of the dominant plants. Its strongly developed rootstocks, from which new plants arise, make it particularly well adapted to withstand abusive grazing. An important fact is that C. nebrascensis is the wet meadow site Carex species least affected by livestock disturbance (trampling and defoliation). Another genus of grasslikes, the Scirpus species (bullrushes), are not as palatable to livestock as many Carices and also have very well established roots and survive well under grazing.

Carex scopulorum is very similar in appearance to Nebraska sedge but is often found at higher elevations mostly where a good source of cold water is present, such as in seeps and wet meadows. It is more susceptible to grazing and trampling disturbances, and when very abundant it indicates later seral ecological conditions (less grazing impacted).

Carex aquatilis is also very similar to the previous two species in appearance, but it is most likely to be found at stream edges with its roots always in running water or saturated soils. However, it is not found in bogs, fens or seeps. Some taxonomists/ecologists have thought that this species is just an ecotype of C. nebrascensis.

Carex rostrata is a large robust sedge occurring on low gradient landforms ranging from permanently flooded basins to floodplains and wet meadows, and not in stagnant water such as bogs, fens or seeps. It is moderately palatable to cattle in late summer. In Oregon, Kovalchik (1987) has observed that beaked sedge is replaced by Nebraska sedge or is lost to streambank erosion or streambed downcutting with continued overuse

Carex athrostachya is a dry to moist meadow species often found at the edges of wet meadows. It grows in a bunch form that withstands grazing. It is a lower elevation species, not normally found in alpine meadows. It is perhaps the most common Carex species which increases in abundance with grazing in wet meadows. Carex microptera indicates similar conditions, but it is more susceptible to intense grazing and thus its abundance indicates later seral moist meadow conditions at low-moderate elevations. Carex praegracilis again is similar to the previous two, but occurs at lower elevations and seems to be more common in the northern Sierra. It tolerates livestock grazing. Carex jonesii indicates much wetter conditions and is often found in seeps, or around springs and wetter meadows at low-moderate elevations, and is more sensitive to dewatering than defoliation. Carex abrupta is very similar in appearance to C. athrostachya, but it grows in montane subalpine and alpine moist/wet meadows and can withstand moderate grazing. Carex integra is very similar to C. praegracilis in appearance but grows at higher elevations and is mostly found in the southern Sierra.

Carex simulata indicates wet to very wet conditions such as seeps, springs, fens and wet meadows. It does not withstand heavy grazing or the subsequent dewatering if abusive grazing and trampling continue, thus it indicates plentiful water and good soil structure conditions. Carex echinata or ormantha are primarily higher elevation sensitive species and when present indicate a good cold water source and later seral conditions.

Carex douglasii is a classic invader species and often indicates severely disturbed, dry, denuded areas, meadow borders and other semi-moist soils, and frequently forms a distinct zone between dry upland vegetation and wet meadow or other moist-soil types.

Carex filifolia was often a misidentification of several other sedges on Parker transects, including C. exserta, C. breweri, C. subnigricans, C. nigricans, C. capitata, C. geyeri, C. rossii, and Eleocharis species. Again these are distinct species with distinct indications. Carex filifolia is a dry/moist montane to alpine species which tolerates a moderate amount of grazing and indicates mid to late seral upland conditions. C. exserta is similar but occurs mostly on drier sites. C. breweri is an alpine meadow species and indicates relatively high species diversity and late seral conditions. C. subnigricans and nigricans are similar to C. breweri but they grow on slightly wetter sites. C. capitata is found at montane to alpine elevations in bogs, seeps and around areas of snowmelt, and indicates relatively high species diversity and late seral conditions. C. geyeri and rossii are upland species.

Other common grasslike plant genera on Sierran rangeland are Juncus, Luzula, Eleocharis, Eriophorum and Scirpus. The rushes (Juncus) are the most common of these and most often identified on Parker transects. J. orthophyllus, J. ensifolius, J. nevadensis, Luzula and Scirpus species were often lumped because of their high palatability to livestock. J. orthophyllus was often misidentified as a Carex, Luzula or Scirpus, and is as palatable as most Carex spp. but not very resistant to overgrazing. It is commonly found along streambanks and in wet meadows. It responds to lowered water tables and when present it indicates late seral conditions and high diversity montane meadows and riparian areas. J. ensifolius grows in habitat very similar J. orthophyllus but grows in wetter areas and does not survive under overgrazing or excessive trampling. J. ensifolius has a very distinct appearance thus was usually identified correctly. Species most commonly misidentified as J. ensifolius are Iris missouriensis, J. drummondii, J. orthophyllus, and Sisyrinchium species. J. nevadensis is a moderately palatable species that grows in moist to wet montane meadows and along streambanks and ephemeral lakes. It was often misidentified as J. balticus, but it does not survive in dry areas like J. balticus, and does not survive heavy grazing. Other Juncus species of moderate palatability to livestock are J. saximontanus, J. occidentalis, J. oxymeris, and J. xiphoides.

J. balticus was the catchall code for all narrow stemmed/leafless grasslike plants. It is by far the most widespread of the Juncus species and is a poor forage value species growing in dry, dewatered areas, and not favored by livestock. It does not hold soil as well as other higher value species and does not provide much ground cover. J. confusus looks like J. balticus but grows at higher elevations and indicates later seral, high diversity wet meadow or riparian conditions. It does not withstand dewatering or trampling well but when abundant it holds soil fairly well. J. drummondii is an upland species that has been extensively misidentified as J. balticus, Eleocharis species, or J. nevadensis. This mistake is misleading since J. drummondii grows only on uplands and is not associated with wet meadows. It should not appear in this SNEP dataset.

J. buffonius is a diminutive species and is often overlooked or misidentified as Eleocharis acicularis. It is found from low to moderate elevations in vernal pools, thermal mud holes, trampled streambanks, open areas in wet meadows and drier areas. It indicates denuded overused wet to seasonally wet areas. Eleocharis acicularis, varieties bella and acicularis, were often misidentified as J. buffonius, J. drummondii and as annual grasses of the genus Agrostis. These are quite distinct indicator species that grow in moist to saturated soil areas, but not bogs with their highly organic soils. They do not seem to grow above 8,000 feet. They are affected by trampling and do not survive in large numbers in overgrazed areas and provide moderately good soil protection.

The Eleocharis species are indicators of very wet conditions and do not withstand trampling and grazing well. Eleocharis pauciflora was mostly misidentified as J. drummondii through the 1970's and even the 1980's, with only the most recent transect data consistently identify it correctly. This misidentification is extremely important since E. pauciflora is a wetland species in contrast with its common misnomer, J. drummondii, an upland species. E. pauciflora grows from low-alpine elevations in wet meadows, seeps, springs, thermal mud holes, snowmelt areas, and streambanks, but not bogs. It is the most common Eleocharis and the only one reported in alpine meadows. E. pauciflora does not withstand a lot of grazing, it is palatable and sensitive to trampling and dewatering. It provides moderately good soil stability. E. palustris (formerly macrostachys) is a low to mid elevation species that is not as commonly reported and tends to grow along streambanks and in some wet meadows. It is similar in grazing sensitivity to E. pauciflora. E. montevidensis occurs on the Sierra National Forest and possibly other western slope forests. It is similar in habitat requirements and growth form to E. pauciflora.

Luzula comosa, L. subcongesta, and L. orestra are the most commonly recorded Luzulas in the Sierra on Parker transects. These are often misidentified as Carex species, J. orthophyllus and Scirpus species, or were simply recorded as members of the family Cyperaceae. They occur on moist soils in meadows and also in adjacent lodgepole pine forests. L. comosa is a montane species and is found in moist/wet montane meadows and wooded riparian areas. L. subcongesta and L. orestra are found in subalpine to alpine meadows and along streambanks; they are susceptible to grazing and trampling and indicate relatively high species diversity and later seral conditions. Other Luzula species are L. divaricata, L. parviflora, and L. spicata and are mostly forest to alpine upland species.

There are two commonly identified Scirpus species in the Sierra Nevada, S. congdonii and S. microcarpus. These were often recorded as the family Cyperaceae, the genus Carex or Juncus orthophyllus. Scirpus species are a rough leaved species and are not very palatable to livestock. This characteristic and their strong root systems allow them to endure grazing and trampling but not dewatering. They bind and protect soil on streambanks. S. microcarpus is a montane species that grows in wet meadows and along streambanks. S. congdonii is a higher elevation species more common in wet meadows and along streambanks, and is not as robust or resistant to grazing as S. microcarpus.

Eriophorum species common in the Sierra are E. criniger (formerly Scirpus criniger), and E. gracilis. Fimbristylis species are low elevation vernal pool and thermal pool species, and only rarely occur in the Sierran Parker transects. Until 1969 that recorded as Fimbristylis was most commonly E. criniger at moderate to high elevations and E. gracilis at high elevations. Both species of Eriophorum are commonly misidentified as Carex species, Luzula species or Juncus orthophyllus. They are very different particularly in that they are generally subalpine to alpine species and only seem to grow in late seral, high species diversity wet meadows, seeps, bogs and snowmelt areas. They do not withstand dewatering or heavy grazing.

Grass Plant Indicators

This section would be much too long if we were to mention all the grasses that occur in the transect data. We concentrate the discussion on those species that indicate specific conditions or were extensively misidentified. The most important wet/moist meadow and riparian grass genera are Agrostis, Calamagrostis, Danthonia, Deschampsia, Glyceria, Muhlenbergia, Phleum, and Poa. We will discuss separately (see below) the grasses important in the perennial bunchgrass, sagebrush-steppe ranges of the Modoc Plateau and eastside Great Basin influenced areas, and upland areas at high elevations.

Agrostis species until about 1968 were lumped into primary and secondary categories on Parker transects. The primary species were Agrostis alba (now stolonifera) (a non-native) and exarata, occurring mainly in the northern Sierra Nevada in larger moist montane meadows. They survive grazing fairly well and indicate mid to late seral conditions. They also occur along streambanks but usually above the waterline. Secondary Agrostis species are annuals including A. scabra (formerly hiemenodies), A. variablis, A. idahoensis, and A. humilis. Of these A. scabra is by far the most common, occurring in moist to wet meadows, seeps, and snowmelt areas at moderate to high elevations. This species indicates late seral conditions when it occurs in low abundance as an understory species in highly diverse wet meadows. When very abundant it indicates early seral conditions. The annual Agrostis species do not hold soil well and cannot be depended upon for protection from soil erosion.

The primary Agrostis species have been confused sometimes with Deschampsia and Calamagrostis species. Only one species of Calamagrostis is reported with any regularity on the Parker transects, that being C. breweri, a subalpine to alpine species which indicates relatively high diversity moist sites. Together with Carex exserta this makes up the 'shorthair' sedge type of the high Sierra Nevada. Like many alpine species, it does not sustain heavy grazing and trampling.

Deschampsia or the hairgrasses are very important in montane and subalpine meadows. D. caespitosa is the most widespread grass in meadows, is a very good livestock and wildlife forage, and provides good soil holding capacity. It is a very sturdy bunchgrass which resists trampling and grazing effects but needs moist to wet conditions. It has been overrated as the classic livestock 'ice cream' plant of meadows, that is, as the most palatable grass of meadows. It is sometimes misidentified as Agrostis, Calamagrostis or Poa, but usually is identified correctly. Deschampsia elongata is most commonly found along streambanks or at low density in wet to moist montane meadows. It is a delicate species and is susceptible to grazing and trampling. It usually indicates good conditions and high diversity. It is also often misidentified as an Agrostis species. Deschampsia danthonioides is a native annual invader species that occurs throughout the Sierra and indicates disturbance. It occurs mostly in moist to dry meadows, or in annual grasslands at lower elevations.

Three species of oatgrasses (Danthonia spp.) occur in the Sierra including D. californica, D. intermedia and D. unispicata. D. californica and intermedia occur in dry to moist meadows and tend to indicate disturbance conditions when found in wet meadows. D. intermedia tends to grow at higher elevations in or near forested areas, while D. californica occurs more often in foothill areas. D. unispicata is a low to mid elevation species, most common in the Modoc Plateau, Great Basin and eastside areas of the Sierra. It is a dry meadow, sagebrush-steppe and gravel bar colonizing species, and indicates early seral conditions in meadows. All Danthonia species tend to increase in abundance with moderate to heavy grazing, and since they are usually identified correctly, they are good indicator species.

The mannagrasses (Glyceria spp.) are most commonly G. elata or striata. All occur in later seral condition wet/moist meadows and along streambanks. They do not grow in alpine areas or in bogs or fens. They do not survive overgrazing, excessive trampling or dewatering. They are rarely misidentified so are a potentially good indicator species, however they are quite uncommon.

The two most common muhly grasses (Muhlenbergia spp.), M. filiformis and M. richardsonis, are very similar mat-like appearing plants and are often confused. M. filiformis is restricted to moist to wet areas, meadows, streams, marshes, bogs/fens, seeps, etc. and thus indicates wetter, later seral conditions. It is an annual, however, and does not provide good soil protection. It indicates later seral conditions when present as an understory species in an otherwise highly diverse meadow. If dominant, it indicates declining soil stability conditions. M. richardsonis can grow in wet, moist and dry areas, so as a generalist it has little value as an indicator species. The muhlys therefore are marginal indicator species except when they increase in abundance over time in formerly wet meadows that once had a greater component of taller statured native grasslike plants or grasses.

