Sierra Nevada Ecosystems in the Presence of Livestock

A report to the

Pacific Southwest Station and Region

USDA Forest Service

Rangeland Science Team

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Executive Summary

This document was prepared by a group of scientists with expertise in California rangeland ecosystems. The group was asked to critically review the Sierra Nevada Ecosystem Project (SNEP 1996), Forest Service Sierra Nevada Science Team (SNST 1998) report, and other literature in order to provide an assessment of the current science base for addressing rangeland issues in the Sierra Nevada. The Range Science Team (RST) prepared a draft report in 5 weeks as requested, which was reviewed by scientists, managers, users, and other interested publics. This final report adds to the literature base provided by SNEP and incorporates many of the reviewer comments.

This report stops short of synthesizing the vast amount of peer-reviewed and gray literature concerning the response of Sierra Nevada ecosystems in the presence of livestock. We believe that this synthesis is the most important next step, and we are committed to such an effort. However, we intend to enlist additional expertise to the team and devote the time such an effort requires in order to make a credible, sound, and useful synthesis for managers.

Our effort does point out the deficiencies in current knowledge of ecosystem response to livestock. To paraphrase a recent article by Hamilton (1997), human understanding of a phenomenon, such as ecosystem response to grazing, improves by building on the work of the past. Sometimes, however, it is necessary to reevaluate the firmness of the foundation on which we stand. The intellectual history of the interactions of grazing and ecosystem response forms a cautionary tale where force of personalities and uncritical acceptance of hypotheses have sometimes overshadowed data and squelched open debate so important for the progress of science.

Our findings are summarized below:

Grazing is a polarized issue with some people arguing for removal of grazing based "science" and others supporting grazing based on "science." The evaluation of grazing effects is not so black and white.

"Grazing" is most often treated as a yes or no proposition, but it really is a complex process where timing, frequency, duration, season of use, and intensity matter. The terms "grazing" and "overgrazing" are not defined in most of the statements where they are used. Kattelmann (SNEP1996; V 2 Ch 30) makes an attempt to define overgrazing as when more than half the available forage is consumed (50% utilization). However, this definition is not strongly supported by the references cited. In many studies it is also difficult to determine when "historic grazing" is being discussed versus "current grazing." Without detailed descriptions of grazing season, frequency, intensity, and system as well as a quantitative description of the range site, riparian type, or stream class it is difficult to interpret the work with regard to current livestock management in the Sierra Nevada. Unfortunately, this problem permeates much of the existing rangeland literature.

Much of the existing work on grazing continues to be conducted as case studies. Although lacking in statistical and experimental design rigor, case studies do serve to provide a wealth of applied information. The key to learning from the tremendous amount of case study work occurring is the development and use of standard pre-treatment and post-treatment monitoring, standard reporting of “grazing” management tested, standard reporting of stream characteristics, and standard reporting of watershed history and characteristics. Such information would allow the resources management community as a whole to benefit from individual case study efforts. Case studies (and all forms of “gray” literature) conducted in the Sierra Nevada need to be collected, evaluated and synthesized.

It is also important to remember that observations of phenomena are valid, and observation is the first step in the scientific method. Observations of grazing effects range from defecation in a creek to reducing fire hazard. Ideally, formulating hypotheses from observations is next; then testing hypotheses to build confidence in their general applicability. Unfortunately, testing of hypotheses is not often done before people leap from observation directly to the conclusion that grazing is the *primary* source of resource degradation.

Tracing SNEP-cited literature back to the original sources has provided varying degrees of support for each statement cited (see Appendix 1). We have found citations that are valid interpretations of research work as well as citations that are completely irrelevant to the statement. We found citations that were based on the author’s conjecture in the discussion section of a paper (not data), and we found SNEP authors offering opinions with no citations, and for which we found no experimental basis in the literature available to us. A key problem with the grazing literature cited in SNEP and SNST is that the authors do not always differentiate between peer-reviewed original research, non-peer-reviewed proceedings, editorials, position statements, or informational pamphlets, etc. when supporting statements. Obviously, non-peer-reviewed proceedings, editorials, position statements, and informational pamphlets are often valuable sources of information and are one means by which science and management interface. In tracing statements back to their original source we found a tendency to extend research results far beyond their original findings. This limits the utility of the document for resource managers.

We did find that there is a large amount of relevant, primary scientific literature that is missing completely from both the SNEP and SNST report. Thus, we were able to add to the research base for making decisions about grazing effects in the Sierra Nevada in this report.

One solution to improve resource management is to more closely link scientific research, extension, and on-the-ground management, so that the feedbacks between them can result in adaptive management strategies (Walters 1986) and lead to better policy decisions. Obviously, experimental research will not keep up with the needs of managers to identify and understand the success and failure of grazing management strategies. If science is to form a basis for ecosystem management decisions, then more thought must be paid to the proportion of management dollars available for research support.

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Part I: Introduction

Background

The Forest Service (FS) requested a review of the science base for understanding the biological and social effects and interactions of grazed rangeland ecosystems in the Sierra Nevada. Public concern had been raised, and echoed by the FS own internal Science Team review (1998), that existing information found in Sierra Nevada Ecosystem Project (SNEP 1996) documents concerning rangelands and grazing effects was insufficient to serve as the base for developing a Sierra Nevada wide EIS and amending Forest Plans. This effort is part of the documentation in the pre-NEPA public participation part of the Forest Service's Sierra Nevada Framework for Conservation and Collaboration, 1998.

The Rangeland Science Team (RST) was chaired by Dr. Barbara Allen-Diaz. Members include Drs. Reginald Barrett, William Frost, Lynn Huntsinger, and Ken Tate. Criteria used to select the team included 1) expertise, 2) academic credentials, 3) no previous authorship of SNEP documents, and 4) availability to participate in an initial 5-week turn-a-round time. The RST was in-place on August 24, 1998; the first draft was issued October 1, 1998. Team expertise included plant ecology and management including oak woodland, meadow and riparian systems, inventory and monitoring, wildlife ecology and management, and watershed hydrology. In-stream vertebrate and invertebrate resources were not included in this report because we did not successfully recruit a fish biologist or an aquatic insect expert because they either did not fit the criteria or because they believed that they were unable to effectively deal with the issue of fish habitat in the short time frame allowed for this review.

The RST initially focused its efforts on a review and evaluation of the science base for statements made about grazing in SNEP documents. This approach was taken because the RST was led to believe that this information would serve as the foundation for building grazing management direction during the Forest Service Ecosystem Conservation Framework EIS process. We first asked the question: Is the information in SNEP concerning grazing sufficient to develop alternative grazing management direction? Our conclusion based on the review of statements concerning grazing made in SNEP was no. Since the vast majority of statements we evaluated concerning grazing were negative, any objective evaluation of the scientific foundation of those statements most likely would be considered "pro" livestock. Indeed many reviewer comments considered the draft RST report to be pro-livestock.

Reviewers rightly criticized the incompleteness of the draft report. In fact, in order to meet the original deadline, the RST did not finish an evaluation of additional literature, topics of importance were left out, and the RST did not make any attempt at synthesis or recommendations. This report does add to the literature base, however. Reviewer comments and criticisms can be found at web site: www.psw.fs.fed.us/sierra.

Structure and approach of this study

The RST charter with the Forest Service stated that the RST will review existing science-based knowledge about Sierra Nevada rangeland ecosystems in the presence of livestock. The RST will critically examine existing research literature and other information, including the SNEP rangeland chapter and FS Science Team report, in order to provide an assessment of the quality of the current science base for addressing rangeland issues. As much as possible, in the short time frame allowed, the RST will point out what we know based on experimental evidence as well as what we don't know about Sierra Nevada ecosystems grazed by livestock.

Science is a process for accumulating knowledge about the natural world; it is not always straightforward. The first step is often to propose testable hypotheses based on observations of events in the natural world that suggest patterns, or based on theoretical constructs. A second step may be to make further observations based on comparisons to detect correlation, which may or may not indicate causal relationships. The final step is a series of experiments or controlled observations designed to test hypotheses.

The Forest Service has embarked on an effort to tie scientific discovery and management goals and decisions through the use of an Ecosystem Management Framework. Ecosystem Management has been defined as the management of "communities of organisms working together with their environments as integrated units…places where all plants, animals, soils, waters, climate, people, and processes of life interact as a whole" (Salwasser and Canta 1993 in Haynes et al. 1998).

Four basic scientific principles have been proposed to guide FS ecosystem management efforts (Haynes et al. 1998):

1. ecosystems are dynamic,
2. ecosystems can be viewed spatially and temporally within organization levels,
3. there are limits to ecosystem's ability to withstand change and still maintain integrity, and
4. there are limits to people's ability to predict change.

SNEP was an effort supported by Congress to conduct an independent science assessment of the conditions and trends in ecosystems and communities of the Sierra Nevada. The effort was enormous; more than 50 scientists authored or co-authored articles which pulled together information on the Sierra Nevada ranging from forest health and productivity to economic impacts of development and human population growth.

The Sierra Nevada was defined as an "ecosystem" incorporating the headwaters of 24 major river basins and covering any area of 20,663,930 acres (SNEP Summary 1996). Watersheds were used as the basis for defining Sierra Nevada ecosystem boundaries, even though SNEP authors recognized that no single boundary adequately defined all the important ecological or social components. Thirty six percent of the core Sierra Nevada ecosystem is privately owned and 66% is in some form of public ownership (SNEP Summary 1996). Most of the high elevation and eastern Sierra Nevada are in Forest Service (41%), Bureau of Land Management (13%), or National Park Service (6%) management. Private land ownership dominates the western portion of the Sierra Nevada below 3000’ (SNEP Summary 1996).

Diversity of plants, animals, soils, climate, and people and their uses of the land and resources are extraordinarily high in the Sierra Nevada Ecosystem. More than 3500 species of native plants, 400 terrestrial vertebrates, and 650,000 people occupy the Sierra Nevada (SNEP Summary 1996).

Domestic grazing animals have utilized Sierra Nevada forage resources since the 1860s. In the beginning, Sierra Nevada forage resources were open to any and all that could capture those resources. Early federal policies encouraged open-access use of public land, and although the exact distribution of grazing by cattle and sheep is unknown, it is clear that it was widespread and excessive.

Grazing as an ecological process is composed of intensity, frequency, kind and class of animal, and season of use. Intensity of use is related to stocking rate (number of animals). Frequency of use is how many times animals are allowed to graze in the same area in one season. Kind and class of animal refers to the species and age class of animal. Season of use is the time of year grazing is allowed. These factors shape the various impacts of grazing – selective consumption of plant materials, trampling and nutrient re-distribution.

The Theoretical Framework for Understanding Grazing Effects

Evaluation of possible responses of Sierra Nevada ecosystems to the presence of livestock must be organized in such a way such that responses at different spatial and temporal scales are explicit. Table 1 provides our theoretical framework for evaluating the large body of information on livestock grazing. The “Ecological Hierarchy” (column 1) focuses analysis on a specific spatial scale within which ecosystem functioning occurs. For example, grazing animals select plants and plant parts. Through selective grazing, some individuals are consumed while others are lightly utilized or not grazed at all. Selective grazing, depending on the intensity, frequency and season of use can result in destruction of the most palatable plant populations with changes in plant community composition. Eventually, with continued “heavy” or “abusive” grazing, ecosystem functioning is altered, carbon stores removed, and nutrient cycles interrupted. Habitat for other organisms is altered, and although some species may initially benefit from ecosystem changes, most do not.

At the same time, the physical system can be affected by grazing intensity, frequency or season of use. The “Physical System” (column 2) outlines the spatial scales at which the physical environment is affected and may respond to grazing. For example, the hydrological cycle starts with precipitation and infiltration. Livestock grazing may affect infiltration through the removal of vegetation that may leave the soil surface exposed as well as the physical impact of hoof action that may compact the soil. This results in a loss of soil surface structure and increased erosion through overland flow at a given site. At the watershed scale this may result in an altered soil moisture regime, increased storm runoff, and increased sediment deposition or erosion in stream channels.

Column 3, The “Management System”, is a compendium of management regulations, current practices, and current scales of application which are arranged roughly to align with our perceived understanding of effects at different ecological scales. For example, management direction currently requires annual operating plans on allotments. These operating plans dictate on/off dates (season of use) and number and kind of animals to graze in a particular allotment. However, allotments are composed of numerous ecosystems, communities, populations and individual plants and animals that may respond differently to grazing pressure. The allotment plan is targeted to the landscape or watershed that may not protect resources at other ecological scales.