Two distinct timothy species (Phleum spp.), P. alpinum and P. pratensis occur in the Sierra. Alpine timothy (P. alpinum) is a native species that occurs in montane, subalpine and alpine wet to moist meadows. It also occurs in bogs/fens, seeps and along streambanks and is a late seral meadow species. P. alpinum is often confused with Alopecurus species which also indicate good wet conditions but tends to grow in lower elevation bogs/fens. Common timothy (P. pratensis), a non-native grass, has been seeded in many montane meadows. Its abundance typically indicates drier sites with a history of overgrazing and a rehabilitation project, but currently may indicate recovered mid seral condition moist meadows. Common timothy does not pose any risk to meadow sustainability and is not invasive.

Many bluegrass (Poa) species occur in the Sierra and Modoc Plateau. They typically are rhizomatous in wet to moist meadows, and bunchgrasses in drier upland sites. Only very common or indicator species are discussed here. Poa pratensis is the most common rhizomatous Poa species complex (several subspecies exist) occurring in livestock grazed dry to wet meadows, stream margins, etc. One subspecies (ssp. pratensis) is introduced, one is probably introduced (ssp. angustifolia) and one is possibly native (ssp. agassizensis) according to Hickman (1993). All have stout rhizomes, provide excellent soil stability, and are excellent forage for wildlife and livestock. There is concern because P. pratensis can replace other natives and is rather invasive. Poa palustris (also introduced) is usually misidentified as P. pratensis but grows at lower elevations and is more susceptible to grazing and trampling. Poa compressa is often confused with P. pratensis and grows on denuded streambanks and moist to dry meadows at lower elevations only and indicates early seral conditions. P. compressa does, however, provide good soil protection when other species are eliminated.

Poa nevadensis, P. secunda and P. scabrella are sagebrush-steppe, perennial bunchgrasses occurring primarily on the eastside of the Sierra and Modoc Plateau. When present in wet meadow areas they indicate disturbance, dewatering and early seral conditions. They tolerate grazing very well. Poa cusickii has a bunchgrass growth form and occurs in drier areas, meadow edges and uplands and indicates disturbance when present in meadows. Poa bolanderi (native annual) occurs at meadow edges adjacent to forest communities, is usually not identified correctly, and again indicates low soil water when present in otherwise wet to moist sites. Poa bulbosa and Poa annua are non-native annuals that are two of the most widespread grass species in the World. They indicate very early seral conditions and disturbance, but both are good forage species for all herbivores and granivores although productivity is low.

From 1940 through the 1960s various range improvement projects were implemented on the eastern slope, Great Basin and Modoc Plateau ranges. These were designed to decrease big sagebrush, western juniper and other shrub densities, and increase the perennial bunchgrass component of sagebrush-steppe communities which formerly had more perennial grasses. Improvement areas were variously burned, mechanically manipulated, sprayed, and seeded.

All Agropyron (currently Pseudoroegneria or Elytrigia) species except the native bluebunch wheatgrass (A. spicatum) were perennials introduced in reseeding projects and include: A. cristatum, A. desertorum, A. intermedium, A. dasytachyum, A. smithii, and A. trachycaulum. Since all these introduced wheatgrass are lower palatability, coarser-leaved grasses, they do not fill the same role as bluebunch wheatgrass. However, all are of moderate palatability when managed for forage production and all provide excellent soil protection in otherwise low soil coverage upland communities. Bluebunch wheatgrass was the primary native perennial grass of upland sagebrush-steppe plant communities. It is very poorly adapted to continuous grazing and was largely grazed out during the historical overgrazing period. Remnant populations are present almost everywhere, but large vigorous stands are rare.

The native perennial grasses California brome (B. carinatus) and introduced smooth brome (B. inermis) indicate mid seral upland conditions typically in large moist to dry meadows and forest openings. Seed of many local ecotypes of B. carinatus are now commercially available for restoration projects. All of the annual bromegrasses are invaders and include B. brizaformis, B. japonicus, and B. tectorum (cheatgrass) on the eastern side of the Sierra, the Great Basin and Modoc plateau, and B. hordeaceus (formerly mollis), B. diandrus, and B. rubens on the western slope of the Sierra in foothills below 3,000 ft. elevation. All annuals in the first group are invaders of montane meadows and sagebrush-steppe ranges and indicate varying degrees of disturbance. Given the rather complete transformation of the herbaceous component of foothill grassland/oak woodland communities on the western slope, the annual bromes listed above in the second group are now considered 'resident annuals' and permanent members of what is now named the California annual grassland. The greatest threat to sustainability of these western slope grasslands is exotic weed invasion, especially yellow star-thistle (Centaurea solstitialis).

Three wildrye species include Leymus cinereus, Elymus glaucus and Leymus triticoides are common in the SNEP study area. The two Leymus species were previously classified in the Elymus genus. Great Basin wildrye (L. cinereus) grows in a bunchgrass form or with short rhizomes and indicates deep soils and lack of grazing abuse when abundant. Much of it was hayed in sagebrush-steppe meadow floodplains and was lost due to too frequent haying, grazing and burning following European settlement of the West. Blue wildrye (E. glaucus) is an incredibly variable species with a wide range of habitats throughout the Sierra. It commonly grows in conifer forest openings, edges of moist meadows, and in the understory of oak woodlands and savannas. Sites with a substantial component of blue wildrye indicate low grazing intensity. Seed of many local ecotypes of blue wildrye are now commercially available for restoration projects. Creeping wildrye (L. triticoides) is a rhizomatous species often growing in saline environments of the Great Basin, but occurs in many other habitats. Invasion of blue or creeping wildrye into formerly wet meadows indicate disturbance.

Idaho fescue (F. idahoensis) bunchgrass habitat is typically eastside pine understory and gaps in conifer forest/sagebrush-steppe complexes. When present in meadows it indicates early to mid seral conditions. Green fescue (F. viridula) is an alpine species and indicates late seral upland conditions. Koeleria macrantha (formerly cristata) is a widespread perennial bunchgrass and indicates later seral conditions; it is never a dominant grass over a large area. The bunchgrass Indian ricegrass, Achnatherum (formerly Oryzopsis) hymenoides, indicates less severe livestock disturbance conditions at low to moderate elevations east of the Sierran crest and on the Modoc Plateau. Ptilagrostis (formerly Oryzopsis) kingii occurs in subalpine to alpine streambanks and meadows and indicates mid to late seral upland conditions. Like many alpine species it is quite sensitive to heavy grazing.

Finally, saltgrass (Distichlis spicata) occurs on the Modoc Plateau and in the Great Basin and is indicative of alkali flats, vernal pool margins, early to mid seral dry meadows, thermal mudholes and generally disturbed, dry open areas especially on alkaline soils. It is a distinctive species and not usually misidentified.

Forb Plant Indicators

Many forbs encountered on Parker transects were either recorded as annual or perennial weeds with the exception of several common and easily identified species. Misidentification is a problem since many forbs are very good indicators of species diversity, meadow seral stage, and soil water status. Some small perennial forbs were consistently classified as annual. Almost all the common forbs discussed below are native, those that are exotic and/or introduced are noted. In addition to Hickman (1993) two other forb references were used (Dayton 1960 and Hermann 1966) in putting this section of the assessment together.

The common native perennial forb Epilobium glaberrimum is indicative of seeps, springs and wet meadows, and begins to decline in abundance with drying or denuded conditions. It occurs from low elevations to subalpine meadows. It is usually not observed until the overstory species are thinned by grazing, but is usually present in small numbers in late seral meadows. Hypericum anagalloides can be annual or perennial and is an elevation generalist native forb restricted to moist meadows that are not too wet or too dry. Polygonum douglasii is a meadow invader annual (native) that colonizes open ground and thus indicates disturbance and early seral conditions. Yarrow (Achillea millifolium) is a very common native annual forb that was usually identified correctly and indicates drier conditions and disturbance, often by small mammals to begin with. It readily invades sites with overgrazing and makes colonization difficult for later seral, less grazing resistant, palatable species.

Other native weed species, Stellaria longipes (perennial), Veronica perigrina (annual), Collomia linearis (annual), Claytonia perfoliata (annual--miner's lettuce) and Collinsia parviflora (annual--blue-eyed Mary), are common in moist meadows and indicate moderately disturbed, early seral conditions. Rorippa curvisiliqua is a native annual or biennial forb that often roots in water and requires wet areas, streambanks, seeps, springs but not bogs and fens. It indicates mid to late seral conditions with some seasonal flowing water. The perennial exotic forb sheep sorrel (Rumex acetosella) is very common in disturbed moist areas of all kinds of habitats. Gayophytum diffusum is a common annual forb in open forest and sagebrush-steppe. Lotus purshianus is a native annual legume occurring in dry, disturbed areas, and bird's-foot trefoil (Lotus corniculatus) is an introduced perennial legume used in irrigated pastures and has likely been introduced to meadows by seed passing the gut of ruminant animals.

The native monkeyflowers Mimulus primuloides (mat-forming perennial) and Mimulus guttatus (annual or rhizomed perennial) both indicate mid to late seral wet meadow conditions near seeps, springs, or streambanks. M. primuloides also grows in bogs, alpine meadows and around snowmelt. M. guttatus can survive better under drying conditions but only grows to moderate elevations; both species are susceptible to grazing impacts. Several of the native annual Navarretia species are indicative of seasonally wet and dry upland conditions such as on the Modoc Plateau and the foothills of the Sierra in vernal pools.

The following native forbs were typically recorded as perennial weeds on Parker transects even though some were annuals (as noted): Ranunculus alismifolius, R. cymbalaria, Gentianopsis simplex (annual), and Veronica americana. All these are found in wet places, streambanks and meadows at moderate to high elevations and indicate later seral conditions; they do not withstand heavy grazing. Penstemon rydbergii, Sidalcea species, Perideridia gairdneri, P. parishii, Iris missouriensis, Achillea millifolium, Potentilla gracilis, P. glandulosa, P. millefolia, Ranunculus occidentalis, Aster occidentalis, A. adscendens, Arnica chamissonis, Geum macrophyllum, and Dodecatheon jeffreyi are found in moist to drying meadows, vernally wet meadows or low slopes and indicate disturbance conditions if present in large numbers in moist meadows. Note that I. missouriensis is classified as a noxious weed because its leaves are unpalatably bitter, it spreads with heavy grazing, and once established, greatly retards the regeneration of palatable species. It was either identified correctly or as Juncus ensifolius on the Parker transects; this is a very misleading mistake since I. missouriensis often indicates overgrazed conditions where J. ensifolius does not.

Dodecatheon alpinum, Potentilla drummondii ssp. breweri, Aster alpigenus, Lewisia species, Veronica wormskjoldii, Gentiana newberryi, and Gentianopsis holopetala are perennial subalpine to alpine species that grow in wet meadows. They indicate later seral conditions and high plant species diversity when present in small numbers. Note that Aster and Erigeron species were often confused on the Parker transects. Most of the species that were identified as Erigeron were Aster species. The most common Aster species is A. occidentalis followed by A. alpigenus, and A. adscendens. Erigeron foliosus and E. peregrinus occur in Sierran meadows, E. foliosus at moderate elevations in moist shaded areas, E. peregrinus in subalpine to alpine meadows.

Horkelia species, Phalacroseris bolanderi, Antennaria media, and A. pulchella (note both Antennaria spp. were formerly A. alpina) are subalpine to alpine species that grow in moist to dry meadows and upland areas and do not necessarily indicate meadow conditions; they do, however, indicate good ground cover for uplands and are affected by grazing.

Sibbaldia procumbens grows mainly in areas of snowmelt. Antennaria rosea is an upland or meadow edge species that when present in dry meadows indicates disturbance. Antennaria species are found to a greater or lesser extent on nearly all western rangeland; on severely overgrazed sites they are sometimes very abundant or dominant. The annual forb Gnaphalium palustre may be mistaken for Antennaria species. It grows in wet areas and is not necessarily an indication of overgrazing, but does seem to occur on basic, somewhat saline, ephemerally wet sites.

Trifolium species are mentioned separately because of their abundance in meadows, and like all clovers, grazing of taller, competitive grasses can favor these legumes. The most common indicative species are: T. cyathiferum (annual), T. longipes, T. wormskioldii, T. variegatum (annual or possibly short-lived perennial), and T. monanthum. T. cyathiferum is a low to moderately high elevation species occurring on drier meadow sites and indicates disturbance conditions. T. longipes and wormskioldii occur from low to subalpine elevations in wet to moist areas, streambanks and springs. These species indicate early to mid seral conditions and moderate grazing and trampling tolerance. T. variegatum occurs in subalpine to alpine wet meadows, seeps, springs, and streambanks, and with decreasing abundance at lower elevations. It is a small prostrate plant of little forage importance but indicates good diversity and wet conditions. All these clovers are native species. Their role in nitrogen fixation should not be overlooked because of the typical nitrogen limitation to plant growth in meadows and the important agricultural role these systems have today.