Explicit in this organization is the understanding that response to grazing will depend also on the temporal scale at which grazing is applied. At any spatial scale within Table 1, the timing of disturbance events (generally season or year, although daily and decade cycles may be of interest) will often result in different ecosystem response.

Table 1.

Ecological Hierarchy	The Physical System	The Management System
Individual	Soil/Infiltration	T&E species
Population	Site	Key areas
Community	Reach	Pastures
Ecosystem	Stream	Grazing systems
Landscape	Watershed	Allotment
Biome	Climate zone	Pastoral systems

Many studies have focused on documentation of the effects of abusive (or heavy) grazing on ecosystem structure and function. The scientific foundation for understanding ecosystem response to abusive grazing is clear: plant cover is destroyed, soil erodes, water quality is degraded, individual wildlife species and their habitats are destroyed, biodiversity declines, invasive plants take hold. Conversely, ample studies have shown removal of domestic grazing animals generally results in increases in plant cover, biomass, and diversity to some point. Water quality, streambank stability, wildlife and fish habitat improve. Again the changes in ecosystem response vary by ecosystem. Arid and semi-arid systems are generally slow to respond while riparian systems and areas with sufficient water are the most resilient in general, and improve the fastest. These studies are sufficient if the goal is to remove livestock grazing. However, if the goal is maintain multiple use of the public lands in the Sierra Nevada, then many more studies quantifying effects at different grazing intensities, frequencies, and seasons of use must be conducted.

The data exist to support the conclusion made in SNEP and elsewhere that Sierra Nevada ecosystems suffered from abusive grazing practices through the turn of the century. It follows then that grazed ecosystems in the Sierra Nevada are now either in static, improving, or still declining condition because of those past abusive grazing practices. In addition, abusive grazing was not the only practice affecting ecosystem response. Changes in fire regime, and changes in hydrology because of mining and road building are other significant activities. It is hard to determine how these factors interact, as well as what the likely ecosystem response will be to a change in one practice such as grazing, given the impact of all the activities. We do know that change in ecosystem condition will not likely be linear in most ecosystems (Allen-Diaz and Bartolome 1998), and that the rate of ecosystem response will most likely vary by ecosystem (e.g. Laycock 1991, Friedel 1991, Kauffman and Krueger 1984).

The question is what practices can managers select in the great middle ground between abusive grazing and no grazing? The answer might be different depending on whether the focus is on ecological, social, or economic considerations. The fundamental choices revolve around grazing systems (rest, season long, deferred, and combinations of short duration, high frequency, etc.), season of use, number of animals, and kind and class of animals.

This report should not be seen as a comprehensive discussion of the topic of grazing, but a contribution towards such an effort. Obviously, unequivocal “scientific” answers to the many questions concerning Sierra Nevada ecosystems response to grazing can only be had after many decades of additional, rigorous scientific study, and detailed, careful synthesis of existing literature. Meanwhile, policy decisions will in most cases be made based on some experimental evidence, educated guesses, and observations made by scientists, managers and land users.

Part II: State of Our Knowledge: Links between Livestock and Water Resources

This section summarizes literature on livestock effects on interception, infiltration, stream channel stability, in-flow stream processes, and watershed water quality. It generally follows the elements of the hydrologic cycle as well as the general spatial hierarchy of the physical system (Table 1). Each subsection below starts with an initial description of how one would expect the system to respond to livestock grazing based on hydrologic principles. The literature is then reviewed and summarized, which clearly points out the weaknesses in uncritically expecting the system as predicted from general hydrologic principles.

Interception and Infiltration

When investigating the potential linkages between livestock and upland hydrologic process, the primary process of concern is infiltration. Any land use or natural event that reduces infiltration capacity has the potential to effect the hydrology of the entire watershed. Hydrologic principles tell us that reduced infiltration and increased overland flow in the uplands can lead to secondary effects on peak flows, erosion, contaminant transport, and water quality degradation. Documenting these secondary effects via watershed scale field research is a difficult task.

From reading SNEP (see appendix 1), we conclude that common beliefs about livestock effects are:

1) Grazing removes vegetation, leaving the soil surface exposed to erosive raindrop impact, and
2) Livestock physically compact the soil via hoof action.

Potential primary results for the site level are:1) Infiltration would be reduced as soil surface structure is lost, 2) Erosion would increase as soil particles are detached and readily transported, 3) Increased soil bulk density, decreased soil porosity and reduced infiltration capacity would lead to increased overland flow and increased erosive and contaminant transport potential.

At the watershed scale potential results include: 1) Altered soil moisture regime, 2) Increased storm flow peaks in streams, 3) Increased stream erosive power, 4) Increased sediment delivery to stream channels, 5) Increased sediment deposition or erosion in stream channels.

<u>Overview of the literature</u>

Does the literature base support this common paradigm? If so, under what grazing management (timing, frequency, intensity, duration, season) are these impacts realized, or not?

A large body of peer-reviewed, experimental literature exists concerning the linkage between livestock and upland hydrologic functions such as interception, infiltration and overland flow. Presented below is a brief glimpse of the amount of literature available, it is by no means comprehensive.

Blackburn (1984) reviews the impacts of livestock grazing on upland watershed parameters by major rangeland vegetation types. He reviews information on cover, soil compaction, infiltration, runoff, and erosion responses and interactions to grazing management treatments. The review is categorized by range ecosystem, and includes California annual grasslands, sagebrush/grass, high elevation rangelands, ponderosa pine/bunchgrass, and pinyon-juniper woodland. The author states “Livestock grazing affects watershed hydrologic properties by removing protective plant cover and by trampling. Reductions in vegetation cover may: (a) increase the impacts of raindrops, (b) decrease soil organic matter and soil aggregates, (c) increase surface crusts, and (d) decrease infiltration rates, and/or increase erosion." He goes on to state "Existing studies show no hydrologic advantage to grazing a watershed lightly rather than moderately. Some studies show no difference in soil loss, infiltration capacity, or soil bulk density between light, moderate, or ungrazed pastures. Little evidence supports claims for specialized grazing systems."

The reader is referred to Blackburn (1984) for a detailed accounting of the 130 publications included in the review. Blackburn has included numerous relationships and tables of data from the original publications, allowing the reader to draw their own conclusions. Blackburn's conclusions include:

> 1. Hydrologic impacts of livestock grazing result primarily from the interactions of climate, vegetation, soil, and intensity and duration of livestock use, Thus, grazing impacts will vary naturally from area to area. Few studies have attempted to account for these natural variations.
>
> 2. Documentation of the intensity and duration of livestock grazing has been poor or completely ignored in most studies. What is described as moderate grazing intensity in one study may be the same as heavy grazing in another study.
>
> 3. Most livestock grazing studies have compared the impacts of heavy grazing with no grazing. It is easy to get the impression from the literature that heavy grazing is a viable management objective or that livestock grazing is universally equivalent to heavy grazing; however, no such oversimplification is justified.
>
> 4. It has been recognized for over 70 years that heavy continuous grazing accelerates erosion and runoff.

Making the point that more research is required on "proper grazing" rather than "overgrazing", Blackburn quotes Love (1958) as writing "There is a large body of information leading to the conclusion that heavy grazing has bad hydrologic consequences. It is doubtful that more investigations are needed to emphasize this conclusion."

Interception and Soil Cover

Gifford (1985) provides a review of the relationship between grazing, soil cover and erosion in which he references 79 publications. He cites 48 peer-reviewed scientific journal articles, 24 technical reports, 4 proceedings papers, and 3 dissertations. Despite its brevity, Gifford's (1985) review appears to be the most comprehensive, or at least the most focused, treatment of the literature on cover with regards to upland range hydrology. He supports the argument that "overgrazing" leads to excessive reduction in vegetative ground cover, increased runoff and erosion. As the Committee for Rangeland Classification (1994) points out, bare soil (inverse of cover) is an important indicator of “range health” or condition. However, Allen (1989) points out that cover alone may not be a good indicator of riparian condition. Gifford concludes the following:

1. Based upon limited data, 50 to 60 % cover is probably sufficient to maximize any benefits to infiltration and also for minimization of sheet or interrill erosion in the Intermountain type.

2. Site specific vegetation cover requirements will vary due to cover type (vegetation, litter, rock, erosion pavement, etc.), seasonal and storm variation, and land use.

3. There is no consistent evidence concerning the importance of one species of vegetation over another with respect to providing cover to safeguard infiltration or reduce erosion.

4. There is no evidence to suggest that cover requirements for either infiltration or erosion should vary depending on class of livestock or wildlife.

Blackburn (1984) reviews numerous papers on the subject of cover. Those of particular interest include Packer (1953) who studied the interacting effects of cover and artificial trampling on bluebunch wheat grass in the Boise River watershed of Idaho, as well as Marston (1952) and Packer (1963). Packer (1953) examines the relative ratios of cover to trampling required to minimized erosion to “safe” levels. Marston recommends 65% ground cover for protection of high elevation watersheds in northern Utah. Packer (1963) recommends that at least 70% plant and/or litter cover is needed to prevent excessive erosion on the Gallatin Elk winter range in Montana.

Infiltration

Infiltration dynamics on rangelands are driven by interacting ecological, soil, hydrological and management factors. Gifford and Hawkins (1978) provide a critical review and statistical analysis of the experiments examining grazing intensity and infiltration capacity throughout western rangelands available at that time. The authors reference 37 papers in the review (23 peer-reviewed journal articles, 10 technical reports, and 4 proceedings papers). Based upon statistical meta-analysis of the available and seemingly comparable data in the literature, Gifford and Hawkins conclude:

> 1. There is an influence of grazing on infiltration. Ungrazed [infiltration] rates are statistically different from grazed at any [grazing] intensity at the 90% level.
>
> 2. It is difficult to differentiate between influences of moderate and light grazing. They may be considered statistically identical.
>
> 3. There is a distinct impact from heavy grazing that is statistically different from that of light/moderate.
>
> 4. There is considerable standard error in the data from the literature, which is to be expected.

Although Gifford and Hawkins give detailed definitions of the term “grazing intensity”, they do not quantify “light”, “moderate”, and “heavy” grazing, leaving the reader uncertain as to the exact interpretation of this work. The greatest research need identified in this work was the need for a detailed definition of the long-term effects of grazing (by year and season) on infiltration rates as a function of site, range condition, and grazing intensity.

Blackburn’s (1984) review contains the main body of the additional work on infiltration conducted from the time of Gifford and Hawkins review (1978) until his own in 1984. In his 1985 review of cover and hydrologic function on rangelands, Gifford (1985) makes the point that the interaction of range-soil community, plant community, vegetation successional stage, range condition, and soil properties to determine infiltration and erosion have not been addressed in the literature. The review also supports the argument that as range condition increases, there is an upward trend in infiltration with improved condition class. Finally, he states that spatial and temporal variability in infiltration rates and erosion have been ignored in most studies.

Recent work has started documenting some of the relationships between soil, vegetation, range condition, and infiltration through space and time on rangeland. Spaeth et al. (1996) cite 98 references and likely capture much of what has been done since Gifford and Hawkins (1978) and Blackburn (1984), but that is not an absolute. Spaeth et al. (1996) reference 56 peer-reviewed journal articles, 9 technical reports, 14 proceedings papers, 3 dissertations, and 16 texts. The breadth of sources is an appropriate reflection of the evolution of this field of work into the examination of ecological, soil, and management influences on rangeland hydrologic processes through space and time.

Subjecting data collected by Rauzi et al. (1968) from 670 plots representing 24 range-soil groups, 35 plant species, and 8 soil and plant parameter measurements from Northern and Central Plains rangelands to detrended correspondence analysis, Spaeth et al. (1996) concluded:

> 1. Infiltration rates were positively correlated with mulch (cover), percent sand, soil structure rating and biomass. Infiltration increased as values for these variables increased.
>
> 2. Infiltration rates were negatively correlated with percent clay, percent silt, and bare ground. Infiltration decreased as values for these variables decreased.
>
> 3. Specific plant species such as western wheatgrass, buffalo grass, needle-and-thread, prairie sandseed, and sedges were correlated with infiltration rate primarily because of soil physical properties.

4. For all data, soil texture was the parameter most correlated with infiltration rates. Biomass and mulch cover protect the soil from raindrop energy, but were secondary to soil texture in predictive models for infiltration rate on a regional scale.

5. Range managers need to be wary of relating range condition to “hydrologic health”, given that the two may not be related depending upon the structure and demography of the plant community. Spaeth et al. (1996) substantiate this statement with references confirming a negative relationship between range condition and “hydrologic health” in sagebrush, rabbitbrush, and broom snakeweed communities (Spaeth 1990, Gutierrez-Castillo 1994, and Spaeth et al. 1994). By hydrologic health the authors are referring to infiltration capacity, interception, surface erosion, etc.

Performing the same analysis on data collected by Blackburn et al. (1990) at the Reynold’s Creek Experimental Watershed in southwest Idaho, Spaeth et al. (1996) examined the spatial and temporal relationships of soil, vegetation, hydrology, and soil erosion in a sagebrush community. Data used represent hydrologic relationships for 13 environmental variables, two soil surface cover types (shrub coppice and interspace between shrubs) over 6 dates. Conclusions are:

1. The shrub coppice was associated with higher infiltration capacity, above ground biomass, aggregate stability, cryptogam cover, surface soil water content, and organic carbon.

2. Less silt, litter cover, rock cover, and erosion was found with the shrub coppice than in interspaces.

3. Infiltration capacity, aggregate stability, above ground biomass, and cryptogamic cover were lower during the winter months.

4. Despite conflicting reports in the literature, cryptogams were found to be important to both infiltration and interrill erosion models in this study.

Finally, Spaeth et al. (1996) analyzed data presented in papers by Wood and Blackburn (1981) on vegetation, soil, infiltration, and sediment production responses to cattle grazing systems. They compared heavy continuous (4.6 ha au-1), moderate continuous (6.2 ha au-1), rest deferred rotation (6.2 ha au-1), grazed deferred rotation (6.2 ha au-1), rested high intensity low frequency (6.5 ha au-1), grazed high intensity low frequency (6.5 ha au-1) and no grazing treatments on Rolling Plains range sites near Throckmorton, TX. Vegetation communities were mesquite shrub canopy zone, as well as midgrass, and shortgrass prairie interspaces. Conclusions were:

1. The existing composition of the plant community had more of an effect on infiltration than grazing treatments.

2. The infiltration gradient (high to low) for plant community was shrub canopy zone, midgrass interspace, and shortgrass interspace.

3. The infiltration gradient (high to low) for grazing treatment was [non-grazed, grazed and rest deferred rotation], [moderate continuous],[heavy continuous], and [rested and grazed high intensity low frequency]. Thus, the authors suggested that there is no difference in infiltration between no grazing and rested and grazed rotation grazing systems. Their ranking of moderate and heavy continuous grazing agrees with Gifford and Hawkins (1978) review, as well as with Blackburn (1984). Intensive grazing systems were found to reduce infiltration to the greatest extent, apparently as the result of concentrated hoof impact and soil compaction.

4. Models using plant community type, regardless of grazing treatment explained 74% of the variability in infiltration rates, grazing alone explained 34% of this variability, and a model containing both plant community and grazing treatment explained 91%. Plant community can be a major confounding factor in infiltration experiments and must be considered in management decisions.

Summary

1. There is evidence that “proper” grazing management can maintain upland hydrologic condition, just as there is evidence that “overgrazing” degrades upland hydrologic condition. The common paradigm is true if the grazing considered is “over-grazing”. However, the paradigm is called into question when “proper grazing” is the case.

2. Unfortunately, we are not much closer to defining “proper grazing” than at the beginning of this exercise. It must be quantified and defined locally, and it must be quantified in any reports, papers, etc. referring to the project or site.

3. Site specific application of the literature to define management will require knowledge of both the literature as well as recognition of site specific soil, vegetation, and grazing information. Site specific application in the form of cover or grazing system recommendations cannot be broad brushed from the existing literature. Rather the literature in conjunction with local field experience provides a platform for knowledgeable first approximations of management recommendations. These first approximations must be fine-tuned via an active adaptive management program. At a minimum the literature tells us that critical site specific parameters to consider when making these first approximations are: a) cover, b) soil texture, c) plant community, d) grazing intensity.

Stream Channel Stability and In-stream Flow Processes

The linkage between livestock, stream channel stability and in-stream flow processes is complex. Streams themselves are complex, Rosgen (1994) describes almost 100 stream reach categories. Watershed/landscape position, watershed gradients, soil/geologic material, climate, and potential/current upland and riparian plant community all interact to define the “natural” structure and function of a stream reach. Each stream type has a unique “stable” channel morphology and pattern. Each will support and/or be supported by different riparian plant communities. Each will respond differently to watershed disturbances, and specifically each will exhibit differing resiliency to differing grazing management strategies.

Leopold (1994), Gordon et al. (1992), and Rosgen (1996) are excellent applications of our basic understanding of stream hydrology and applied river morphology from a watershed perspective. In addition, a team with USDI-BLM (1998) has developed a qualitative method to assess the function of lotic areas on western rangelands. The reader is referred to USDI-BLM (1998) for two reasons: 1) it represents a well thought-out attempt to merge science-based hydrologic, soil, and ecological information with practical experience into an efficient assessment tool for trained, objective land managers; and 2) it is the method used by Menke et al. (1996; SNEP Volume 3, Chapter 22) to assess 24 meadows in the Sierra Nevada. The method cannot be, and was not designed to be, used to determine cause and effect at the watershed or stream reach scale, nor should it be utilized for long term trend monitoring. More detailed watershed scale investigations are required to determine cause and management remedy when streams are identified to be not functioning or at risk.

Finally, phenomena such as stream bank instability result from interacting watershed scale mechanisms occurring through time. These phenomena are almost always linked to several co-occurring natural and human-induced phenomena in the watershed such as wildfire, large storm events, road construction, urban expansion, etc. This is often termed cumulative impacts. In that light, it is difficult to pull “grazing” out of the mix of land uses and natural phenomena occurring in the watershed in recent history and assign some quantity of cause and effect to it alone. Despite this, an attempt is made to examine both reach specific and watershed scale concepts linking livestock to stream channel instability and in-stream flow process.

From reading SNEP, we conclude that the common belief is:

1) Riparian grazing by livestock reduces plant vigor leading to reductions in mass and depth of roots holding soils and stream banks together against stream flow;
2) Long-term riparian grazing shifts plant community away from species which have the root structure to hold soils and stream banks together against stream flow; and
3) Livestock trample and break down stream banks by hoof action.

Potential primary results for the stream reach would include:

1) Increased storm flow peaks in streams, increased stream erosive power, increased sediment delivery to stream channels, and increased sediment deposition or erosion in stream channels.
2) Stream banks become unstable,
3) Stream channels with "hard" bottoms widen,
4) Stream channels with "soft" bottoms down-cut,
5) Stream shading decreases on the widened stream, increasing solar input and water surface area exposed to solar radiation, and
6) Riparian water table is lowered when stream channel down-cuts changing the site potential of the adjacent riparian area.

Potential contributing watershed-scale upland mechanisms include:

1) In the uplands *overgrazing* removes vegetation, leaving the soil surface exposed to erosive raindrop impact, and

2) Livestock physically compact the soil via hoof action.

Potential watershed scale results of stream bank instability:

1) Entire stream system becomes unstable,

2) Stream widening moves headward from impacted reach(s), expanding throughout the watershed,

3) Stream channel down-cutting moves headward from impacted reach(s), expanding throughout the watershed,

4) Watershed drainage efficiency is improved and magnitudes of return interval storms increase (i.e. 5 year storm increases from 5000 to 10,000 cfs), and

5) Sediment eroded from stream channel is deposited in lower gradient low landscape position reaches the watershed, leading to instability of down stream reaches.

<u>Overview of the Literature</u>

Does the literature support this common paradigm? If so, under what grazing management and for which stream types? A large body of literature exists concerning grazing and riparian system stability. Several reviews have been conducted, and the overwhelming conclusion is that this literature is inadequate to adequately answer the question above. There is strong case study evidence documenting the negative impacts of overgrazing on stream channels, as well as the rapid improvement of these systems when the abusive grazing is removed completely.

Platts (1991) discusses 21 case studies focusing on aquatic habitat, of which channel stability is a major component. Twenty of these case studies report that riparian and stream habitats had been degraded by livestock grazing and that these habitats improved when grazing was prohibited. However, Platts demonstrates that each of these studies was flawed to a greater or lesser degree and its results were compromised accordingly. Examples include lack of pre-exclosure data to determine similarities/dissimilarities between "grazed" and ungrazed stream reaches before livestock exclosure, the stocking of trout following livestock exclosure, etc. Platts concludes that the weight of evidence from these studies as a group documents fish abundances and biomasses decline as a result of habitat degradation in the presence of grazing.

Larsen et al. (1998) reviewed 428 papers on the impacts of grazing on riparian zones. The authors classified the papers into 3 categories: 1) original data/research, 2) commentary/opinion, and 3) methodology papers. Eighty-nine of the papers were classified as experimental, where treatments were replicated and results were statistically valid. General problems with the literature are reported as: 1) inadequate description of grazing management practices or treatments, 2) weak study designs, and 3) lack of pre-treatment data.

Elmore and Kauffman (1994) discuss historical overgrazing and degradation of riparian areas. The authors also review riparian grazing management strategies, making general recommendations for developing these strategies. The authors discuss the results of work examining grazing strategies involving three pasture rotation, winter grazing, early growing season, deferred grazing, deferred rotation, rotation grazing, spring-summer grazing, season long grazing, fall grazing, riparian exclusion, and riparian pastures.

Ohmart (1996) reviews over 250 publications which substantiate the negative effects of overgrazing, the need for further research on "proper" grazing management strategies, and the need for increased rigor and consistency in case studies and experiments on these grazing strategies.

Summary

There are significant problems with the existing literature, making it difficult to interpret and apply much of it to support or debate the common paradigm developed in SNEP. A few points seem clear:

1. Each stream will have a different resiliency and response to grazing within the riparian area as well as within the watershed.

2. There is a substantial body of observation, case study, opinion, and review/viewpoint papers that support the accepted fact that "overgrazing" leads to streambank instability and alteration of channel morphology and in-stream flow processes such as sediment

trapping. The amount of statistically valid, experimental information examining this phenomena and explaining the mechanisms which drive it are surprisingly limited.

3. There is also a substantial body of observation, case study, opinion, and review/viewpoint papers which support the premise that site specific riparian grazing management strategies can balance riparian "needs" to insure streambank stability and in-stream flow processes are protected with livestock production. The amount of statistically valid, experimental information examining the grazing strategies, explaining the mechanisms which make them successful, and documenting the positive and negative results of each strategy are also surprisingly limited.

4. Future studies must clearly define the past and current grazing management as well as study site characteristics such as past and current non-grazing land use, soils, climate, etc.

5. Additional studies of abusive grazing v. no grazing are of limited value in identifying proper grazing systems.

6. Funding, time, logistics, as well as watershed and stream variability make it unlikely that enough long-term, "scientifically valid" experiments will ever be conducted to examine each grazing system by stream type combination.

7. Identification of "proper" grazing for a given management unit is dependent upon site specific riparian function objectives and conditions. The literature clearly agrees that off-the-shelf, one-size-fits-all grazing management standards and riparian grazing management strategies will not insure that riparian areas are not "overgrazed". A successful riparian grazing strategy must be custom designed to fit the specific circumstances. A clearly defined objective or desired future condition for the riparian area is the foundation of a successful grazing strategy.

8. New case studies concerning "grazing" and riparian function start every year, yet as a community of rangeland resource managers we all-to-often learn little about economically viable, proper riparian grazing from them. Despite this, Larsen et al.'s (1998) review tells us that case studies are, and will most likely continue to be a large portion of the literature.

Watershed Water Quality and Pathogens

Concerns regarding pathogen loading to water bodies focus on livestock excrement. Pollutants from rangeland beef cattle excrement can effect water quality if the pollutants are directly deposited in the water body or if they are transported to the water body during storm events. Pathogen dynamics on rangeland watersheds are complex and vary through time and space. Often background levels of pathogens are unknown. The spatial and temporal distribution of rangeland beef cattle excrement also varies within and across watersheds. Cattle distribution is a function of topography, soils, vegetation, air temperature, animal class, and grazing management.

Overview of the Literature

A significant body of literature exists on this subject. Nader et al. (1998a,b) utilize a total of 66 references. Of these, 46 are peer-reviewed journal articles, 11 are technical reports, 4 are proceedings papers, 3 are text, and 2 are dissertations.

As discussed in Nader et al. (1998b), the primary water-borne protozoa potentially transmitted by cattle excrement includes *Cryptosporidium parvum* and *Giardia duodenalis* (also known as *Giardia lamblia*) (Fayer and Ungar 1986, Craun 1990, Atwill 1996). *C. parvum* is a tiny protozoal parasite that can cause gastrointestinal illness in a wide variety of mammals, including humans, cattle, sheep, goats, pigs, and horses. It also occurs in various wildlife species such as deer, raccoons, opossums, rabbits, rats, mice, and squirrels (Fayer and Ungar 1986). In cattle, shedding of the parasite is usually limited to calves (Atwill 1998a), but there are a few reports of subclinical shedding in adult cattle (Lorenzo et al. 1993). Dairy calves are commonly infected with *C. parvum* and *G. duodenals* (Ongerth and Stibbs 1989, Xiao 1994), but little is known of their distribution in beef cattle herds, particularly in those herds located on open range.