Other forbs often recorded on the Parker transects are the native perennials western bistort (Polygonum bistortoides) and corn lily or false hellebore (Veratrum californicum), the biennial, woolly mullein (Verbascum thapsus), the perennial, common dandelion (Taraxacum officinale), and the usually perennial, common plantain (Plantago major). Polygonum bistortoides grows in wet meadows, seeps and streambanks from moderate to high elevations. It indicates fair to good conditions, but when very abundant it indicates overgrazing, especially historical overgrazing by sheep in higher elevation meadows. Veratrum californicum provides similar indications when found in meadows, but it does not grow as high in elevation or in such wet areas. Verbascum thapsus, Taraxacum officinale, and Plantago major are all exotic weeds. A typical habitat for dandelion (T. officinale) is the gully-drained soils of eroded meadows. All these exotics indicate poor to very poor conditions and possibly previously denuded areas. Another group of large forb species, mules ears (Wyethia spp.), are all natives and have increased with overgrazing by sheep.

SAGEBRUSH-STEPPE RANGELAND ASSESSMENT

The highly altered state of sagebrush-steppe rangelands in the West is clearly articulated in a recent symposium proceedings (Monsen and Kitchen 1994) where management of these lands as 'annual rangelands' is discussed. Heavy livestock grazing coupled with Quaternary climate change (Tausch et al. 1993) and little herbivore adaptive evolutionary background in these communities has led to a rangeland system that has been highly modified since European settlement (Young et al. 1988). The primary alteration has been the loss of native perennial grasses, an increase in sagebrush and alien annual grasses, especially cheatgrass (Bromus tectorum), and an increase in fire frequency. The significant characteristic of these altered sagebrush-cheatgrass systems is that they are stable systems from many perspectives (Laycock 1991). Livestock exclosures established by Professor Ed Tisdale more than 6 decades ago and followed by Tueller (1973) and others, including Menke's personal observations over 25 years, have shown that these systems don't recover to what scientists suspect were pre-disturbance states of the sagebrush-steppe.

From two other perspectives, sagebrush-steppe communities are not stable systems. They continue to be invaded by new weed species, and with increased ignition sources from human habitation, fire tends to remove sagebrush (Artemisia spp.), further exacerbating ecosystem function. Fire is a natural disturbance process in sagebrush-steppe, but when it occurs too frequently the shrub component can become inadequate for maintanance of critical elements of the ecosystem. For example, sagegrouse and pronghorn antelope habitat must include a sagebrush component and a substantial component of forbs is highly desirable. The tendency for replacement of understory forbs by cheatgrass is a definite negative for ground-nesting birds. The question is, with continued livestock grazing are sagebrush shrubs and native perennial grasses declining and are these systems becoming more weedy and unstable.

Seven attributes (% composition) were analyzed from Parker C&T transect data for the 7 National Forests with significant acreage of sagebrush-steppe:

Big sagebrush composition
Native perennial grass composition
Forb composition
Non-native species composition
Litter cover
Bare soil exposure
Erosion pavement

The Parker loop sampling frame is not very sensitive to plant composition changes in desert communities where plant cover is low and many readings are on bare ground. The loop method is particularly insensitive to annual grass change since these plants have little basal area, and with summer sampling, much annual material is lumped in the litter category making it indistinguishable from other shrub and forb litter. Sagebrush-steppe communities naturally have always had a very high level of bare ground exposed because they are cold desert systems.

In all cases 2-4 repeated readings of the same transects were used in the analysis and averaged within the decade for which they were read. We always used the first and latest readings of each transect to get the longest term trend indications possible. The following findings are trends and have not been subjected to statistical testing. We realize that results can be affected by weather pattens in the year of sampling. By averaging response variables over decades, some of the annual weather effect is removed. One very positive aspect of the Parker loop method is that it measures plant occurrence at the ground surface level, thereby not being affected by foliar canopy which changes during the growing season.

Big sagebrush cover (%) appears to have declined based upon the weighted average over all 7 Forests (Table 3). Four out of 7 Forests had less sagebrush during the last decade than at least two of the previous 4 decades, and two others not sampled in the most recent decade showed declines in the 1976-85 decade compared to at least one previous decade. Limited samples for the seventh Forest (Plumas) did not allow any trend detection. Using averages from those decades with at least 8 transects of data indicate that native perennial grass composition increased at least by one third on the Modoc, Lassen, Toiyabe and Inyo National Forests (Table 3). Trends for native perennial grasses on the other three Forests appear to be static or downward. Overall forb composition has been remarkably stable with a tendency for a small downward decline in abundance on most Forests (Table 3).

Cheatgrass is the most common non-native component of the monitored sagebrush-steppe communities (Table 4). While cheatgrass cover in all cases was low relative to native perennial grasses, competitive effects reducing native perennial grass and forb seedling recruitment could be important. The Modoc, Tahoe and Inyo National Forests had the highest composition of cheatgrass but sample sizes are so small that it is impossible to detect trends. Further discussion of cheatgrass and other annual grasses is given below in the litter discussion. No other non-natives except wheatgrasses on a few transects on the Plumas were of significance. Medusahead (Taeniatherum caput-medusae) is known to be a major problem on many sagebrush-grass ranges but it was not an important component of any of these transects. Overall, weeds other than cheatgrass were not detected as a problem. General knowledge of resource managers indicates that medusahead has become a much more important invader in the 1980s and 90s, so some of its increase has likely been missed due to lack of repeat readings of transects.

Litter cover (%), and bare soil and erosion pavement exposure (%) indicate soil surface processes and protection or lack there-of from wind and water erosion (Table 5). All three measures showed no clear overall trend based upon weighted average values, but individual Forests showed important changes and the canceling effects of bare soil and litter parameters. Litter cover on the Modoc and Lassen Forests has increased by more than a third and that on the Inyo is upward but to a lesser degree. We suspect this is primarily due to the increasing abundance of cheatgrass. The trend in litter cover appears to be downward on the Toiyabe and static on the other 3 Forests.

While sample sizes are small, bare soil appeared to decline on the Modoc and Lassen Forests and increase on the Stanislaus and Inyo Forests. The other 3 Forests exhibited more static bare soil exposure when small samples were discounted. Most if not all of the reduced bare soil exposed on the Modoc and Lassen Forests was likely due to cheatgrass litter. Cheatgrass litter is a much less effective agent protecting against surface soil erosion than bases of perennial bunchgrasses or sagebrush canopy cover protecting against raindrop impact. Since litter cover has increased and bare soil has also increased on the Inyo Forest, some serious concerns arise on these upland sagebrush-steppe communities. Given that most of the Inyo sagebrush-steppe communities have strong rainshadow influences and are relative dry systems, they need particularly well managed livestock grazing programs. The same can be said for the Toiyabe Forest.

Based on our historical review of livestock grazing on what is now National Forest land, the Modoc Forest was the most disturbed in the sagebrush-steppe and the Lassen, Inyo and Toiyabe were probably not far behind. While the Modoc and other Forests are showing declines in sagebrush and increases in cheatgrass, the increase in native perennial grasses is a very favorable change. Similarly, increases in native perennial grasses on the Lassen, Toiyabe and Inyo National Forests is a very favorable indicator of improving ecosystem biodiversity. The general reduction in sagebrush cover is desirable so long as it remains as a major component of the sagebrush-steppe. Promiscuous prescribed burning of sagebrush-steppe must be avoided where additional spreading of cheatgrass is the likely result (Rasmussen 1994). Some reduction in sagebrush will be required to free up water resources for maintenance of a larger composition of perennial grasses. The slowly declining forb composition will likely contribute to poorer ground nesting bird diets in the future. The high and increasing cheatgrass component on many of the Forests is alarming especially as California becomes more populated and even remote areas have greater probability of fire ignitions.

While this assessment spans 5 decades of monitoring, it is important to reiterate that although substantial reductions in livestock grazing intensity have occurred, most ranges were stocked above carrying capacity for decades until very recently. A key indicator of improved condition that we have observed is an increase in native perennial grass composition on some of these upland rangelands. A key indicator of declining condition is the continued cheatgrass invasion. We agree with Young (1994) that sagebrush-steppe managers should continue to seek to improve the native perennial grass component of these systems on public land. Use of livestock as a management tool appears to be limited (Valentine and Stevens 1994), although some Holistic Resource Managers (HRM) may have new alternatives which should be scrutinized. We were unable to locate relevant long-term HRM results for this assessment. Close monitoring data on the perennial component of sagebrush-steppe communities should direct management so long as perennial grasses continue to increase in abundance.

MOUNTAIN MEADOW RANGELAND ASSESSMENT

In highly productive wet and mesic meadows grazed by livestock, change in plant community species composition is the primary way to assess a complex of direct and indirect impacts and responses to management of livestock grazing. Temporal information on bare soil exposure complements the interpretation of species composition and successional processes since open patches are colonization sites for weeds as well as late successional grasses and forbs. As described in the plant indicator section of this assessment, much is known about many individual species' responses to grazing. Ratliff (1985) has compiled an extensive list of species responses to grazing in Sierran meadows.

Moderate livestock grazing usually increases native plant species' diversity in wet and mesic meadows, but can depress diversity in dry meadows (Ratliff 1985). Particularly in grasslike plant (Carex spp. especially) dominated wet parts of meadows, livestock grazing can reduce dominance and litter accumulations and allow more species to inhabit a site. These species are usually native. Heavy grazing usually reduces foliage density and increases bare ground in the community thereby making sites available to invasion of exotic species if they are present on a grazing unit. Many of the so-called 'increasers' on mountain meadow rangelands are native forbs which can be substantially increased in abundance with frequent grazing (Ratliff 1985).

Trampling impacts can also indirectly affect plant species diversity. Trampling reduces soil porosity especially when soils are wet and of high clay content (D. Zamudio, Toiyabe National Forest, pers. comm.). Repeatedly trampled wet or mesic meadows tend to become drier and of lower productivity due to lowered water infiltration and water holding capacity, and increased runoff. Reduced rooting depth and plant vigor, lowered productivity of aboveground biomass of grasses, grasslike plants and forbs, and bare ground exposure, promote colonization of exotic species (weeds). All these processes indirectly affect microhabitat conditions (water, light and nutrient regimes) and competitive conditions for native plant species. From an agricultural perspective the decline in productivity of these sites tends to shift the burden of grazing to uplands which can lead to unsustainable capacity for a grazing permit and needed reductions. It is imperative that meadows be managed carefully since they often provide the bulk of an allotment's forage productivity.

In the 1990's impairment of riparian ecosystem function has become a primary issue in range management (NRC 1994). For example, stream reaches that pass directly through meadows without adequate meanders tend to produce dry meadow water regimes since the passing of each unit of water through the meadow happens rapidly. Natural meandering keeps water on meadows longer thereby creating or maintaining water tables and more mesic or wet meadow conditions. A common meadow riparian problem is one where meanders have been lost, streams have become straighter with steeper gradients, and have downcut due to faster moving water. One primary livestock-related cause of loss of meanders is overgrazing and loss of woody plants which provide armoring of bends in meanders. The result is that much of the undercut bank structure and therefore fish habitat functionality is lost. Likewise, meadow productivity is depressed due to lowered water tables. Enhanced fish and forage production are shared meadow restoration goals.

The rate of streambank and in-stream recovery is highly site specific. Recovery to a former meandering structure may require increased stream protection from bank disturbance so that over time banks can rebuild, meandering can increase, meadows can become wetter, and fish and other aquatic habitat functionality can return. On the other hand, upstream water quantity and water quality changes could prevent streambank-based approaches from ever working; extreme flood events are a serious risk. Many streams have become degraded due to a combination of grazing disturbance and flood events, especially before land management agencies were established and before humans knew about important riparian ecosystem dynamics. Little information exists on time frames needed for such full functionality to return. One can expect the vegetative functionality to recover most rapidly, followed by the erosion deposition processes, and finally the hydrologic and aquatic habitat functions. Too often in riparian demonstration projects, vegetative recovery is equated with a return of functionality when, in fact, it is the undercut banks and clean gravel deposits which are limiting fish habitat--both physical attributes which take longer to develop.

Resource experts are able to interpret species composition indicators and riparian ecosystem functionality impairment. Teasing out the ultimate causal mechanism, i.e. separating historic effects of extreme flood events from excessive overgrazing periods or their interaction, which is in the history of many meadow/riparian ecosystems, is difficult or impossible in most situations. 'Reading the system functionality', however, and determination of trend in a recovering system is readily possible in most situations with an adequate set of temporal monitoring data. Functionality parameters include such factors as healthy recent recruitment of seral willow vegetation which tends to armor streambanks if the site has the potential for willow; abundance of large woody debris in larger stream systems, and where the adjacent riparian forest contains decadent trees and snags, assurance of a source of woody material into the foreseeable future; lack of excessive erosion or sediment deposition even in relative high precipitation years; adequate herbaceous vegetative cover along streambanks at the end of each grazing season; etc.

What is the target level of protection of riparian ecosystem functionality, how much protection is enough, and how do you tell it is enough? Meadow and riparian ecosystems have greater potential for response to management and recovery than any other range ecosystem type. By their very nature they are well watered systems, plant growth is rapid, and species composition is diverse. There exists many plant community successional pathways and possible future conditions so long as the primary soil resource has not been lost. Trampling compaction effects will naturally reverse themselves with natural freeze/thaw and wetting/drying annual cycles if sites are protected from grazing during wet periods for 5-10 years. Tap roots of abundant forbs in overgrazed meadows will decompose providing routes for improved water infiltration so that it again reaches subsoil layers. Fibrous rooted grasses will become more deeply rooted during meadow/riparian restoration stages. Productivity will increase. Temporally controlled livestock grazing can be a part of this restoration process because grazing stimulates nutrient availability and plant growth if managed strategically.