Detailed studies that attempt to link rangeland cattle grazing with the presence of water-borne pathogenic bacteria have for the most part not been done (Atwill 1996). Instead, indicator bacteria have been used. These studies need to be interpreted with some caution since indicator bacteria have been shown to be poorly correlated with some pathogenic bacteria such as *Campylobacter jejuni* (Carter et al. 1987, Bohn and Buckhouse 1985). However, an increase in indicator bacteria in waterways, due to cattle grazing has been documented in many studies (Gary et al. 1983, Robbins 1979, Dixon et al. 1979, Stephenson and Street 1978). Yet, grazing has also been found to have little or no effect on fecal indicator counts (Frear 1983, Buckhouse and Gifford 1976). Fecal indicators may not always signify the presence of pathogens in the water column (Bohn and Buckhouse 1985). When contamination does occur, it may be temporary and short-lived (Gary et al. 1983, Robbins 1979), or may persist for several months. (Stephenson and Street 1978). Furthermore, concentrations tend to decrease downstream (Robbins 1979).

A special concern for bacterial pollutants is their ability to survive in the environment, only to become a factor in pollution at a later time. Bacteria such as *Salmonella newport* and *E. coli* have been shown to survive several months in freshwater sediments (Burton et al. 1987). Fecal coliforms may survive up to two months in soil, but in the protective medium of feces, can persist up to a year (Bohn and Buckhouse 1985). Bottom sediments have been found to harbor concentrations of indicator organisms up to 760 times greater than the overlying water (Stephenson and Rychert 1982).

Studies that carefully evaluate the association between rangeland cattle and the presence of these water-borne protozoa have not been conducted. The majority of the existing literature deals with dairy cattle, or was conducted in laboratory settings. These studies do not explicitly state how the cattle were managed nor define the cattle's proximity to contaminated water bodies. Madore et al. (1987) measured 5,*800 Cryptosporidium oocysts*/L in irrigation canal water running through agricultural acreage with cattle pastures compared to 127 oocysts/L in river water subject to human recreation and 0.8 oocysts/L for stream water exposed to ranch land runoff. Unfortunately, the authors do not specify if the cattle were beef or dairy cattle or if the species of Cryptosporidia was the of human health concern, *parvum*.

Atwill et al. (1998a) measure the distribution of fecal shedding of *C. parvum* from California cow-calf herds. A total of 1399 (915 calves and 484 yearlings/adults) from 38 herds across the State were tested between Feb. and Aug. 1995. The author's report a total of 3.9% of all animals were shedding *C. parvum* oocysts. Age-stratified prevalence of shedding among calves ranges from 0-13%. The prevalence of shedding among cattle 12 months or older was 0.6%. Thus, fecal shedding by cow-calf herds is primarily limited to calves 1-4 months of age. The author concludes that the risk that cattle contaminate watersheds with appreciable levels of *C. parvum* is primarily limited to those periods when young calves are present in the herd. This finding is confirmed in mature dairy cattle as well (Atwill et al. 1998b).

Along California's central coast range, Atwill et al. (1997) found that 12 (5.4%) and 17 (7.6%) of 221 feral pigs were shedding *C. parvum* and *Giardia* sp. cysts, respectively. The authors also found that younger pigs (8 months) and pigs from dense populations (> 2 pigs/km2) were significantly more likely to shed oocysts compared to older pigs (>8 months) and pigs from low density populations (< 1.9 pigs/km^2). The authors conclude that given the propensity of feral pigs to focus their activity in the riparian area, feral pigs may serve as a source of protozoal contamination for surface water.

Johnson et al. (1997) examined the prevalence of shedding of *C. parvum* and *Giardia* spp. by backcountry recreational horses. In fall 1994 the authors collected fecal samples from 91 horses with a history of backcountry use during 1993 and 1994. Five to six horses from each of 16 locations throughout California were sampled. Horses ranged from 4 to 24 years of age. None of the horses sampled were positive for either *of C. parvum* and *Giardia* spp. The authors conclude that, even accounting for the sensitivity of the test employed (potential for false negatives), the highest probable prevalence of shedding for either pathogen was < 3.2% for the cohort of horses studied.

Summary

1. Water quality data should be examined carefully before assigning a cause and effect relationship between cattle grazing and nonpoint pollution

2. Given the recent prevalence work by Atwill et al. (1998ab, Johnson et al. 1997), it would be premature to claim that rangeland cattle production is the leading source of *C. parvum* or *G. duodenalis* for surface water contamination.

3. Rangeland beef cattle excrement has been shown to increase pathogen contamination in waterways beyond background levels. It has also been shown to have no detectable effect.

4. In managing livestock to minimize potential contamination one must consider the age of the animals, the hydrology of the area, and the proximity of feeders, etc. to waterways.

5. Livestock's distribution within a watershed can be manipulated using sound range management practices such as salting, water location, fencing, and selecting against cattle that graze riparian areas. Salt, mineral or protein supplements placed next to the streams can result in direct pollution of the water as well as increase cattle dung, urine and trampling next to the stream. Alternative water sources, such as windmill or solar powered wells, reservoirs, and guzzlers, can be developed in upland areas to draw cattle away from streams.

Water Quality (Water Temperature)

Water temperature is a critical physical property of rivers and streams, influencing a number of physical, chemical and biological characteristics. Stream temperature influences solubility of oxygen and other gasses, chemical reaction rates, and sediment transport capacity (Webb 1996). It has strong impacts on freshwater biota influencing distribution, growth, reproduction, disease, migration and behavior of both vertebrate and invertebrate populations (Baltz 1987, Beschta et al. 1987, Ward 1992, Elliot 1994). Stream temperature effects survival of waterborne pathogens such as *Cryptosporidium parvum* and *Giardia* spp. (Atwill 1996).

As a general rule, stream temperature will rise and fall with air temperature. The amount of fluctuation will depend on a range of secondary environmental and management considerations. For instance, shading by streamside vegetation and deep pools can keep temperatures cooler as well as moderate diurnal extremes. Thus, management activity which alter streamside vegetation or channel morphology have the potential to alter stream temperature dynamics. This reasoning assumes that stream temperature in the reach is actually controlled by streamside shade and channel morphology, rather than flow dynamics, cool/warm spring-flow input, snow-melt, stream latitude, elevation, stream order, substrate, etc.

On rangeland watersheds in particular, livestock grazing is believed to increase stream temperature via removal of riparian vegetation and stream bank instability resulting in increased channel width-to-depth ratios (Platts 1991).

From reading SNEP, we conclude that the common belief is:

1) Livestock grazing reduces riparian vegetation, and
2) Streambank instability due to grazing causes stream channels to widen, increasing the channel's width to depth ratio.

This would result in:

1) Increased solar radiation reaches the water surface, and

2) Stream temperature increases.

Overview of the Literature

There is still much we do not know about the basic processes driving stream thermal dynamics, or the mechanisms by which livestock may impact this dynamic. Existing research on stream temperature falls into four main areas: 1) the impact of temperature variations on aquatic biota; 2) the effects of temperature on other processes within streams; 3) factors contributing to temperature increases; and 4) models for predicting temperature changes. Although there is a degree of overlap, in the interests of clarity the four areas will be considered separately.

The impact of temperature variations on aquatic biota.

There has been substantial research into the impact of temperature variations on aquatic vertebrates and invertebrates, particularly salmonids. Water temperature has both direct and indirect effects on trout and salmon. Because they are poikilotherms whose body temperature will average only 2-3^{o}C below ambient temperature, metabolic processes are driven in large part by water temperature (Berman and Quinn 1991). For example, growth rates of juvenile rainbow trout (*Oncorhynchus mykiss*) in laboratory experiments are highest at temperatures between 15^{o}C and 20^{o}C (Linton et al. 1997). However, temperatures above 25^{o}C are believed to be lethal to most salmonids (Jobling 1981), and spawning does not occur unless temperatures are near 9^{o}C. Recent studies have focused on the impacts of temperature changes on salmonid behaviors such as aggression, feeding, and swimming (Matthews et al. 1994, Neilsen et al. 1994, Scott and Pointer 1991). Preliminary results from these studies suggest that age of the study fish is a confounding factor, and have also raised the possibility that salmonids from warmer climates may have adapted to a wider range of temperatures than previously thought possible (Matthews et al. 1994). Matthews et al. (1997) reports field observations of trout at 28 and 29^{o}C, well above the 25^{o}C lethal limit reported from laboratory studies using commercially available trout.

Studies on macroinvertebrates indicate that temperature plays a significant role in community composition which in turn influences prey availability for larger invertebrates and fish (Murphy and Hall 1981, Hawkins et al. 1983, Lester et al. 1994). Until recently, research indicated that elevated stream temperatures had a positive impact on food availability for salmonids, but this research is now being reexamined on three fronts. First, it appears that the factor which raised stream temperature in the earlier studies (canopy removal) was itself the driving force behind macroinvertebrate increases, because increased light levels (not temperature) increased autotrophic production. Second, it has been pointed out that although stream temperatures increased in the Murphy and Hall (1981) and Hawkins et al. (1983) studies, it still remained below critical levels for salmonids and for cold stenothermic macroinvertebrates (Tait et al. 1994). Third, research by Lester et al. (1996) has raised the possibility that some streamside vegetation, particularly willows (*Salix* spp.), exude chemicals which constrain certain macroinvertebrates, and that removal of that vegetation, not resultant temperature increases or higher periphyton production, is the force behind macroinvertebrate increases. Consequently, this area of research is currently in a state of some confusion.

The effects of temperature on other processes within streams

Temperature regulates so many biological and chemical processes within streams that the Federal Water Pollution Control Administration (a precursor of the EPA) once described it as “a catalysts, a depressant, an activator, a restrictor, a stimulator, a controller, a (EPA 1986). Aquatic plant respiration and photosynthesis are temperature dependent, as are microbial processes such as decomposition, chemical reaction rates, sediment transport, and gas solubility (Allan 1995). One of the most crucial effects of elevated temperature is that it both increases organismal demand for dissolved oxygen and decreases its availability, so much so that the real limiting factor for many cold stenotherms may be oxygen availability at high temperatures, not the temperatures themselves (Hynes 1970). In some circumstances, oxygen depletion in streams is further exacerbated when temperatures are sufficiently heightened to increase the decomposition of organic matter, since that process also draws on available oxygen (Chamberlin 1982). Similarly, warm water carries considerably more sediment than cold water, and water with a high amount of suspended sediment absorbs heat more rapidly than clear water (Webb 1996).

Factors contributing to temperature increases

In a relatively undisturbed ecosystem, stream temperatures will be determined by combination of environmental factors such as air temperature, flow, channel morphology, substrate, solar radiation and riparian shading. Of these factors, it appears that in the absence of strong localized inputs from groundwater or snowmelt, the most important factor driving water temperature is air temperature (Webb 1996). In slow moving streams, where the water does not mix thoroughly, or in rivers where gravel bars promote deep pools away from the main channel of the river, thermal stratification may occur. Deeper levels may maintain a more constant temperature while upper levels fluctuate in response to air temperature (Matthews et al. 1994, Neilsen et al. 1994).

Because water temperatures are sensitive to a wide range of interacting environmental factors, human activities that affect these factors have the potential to effect stream temperature. Temperatures have been shown to be dramatically affected by land use change within the watershed (Li et al. 1994) particularly by impoundments (Mackie et al. 1983, O’Keeffe et al. 1990) and deforestation (Holtby 1988, Beschta and Taylor 1988, Rowe and Taylor 1994, Davies and Nelson 1994). While there is widespread agreement that large-scale watershed deforestation will result in elevated temperatures, there is less agreement about the impacts of smaller scale disturbances such as grazing in riparian areas.

Larson and Larson (1996) argue that shade does not cool a stream rather it merely prevents heating to the degree that watershed attributes and site characteristics allow it.

They contend that the air mass characteristics of the watershed, its elevation, surrounding landscape and instream inputs, coupled with site specific characteristics like flow, aspect, and slope will be the primary determinants of temperature, and that direct riparian shading will play at best a small role in rangeland streams. Beschta (1997) challenges these conclusions, arguing that shade, whether supplied by dense canopies of conifer over larger streams or by sedges, rushes, and willows along smaller rangeland streams, has historically been the moderating factor which has allowed salmonid survival in waters of the high deserts and intermountain West. What both authors agree on, however, is that riparian vegetation has a significant impact on channel morphology and on nutrient and organic matter inputs (leaf litter, insect drop, etc.). Fish biologists would further emphasize the importance of overhanging bank as cover for salmonids (Wesche et al. 1987).