The key level of protection is where local meadow and riparian disturbance mechanisms cease to happen with any regularity. For example, periodic and locally excessive grazing and trampling on wet meadows prior to normal range readiness, virtually never is allowed to happen. Herding and salting practices are frequent and ongoing management tools, and visual monitoring by knowledgeable permittees with modifications of livestock distribution occurring with regularity (permittees apply principles of 'adaptive management' at the allotment and grazing subunit scale). Acute stream head cuts, where possible, are dealt with in a timely fashion by erosion control experts from the responsible land management agency or landowner. Where plant species diversity problems are apparent, grazing monitoring and management options, i.e., alternative grazing rotations, numbers and distributions are used in an adaptive way to determine the suitable solution. When necessary, special aquatic resources, for example, fens, bogs, or critical riparian habitat may need to be protected for a recovery period or permanently using electric or 'let-down' fencing to exclude livestock.

Six plant community composition attributes were analyzed from Parker C&T transect data on mountain meadows for 10 National Forests of the Sierra Nevada and Modoc Plateau including grass, legume, sedge and rush species composition, non-native species composition, and bare soil exposed. The Parker loop sampling frame reading of basal cover of plants or bare soil is most appropriately used in these thick-sward herbaceous plant communities. Sample sizes are indicated in the three tables of results and emphasis is given to values based upon larger numbers of transects and allotments.

The first complex of indices we used to indicate meadow functionality is grass, legume, sedge and rush relative composition and trends. Wet and mesic meadow ecosystems should not show a trend of grass and legume composition increase at the expense of sedge and rush composition. Such trends usually result from those mechanisms discussed above which ultimately result in drier site conditions and lowered productivity. The opposite trend, however, typically indicates restoration of a water table, reduced runoff and increased infiltration, gully repair, etc. Given that livestock numbers have been reduced and many grazing systems and restoration projects have occurred during the 5 decade monitoring period, we should expect some reversal of dewatering indicators i.e., increases in grasslike plant composition.

Two Forests, the Modoc and Toiyabe, showed the apparent unfavorable meadow water regime response of a reduction in sedges and an increase in grasses as an aggregate response. The trend was strong for the Modoc and weak for the Toiyabe (Table 6). In both cases rushes (Juncus spp.) did not compensate for the sedge reduction. On the Eldorado Forest grasses increased through the third decade (ending 1975) at the expense of sedges, but rushes compensated in the grasslike plant category. Grasses increased on Lassen meadows over the past 4 decades with a relatively stable component of grasslike plants. Grasses have tended to decline on the Plumas, Tahoe and Stanislaus meadows with upward compensation by sedges, and together with rushes appear to be a stable grasslike component. Sedges are dominating meadows on the Sierra and Sequoia Forests, and grasses continue to decline on the Sierra Forest. Grass relative to grasslike composition trends have been relatively stable for the Sequoia but appears somewhat cyclical on the Inyo meadows with recent changes leading to about the same relative composition as 30 years ago. Native legume (Trifolium spp. almost exclusively) composition has tended to increase on the Modoc, Lassen, Plumas, Tahoe, and Toiyabe Forests and show no obvious trend on the other forests.

The non-native species, Kentucky bluegrass, is the primary invader of mountain meadows on all 10 Forests, especially in the north and also the Inyo (Table 7). Generally, bluegrass appears to be increasing on mountain meadows, especially on the Modoc, Lassen and Tahoe Forests. Redtop grasses are the second most common non-native component of meadows with greatest composition on the Plumas through the Stanislaus Forests (Table 7). Increases in composition of redtop are occurring but to a lesser degree than for bluegrass.

Common dandelion is the third most common non-native species occurring on mountain meadows, and while being the most common non-native forb its abundance is substantially less than for bluegrass and redtop (Table 7). Cheatgrass was the next most common invader on drier parts of meadows especially from the Tahoe Forest northward, and except for the Modoc Forest its abundance is usually very low (Table 7). Other non-native species encountered on the Parker transects include medusahead, wheatgrasses, orchardgrass, Alopecurus sp., timothy, silver hairgrass, clovers, tumble mustard, buttercup, Klamathweed, velvet grass, dock and Borago officinalis. None of these latter species appear to be increasing in abundance.

Weighted average bare soil exposure in mountain meadows on 10 National Forests appears to have stabilized at between 4 and 5% more than 30 years ago (Table 8). Trends toward reduced bare soil exposure are most apparent on the Modoc, Lassen, Tahoe, Stanislaus, Sierra, and Sequoia Forests. Bare soil exposed on the Plumas and Eldorado may be increasing, while that on the Inyo appears static and for the Toiyabe, cyclical or indeterminant. The very high bare soil exposure on the Eldorado of 25% for the 1986-95 decade was an average of only three sites, 0%, 31% and 44%, which indicates some severe local disturbance problems in need attention.

Based on the historical evidence of abuse of California mountain meadows during the post-Gold Rush Era (Kinney's and our reports above), the recolonization by native plants, low abundance of non-native weeds, and the soil protection being provided by herbaceous vegetation as indicated by 4-5 decades of range monitoring data is significant. Considering past heavy grazing (see above) in northeastern California, the eastern Sierra in the Carson City and Tahoe environs, and lands of the Mother Lode nearest Sacramento, it is not surprising that the Modoc, Plumas, Tahoe, Eldorado and Toiyabe Forests are continuing to lag a bit in recovery since their meadows were probably most impacted during the early days following settlement. The declining abundance of grass species on the Sierra National Forest and the low abundance of grass species on the Sequoia National Forest during the 4-5 decade monitoring period is a biodiversity concern. The status of grasses and sedges on these two forests may be due to grazing use standards too closely tied to Nebraska sedge which may underestimate forage utilization by livestock on drier components of monitored meadows.

CORRELATION OF MEADOW AND RIPARIAN CONDITION--A CASE STUDY

During summer 1995, 24 Parker transects were re-read on 7 National Forests from the Lassen through the Inyo (see Appendix 1 for summarized data from 1995 and previous readings). The nearest stream/riparian segment to the transect was evaluated using the riparian system functionality 'standard checklist' of 17 parameters developed by the Bureau of Land Management (USDI-BLM 1993). Six other parameters: elevation, width/depth ratio, BLM checklist-predicted functionality and trend in functionality, whether the stream/riparian system previously had a specific restoration project, and whether the allotment has been vacant (non-use for 3 or more years) in the last decade not including 1995, were recorded (Table 9). Functionality and trend in functionality ratings were based on finding several corroborating parameters not in conflict with other parameters to make a determination (see classes of responses in Table 9). Trend was not estimated for those riparian systems determined to be fully functioning.

This exercise was done to determine whether meadow status from Parker transect information, as evaluated using such parameters described above in the plant indicator and meadow assessment sections of this report, could predict nearby stream/riparian system condition. The 24 transects were chosen pseudo-randomly to cover the southern Cascade and Sierra Mountain range wet and mesic meadows, including transects which had been read several times over the last 5 decades, and ones that had a perennial stream in the meadow within 100 meters of the transect location (Table 10). In addition to testing for meadow and riparian status relationships, this exercise was invaluable in that it got us out in the field with experienced range professionals on many sites, and we got up to date transect readings which were used in the regional meadow assessments as well. During this field project many ideas, issues, problems and opportunities for improved range management were discussed with each agency person.

Individual hydrologic, vegetative, erosion deposition and other ratings are presented in Table 11, where sample numbers cross-reference each of the transects (Table 10 and Appendix Table 1). Restoration projects (RP) included fenced riparian exclosures, in-stream structures to reduce stream velocity and to dissipate energy, and planting of vegetation, usually willow cuttings. Animal management (AM) ratings include allotment vacancy in all but one case where substantial changes in animal distribution occurred. The projects and management changes are described below by Forest, District and allotment:

Lassen/Almanor/Butte Meadows: In-stream structures

Lassen/Almanor/Soldier Meadows: In-stream structures within the segment surveyed and exclosures placed upstream. Rewetting of the meadow has occurred where it was previously dry and dominated by bluegrass. High human impact (camping) and an old railroad grade also impact the site.

Lassen/Almanor/Feather River: Electric fence that shocked cattle if in stream. Aspen regeneration project upstream in 1984 because of lack of recruitment.

Plumas/Milford/Ridenour: Two mile livestock exclosure along stream with off-site watering. This site has had extensive logging in the watershed throughout the 1960's and more recently some clear cutting.

Tahoe/Sierraville/Bear Valley: Upper reaches of stream had considerable problems with erosion of streambanks and stream widening so a fence was constructed to exclude cattle. Rock material was placed in the channel to dissipate energy. The site is within the Cottonwood Fire of 1994.

Tahoe/Sierraville/Perazzo: Ongoing stream restoration includes in-stream log structures, bank stabilization with willow, logs placed vertically against steep banks, and split rail fencing not to exclude livestock but to minimize impacts to steeply incised segments of the stream. The site has had extensive logging including clear cuts in the watershed.

Eldorado/Placerville/Little Round Top: Limited restoration project. Rock material has been placed in the channel to dissipate energy. The high elevation watershed with south facing aspect is considered potentially flashy.

Inyo/Mt. Whitney/Monache: Sediment dam far upstream erected in 1980s for blockage of brown trout predation on golden trout. Extensive riparian pasture fencing, streambank log and branch in-stream structures, and rock placements in stream at crossings. High elevation, very large meadow system with deeply incised stream which occurred prior to 1905. Area impacted by high recreation including ORVs.

Animal management and allotment vacancies include the following:

Lassen/Almanor/Butte Meadows: 70% reduction in numbers of cattle and one month shorter season.
Lassen/Almanor/Soldier Meadows: change in animal distribution management by permittee.
Plumas/Beckwourth/Mapes: 3 years vacancy
Plumas/Milford/Doyle: 8 years vacancy
Tahoe/Sierraville/Haypress: 5 years vacancy
Tahoe/Sierraville/Lincoln allotments: 5 years vacancy
Eldorado/Amador/Indian Valley: vacancy for some time but length unknown

Other possible contributing factors leading to meadow and riparian degradation on the 24 sites include logging of uplands, wildfire, historical homesteads, and recreation. Recent high intensity logging in the watersheds above Lincoln and Perazzo (including clear cuts) on the Tahoe, and Ridenour, Jenkins and Doyle on the Plumas. All sites visited have had at least some moderate selective logging in the past. Fire-affected areas include Ridenour, Jenkins, and Doyle on the Plumas and Bear Valley on the Tahoe. The combination of heavy logging and intense fires make watershed conditions potentially flashy and may have contributed significantly to poor riparian conditions seen on many of the Plumas Forest allotments we evaluated. High human impacts due to homestead and/or recreational activities have affected Soldier Meadows (combination of close proximity to major road, camp site, and old railroad grade) on the Lassen. The Mattley (C2) site in Pumpkin Valley, formerly part of the Stanislaus Forest, has remnants of an old homestead, a developed spring, and currently is in private ownership. The complexity and diversity of site specific disturbance elements which interact with the primary focus here, livestock impacts, can make accurate interpretation of causal mechanisms difficult.

Results

Eight of the 24 riparian systems in this case study had restoration projects done on them in the last decade, two of which also had reductions in animal use for the allotment in general, including the meadows where the Parker transects are located (Table 11). Six additional allotments had reductions in use for 3-8 years of the last decade. This finding is indicative of the increased management attention riparian areas and meadows are receiving today.

Seven of the 24 riparian systems were rated as fully functioning, 13 were functioning but at risk, and 4 were not functioning (Table 11). For the functioning-at-risk group of 13, 6 showed upward trend in functioning, 4 showed static trend, and 3 downward trend. Functioning and not functioning riparian systems in the study were not rated for trend. It is the functioning-at-risk riparian systems that we are interested in determining whether we can predict their status and trend from the nearby permanent Parker transect condition and trend plant composition and bare soil exposure database (Appendix Table 1) for the meadow. It is the functioning-at-risk riparian systems that managers have the greatest likelihood of restoration in the foreseeable future and so they are of greatest interest. If prediction were possible, more of this kind of detailed analysis could be done with exisiting data to evaluate many mountain meadow riparian systems in the Sierra without having to do riparian surveys. Such analysis is also an outstanding training exercise for learning how to interpret meadow/riparian system dynamics for improved management in the future.

The canonical correspondence analysis (CANOCO) helped in two important ways. First it identified riparian/stream condition variables (Table 11) not contributing to the separation of conditions along species gradients in the ordination space, and also that cause inflation in variance of the predictive model or have undue influence on the model coefficients. Hydrologic variables 2 and 4, vegetative variables 2 and 5, and erosion deposition variable 2 were thus eliminated from the analysis (see Table 9). On further consideration of these variables, their lack of application or subjectivity became apparent. Beaver dams and their rarity (HYD2), apparent widening of riparian zones which is difficult to judge with one visit (HYD4), diverse composition in largely herb dominated meadows (VEG2), the subjective evaluation of plant vigor in herbs (VEG5), and revegetation of usually non-existent point bars for these sites (ED2) made elimination of these variables an easy decision. The AM variable was not included in the analysis because of the variable effects of different periods of vacany or reductions in numbers of livestock. The BLM checklist obviously was designed for a wide range of riparian systems, and our narrow application to Sierran montane meadows made some of the variables less applicable or redundant (multicollinear) with others.

Secondly and most important, it became apparent from the model that if a site had had a riparian restoration project performed on it, or if the riparian system showed a downward trend (or both), the system had some functionality deficiencies. Functionality and performance of a restoration project were most closely correlated with the first canonical axis but in opposite directions (Appendix Table 2). The FU correlation with Axis 1 equals -.29 and the restoration project (RP) correlation with Axis 1 equals +.33. Trend was close in ordination space to RP with an Axis 1 correlation of +.21. What this means is that in the dual ordination of Parker species and bare soil exposure variables on the riparian/stream site data and vice versa in CANOCO, there were variables in both datasets which successfully separated the species and sites along a common axis, in this case Axis 1. With all the variables involved, the Parker species and bare soil exposure and the riparian stream environment had an overall correlation of 0.99 and an explained variance (eigenvalue for Axis 1) of 72%. This result indicates that prediction should be possible.

Using the aggregated Parker transect data to the genus level, the lifeform categories of grasses, legumes, sedges, rushes, and forbs, and the raw data of bare soil exposure, litter and non-native species (Appendix Table 1) present currently and over the last 5 decades, we were able to predict 11-12 of the 13 functioning-at-risk riparian/stream trend directions correctly. As used in the assessments above, variable dynamics indicating sedge to grass ratio changes without compensation of rushes, invasion or retreat of weedy forbs, reductions in abundance of late seral grasses such as <u>Deschampsia</u> and <u>Glyceria</u> species, radical fluctuation in clovers, and 'red-flag indicators like more than 7-10% bare soil exposure sometime in the meadow's 40-50 year history, was adequate to make the predictions. Using the typical Forest Service allotment folder information on changes in grazing management and site-specific restoration project history would improve this predictive power. This finding should stimulate further testing of these approaches for more diverse meadow/riparian and sagebrush-steppe rangeland plant communities in the future.

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Table 1. Approximate number of Forest Service condition and trend (Parker C&T) transects read or re-read per decade by National Forest for the Sierra Nevada and Modoc Plateau.

National Forest	1950	1960	1970	1980	1990
Modoc	84	190	99	38	2
Lassen	107	323	107	25	50
Plumas	42	153	127	62	21
Tahoe	43	107	77	0	18
Lake Tahoe Basin	3	6	2	0	0
Eldorado	10	50	12	0	3
Toiyabe	3	20	20	11	1
Stanislaus	17	65	70	9	2
Sierra	73	150	80	3	6
Sequoia	41	182	71	5	0
Inyo	29	101	45	52	38
Total	452	1347	710	205	141

Table 2. Approximate number of Forest Service condition and trend (Parker C&T) transects by range type in the Sierra Nevada and Modoc Plateau[1].

Range type	Number of C&T transects
Perennial grassland	47
Meadow	504
Perennial forb	22
Sagebrush	171
Browse-mountain shrub and chaparral	23
Conifer	114
Waste	0
Barren	0
Pinyon-juniper	22
Woodland-annual grass	55
Annual grassland	18
Cultivated	0
Transitory	27

Total number of allotments = 467

[1]Does not include all the Toiyabe NF allotment data since that Forest has adopted nested frequency methods as part of the Forest Service Region 4 policy.

Table 3. Big sagebrush, native perennial grass and forb composition (%) in sagebrush-steppe communities on 7 National Forests over 5 decades from Parker transect (n = no. of 100-loop transects) data.

Forest	before 1956	1956-65	1966-75	1976-85	1986-95
Modoc (n)	(9)	(3)	(0)	(1)	(11)
Big sagebrush	15.4	22.0	-	15.0	14.8
Perennial grasses	7.3	3.0	-	6.0	10.5
Forbs	21.7	24.3	-	27.0	18.2
Lassen (n)	(0)	(12)	(2)	(0)	(8)
Big sagebrush	-	12.8	17.0	-	11.2
Perennial grasses	-	6.5	6.5	-	8.4
Forbs	-	19.8	20.0	-	22.1
Plumas (n)	(0)	(11)	(3)	(3)	(3)
Big sagebrush	-	23.7	9.7	17.7	30.0
Perennial grasses	-	2.9	5.0	5.3	3.0
Forbs	-	35.0	19.7	22.3	38.0
Tahoe (n)	(3)	(5)	(11)	(3)	(0)
Big sagebrush	1.7	20.8	14.3	16.7	-
Perennial grasses	1.7	2.8	3.0	1.7	-
Forbs	8.7	29.6	21.7	19.3	-
Stanislaus (n)	(0)	(0)	(7)	(5)	(0)
Big sagebrush	-	-	31.7	19.0	-
Perennial grasses	-	-	7.1	4.2	-
Forbs	-	-	41.7	25.6	-
Toiyabe (n)	(0)	(10)	(2)	(10)	(2)
Big sagebrush	-	24.4	32.0	20.4	21.0
Perennial grasses	-	2.8	2.0	5.2	0.5
Forbs	-	29.3	25.3	28.1	43.0
Inyo (n)	(0)	(8)	(2)	(0)	(10)
Big sagebrush	-	16.9	14.0	-	13.4
Perennial grasses	-	0.4	0.0	-	3.3
Forbs	-	24.8	25.5	-	23.7
Weighted Average (n)	(12)	(49)	(27)	(22)	(34)
Big sagebrush	12.0	19.7	19.8	19.0	15.2
Perennial grasses	5.9	3.3	4.2	4.5	6.6
Forbs	18.4	27.2	27.1	25.5	23.9

Table 4. Non-native species[1] composition (%) in sagebrush-steppe communities on 7 National Forests over 5 decades from Parker transect (n = no. of 100-loop transects) data.

Forest	before 1956	1956-65	1966-75	1976-85	1986-95
Modoc (n)	(9)	(3)	(0)	(1)	(11)
Cheatgrass	0.8	3.7	-	0	2.5
Medusahead	0	0	-	0	0.6
Filaree	0.1	0	-	0	0
Dandelion	0.1	0	-	0	0
Lassen (n)	(0)	(12)	(2)	(0)	(8)
Cheatgrass	-	0	2.0	-	0.1
Filaree	-	0.4	0	-	0
Plumas (n)	(0)	(11)	(3)	(3)	(3)
Cheatgrass	-	0.2	0.3	0	0
Filaree	-	0.6	0	0	0
Wheatgrass	-	0	0	9.0	0
Tahoe (n)	(3)	(5)	(11)	(3)	(0)
Cheatgrass	2.3	0.2	5.5	0.3	-
Wheatgrass	0	0	0.3	0	-
Plantain	1.3	0	0	0	-
Stanislaus (n)	(0)	(0)	(7)	(5)	(0)
Filaree	-	-	0.4	0	-
Toiyabe (n)	(0)	(10)	(2)	(10)	(2)
Bull thistle	-	0	0	0.2	0
Inyo (n)	(0)	(8)	(2)	(0)	(10)
Cheatgrass	-	0.9	0.5	-	4.8

[1]Cheatgrass (Bromus tectorum), medusahead (Taeniatherum caput-medusae), filaree (Erodium spp.), dandelion (Taraxacum officinale), wheatgrass (Agropyron spp.), plantain (Plantago spp.), and bull thistle (Cirsium spp.)

Table 5. Litter (%), bare soil (%), and erosion pavement (%) in sagebrush-steppe communities on 7 National Forests over 5 decades from Parker transect (n = no. of 100-loop transects) data.

Forest	before 1956	1956-65	1966-75	1976-85	1986-95
Modoc (n)	(9)	(3)	(0)	(1)	(11)
Litter	29.6	20.3	-	28.0	40.1
Bare soil	33.3	41.7	-	27.0	20.3
Erosion pavement	1.6	0.7	-	4.0	3.3
Lassen (n)	(0)	(12)	(2)	(0)	(8)
Litter	-	24.4	16.0	-	38.9
Bare soil	-	18.2	2.0	-	9.6
Erosion pavement	-	12.3	0.0	-	10.5
Plumas (n)	(0)	(11)	(3)	(3)	(3)
Litter	-	34.5	36.3	38.7	34.0
Bare soil	-	14.5	17.3	18.0	17.0
Erosion pavement	-	10.5	23.0	0.0	2.7
Tahoe (n)	(3)	(5)	(11)	(3)	(0)
Litter	36.3 33.0	36.9	44.0	-	
Bare soil	47.0	25.4	23.9	29.3	-
Erosion pavement	3.7	8.4	5.4	5.7	-
Stanislaus (n)	(0)	(0)	(7)	(5)	(0)
Litter	-	-	16.1	14.2	-
Bare soil	-	-	9.0	19.4	-
Erosion pavement	-	-	24.7	34.4	-
Toiyabe (n)	(0)	(10)	(2)	(10)	(2)
Litter	-	35.3	21.5	30.2	23.5
Bare soil	-	18.5	20.0	24.8	10.5
Erosion pavement	-	8.5	18.5	6.4	19.0
Inyo (n)	(0)	(8)	(2)	(0)	(10)
Litter	-	19.9	29.5	-	23.5
Bare soil	-	19.2	23.5	-	26.5
Erosion pavement	-	32.9	20.5	-	17.4
Weighted average (n)	(12)	(49)	(27)	(22)	(34)
Litter	31.3	28.8	28.2	29.5	33.4
Bare soil	36.7	19.8	17.4	23.4	18.7
Erosion pavement	2.1	13.4	14.0	11.7	10.0

Table 6. Grass, legume, sedge and rush species[1] composition in wet and mesic meadows on 10 National Forests over 5 decades from Parker transect (n = no. of 100-loop transects) data.

Forest	before 1956	1956-65	1966-75	1976-85	1986-95
Modoc (n)	(2)	(9)	(9)	(0)	(10)
Grasses	7.5	10.6	26.1	-	25.0
Legumes	5.0	7.0	10.3	-	9.0
Sedges	14.5	16.3	17.2	-	7.7
Rushes	4.5	5.0	6.1	-	2.5
Lassen (n)	(0)	(13)	(13)	(1)	(15)
Grasses	-	22.6	19.9	31.0	29.4
Legumes	-	2.8	4.8	1.0	7.2
Sedges	-	20.4	22.0	26.0	19.6
Rushes	-	12.5	9.2	4.0	10.2
Plumas (n)	(0)	(14)	(13)	(5)	(13)
Grasses	-	25.1	18.4	14.0	20.5
Legumes	-	6.6	3.4	4.0	13.0
Sedges	-	20.6	21.1	22.8	23.2
Rushes	-	13.1	16.1	9.6	11.1
Tahoe (n)	(1)	(16)	(12)	(11)	(7)
Grasses	13.0	32.9	31.9	28.6	20.3
Legumes	0.0	10.1	4.8	3.9	15.0
Sedges	25.0	18.6	22.2	22.3	24.4
Rushes	19.0	2.9	11.8	10.1	11.0
Eldorado (n)	(5)	(12)	(13)	(0)	(3)
Grasses	24.4	22.6	46.7	-	16.7
Legumes	4.6	6.0	8.0	-	4.0
Sedges	20.6	13.1	12.9	-	1.0
Rushes	0.4	9.1	12.2	-	0.0
Stanislaus (n)	(1)	(8)	(14)	(10)	(2)
Grasses	10.0	27.4	20.3	19.1	7.5
Legumes	0.0	18.0	6.4	11.0	2.0
Sedges	2.0	28.8	35.6	31.7	30.5
Rushes	0.0	0.6	1.9	0.8	3.5
Sierra (n)	(6)	(13)	(15)	(0)	(4)
Grasses	29.2	19.3	18.6	-	6.2
Legumes	10.3	3.6	4.3	-	4.5
Sedges	19.7	40.8	34.3	-	47.0
Rushes	1.7	4.6	6.1	-	9.0

Table 6. (continued)

Forest	before 1956	1956-65	1966-75	1976-85	1986-95
Sequoia (n)	(0)	(10)	(8)	(4)	(0)
Grasses	-	12.5	8.5	11.8	-
Legumes	-	8.0	8.8	8.0	-
Sedges	-	41.9	50.4	41.2	-
Rushes	-	10.8	6.1	6.2	-
Toiyabe (n)	(0)	(10)	(1)	(10)	(0)
Grasses	-	16.3	17.0	24.8	-
Legumes	-	6.7	0.0	8.7	-
Sedges	-	26.4	44.0	22.4	-
Rushes	-	6.2	14.0	7.4	-
Inyo (n)	(0)	(20)	(3)	(15)	(11)
Grasses	-	12.5	13.0	9.6	18.0
Legumes	-	6.9	5.0	10.2	2.5
Sedges	-	37.8	25.5	53.8	35.3
Rushes	-	8.6	33.5	3.4	8.1

[1] Grasses (Poaceae), legumes (Fabaceae, primarily Trifolium spp.), sedges (Cyperaceae, primarily Carex, Scirpus and Eleocharis), and rushes (Juncaceae, primarily Juncus).

Table 7. Non-native species[1] composition (%) in wet and mesic meadows on 10 National Forests over 5 decades from Parker transect (n = no. of 100-loop transects) data.