Models for predicting temperature change

Models for predicting stream temperature fall into two broad categories: A). models designed to assess the effects of particular management alternatives, such as logging or diversions (Brown 1972, Beschta 1984, Theurer et al. 1984 Bathelow 1989, Weatherley and Ormerod 1990, Hostetler 1991, Sinokrot and Stefan 1993, Bicknell 1993, Donigian 1995, Chen 1997); and B). models primarily designed to predict the impacts of global climate change and air temperature on stream temperature (Stefan and Preud'homme 1993, Stefan and Sinokrot 1993, Webb and Nobilis 1997). While each of these models has its strengths and limitations, a few generalizations can be offered. First, most of the models intended for use in decision-making are highly complex. For example, the EPA has developed a computer watershed simulation model capable of predicting stream and river temperatures in certain situations (Bicknell 1993), but its use requires hourly input data and considerable technological sophistication from the user (Donigian et al. 1995). Second, these models are primarily geared towards streams and rivers with substantial instream flow, and depend on historical flow records; consequently they are not especially useful for small headwaters streams (Jeppesen and Iversen 1987). Third, several models infer the impact of shade from temperature measurements taken on either end of a shaded stream reach (Sinokrot and Stefan 1993) and use the inferred value to predict what would happen if the shade were eliminated. As a result, these models have limited usefulness in a restoration context where the question centers on establishment, rather than removal, of vegetation. Fourth, while the linear regression models based on air temperature have the advantage of being cheap, easy to use, and reasonably accurate, they are quite site-specific, since groundwater, snowmelt or other environmental factors not considered by the model may exert considerable influences on a particular stream or reach (Webb and Nobilis 1997).

Summary

Comprehensive investigations of stream temperature dynamics, the effect of management on these dynamics, and the effect of both on fisheries must draw on many disciplines (hydrology, geology, biochemistry, fisheries biology, stream ecology, organismal biology, range management, forestry, etc).

There remains a wealth of information to be learned about: 1. the factors controlling stream temperature dynamics, 2. the relative importance of each factor under different circumstances, 3. how these factors interact at various spatial and temporal scales, and 4. under what circumstances common range management practices increase stream temperature and what can be done to avoid stream temperature increases with economically and socially viable management measures.

From a rangeland management perspective one of the most crucial areas for investigation is the extent and function of shading on stream temperature.

Many (Platts 1991, Moyle and Liedy 1992) remain firmly convinced that loss of riparian vegetation due to grazing is one of the most critical problems facing fisheries, some contend it is not entirely clear that vegetation typical of many rangeland streams can have significant effect on stream temperature (Larson and Larson 1996). If the role value of rangeland riparian shading is overestimated, efforts at riparian vegetation restoration may not achieve desired stream temperature reduction goals.

While it may be true that grazing in riparian corridors is problematic even if it does not lead to elevated stream temperatures, temperature increase due to vegetation removal is a testable hypothesis and deserves further investigation. Although a link between livestock grazing and increased channel width to depth ratios is extremely difficult to establish in a research setting, the relationship between stream temperature and channel morphological characteristics is manageable, even if observational, research objective.

Part III: State of Our Knowledge: Links between Livestock and Plant Resources

Meadows and Riparian Resources

Montane and subalpine/alpine meadows occupy less than .01% of the SNEP study area (Davis 1996). As described in Shiftlet (1994, SRM Types 213, 216), meadows are habitats occupied by grass (Poaceae family) and grasslike species primarily of the genera *Carex*, *Juncus* and *Luzula*. Meadow composition is diverse and Ratliff (1985c) suggests that over 1500 meadow types, based on species, topography, and hydrology may be identifiable. The primary environmental characteristic of meadow vegetation is an associated high water table during all or part of the year (Benedict 1982, Ratliff 1985, Allen-Diaz 1991).

Montane riparian systems occupy less than .002% of the Sierra Nevada area (Davis and Stoms 1996, v.II, Chpt 23). As described in Shiftlet (1994, SRM Type 203) riparian woodlands occur along rivers, streams, and creeks, although some streams in the Sierra Nevada may not have a woody species component. Species composition and vegetation structure vary throughout the Sierra Nevada, but the principal overstory associates include willow (*Salix* spp.), cottonwood (*Populus* spp.), alder (*Alnus* spp.), maple (*Acer* spp.) and oak (*Quercus* spp.). The distribution of the type is limited to environments along water courses, where riparian species are adapted to seasonal inundation by water. Sucessional studies by McBride and Strahan (1984a, 1984b; Strahan 1984) suggest that riparian zones never exhibit a stable climax at any one location, rather the riparian zone should be viewed as a mosaic of establishment, replacement, and destruction controlled by fluvial geomorphic processes.

From reading SNEP and FS Science Team report, we would conclude:

1. The potential primary result of grazing at the population/community level is: loss of cover, change in species composition through vegetation removal, invasion of non-native plants.
2. The potential result at the ecosystem: channel degradation, sedimentation, increased erosion, loss of native plant species, increase in weedy and/or invasive species, loss of herbaceous productivity, change in vegetation composition and structure linked to wildlife and fish habitat.
3. The potential landscape level result: lowering of water table, loss of ecosystem type (meadow or riparian system).

<u>Overview of the Literature</u>

Skovlin (1984), Platts and Raleigh (1984) who review Skovlin (1984), and Ratliff (1985) provide somewhat dated but the most comprehensive reviews of the interactions between livestock (cattle) grazing and meadow/riparian resources. Skovlin reviewed 104 refereed journal articles, 29 technical reports, 24 dissertations/theses, and 10 unpublished reports in his review. Ratliff (1985) synthesized his own research and years of experience on Sierra Nevada meadow ecology and management. The potential effects of grazing on meadow and other woody vegetation come from animal defoliation, preferential grazing, trampling, and the redistribution of nutrients. Plant responses can include reduced vigor, lower productivity, and altered species composition with the potential for erosion, plant invasion, small mammal interactions and changed fire regimes.

Meadow/riparian research can be organized into several categories. Some studies focused on grazing system effects, others on grazing intensity or grazing season. Some studies examined rooting potential to hold streambanks. Finally Skovlin (1984) and Platts and Raleigh (1984) suggest some problems with existing research.

Grazing system

Davis (1977), Ames (1977) and Behnke (1979) have suggested that no grazing system short of fencing (total livestock exclusion) has any significant effect on recovery of riparian habitat. These three articles, although often cited, are opinion pieces with no experimental evidence to support the authors' opinions. Szaro (1980) cites Davis (1977) and Ames (1977) when he states that livestock exclusion is the only effective way of insuring significant recovery of riparian habitat. Other authors (Busby (1979), Kimball and Savage (1977)) cited by Skovlin suggest that proper grazing and riparian recovery can go together. However, Busby (1979) is an opinion paper published in a Forum for Trout Unlimited, while Kimball and Savage (1977) is an unpublished report.

Evidence cited by Skovlin (1984) from clipping studies by Etter (1951) and Pond (1961) indicate that heavy grazing results a decline in *Deschampsia caespitosa* and *Carex* spp. and increases in the sodforming bluegrass (*Poa pratensis*). Variations in timing of clipping in addition to intensity of clipping gave different results. Volland (1978) sampled meadows in Oregon rested for 11 years and found production increased on rested meadows 4-6 years post grazing, but then declined to grazed area levels. Allen (1989) found no differences in stringer meadow composition after 7 years rest from grazing.

Elmore and Kauffman (1994) describe potential effects of different grazing systems using Platts (1989) which are based on Platts personal observations of riparian system response over his career, not experimental studies. Elmore and Kauffman conclude that complete removal of livestock is the only viable grazing alternative. These authors say that the major shortcomings of grazing strategies, that fail to result in restoration of degraded riparian zones, are that they are cookbook, apply to uplands, and devised to increase livestock.

Grazing intensity

Skovlin (1984) reviews numerous authors who reported that intensity of grazing has a much greater effect on vegetation than type of grazing system (Van Poolen and Lacey (1979), Bryant (1979), Roath (1979), Gillen (1981). Van Poolen and Lacey (1979) did conclude that herbage production was more affected by intensity of grazing than grazing system. Bryant (1979) and Roath (1979) are theses, while Gillen (1981) is a PNW Office Report that we did not review. Skovlin concurs with others' observation that grazing systems in general were designed primarily to maintain or improve upland not the riparian zone or adjacent meadow plots.

Shaw (1991) studied the effects of cattle grazing on willows, *Salix eigua* and *Salix lasiandra*, over a 4-year period under 2 seasons at moderate to light grazing intensities, continuous season heavy and no grazing. She found no effect on seedling growth under light/moderate spring and fall grazing and no grazing, but significant decline in density and growth of *S. exigua* in heavily grazed pastures. Similarly growth declined under heavy season continuous grazing in *S. lasiandra*, but not density. She also found that heavy deer browsing prevented most seedlings from growing beyond the reach of grazing animals in year 4 of all treatments. Kay and Chadde (1991) found that native elk grazing resulted in significant reduction in willow seed production and growth compared to ungrazed exclosures in Yellowstone. One study conducted comparing differences in willow palatability in New Zealand (McCabe and Barry 1983) found that their willows contain different amounts of tannins and lignin suggesting differences in palatability, thus possible differences in browsing impacts.

Skovlin also found in his review that uncontrolled, heavy grazing results in heavy mortality of seedlings, and concluded that the long-term effect of heavy grazing is on regeneration of woody species. In our review of Skovlin's citations we found that Harlow and Halls (1972) did find this for yellow poplar and dogwood.

Stohlgren et al (1989) conducted a clipping experiment on high elevation/subalpine meadows in Sequoia Kings Canyon NP. They found clipping for 5 years that repeated clipping to 1.5cm (0.6 inches), which simulated heavy grazing, negatively affected productivity in wet/mesic meadows, but not dry *Carex exserta* meadows. The authors caution that these results cannot be extrapolated to address grazing at light or moderate levels.

Grazing season

Skovlin (1984) reviewed numerous papers on the response of shrubs and trees to cattle grazing. His synthesis of available research showed that moderate/heavy grazing during winter and moderate/light grazing during the growing season had little effect on shrub productivity the next year. Our review of Willard and McKell (1978), Harlow and Halls (1972) and Krefting (1966), that were all cited by Skovlin (1984), generally supports this view. Wolff (1978) however focused on *Salix scouleriana* response to twig browsing. He found that overwinter browsing was compensated for by next years growth, but also cautioned that not all willows will respond in the same way. Skovlin (1984) in his review found studies that suggested that riparian species of *Cornus*, *Acer*, *Populus*, *Salix*, and *Betula* were more resistant to foliage and twig removal than their upland (presumably drier zone) counterparts. We did not find evidence for this specific statement.

Some authors (e.g. Elmore and Kauffman 1994) state that livestock grazing has damaged the willow component beyond repair by reducing cover, eliminating seedling regeneration, and preventing substrates suitable for willow reestablishment (Kauffman et al. 1983). Conroy and Svejcar (1991) found that willow location relative to the water table was more important to survival than season of grazing in the northeastern Sierra Nevada.

Willow response to herbivory varied by intensity and season of use. Knopf and Canon (1982) studied structural resilience of willows to cattle grazing, but their results were inconclusive. The authors suggested that willows suffered less damage in winter than summer grazing. Kauffman et al. (1983) found that late season grazing was worse than early season grazing on willow communities in northeastern Oregon. Kindschy (1989) found that willow growth the following year was greater when clipping occurred in early spring or late fall when the plants were dormant rather than in mid-summer.

Clary and Booth (1993) conducted a study of season of grazing use on mountain meadow utilization on the Sawtooth National Forest. The study used 2 meadow/riparian pastures grazed at light stocking rates (1.19 AUM/ha) and 2 at medium stocking rates (2.08 AUM/ha). Authors conducted the study for 6 years, grazing only during the last two weeks of June. They found cattle did not concentrate on the wetter riparian zone during this season of grazing.

Rooting potential

A recent study examined rooting characteristics of sedge, rush and grass meadow community types in Nevada and found that sedge and rush communities had significantly more total live root length per volume of soil compared to other literature and their study values for grass species (Manning et al. 1989). Their data suggest that root length and root mass were also greater for wet community types than drier types. The authors suggest in their abstract that wet community types will have superior site-stabilizing characteristics, although in their conclusions they state simply that more research will need to be done to determine how root length and mass influence soil-binding and stability characteristics of a riparian community.

To determine the role of herbaceous roots in holding trapped sediment in place against flow, Duneway et al. (1994) and Kleinfelder et al. (1992) examined the effect of herbaceous plant communities and soil textures on particle erosion of alluvial streambanks, and the unconfined strength of some streambank soils with herbaceous roots, respectively. Duneway et al. (1992) report the gradient of erosion from lowest to highest by plant community to be Nebraska sedge (*Carex nebrascensis*), baltic rush (*Juncus balticus*), mixed sedge (*Carex lanuginosa, C. rostrata*, and others), and mixed grass (*Poa pratensis* with *Deschampsia caespitosa*). This was attributed to the root-volume density differences of the plant communities. Root-volume density was negatively correlated with erosion. Kleinfelder et al. (1992) report that herbaceous roots appear to supply most of the compressive strength and soil stability found in meadow streambanks, especially those dominated by Nebraska sedge.

Willows are thought to have differential rooting capabilities (Platts 1987), but little experimental work has been conducted. Platts (1987) reference to Stabler (1985) which credited this study with finding that ‘root systems of willow help stabilize stream banks through binding of soil particles’ was unsubstantiated.

Problems with Research

Skovlin (1984) concluded from his review that:

1. researchers in range management study grazing, forage, soils, and watersheds but rarely examine effects on wildlife or fisheries;

2. fish and wildlife biologists have tended to use studies that have grazing at the extremes, very heavy or no grazing; and

3. the literature available on wildlife response to moderate and seasonally controlled grazing is encouraging.

Finally Skovlin states that studies which have used no grazing as a treatment and time lapse comparisons, although not experimentally sound or statistically reliable, show rather convincing evidence of improved riparian and aquatic environment in 4-7 years after protection from heavy grazing. Skovlin's opinion about potential recovery rates may be the basis for SNEP quotes.

Platts and Raleigh (1984) in the same National Research Council/National Academy of Sciences report reiterate many of the research problems identified in Skovlin:

1. Lack of adequate experimental design with before and after or control data,

2. Insufficient frequency and precision of measurement to statistically support conclusions, and

3. Lack of adequate definition of grazing intensity, season, utilization, and animal distribution.

Platts and Raleigh (1984) concurred with Skovlin's assessment that there are few studies that identify how any present cattle grazing system will adequately restore riparian habitats in a reasonably acceptable time frame. Platts and Raleigh also concur that range, fish, and wildlife managers base management decisions on different sets of criteria and thus riparian condition is in the eye of the beholder; good condition for livestock and range managers is not necessarily good for other components of the ecosystem. Vegetation is just one parameter of a healthy stream.

Foothill oak woodlands

The Blue oak woodland and Foothill pine-oak woodland occupy about 15% (Davis and Stoms1996, v.II, Chpt 23) of the total area of the SNEP study area. Annual grassland dominated systems occupy another 2.8 - 3.0%. As described in Shiftlet (1994, SRM Type 201), foothill oak woodlands are dominated by blue oak (*Quercus douglasii*) which form extensive woodlands, savannas and occasional forests generally between 90 m and 700 m on the west slope of the Sierra Nevada. The most common associate is foothill pine (*Pinus sabiniana*). Composition of understory annuals is highly variable in these oak woodlands, but is strongly influenced by oak tree cover, solar insolation, and slope angle (Borchert et al. 1991).

The issues concerning grazing in foothill woodland communities revolve around blue oak regeneration and conversion of perennial to annual grassland.

<u>Overview of the Literature</u>

Research in the foothill oak woodland has focused on herbaceous productivity and residual dry matter, oak productivity, and oak regeneration. Numerous studies have examined herbivore and predator effects on these factors.

The following section has been organized to focus on residual dry matter and productivity issues, and blue oak regeneration. Since recent symposium (PSW 1997) and workshops (Standiford and McCreary 1996) have presented or synthesized much of the recent literature in this area, benefits of that synthesis are provided in overstory and grazing management recommendation sections.

Residual Dry Matter

Research on the impacts of grazing on soils includes bulk density studies. Bulk density is often inversely related to plant productivity and rooting potential in a given ecosystem. In the foothill oak woodland, studies have related grazing intensity, residual dry matter levels, and bulk density. Liacos (1962) found that the bulk density (quote 50) of the surface horizon on ungrazed Los Osos clay loam soils in the annual grassland hills east of Berkeley, CA averaged 1.4 g cm^{-3}, while soils grazed heavily for 35 years were more dense with an average bulk density of 1.6 g cm^{-3}. Sites that were lightly or moderately grazed were intermediate. The heavily grazed, lightly grazed, and ungrazed sites had residual dry matter levels of 600, 1250, and 3400 lb/ac on the soil surface at the end of the grazing season. Asaeed (1982) observed higher bulk densities due to grazing, but only on swale sites. Bulk density on grazed and ungrazed upland sites were not statistically different. Swales ungrazed by cattle for 10 years had densities of 1.22 g cm^{-3}, while those continuously grazed had densities of 1.38 g cm^{-3}. Supporting Asaeed’s (1982) findings, Van Haveren (1983) reported that bulk densities on fine-textured soils increased with grazing pressure but coarse-textured soil bulk densities were not affected by grazing intensity. Frost and Edinger (1991) also found no difference in bulk densities on coarse sandy loam soils among areas grazed yearly (leaving 800 lb/ac of residual dry matter) and areas ungrazed for over 50 years.

The effect of livestock grazing on the annual herbaceous plant material is generally evaluated by the amount of residual dry matter (RDM) left at the end of the dry season. Management of residual dry matter (the dry plant material left on the ground from the previous year’s growth) has a significant effect on subsequent year’s herbaceous plant productivity and composition. RDM works as mulch providing a more favorable microenvironment for seedling establish through moderation of air and soil temperatures, and reduction of evaporation from the soil. General guidelines for RDM have been established which range from 200 pounds per acre on gentle slopes in southern California to over 1200 pounds per acre on steep north coast slopes (Clawson et al. 1982). The suggested RDM guidelines were developed using the criteria of herbage productivity, desired plant species composition, livestock performance, and ground cover.

Research has shown in some areas that reducing RDM to low levels in the fall encourages higher proportions of silver hairgrass, little quakingrass, nitgrass, broadleaf filaree, burcolver, redstem filaree, and clover. Leaving large amounts of RDM in the fall encourages dominance by slender wildoats, soft chess, wild oats, and ripgut brome. In addition to the influence on species composition, leaving low amounts or very high amounts of RDM will result in lower herbaceous plant production the following year (Bentley and Talbot 1951, Bartolome et al. 1980, McDougald and Frost 1989).

Blue Oak Regeneration

Livestock grazing has been shown to reduce the survival of blue oak seedlings in some locations (Davis et al. 1991), while in others grazing did not affect oak seedling survival or density (Davis et al. 1991, Allen-Diaz and Bartolome 1992). Phillips et al. (1997) reported no evidence of livestock grazing on blue oak seedlings from their yearly evaluation over a 5-year period in Kern County. While not addressing seedling mortality, Hall et al. (1991) did find a differential effect on seedling damage among season of use and cattle stocking densities in a one year study. Other researchers attribute blue oak seedling mortality to other factors such as: herbivory by rodents, insects and deer; competition from herbaceous vegetation; changes in fire regime; and climatic and edaphic factors (Davis et al. 1991, Gordon et al. 1989, Adams et al. 1997, McCreary and Tecklin 1997). Furthermore, improved survival and growth has been shown to occur following reduction of herbaceous plant competition, either through mechanical means or herbicide (Adams et al. 1997, McCreary and Tecklin 1997), or a combination of protection of individual oaks combined with livestock grazing (on valley oak seedlings) (Bernhardt and Swiecki 1997).

The ability of blue oak seedlings to progress to the sapling stage, then grow above the browse line into a tree no longer susceptible to possible grazing effects is a critical element in oak woodland regeneration. Research on the effects of cattle grazing on saplings, and their ability to make the transition to tree size above the browse line has produced varying results. Swiecki et al. (1997a) found that areas with "high levels of vertebrate browsing" were less likely to have sapling recruitment in 5 of the 13 grazed locations they sampled. Jansen et al. (1997) found no significant difference in the growth (change in height) of blue oak saplings over a 3 year period among "traditional moderate" grazing, high intensity-short duration grazing, and no grazing treatments. Standiford et al. (1998) found that blue oak sprout growth following harvest was greater in both height and spread in areas where livestock grazing occurred than in non-grazed areas. Muick and Bartolome (1987), using sapling to tree ratio to assess successful regeneration, found no difference in the sapling to tree ratio regardless of grazing history in a statewide assessment of blue oak regeneration. Bartolome and McClaran (1989) suggested that in areas of moderate grazing with fire intervals around 7 years, seedlings could take up to 20 years to exceed the browse line and still become saplings and persist in the stand. In heavily grazed areas, they hypothesized that seedlings would have to exceed the browse line within 13 years in order to become saplings and persist.

Long term change in blue oak stands was investigated in 4 biogeographical regions by re-sampling plots established in the 1930s (Holzman 1993). She found a significant increase in the mean total basal area of blue oaks. This was attributed to the growth of trees existing in the 30s and to the introduction of new trees (average of 3 trees per .2 acre plot) into the stand. These results were consistent across grazed and ungrazed plots (54% and 46% of the sample plots, respectively).

Summary

With few exceptions, the studies presented do not define the type of grazing occurring in the study sites. This makes a clear assessment of “grazing” impacts extremely difficult. The studies examining saplings indicate that the effect of grazing is variable, perhaps based upon site differences or grazing management strategies. Evidence from research examining seedlings also shows differences that may be attributable to site or grazing management strategies. There is evidence from the long-term changes in blue oak stands that blue oak regeneration is occurring, in general, with current and past livestock management strategies.

Research in this area is needed to investigate the long term relationship among differing grazing management strategies (season, timing, duration, stocking rates) and the effects on seedling survival, sapling recruitment to tree status, and long term dynamics of oak woodlands.

Woodland Overstory Management Recommendations

Management recommendations as recent as the 1970's called for removal of blue oaks to increase forage production for livestock. Much research into this practice, summarized by Frost et al. (1997) has been used to develop the following guidelines:

1. There is little or no benefit gained from removing blue oaks in areas with less than 20 inches of annual precipitation.

2. In areas with greater than 20 inches or rainfall, thinning oak stands where the canopy cover exceeds 50 percent will have the greatest effect on forage production.

3. In areas thinned for forage enhancement, residual tree canopies of 25 to 35 percent are able to maintain soil fertility, retain some components of wildlife habitat, and minimize erosion processes.

4. Tree removal activities should always be planned considering all values of trees, including wildlife habitat, soil stability, etc. in addition to the possible forage production benefits.

Grazing Management Recommendations

Current grazing management recommendations center around leaving enough RDM to provide a favorable microenvironment for early seedling growth and adequate soil protection. The general guidelines presented by Clawson et al. (1982) are commonly used. It is recommended that locally developed RDM standards be established to account for local site conditions. In addition, if considerations other than soil protection and annual herbaceous productivity are important, such as wildlife habitat, oak regeneration, or perennial herbaceous species, different RDM standards may be needed. The overriding factor is that the RDM standard must result in adequate soil protection.

Specialized grazing management systems adapted to hardwood rangelands have not been widely used nor have they been the subject of extensive research. Some evidence from the literature supports year-long grazing rather than a three pasture deferred rotation, where a different pasture was used during each third of the grazing season (George et al. 1996).

Grazing Management for Blue Oak Regeneration

Standiford and McCreary (1996) concluded that some research studies have shown how grazing management can be applied to actually encourage the development of young seedlings. These studies have shown that early season grazing, with cattle removed from the area prior to the drying up of the annual forages, actually improves moisture available to the developing seedling and results in higher rates of growth. This grazing activity also reduces the habitat available for rodents that may be a major source of seedling depredation. These same grazing studies also show that if cattle are left on an area late into the spring and summer, that they will preferentially seek out the young oaks, which are often the only green plants on the site. On areas that have been planted or where naturally occurring seedlings are found, grazing should be managed in such a way as to use these pastures early in the season to reduce the competition from annual grasses and forbs. The cattle should then be moved in the spring to other pastures where regeneration is not a problem. This rotational system can be continued for several years until the seedlings have grown sufficiently large to withstand grazing pressure (Standiford and McCreary 1996).