Forest	before 1956	1956-65	1966-75	1976-85	1986-95
Modoc (n)	(2)	(9)	(9)	(0)	(10)
Bluegrass	0	0.6	3.4	-	10.5
Redtop	0	0.4	0.8	-	0.6
Dandelion	0	0	0.1	-	0.5
Cheatgrass	0	2.7	0.1	-	1.0
Medusahead	0	0	0.3	-	0.3
Wheatgrass	0	0	0.1	-	1.2
Orchardgrass		0	0	0	-
0.1					
Alopecurus sp.	0	0	0	-	0.1
Lassen (n)	(0)	(13)	(13)	(1)	(15)
Bluegrass	-	2.4	4.1	0	6.7
Redtop	-	0.2	0.1	0	0.7
Dandelion	-	0.5	0.1	0	1.3
Timothy	-	0	0	0	0.3
Silver hairgrass	-	0.1	0	0	0
Clover	-	0	0	0	0.3
Tumble mustard	-	0	0	0	0.2
Plumas (n)	(0)	(14)	(13)	(5)	(13)
Bluegrass	-	2.0	4.6	1.8	1.8
Redtop	-	0	3.0	0.4	2.6
Dandelion	-	0.2	0.5	0.4	0.1
Cheatgrass -	0	0	0.2	0.1	
Wheatgrass -	0	0	0.4	0	
Buttercup	-	0	0	0	0.1
Tahoe (n)	(1)	(16)	(12)	(11)	(7)
Bluegrass	0	2.0	1.0	3.6	5.7
Redtop	0	0.4	0.2	0.5	1.6
Dandelion	0	0	0	0	1.6
Cheatgrass	0	0	0.2	0	0
Eldorado (n)	(5)	(12)	(13)	(0)	(3)
Bluegrass	0	0	0.8	-	1.7
Redtop	0	0.6	1.1	-	0
Stanislaus (n) (1)	(8)	(14)	(10)	(2)	
Bluegrass	1.0	0.4	0.3	0.1	2.5
Redtop	0	0.2	0.6	1.6	1.5
Dandelion	1.0	0.1	0.1	0.4	0

Table 7. (continued)

Forest	before 1956	1956-65	1966-75	1976-85	1986-95
Sierra (n)	(6)	(13)	(15)	(0)	(4)
Bluegrass	0	0.8	0.1	-	0.2
Redtop	0	0.6	0	-	0
Cheatgrass	0	0	0.1	-	0
Klamathweed	0	0	0.9	-	0
Velvet grass	0	0	0	-	2.2
Dock	0.3	0	0	-	0
Sequoia (n)	(0)	(10)	(8)	(4)	(0)
Bluegrass	-	2.1	0.2	0	-
Redtop	-	0	0.1	0	-
Dock	-	0	0	2.0	-
Toiyabe (n)	(0)	(10)	(1)	(10)	(0)
Bluegrass	-	0	0	3.3	-
Dandelion	-	1.4	0	2.4	-
Wheatgrass -	0	0	0.5	-	
Borago officinalis	-	0	0	0.3	-
Inyo (n)	(0)	(10)	(2)	(5)	(11)
Bluegrass	-	2.8	5.5	0.6	0.3
Dandelion	-	0.7	2.0	0	0.5
Dock	-	0.1	0	0	0

[1]Bluegrass (*Poa pratensis*), redtop (*Agrostis stolonifera*), dandelion (*Taraxacum officinale*), cheatgrass (*Bromus tectorum*), medusahead (*Taeniatherum caput-medusae*), wheatgrass (*Agropyron* spp.), orchardgrass (*Dactylis glomerata*), timothy (*Phleum pratense*), silver hairgrass (*Aira caryophyllea*), tumble mustard (*Sisymbrium* sp.), buttercup (*Ranunculus* sp.), Klamathweed (*Hypericum perforatum*), velvet grass (*Holcus lanatus*), and dock (*Rumex* spp.).

Table 8. Bare soil (%) in wet and mesic meadows on 10 National Forests over 5 decades from Parker transect (n = no. of 100-loop transects) data.

Forest	before 1956	1956-65	1966-75	1976-85	1986-95
Modoc	23.0	16.0	5.3	-	7.3
Lassen	-	3.9	5.0	0.0	2.3
Plumas	-	3.2	2.5	9.4	3.8
Average	23.0	6.7	4.1	7.8	4.1
n	2	35	35	6	38
Tahoe	16.0	2.1	2.5	5.5	1.9
Eldorado	16.2	9.6	5.3	-	25.0
Stanislaus	10.0	1.9	6.8	2.2	3.5
Average	15.3	4.6	5.0	3.9	7.9
n	7	36	40	21	12
Sierra	1.5	2.2	2.1	-	0.5
Sequoia	-	2.5	1.5	0.0	-
Average	1.5	2.3	1.9	0.0	0.5
n	6	23	22	4	4
Toiyabe	-	7.4	2.0	7.2	-
Inyo -	3.6	0.0	4.2	4.1	
Average	-	5.5	0.7	6.2	4.1
n	0	20	3	15	11
Weighted average	10.8	4.9	3.9	4.8	4.6
n	15	114	100	46	65

Table 9. Checklist for rating riparian system functionality[1].

Variable[2]	Description
Hydrologic	
HYD1	Floodplain inundated in 'relatively frequent' events (1-3 years)
HYD2	Active/stable beaver dams
HYD3	Sinuosity, width/depth ratio, and gradient are in balance with landscape setting (i.e., landform, geology, and bioclimatic region)
HYD4	Riparian zone is widening
HYD5	Upland watershed not contributing to riparian degradation
Vegetative	
VEG1	Diverse age structure of vegetation
VEG2	Diverse composition of vegetation
VEG3	Species present indicate maintenance of riparian soil moisture characteristics
VEG4	Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events
VEG5	Riparian plants exhibit high vigor
VEG6	Adequate vegetative cover present to protect banks and dissipate energy during high flows
VEG7	Plant communities in the riparian area are an adequate source of coarse and/or large woody debris
Erosion Deposition	
ED1	Floodplain and channel characteristics (i.e., rocks, coarse and/or large woody debris) adequate to dissipate energy
ED2	Point bars are revegetating
ED3	Lateral stream movement is associated with natural sinuosity
ED4	System is vertically stable
ED5	Stream is in balance with the water and sediment being supplied by the watershed (i.e., no excessive erosion or deposition)
Other	
EL	Elevation in feet: 1=4,000-4,999, 2=5,000-5,999, 3=6,000-6,999, 4=7,000-7,999, 5=8,000+
WD	Width/depth ratio: 1=<1, 2=1, 3=>1, 4=>>1
FU	Functionality: 1=proper, 2=functioning at risk, 3=not functioning
TR	Trend in functionality: 1=up, 2=not apparent, 3=down, 5=not rated
RP	Restoration project: 1=yes, 2=no
AM	Allotment vacant for a period or change in grazing use: 1=yes, 2=no

[1] Taken from USDI-BLM. 1993. Riparian Area Management. Tech. Ref. 1737-9. USDI-BLM Serv. Cntr., Denver, CO. 51 pp. except for variables EL, WD and RP.

[2] Hydrologic, vegetative and erosion deposition variables: 1=yes, 2=intermediate, possibly or somewhat, 3=no or not the case, 5=not rated.

Table 10. Forest, sample number, distict, allotment, cluster and SNEP code for 24 meadow condition and trend transects re-read in summer 1995 to test correlation with stream functionality[1].

Forest	Sample No.	District	Allotment, Cluster	Code
Lassen	1	Almanor	Butte Mdws., 115	LBM19519
	2		Soldier Mdws., 36	LSM39520
	3		Feather River, 9A	LFR99521
Plumas	4	Beckwourth	Mapes Canyon, 1	PMA19307
	5		Grizzly Vly., 1	PGV19508
	6	Milford	Ridenour, 2	PRI29509
	7		Jenkins, 3	PJE39510
	8		Doyle, 4	PDO49511
Tahoe	9	Sierraville	Lincoln, 2	TLI29501
	10		Bear Valley, 1	TBE19502
	11		Perazzo, 1	TPE19503
	12		Bickford, 1	TBI19504
	13		Haypress, 2	THA29505
	14		Independence, 2	TIN29506
Eldorado	15	Placerville	Ltl. Round Top, 1	ERT19522
	16	Amador	Silver Lake, 1	ESL19523
	17		Indian Valley, 1	EIV29524
Stanislaus	18	Calaveras	Mattley, 2	STM29516
	19		Mattley, 3	STM39517
Sierra	20	Minarets	Chiquito, 1	SCH19512
	21	Pineridge	Mt. Tom, 1	SMT19513
	22		Mt. Tom, 2	SMT29514
	23		Mt. Tom, 3	SMT39515
Inyo	24	Mt. Whitney	Monache, 3	IMO39118

[1]Color photographs of the transects and stream segments taken in summer 1995 are available in the SNEP database for these transects.

Table 11. Hydrologic, vegetative, erosion deposition and other stream/riparian system functionality ratings[1] for 24 stream segments on 7 National Forests read in summer 1995.

	Sample	Hydrologic					Vegetative							Erosion Dep.					Other					
Forest	No.	1	2	3	4	5	1	2	3	4	5	6	7	1	2	3	4	5	EL	WD	FU	TR	RP	AM
Lassen	1	3	3	3	3	1	1	1	1	3	1	3	3	3	1	1	1	1	4	1	2	1	1	1
	2	3	3	1	3	3	1	1	1	1	1	1	3	1	2	3	3	3	3	2	2	1	1	1
	3	1	1	3	1	3	1	1	3	1	1	3	3	3	1	1	1	3	3	4	3	5	1	2
Plumas	4	3	3	1	3	1	1	1	1	3	1	1	3	1	1	1	1	1	3	3	2	2	2	1
	5	3	3	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	3	2	1	5	1	2
	6	3	3	1	3	1	1	1	1	3	3	3	3	3	1	1	1	1	3	4	2	2	1	2
	7	1	3	1	3	3	5	1	1	1	1	1	3	1	1	1	1	1	2	1	2	1	2	2
	8	1	3	1	3	1	1	1	1	1	1	1	3	1	1	1	1	1	3	3	1	5	2	1
Tahoe	9	1	3	3	3	1	1	1	3	3	1	3	3	3	1	3	3	3	2	4	3	5	2	1
	10	1	3	3	2	3	3	3	3	3	1	3	3	3	3	3	3	3	2	3	3	5	1	2
	11	1	1	3	3	3	1	1	2	1	1	3	3	3	1	3	1	3	2	3	2	3	1	2
	12	3	3	1	3	1	5	1	1	1	1	1	3	1	1	1	1	1	1	3	1	5	2	2
	13	1	3	1	2	1	3	1	1	1	1	1	3	1	1	1	1	1	4	2	2	2	2	1
	14	3	3	3	1	3	1	1	1	1	1	3	1	3	3	3	1	3	5	4	2	3	2	2
Eldoorado	15	1	3	1	3	1	5	1	1	1	1	1	3	1	1	1	1	1	5	l	1	5	1	2
	16	3	3	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	1	5	2	2
	17	1	3	1	3	1	1	1	1	1	1	1	3	1	1	1	1	1	4	3	2	1	2	1
Stanislaus	18	3	3	3	3	3	3	3	3	3	1	3	3	3	1	3	3	3	5	4	3	5	2	2
	19	3	3	3	3	3	1	1	1	3	1	3	1	3	1	3	1	3	2	4	2	3	2	2
Sierra	20	1	3	1	3	3	1	1	1	1	1	1	3	1	1	3	1	1	1	3	2	1	2	2
	21	1	3	1	3	1	l	1	1	1	1	1	1	1	1	1	1	1	2	3	1	5	2	2
	22	1	3	1	3	1	1	1	1	1	1	3	3	3	1	1	1	1	5	3	2	2	2	2
	23	1	3	1	3	1	3	1	1	1	1	1	1	1	1	1	1	1	5	3	1	5	2	2
Inyo	24	3	3	1	3	1	3	3	1	3	3	1	3	3	1	1	3	1	5	3	2	l	1	2

[1]See Table 9 for explanation of functionality ratings.

Appendix Table 1. Condition and trend transect bare soil (%), litter (%), non-native species (%), and plant species[1] composition (%) for 24 meadow transects on 7 National Forests read in 1995[2] and over the previous 5 decades. Transect sample numbers cross-reference Tables 10 and 11, and year and month for each transect reading are given.