Long term vegetation change in oak woodland

Overview of the literature

To address the issue of grazing induced changes from perennial to annual grassland, one must first establish that perennial grasslands were the pre-European vegetation type. There are many hypotheses about the dominant vegetation type before European influence and the introduction of exotic annuals in the Sierra Nevada. It is important to note that these are all hypotheses, with support from examination of relict areas, historical accounts from early European explorers and settlers, and inference from later research into climatic and edaphic effects on vegetation communities.

There appears to be no experimental support for the statement that grazing contributed to a change from perennial grass domination to annual species (if that hypothesis is accepted). Such statements are based upon historical accounts of large numbers of livestock, observational reports of "overgrazing" and inferences from research into the effects on perennial grasses with various levels of grazing pressure. The theory that overgrazing led to this change is most commonly attributed to Burcham (1982[1957]) who provided a list of effects without supporting documentation. Those effects causing modification of the vegetation of native plant communities were grazing, disturbance of the soil for cultivation, and development of urban communities (Burcham, 1982[1957], pg. 185). Burcham also attributed the change of native flora to introduced species to:

1) the composition of the original plant cover, the adaptations of the introduced species for dissemination and survival,
2) the grazing and agricultural practices employed during development of the range livestock industry,
3) the climate of the California range lands (Burcham, 1982[1957], pg.189).

Mack (1989), in a review article that addresses changes in the Central Valley, also states that "the huge numbers of cattle and sheep recorded for the Central Valley from the mid-19th century onward testify to the tremendous grazing and trampling these animals must have exerted on the communities dominated by caespitose grasses.". Mack, however, cites Burcham (1982[1957]) as the source.

The most widely adopted hypothesis for pre-European plant communities (Burcham, 1982[1957]; Heady, 1977; and many others) is that areas now dominated by non-native annual grasses were originally dominated by perennial bunchgrasses, as initially proposed by Clements (1920). This theory is based upon Clements work using scattered relict stands, observational evidence of vegetation and applying Clements climax theory. Much of this hypothesis is based upon relict stands of *Stipa setigera* and used this species to support the theory of a grassland climax community over much of this area, and much of the West. Later *Stipa pulchra* (now *Nassella pulchra*) was recognized as a different species, which lends less credence to the similarity of this community type to others throughout the West. In addition, *Nassella pulchra* has been shown to colonize road cuts (Clements 1934) and to be promoted by fire (Sampson 1944, Jones and Love 1945). These facts have been used (Hamilton, 1997) to question Clements hypothesis, pointing out that many of Clements relict stands were along railroad right of ways, many of which were highly disturbed sites and regularly burned (Biswell 1956).

Cooper (1922) also used relict patches of vegetation and observations, combined with Clements climax theory, and developed a model in which precipitation zones where identified which corresponded to various pre-European vegetation types. According to this model large portions of the foothills of the Sierra Nevada (those with less than about 30 inches of precipitation per year) would have contained a chaparral vegetation type. Others have supported this hypothesis, such as Naveh (1967) who compared California with areas of the Mediterranean Basin and concluded that there was a very low probability that these areas contained a bunchgrass climax community, but were probably dominated by chaparral.

Jepson (1925) developed a hypothesis that the pre-European vegetation was dominated by annual plants. Research at the San Joaquin Experimental Range indicates that native annual grasses were an important part of the flora (Talbot et al. 1939, Talbot and Biswell

1942). Based on this work, Bentley and Talbot (1948) concluded that annuals may have dominated some areas of the foothill grasslands. Research investigating climatic conditions that favor annual plants over perennial plants has supported the hypothesis of annual plants dominating in some areas (Blumler 1992). Biswell (1946) proposed that perennial grasses were the dominant vegetation type along the coast where conditions were more favorable to them, and native annual were dominant in areas such as the lower foothills of the western slope of the Sierra Nevada.

Another hypothesis presented is that vegetation types are determined primarily by soil characteristics, not by climate. This hypothesis, presented by Shreve (1927) indicates that grasslands were found on deep soils, with different vegetation types on other soils. This hypothesis is supported by others (Robinson 1971, Keeley 1993) who conclude that *Stipa pulchra* (*Nassella pulchra*) was dominant only on deep soils (agricultural type) or high clay content soils high in mineral nutrients. They also concluded that well drained sandy soils and those poor in mineral nutrients probably never supported such associations.

Research on soil moisture (Gordon et al.1989, Holmes and Rice 1996) found that exotic cool-season annuals completed their life cycle early in the dry season and tend to concentrate root growth and soil-water utilization in the upper soil profile. In contrast, native perennial bunchgrasses allocate a high proportion of their biomass to the production of a deep root system, which allows them to continue soil-water utilization well in to the dry season and contribute to the formation of a very dry soil profile. They suggest that these contrasting patterns suggest that the invasion of exotic cool-season annuals might have produced a corresponding increase in the amount of water present at depth in the soil profile during the dry season.

Part IV: State of Our Knowledge: Links between Livestock and Wildlife Resources

There are over 640 regularly occurring terrestrial vertebrate species in California and over 400 of these can be found in the Sierra Nevada. Of these many species, a combination of scientific and political decisions have been made to focus on a tiny fraction of these in this review. Hopefully, the species considered below include those most likely to be impacted by livestock grazing in the Sierra Nevada. However, since the majority of California's wildlife is not monitored in such a way as to be confident about it's status (increasing or decreasing), we are not able to confidently say that there are no other species of wildlife that are of interest in this matter. This unfortunate and frustrating situation will continue as long as the public, which owns the wildlife, is unwilling to fund efforts to systematically monitor the status of all wildlife species in California. A major policy issue is to what extent such efforts should be funded and who should bear the cost. The crux of this debate will center on who should bear the burden of proof on any given question.

A brief evaluation of the literature reviewed for the project concerning livestock effects on wildlife suggests that most studies have found negative responses of wildlife to livestock grazing (Appendix 2). It is unclear if this is a general pattern since the published literature provides a small and biased sample of the total wildlife community in the Sierra Nevada. Also, there are many observational studies and few experiments.

The following summary is provided in "taxonomic" order. This order is not necessarily the order of political or ecological priority. We note that each species has its own unique habitat requirements. Therefore it is difficult if not impossible to state that all members of a group, such as amphibians, will respond to livestock grazing in a similar manner. We argue that each species must be assessed individually; there are no easy shortcuts.

Overview of the literature

From reading the SNEP and FS Science Team Review, we would conclude that livestock grazing generally negatively impacts wildlife in the Sierra Nevada.

Amphibians

There is strong evidence that certain species of amphibians, California tiger salamander (*Ambystoma californiense*), Yosemite toad (*Bufo canorus*), California red-legged frog (*Rana aurora draytonii*), foothill yellow-legged frog (*R. boylii*), Cascade frog (*R. cascadae*), mountain yellow-legged frog (*R. muscosa*), and northern leopard frog (*R. pipiens*), have declined considerably. Some of these species are likely continuing to decline (Jennings 1996).

However, we found no peer reviewed, scientific studies dealing with the response of amphibians to livestock grazing based on experimentation (see Table 1). Most of the published information is speculative or based on observed changes in species distribution

Reptiles

We found only one reference to a reptile in the SNEP or SNST reports in the context of grazing. The common garter snake (*Thamnopis elegans*) may depend on ranid frogs in the Sierra Nevada (Jennings et al. 1992). If so this snake could be in decline as a consequence of declines in its required prey. We found no peer reviewed scientific studies dealing with the response of reptiles to livestock grazing based on experimentation (see Appendix 2 for a listing of all literature reviewed).

Willow flycatcher

By the 1980s it was clear the willow flycatcher's (*Empidonax trailii*) distribution in California was drastically reduced from it's original distribution (Serena 1982, Unitt 1987). Repeated and thorough field surveys have confirmed that there are now less than 150 breeding pairs of willow flycatchers in the Sierra Nevada (Harris et al. 1987, Harris et al. 1988, Sanders and Flett 1989). This habitat specialist is restricted to meadows and riparian areas with willows adjacent to water (Serena 1982, Stafford and Valentine 1985, Taylor 1986, Taylor and Littlefield 1986, Flett and Sanders 1987, Harris et al. 1987, 1988, Valentine et al. 1988, Sanders and Flett 1989). Since all willow flycatcher nests found to date have been in the lower branches of willows within reach of livestock it has been hypothesized that browsing of willows by livestock, and even livestock movements through willows, may reduce nesting success (Serena 1982, Stafford and Valentine 1985, Taylor 1986, Taylor and Littlefield 1986, Flett and Sanders 1987, Harris et al. 1987, 1988, Valentine et al. 1988, Sanders and Flett 1989).

The most convincing results regarding the response of willow flycatchers to livestock grazing are from comparative studies along the Blitzen River on the 73,200ha, Malheur National Wildlife Refuge in Oregon. A decreasing trend in yearlong cattle grazing intensity (<1.7AUMs/ha) was correlated with increasing relative abundance of willow flycatchers (Taylor 1986, Taylor and Littlefield 1986). These researchers hypothesized that the mechanism involved was that cattle grazing reduced willow nesting cover for willow flycatchers (Taylor 1986, Taylor and Littlefield 1986). Comparative studies along the Kern River in the southern Sierra Nevada also found a correlation between reduced cattle grazing and increasing willow flycatcher abundance (Harris et al. 1987, 1988). Similar patterns were noted in the Dinky Creek region of the Sierra National Forest (Valentine et al. 1988). Willow flycatchers can be parasitized by cowbirds (Harris 1991) as discussed below, but it remains unclear if this factor is a major cause of endangerment.

Brown-headed cowbird

The cowbird (*Molothrus ater*) was originally found throughout the Great Plains of North America, commonly in association with bison (*Bison bison*), but since about 1930 has greatly expanded its range (more than any other native bird in North America) to include the Sierra Nevada (Rothstein et al. 1980, Laymon 1987, Rothstein 1994). Cowbirds lay their eggs in the nests of other birds, typically in the morning, then travel up to 7km to feed on grain in the afternoon (Rothstein et al. 1984, Coker and Capen 1995). During the nonbreeding season, cowbirds gather in large flocks, often with other species of granivorous birds in agricultural regions such as the Central Valley. Many species of native birds have been parasitized by the cowbird, but the significance of this parasitism to the viability of a host species has rarely been quantified (Rothstein 1994). It is the opinion of Goldwasser et al. (1980) that cowbird parasitism may have been a major factor in the extirpation of least Bell’s vireo from the Sierra Nevada. In comparative studies, cowbird parasitism was suggested to be a contributing factor in the decline of willow flycatcher numbers in the Sierra Nevada (Harris 1991, Rothstein 1994). It may be important in very small flycatcher populations already reduced by other factors (Rothstein 1994). Direct removal of cowbirds has increased populations of least Bell’s vireo (Beezley and Rieger 1987).

Consequently, any factors increasing the abundance of cowbirds (nonnative to the Sierra Nevada) could be seen in a negative light by those attempting to restore endangered native species such as the willow flycatcher. The primary factor limiting cowbird numbers in the Sierra Nevada is unknown. However, a reasonable hypothesis is that any land use providing sources of grain (grass seed) is likely to favor cowbirds. Numerous observations have been made of cowbirds feeding at cattle feedlots, horse corrals, meadows with sheep or cattle, clearcuts grazed by cattle, and suburban bird feeders (Rothstein et al. 1980, Airola 1986, Flett and Sanders 1987, Laymon 1987, Sedgwick and Knopf 1988), Harris 1991, Gaines 1992, Rothstein 1994, Coker and Capen 1995). Nesting opportunities do not seem as limited.

Mammals

Concern over competition of "big game" and livestock for available forage has long been an issue for both wildlife conservationists and the livestock industry (Skovlin 1984). Interest in the response of other mammals to livestock management practices is more recent. Given the constraints of this project, we will review only the available information for mule deer (*Odocoileus hemionus*) and mountain sheep (*Ovis canadensis californicus*) in the Sierra Nevada. These two mammals have been studied sufficiently to make some statements about their relationship to livestock. As noted for the three other classes of terrestrial vertebrates, we find that some species will respond positively and some negatively to livestock grazing practices. We also find that for the majority of mammals in California, there are no data to indicate whether a species is increasing or decreasing, much less the cause of any trend. Until monitoring of wildlife distribution and abundance is more common in California, science can provide little input to political decision making regarding wildlife matters beyond speculation by wildlife experts.