Forest/Allotment	Year-Month	Management and Transect Summary
Lassen		
Butte Meadow	Sample no. 1	
	1995-8	Bare soil 1 Litter 4 Non-native species 30 Danthonia 17 Deschampsia 2 POPR 29 Carex 3 (CANE 3) Juncus 13 (JUBA 13) Trifolium 17 Cirsium 1 Grasses 48 Legumes 17 Sedges 3 Rushes 13 Forbs 31
	1986-7	Bare soil 0 Litter 0 Non-native species 8 Danthonia 25 Deschampsia 3 Muhlenbergia 1 POPR 8 Carex 17 (CANE 7) Juncus 3 (JUBA 3) Eleocharis 7 Trifolium 34 Grasses 37 Legumes 34 Sedges 24 Rushes 3 Forbs 36
	1970-9	Bare soil 0 Litter 15 Non-native species 20 Danthonia 13 POPR 20 Carex 9 Juncus 28 (JUBA 26) Trifolium 5 Grasses 33 Legumes 5 Sedges 9 Rushes 28 Forbs 15
	1965-7	Bare soil 1 Litter 5 Non-native species 5 Danthonia 9 Deschampsia 2 Muhlenbergia 1 POPR 3 Carex 14 (CANE 1) Juncus 38 (JUBA 30) Eleocharis 2 Trifolium 5 Taraxacum 2 Grasses 15 Legumes 5 Sedges 17 Rushes 38 Forbs 22
	1960-7	Bare soil 1 Litter 15 Non-native species 6 Danthonia 5 Deschampsia 5 Muhlenbergia 1 POPR 6 Carex 27 (CANE 4) Juncus 21 (JUBA 21) Eleocharis 4 Trifolium 1 Grasses 17 Legumes 1 Sedges 32 Rushes 21 Forbs 1
Soldier Meadow	Sample no. 2	
	1995-8	Bare soil 0 Litter 0 Non-native species 12 Danthonia 10 Deschampsia 12 Phleum 4 Poa 14 (POPR 1) AGST 1 Carex 13 (CANE 11) Juncus 14 (JUBA 14) Eleocharis 6 Trifolium 6 Taraxacum 3 Sisymbrium 3 Grasses 41 Legumes 6 Sedges 19 Rushes 14 Forbs 26

Appendix Table 1 (continued):

	1986-7	Bare soil 0 Litter 4 Non-native species 25 Danthonia 1 Deschampsia 2 Muhlenbergia 3 POPR 5 AGST 2 Carex 25 (CANE 7) Juncus 17 (JUBA 17) Eleocharis 7 Trifolium 3 (all non-native) Taraxacum 15 Grasses 13 Legumes 3 Sedges 32 Rushes 17 Forbs 33
	1964-5	Bare soil 0 Litter 7 Non-native species 12 Danthonia 22 Deschampsia 2 Muhlenbergia 4 POPR 8 Agrostis 2 Carex 15 Juncus 4 (JUBA 3) Trifolium 4 Taraxacum 4 Grasses 38 Legumes 4 Sedges 19 Rushes 4 Forbs 28
Feather River	Sample no. 3	
	1995-9	Bare soil 0 Litter 9 Non-native species 15 Danthonia 2 Deschampsia 8 Hordeum 3 AGST 1 POPR 13 Carex 32 (CANE 32) Juncus 5 (JUBA 1) Trifolium 5 Taraxacum 1 Salix 15 Grasses 27 Legumes 5 Sedges 32 Rushes 5 Forbs 26
	1969-7	Bare soil 0 Litter 12 Non-native species 3 Glyceria 5 POPR 3 Carex 37 Cyperus 5 Juncus 0 Salix 6 Grasses 8 Legumes 0 Sedges 42 Rushes 0 Forbs 34
	1967-8	Bare soil 1 Litter 12 Non-native species 8 Danthonia 1 Deschampsia 2 Hordeum 1 Agrostis 3 (AGST 1) POPR 6 Carex 33 Eleocharis 1 Trifolium 1 Taraxacum 1 Salix 21 Grasses 13 Legumes 1 Sedges 34 Rushes 0 Forbs 32
Plumas Mapes Canyon	Sample no. 4	
	1993-9	Bare soil 0 Litter 2 Non-native species 2 Agrostis 8 Poa 6 (POPR 2) Hordeum 6 Deschampsia 1 Agropyron 1 Carex 23 Juncus 18 (JUBA 16) Trifolium 2 Grasses 22 Legumes 2 Sedges 23 Rushes 18 Forbs 35

Appendix Table 1 (continued):

	1975-7	Bare soil 1 Litter 16 Non-native species 6 POPR 5 Hordeum 3 Muhlenbergia 1

Carex 18 (CANE 11) Juncus 16 (JUBA 16) Eleocharis 1
Trifolium 4
Grasses 9 Legumes 4 Sedges 19 Rushes 16 Forbs 16

1963-6

Bare soil 7 Litter 3 Non-native species 4
Poa 14 (POPR 4) Hordeum 1 Muhlenbergia 1 Agrostis 6
Carex 11 (CANE 11) Juncus 22 (JUBA 22)
Trifolium 2
Grasses 22 Legumes 2 Sedges 11 Rushes 22 Forbs 23

Grizzly Valley Sample no. 5

1995-6

Bare soil 4 Litter 1 Non-native species 8
Poa 13 (POPR 6) BRTE 1
Carex 9 (CANE 8) Juncus 14
Trifolium 5
Taraxacum 1
Grasses 14 Legumes 5 Sedges 9 Rushes 14 Forbs 58

1979-7

Bare soil 1 Litter 41 Non-native species 0
Poa 17
Carex 23 (CANE 23) Juncus 8 (JUBA 8)
Trifolium 1
Grasses 17 Legumes 1 Sedges 23 Rushes 8 Forbs 10

1959-9

Bare soil 7 Litter 24 Non-native species 0
Poa 38
Carex 12 JUBA 18
Grasses 38 Legumes 0 Sedges 12 Rushes 18 Forbs 0

Ridenour Sample no. 6

1995-8

Bare soil 0 Litter 4 Non-native species 14
Danthonia 1 Deschampsia 7 Muhlenbergia 10 Agrostis 1
Hordeum 5 POPR 14
Carex 26 (CANE 26) Juncus 10 (JUBA 0) Eleocharis 1
Trifolium 6
Grasses 38 Legumes 6 Sedges 27 Rushes 10 Forbs 15

1970-7

Bare soil 4 Litter 30 Non-native species 0
Deschampsia 16 Muhlenbergia 1 Poa 6
Carex 35 (CANE 35) Juncus 4 (JUBA 4)
Trifolium 1
Grasses 23 Legumes 1 Sedges 35 Rushes 4 Forbs 3

1959-7

Bare soil 0 Litter 28 Non-native species 6
Deschampsia 10 POPR 6 Hordeum 2
Carex 32 (CANE 32) Juncus 9 (JUBA 8)
Trifolium 5
Grasses 18 Legumes 5 Sedges 32 Rushes 9 Forbs 9

Appendix Table 1 (continued):

Jenkins Sample no. 7

1995-8

Bare soil 0 Litter 6 Non-native species 14
Poa 30 (POPR 2) Hordeum 2 Muhlenbergia 2 AGST 12
Agropyron 8

Carex 20 (CANE 14) Juncus 6 (JUBA 2)
Trifolium 2
Grasses 54 Legumes 2 Sedges 20 Rushes 6 Forbs 14

1975-7

Bare soil 6 Litter 29 Non-native species 9
Poa 9 (POPR 0) Hordeum 1 AGST 9 Agropyron 2
Carex 11 (CANE 4) Juncus 13 (JUBA 7)
Grasses 21 Legumes 0 Sedges 11 Rushes 13 Forbs 17

1957-7

Bare soil 5 Litter 38 Non-native species 0
Agrostis 10 Agropyron 1 Festuca 15
Carex 7 (CANE 3) Juncus 9 (JUBA 9)
Grasses 26 Legumes 0 Sedges 7 Rushes 9 Forbs 12

Doyle Sample no. 8

1995-8

Bare soil 0 Litter 6 Non-native species 22
Agrostis 24 (22 AGST) Poa 3
Carex 5 (CANE 1) Juncus 59 (JUBA 38) Luzula 2
Grasses 27 Legumes 0 Sedges 5 Rushes 61 Forbs 1

1973-7

Bare soil 0 Litter 23 Non-native species 6
AGST 5 POPR 1
Carex 12 (CANE 4) Juncus 43 (JUBA 26)
Trifolium 0
Grasses 6 Legumes 0 Sedges 12 Rushes 43 Forbs 14

1968-7

Bare soil 1 Litter 27 Non-native species 7
AGST 7
Carex 42 (CANE 42) Juncus 14 (JUBA 14)
Trifolium 1
Grasses 7 Legumes 1 Sedges 42 Rushes 14 Forbs 9

Tahoe

Lincoln Sample no. 9

1995-8

Bare soil 1 Litter 0 Non-native species 0
Hordeum 7 Muhlenbergia 3
Carex 21 (CANE 10) JUBA 3
Trifolium 35
Grasses 10 Legumes 35 Sedges 21 Rushes 3 Forbs 65

1977-8

Bare soil 1 Litter 19 Non-native species 0
Deschampsia 22 Muhlenbergia 18
Carex 17 (CANE 11)
Trifolium 20
Grasses 40 Legumes 20 Sedges 17 Rushes 0 Forbs 23

Appendix Table 1 (continued):

1958-10

Bare soil 2 Litter 10 Non-native species 0
Poa 18 Muhlenbergia 13
Carex 24 (CANE 0) JUBA 1
Trifolium 31
Grasses 31 Legumes 31 Sedges 24 Rushes 1 Forbs 31

Bear Valley Sample no. 10

1995-8

Bare soil 0 Litter 5 Non-native species 0
Agrostis 5 Poa 2 Muhlenbergia 1 Hordeum 1
Carex 47 (CANE 43) JUBA 6
Trifolium 1
Grasses 9 Legumes 1 Sedges 47 Rushes 6 Forbs 33

1974-7

Bare soil 1 Litter 14 Non-native species 0
Poa 3 Muhlenbergia 5 Hordeum 3
Carex 29 (CANE 27) JUBA 7
Grasses 11 Legumes 0 Sedges 29 Rushes 7 Forbs 14

1954-6

Bare soil 16 Litter 12 Non-native species 0
Poa 12 Sitanion 1
Carex 16 (CANE 16) JUBA 19 Eleocharis 1 Fimbristylis 8
Grasses 13 Legumes 0 Sedges 25 Rushes 19 Forbs 6

Perazzo Sample no. 11

1995-8

Bare soil 1 Litter 0 Non-native species 34
Poa 28 (POPR 27) Agrostis 1 Hordeum 1
Carex 1 (CANE 1) Eleocharis 5
Trifolium 23
Taraxacum 7
Grasses 30 Legumes 23 Sedges 6 Rushes 0 Forbs 62

1976-9

Bare soil 5 Litter 14 Non-native species 40
POPR 35 AGST 5
Carex 5 (CANE 5) Juncus 31
Grasses 40 Legumes 0 Sedges 5 Rushes 31 Forbs 5

1965-8

Bare soil 0 Litter 14 Non-native species 31
POPR 16 AGST 6 Deschampsia 2
Carex 29 (CANE 28) Juncus 1
Trifolium 11
Taraxacum 9
Grasses 24 Legumes 11 Sedges 29 Rushes 1 Forbs 32

Bickford Sample no. 12

1995-8

Bare soil 0 Litter 0 Non-native species 11
POPR 8 Deschampsia 14
Carex 36 (CANE 27) JUBA 1
Trifolium 24
Taraxacum 3
Grasses 22 Legumes 24 Sedges 36 Rushes 1 Forbs 41

Appendix Table 1 (continued):

1977-8

Bare soil 0 Litter 16 Non-native species 5
POPR 5 Deschampsia 31 Muhlenbergia 4
Carex 29 (CANE 29)
Grasses 40 Legumes 0 Sedges 29 Rushes 0 Forbs 7

1965-8

Bare soil 0 Litter 11 Non-native species 0
Deschampsia 35 Muhlenbergia 6 Danthonia 1
Carex 13 (CANE 13) Eleocharis 23

Trifolium 1
Grasses 42 Legumes 1 Sedges 36 Rushes 0 Forbs 9

Haypress Sample no. 13

1995-8

Bare soil 10 Litter 0 Non-native species 3
POPR 3 Deschampsia 12 Hordeum 17 Agrostis 1
Carex 10 (CANE 5) JUBA 1 Eleocharis 1 Scirpus 1
Trifolium 9
Veratrum 7
Grasses 33 Legumes 9 Sedges 12 Rushes 1 Forbs 44

1972-9

Bare soil 5 Litter 14 Non-native species 6
POPR 6 Deschampsia 25 Hordeum 13 Muhlenbergia 13
Carex 2 (CANE 2) Juncus 10
Trifolium 10
Grasses 57 Legumes 10 Sedges 2 Rushes 10 Forbs 12

1958-10

Bare soil 1 Litter 6 Non-native species 0
Poa 24 Deschampsia 23 Hordeum 5 Muhlenbergia 4
Carex 8 (CANE 6) Juncus 0
Trifolium 19
Grasses 56 Legumes 19 Sedges 8 Rushes 0 Forbs 27

Independence Sample no. 14

1995-8

Bare soil 0 Litter 0 Non-native species 3
POPR 2 Deschampsia 6
Carex 45 (CANE 32) JUBA 19 Eleocharis 1
Trifolium 13
Taraxacum 1
Grasses 8 Legumes 13 Sedges 46 Rushes 19 Forbs 27

1979-8

Bare soil 0 Litter 5 Non-native species 1
Deschampsia 12 Muhlenbergia 8
Carex 26 (CANE 17) JUBA 14
Trifolium 4
Hypericum 1
Grasses 20 Legumes 4 Sedges 26 Rushes 14 Forbs 14

1964-9

Bare soil 1 Litter 3 Non-native species 0
Deschampsia 26 Muhlenbergia 12
Carex 9 (CANE 0) JUBA 11
Trifolium 2
Grasses 38 Legumes 2 Sedges 9 Rushes 11 Forbs 13

Appendix Table 1 (continued):

Eldorado

Ltl. Roundtop Sample no. 15

1995-8

Bare soil 31 Litter 16 Non-native species 5
Muhlenbergia 10 Hordeum 2 POPR 5
Carex 0
Trifolium 12
Grasses 17 Legumes 12 Sedges 0 Rushes 0 Forbs 36

1972-7

Bare soil 1 Litter 3 Non-native species 8
Muhlenbergia 65 Hordeum 2 POPR 8

Carex 4
Trifolium 9
Grasses 75 Legumes 9 Sedges 4 Rushes 0 Forbs 17

1969-7
Bare soil 11 Litter 2 Non-native species 3
Muhlenbergia 54 Poa 5 (POPR 3)
Carex 1
Trifolium 6
Grasses 59 Legumes 6 Sedges 1 Rushes 0 Forbs 26

Silver Lake Sample no. 16
1995-8
Bare soil 44 Litter 1 Non-native species 0
Grasses 0 Legumes 0 Sedges 0 Rushes 0 Forbs 55

1972-7
Bare soil 10 Litter 9 Non-native species 0
Deschampsia 5
Juncus 47 Eleocharis 5
Trifolium 10
Grasses 5 Legumes 10 Sedges 5 Rushes 47 Forbs 24

1962-8
Bare soil 19 Litter 18 Non-native species 0
Muhlenbergia 2
Carex 14 Juncus 29
Trifolium 10
Grasses 2 Legumes 10 Sedges 14 Rushes 29 Forbs 13

Indian Valley Sample no. 17
1995-8
Bare soil 12 Litter 24 Non-native species 0
Deschampsia 22 Muhlenbergia 6 Danthonia 5
Carex 3
Grasses 33 Legumes 0 Sedges 3 Rushes 0 Forbs 24

1967-8
Bare soil 0 Litter 0 Non-native species 0
Deschampsia 10 Muhlenbergia 3 Danthonia 41 Poa 17
Carex 11 Juncus 5
Trifolium 6
Grasses 71 Legumes 6 Sedges 11 Rushes 5 Forbs 12

Appendix Table 1 (continued):

1955-10
Bare soil 19 Litter 15 Non-native species 0
Deschampsia 1 Danthonia 4 Poa 27
CANE 13
Trifolium 1
Grasses 32 Legumes 1 Sedges 22 Rushes 0 Forbs 7

Stanislaus
Mattley 2 Sample no. 18
1995-8
Bare soil 7 Litter 5 Non-native species 8
POPR 5 AGST 3 Danthonia 7
Carex 16 Juncus 7 Eleocharis 2

Trifolium 2
Veratrum 1
Grasses 15 Legumes 2 Sedges 18 Rushes 7 Forbs 26

1975-8
Bare soil 2 Litter 9 Non-native species 1
AGST 1 Muhlenbergia 1
Carex 42 Juncus 12 Scirpus 5
Trifolium 2
Veratrum 3
Grasses 2 Legumes 2 Sedges 47 Rushes 12 Forbs 28

1958-8
Bare soil 2 Litter 12 Non-native species 10
POPR 3 Muhlenbergia 9
Carex 50 Juncus 0
Trifolium 2
Taraxacum 1 Hypericum 6
Grasses 12 Legumes 2 Sedges 50 Rushes 0 Forbs 19

Mattley 3 Sample no. 19

1995-8
Bare soil 0 Litter 5 Non-native species 11
Carex 24 Juncus 0 Eleocharis 12 Scirpus 7
Trifolium 2
Hypericum 11
Grasses 0 Legumes 2 Sedges 43 Rushes 0 Forbs 51

1977-6
Bare soil 0 Litter 10 Non-native species 3
Muhlenbergia 11 Danthonia 1
Carex 58 Juncus 0 Eleocharis 8 Scirpus 2
Hypericum 3
Grasses 12 Legumes 0 Sedges 68 Rushes 0 Forbs 9

1967-8
Bare soil 0 Litter 0 Non-native species 0
Muhlenbergia 1
Carex 73 Juncus 0 Eleocharis 24
Grasses 1 Legumes 0 Sedges 97 Rushes 0 Forbs 2

Appendix Table 1 (continued):

Sierra
Chiquito Sample no. 20

1995-9
Bare soil 1 Litter 3 Non-native species 12
HOLA 9
Carex 6 Juncus 21 (JUBA 1) Eleocharis 23
Trifolium 16
Cirsium 1 Hypericum 2
Grasses 9 Legumes 16 Sedges 29 Rushes 21 Forbs 36

1971-8
Bare soil 4 Litter 6 Non-native species 13
Danthonia 6 Muhlenbergia 29
Carex 21 (CANE 10) Juncus 5 (JUBA 0) Eleocharis 5

Trifolium 5
Hypericum 13 Veratrum 1
Grasses 35 Legumes 5 Sedges 26 Rushes 5 Forbs 22

1959-8
Bare soil 3 Litter 8 Non-native species 10
POPR 10 Danthonia 5
Carex 13 (CANE 6) Juncus 0 Eleocharis 45
Trifolium 3
Grasses 15 Legumes 3 Sedges 58 Rushes 0 Forbs 16

Mt. Tom 1 Sample no. 21

1995-9
Bare soil 1 Litter 7 Non-native species 1
POPR 1
Carex 28 Juncus 14 Eleocharis 5 Scirpus 4
Trifolium 2
Grasses 1 Legumes 2 Sedges 37 Rushes 14 Forbs 31

1975-8
Bare soil 0 Litter 0 Non-native species 6
POPR 2 Muhlenbergia 12 Agrostis 6 Danthonia 1
Carex 21 Juncus 21 Eleocharis 6
Hypericum 4
Grasses 21 Legumes 0 Sedges 27 Rushes 21 Forbs 16

1960-8
Bare soil 4 Litter 5 Non-native species 1
POPR 1 Muhlenbergia 25 Danthonia 1
Carex 36 (CANE 1) Juncus 3 (JUBA 3) Eleocharis 4
Grasses 27 Legumes 0 Sedges 40 Rushes 3 Forbs 11

Mt. Tom 2 Sample no. 22

1995-9
Bare soil 0 Litter 12 Non-native species 0
Muhlenbergia 2 Poa 1
Carex 47 (CANE 1) Juncus 1 Eleocharis 20
Grasses 3 Legumes 0 Sedges 67 Rushes 1 Forbs 5

1975-8
Bare soil 1 Litter 20 Non-native species 0
Muhlenbergia 3
Carex 27 Juncus 19 Eleocharis 26
Grasses 3 Legumes 0 Sedges 53 Rushes 19 Forbs 4

Appendix Table 1 (continued):

1960-8
Bare soil 3 Litter 14 Non-native species 5
Muhlenbergia 4 AGST 3
Carex 22 (CANE 3) Juncus 2 Eleocharis 37
Hypericum 2
Grasses 7 Legumes 0 Sedges 59 Rushes 2 Forbs 10

Mt. Tom 3 Sample no. 23

1995-9
Bare soil 0 Litter 4 Non-native species 1
Muhlenbergia 8 Agrostis 4
Carex 26 (CANE 17) Juncus 0 Eleocharis 29
Hypericum 1
Grasses 12 Legumes 0 Sedges 55 Rushes 0 Forbs 17

1975-8
Bare soil 2 Litter 0 Non-native species 1

		Muhlenbergia 4 Carex 11 (CANE 5) Juncus 4 Eleocharis 65 Hypericum 1 Grasses 4 Legumes 0 Sedges 76 Rushes 4 Forbs 12
	1960-8	Bare soil 0 Litter 2 Non-native species 5 Muhlenbergia 10 AGST 5 Carex 1 (CANE 0) Juncus 1 Eleocharis 59 Grasses 15 Legumes 0 Sedges 60 Rushes 1 Forbs 21
Inyo Monache Sample no. 24		
	1991-7	Bare soil 14 Litter 51 Non-native species 0 Muhlenbergia 18 Carex 7 Juncus 4 Trifolium 1 Artemisia 2 Grasses 18 Legumes 1 Sedges 7 Rushes 4 Forbs 6
	1980-8	Bare soil 10 Litter 7 Non-native species 0 Muhlenbergia 4 Carex 56 (CANE 25) Juncus 1 Trifolium 10 Grasses 4 Legumes 10 Sedges 56 Rushes 1 Forbs 22
	1963-7	Bare soil 0 Litter 16 Non-native species 3 POPR 3 Muhlenbergia 16 Hordeum 1 Carex 25 Juncus 5 (JUBA 4) Trifolium 10 Grasses 4 Legumes 10 Sedges 56 Rushes 1 Forbs 34

[1]Species codes are POPR (Poa pratensis), AGST (Agrostis stolonifera), HOLA (Holcus lanatus), CANE (Carex nebrascensis), JUBA (Juncus balticus), and BRTE (Bromus tectorum). Plant abundances in parentheses are included in the previous genus abundances.

[2]In a few cases transects had been read recently so were not re-read in 1995.

Appendix Table 2. Canonical correspondence analysis results from CANOCO program computer output. Environmental variable[1] names are described in Table 9.

Program CANOCO Version 3.12 April 1991 - written by Cajo J.F. Ter Braak

Box 100, 6700 AC Wageningen, the Netherlands.
For explanation of the input/output see the manual or
Ter Braak, C.J.F. (1987) Ordination. Chapter 5 in:
Data Analysis in Community and Landscape Ecology
(Jongman, R.H.G., Ter Braak, C.J.F. and Van Tongeren, O.F.R., Eds), Pudoc, Wageningen.

No samples omitted	0
Number of samples	24
Number of species	99
Number of occurrences	326
No interaction terms defined	
No transformation of species data	
No species-weights specified	
No sample-weights specified	
No downweighting of rare species	
No. of active samples:	24
No. of passive samples:	0
No. of active species:	99

Weighted correlation matrix:

	SP-AX1	SP-AX2	SP-AX3	SP-AX4	EV-AX1	EV-AX2	EV-AX3	EV-AX4
SP-AX1	1.0000							
SP-AX2	-.0075	1.0000						
SP-AX3	-.0226	.0088	1.0000					
SP-AX4	.0057	.0011	-.0030	1.0000				
EV-AX1	.9902	.0000	.0000	.0000	1.0000			
EV-AX2	.0000	.9875	.0000	.0000	.0000	1.0000		
EV-AX3	.0000	.0000	.9832	.0000	.0000	.0000	1.0000	
EV-AX4	.0000	.0000	.0000	.9826	.0000	.0000	.0000	1.0000
HYD1	.1565	.0446	-.2145	-.2629	.1580	.0452	-.2182	-.2676
HYD3	-.1534	-.1497	-.0225	.2485	-.1549	-.1516	-.0229	.2529
HYD5	-.2509	-.1864	-.2492	.3595	-.2533	-.1888	-.2534	.3658
VEG1	.5044	.0197	-.1758	.0598	.5094	.0200	-.1788	.0608
VEG3	-.2143	-.0938	.0779	.1686	-.2164	-.0950	.0792	.1716
VEG4	-.2941	.0269	.0266	-.1068	-.2970	.0272	.0270	-.1087
VEG6	-.1891	-.0552	-.0157	.2257	-.1910	-.0559	-.0160	.2297
VEG7	-.0506	-.3163	-.1051	-.0149	-.0511	-.3203	-.1069	-.0152
ED1	-.1841	.0541	.0011	.2041	-.1859	.0548	.0011	.2078
ED3	-.1932	-.1020	-.1836	.5077	-.1951	-.1033	-.1867	.5167
ED4	-.1564	.1448	.1074	.0884	-.1579	.1467	.1092	.0899

Appendix Table 2 (continued):

ED5	-.1594	-.1435	-.0563	.3397	-.1610	-.1454	-.0573	.3457
EL	.2547	.6718	.3839	-.0012	.2572	.6803	.3905	-.0012
WD	-.0157	.0626	.1431	.2089	-.0158	.0634	.1455	.2126
FU	-.2859	.0071	-.0827	.0419	-.2887	.0071	-.0841	.0426
TR	.2068	-.1240	.3535	.1045	.2089	-.1255	.3595	.1063
RP	.3269	-.0520	.0333	.2655	.3302	-.0526	.0339	.2702

Summary:

Axes	1	2	3	4	Total
Eigenvalues	.720	.590	.537	.506	7.332
Species-environment correlations	.990	.988	.983	.983	
Cumulative percentage variance					
of species data	9.8	17.9	25.2	32.1	
of species-environment relation:	12.9	23.4	33.0	42.1	

Sum of all unconstrained eigenvalues	7.332
Sum of all canonical eigenvalues	5.591

No transformation
Biplot scores of environmental variables:

N	NAME	AX1	AX2	AX3	AX4
	R(SPEC,ENV)	.9902	.9875	.9832	.9826
1	HYD1	.1580	.0452	-.2182	-.2676
3	HYD3	-.1549	-.1516	-.0229	.2529
5	HYD5	-.2533	-.1888	-.2534	.3658
6	VEG1	.5094	.0200	-.1788	.0608
8	VEG3	-.2164	-.0950	.0792	.1716
9	VEG4	-.2970	.0272	.0270	-.1087
11	VEG6	-.1910	-.0559	-.0160	.2297
12	VEG7	-.0511	-.3203	-.1069	-.0152
13	ED1	-.1859	.0548	.0011	.2078
15	ED3	-.1951	-.1033	-.1867	.5167
16	ED4	-.1579	.1467	.1092	.0899
17	ED5	-.1610	-.1453	-.0573	.3457
18	EL	.2572	.6803	.3904	-.0012
19	WD	-.0158	.0634	.1455	.2126
20	FU	-.2887	.0071	-.0841	.0426
21	TR	.2089	-.1255	.3595	.1063
22	RP	.3302	-.0526	.0339	.2702

[1] Environmental variables eliminated from analysis were HYD2, HYD4, VEG2, VEG5, ED2 and AM.