We found no mention of links between livestock and mule deer in the SNEP or STR documents. A substantial amount of research dealing with deer-livestock competition has been published based on studies outside the Sierra Nevada (Mackie 1981). We will focus here only on recent studies specific to the Sierra Nevada sponsored by the Pacific Southwest Forest and Range Experiment Station of the USFS. Mule deer are migratory in the Sierra Nevada, from both the western and eastern slopes. They summer in the higher mountain meadow-riparian habitats, and they winter in chaparral or oak woodland in the west and sagebrush-bitterbrush steppe in the east. Livestock and deer occur together throughout much of the Sierra Nevada, sharing the high country in the summer and low country in the winter. Descriptions of each deer herd, including speculation regarding the most important limiting factors, are provided in herd management plans located in the files of the California Department of Fish and Game, Sacramento. Nearly all herds in the Sierra Nevada have been declining in size over the past three decades.

We found reference to only two experiments dealing with the relationships between livestock and mule deer in the Sierra Nevada. Experimental results from the summer range can be summarized by the following quotations. "Deer spent more time feeding and less time resting with increased cattle stocking rates [<1.5AUMs/ha]…Time spent feeding by deer was negatively correlated with standing crop of herbaceous forage…" (Kie et al. 1991). "In the absence of [cattle] grazing, meadow-riparian habitat comprised a greater proportion of deer home ranges…Within home ranges, deer preferred meadow-riparian habitat…" (Loft et al. 1991). Deer home ranges increased in area as cattle grazing level increased [<1.5AUMs/ha]…deer and cattle were attracted to the patchily distributed meadow-riparian and aspen habitats where herbaceous forage was most available…" (Loft et al. 1993). Finally, Kie (1996) found increased cattle grazing [<1.5AUMs/ha] caused does to forage beyond their preferred crepuscular activity period. These results provide strong support for the hypothesis that cattle and deer may compete for summer forage in meadow-riparian habitat in the Sierra Nevada. Kie and Boroski (1995) found "...[on winter range] competition with cattle resulted in deer home range sizes remaining large. In poor forage production years, deer traveled greater distances to locate adequate forage and home ranges remained large during late winter and spring regardless of cattle grazing intensity."

The Sierra Nevada mountain sheep, or bighorn, is now limited to three population fragments totaling less than 100 individuals; it is listed as threatened by the state of California (Bleich et al. 1990, Ramey 1995, Wehausen 1996). John Wehausen has been monitoring Sierra Nevada bighorn populations since 1975. Bighorn move from high elevation summer range, downslope to winter range in sagebrush-bitterbrush slopes east of the Sierra Nevada crest (Wehausen et al. 1987). Bighorn are very susceptible to infection by Pasteurella haemolytica carried by healthy domestic sheep (Foreyt and Jessup 1982, Jessup 1985, Coggins 1988, Onderka et al. 1988, Weaver and Clark 1988, Foreyt 1989, 1990, 1994, Jaworski et al. 1993, Foryet et al. 1994, Pybus et al. 1994, Fitzsimmons et al. 1995). If bighorn populations are to be maintained, domestic sheep cannot be allowed to come in contact with them. The primary limitation on Sierra Nevada mountain sheep is now predation by mountain lions (*Puma concolor*)(Wehausen 1996). Restoration of Sierra Nevada mountain sheep will require reintroducing them to historic ranges free of domestic sheep and mountain lions. Captive breeding may now be required to carry out any reintroductions. One study done elsewhere determined that bighorn moved elsewhere when cattle were present (Bissonette and Steinkamp 1966).

Part V: Historic and Current Ranching Use of the Sierra Nevada

Knowledge of the history and current status of grazing in the Sierra is important to understanding the relationship between the Sierra landscape, vegetation, and livestock grazing. Misunderstandings of history contribute to the misreading of current landscapes. The first section of Part III discusses the history of grazing in the Sierra reviewing what has been presented in recent compilations of information about the historical and social dimensions of livestock grazing in the Sierra, most notably the SNEP report, and highlighting useful contributions from these and more recent works. The second section discusses the current status of ranching in the Sierra in relation to ecosystem management.

Abstract/summary

Our understanding of historic grazing and livestock-related management impacts comes from two main sources: contemporaneous accounts, and vegetation histories from tree-ring, pollen, and other forms of paleo-botanical study. Use of the Sierra for summer range as part of the transhumance pattern

of grazing began in the 1860s. Anecdotal accounts unanimously lament the influence of excessive livestock grazing during the period when Sierran public domain lands were open to all, which peaked sometime in the late 1800's or perhaps even early twentieth century. Early federal government policies effectively imposed what property theorists refer to as an "open-access" property regime on public domain lands. Only with the establishment of Forest Reserves and National Parks, and eventually the passage of Taylor Grazing Act, which led to the development of federal land management institutions and policy for grazing on public lands, was the open access period ended. Grazing policies initially favored cattle producers, gradually closing off ranges to use by sheep and overcrowding the remaining ranges until nomadic sheepherding was excluded completely.

One grazing-related impact that is much discussed in accounts of the time is the use of fire by graziers for vegetation management. Sheepherders in particular are singled out as guilty of burning the forests repeatedly, and for overgrazing the range. A careful examination of anecdotal accounts reveals that the situation was far more complex, and that it was part of a struggle for natural resources between those who owned land, and those who did not. The literature indicates that cattle grazing was by all indications no less abusive.

Tree-ring data presented in the SNEP report indicate that burning in late 19th century, while frequent, was not extensive, and probably no more severe than that caused by a combination of lightning and indigenous burning prior to Euro-American settlement. In fact, some evidence indicates a thickening of the underbrush and trees during this period. Anecdotal accounts reviewed here provide support for this finding.

Knowledge of fire history is important in evaluating the relationship between grazing, fire frequencies, and vegetation change over time. The more we know about how and why the vegetation has changed, the better chance we have of predicting the effects of current and potential management practices. Overall, stocking rates in the Sierra have declined steadily through the twentieth century. At the same time, reductions in fire frequency have likely reduced the amount of forage available to grazing animals over the same time period.

Since the establishment of managed grazing on the national forests in about 1906, stocking rates on the forests have declined overall from highs achieved in response to increased demand during WWI. Sheep have been gradually replaced by cattle, though there are a number of viable sheep permits remaining. Stocking rates have been by reduced by shortening the season of use, and by the elimination of some permits, as well as by reductions in numbers.

The present-day linkage between ranching and an ecosystem management approach that considers the role of public lands in conserving the Sierra ecosystem at a landscape scale is not directly addressed the SNEP report or in most others for that matter. Considerable acreage in the Sierra foothills is privately owned by ranchers who to some degree depend on access to public forage. On the west side of the Sierra, this land is largely foothill oak woodland, a type described in SNEP as severely threatened by development and lacking needed protections (Vol II, Chap. 11). In the SNEP document, Duane states, "…any factor influencing future patterns of human settlement has the potential to affect...the health and sustainability of Sierra Nevada ecosystems" (Vol II Chap 11, pg. 310). Ranching is one such factor.

Linkage between ranch foothill woodland ownerships and the use of public lands by the ranching community is an issue that should not be ignored. Ranchers own a lot of land, and it is ecologically important (Ewing et al. 1988). The amount of land in the SNEP study area that is "range," land used for grazing, ranges from 4% in Shasta county, to 89% in Inyo County (Vol II, Chap 17, pg. 512). Smethurst (1997) found that in the Central Sierra, private land used for grazing is second only to land used for timber production. Johnson (1998) points out that "the future of these (foothill) woodlands lies almost entirely in the hands of individuals, whose separate, independent decisions about the disposition and management of their lands will cumulatively determine the future of California's oak woodlands." Unfortunately, not enough is known about the basis of rancher decisions and their possible response to various kinds of ecosystem-wide conservation initiatives.

<u>Overview of the Literature</u>

Grazing in the nineteenth century

Historic writings show that a lack of active ownership and regulation of public domain lands led to overgrazing in the Sierra as livestock owners competed for available forage in the latter part of the nineteenth century. Both sheep and cattle are implicated, though sheep are more mobile and seem to have been the most frequently observed in contemporaneous accounts, as is well documented in Vol 2 Chapter 1, and Vol 2 Chapter 3 of SNEP. According to most accounts, even the Gold Rush did not lead immediately to widespread grazing in the Sierra, but the droughts, floods, and over-supply of cattle and sheep that followed in the 1860's caused ranchers to drive their stock into the foothills (Burcham 1982[1957], Burcham 1981, Burcham 1961, Claytor and Beesley 1979, Edwards 1883, Gomez-Ibanez 1967, LeConte 1875). Competition for level crop lands gradually limited ranching to the foothills and Sierra thereafter (Burcham 1982[1957]). One author asserts that livestock began to be driven into the Sierra in 1864, in response to devastating drought, and that before that time, forage in the Central Valley area was sufficient (Gomez-Ibanez 1967, pg. 10). He points out that the well-known explorers

Henry Brewer and Clarence King first noted the presence of livestock in the Sierra in 1864 (Gomez-Ibanez 1967, pg. 36).

The exact distribution of grazing by cattle and sheep in the Sierra in the nineteenth century is only known by implication, but it is clear that it was widespread. Burcham (1982[1957]), a well known historian of California rangelands, describes a large overstocking of beef cattle in the 1860s, and a number of authors mention that they were driven into the Sierra due to drought and flood during this period (Burcham 1982[1957], Burcham 1981, Burcham 1961; Claytor and Beesley 1979, Edwards 1883, LeConte 1875). Dairy cattle were also grazed in the Sierra, and as they must be kept within a relatively short distance of the milking barn, at least one author states that "Dairy cattlemen graze their herds entirely within fenced ranges in the higher mountains, always including as much alpine meadow land as possible" (Sudworth 1900, pg. 511). On the other hand Sudworth states that those who graze beef cattle claimed to own large tracts of mountain land, but mostly used unfenced forest land during the summer grazing season (Sudworth 1900, pg. 511). The regional histories presented in SNEP (Vol III, Chap 22 and Vol 11 Chap 17 pg. 502) mention reports that overstocking with cattle was reported in early Forest Service documents as a problem in some areas. Farquar (1925, pg. 25) observed that once transhumance was introduced into the Sierra, "cattle and sheep were to be found in the most remote mountain meadows and canyon heads." In his very thorough and fair-minded report on conditions in the northern Sierra, Leiberg (1902) found cattle grazing to be more extensive in many basins, particularly on the west slope, than sheep grazing. He does imply that the steepest, most arid ranges are used primarily by sheep, but does not make consistent observations about this. Sheep are known to be able to graze further from water, and to use steep slopes, more easily and willingly than cattle.

In 1900, George Sudworth's report to the Department of the Interior states "the necessity for constantly seeking new pasture makes it impossible for sheepmen to maintain headquarters at one point in the mountain range longer than a week or two at most, but they graze their flocks over areas within boundaries fixed by common consent, or by seniority of possession from year to year. The ranges used by sheepmen are usually those not claimed or used by cattlemen" (Sudworth 1900, pg. 511). He also pointed out that there was common agreement among sheepmen and cattlemen about which ranges were to be used by whom. He found that the effects of sheep and cattle grazing were observed throughout the unprotected forests of the entire region – in this case the Stanislaus and Lake Tahoe Forest Reserves (pg. 553).

Abusive grazing by sheep is often held up disparagingly as the main cause of grazing damage in the Sierra in the nineteenth century. A careful examination of anecdotal accounts reveals that the situation was far more complex, and that it was part of a struggle for natural resources between those who owned land, and those who did not. Accounts cited in SNEP (Vol II Chap 3 pg. 41) and other histories indicate that there was pressure to extend the season of grazing for sheep early (Muir 1911) because of competition for the first forage, and late (Vankat 1970), because troops protecting reserve areas would leave in the Fall. There is also ample evidence that the same areas were grazed more than once (Magee, 1885). Beesley states that a common complaint made by nineteenth century critics of sheepherding was that too many animals were grazing for too long (LeConte [1875]1930, Edwards 1883) (SNEP, Vol 2, Chap 1, pg. 8). Sudworth comments that he observed several flocks of sheep in 1900 that were so hungry they ate even pine needles (Sudworth 1900, pg. 554). He also comments that while in 1900 "cattle grazing is now carried on over the best range, sheep grazing has, on the whole, obtained over a far more extensive territory and for a much longer time." By 1900, according to Sudworth, sheep had been "nominally excluded" by law from the Stanislaus and Tahoe Forest Reserves, and from the best rangelands by cattlemen. Gomez-Ibanez makes the point that between 1890 and 1905, "sheepherders suddenly were barred from taking their bands onto most of the customary grazings in the Sierra Nevada, and this came at a time when they also suffered from the continuing encroachment of crop agriculture upon their winter ranges" (Gomez-Ibanez 1967, pg. 59). Trespass and overcrowding resulted.

The intensity, timing, and type of grazing in various areas in the Sierra varied. Kinney (1996) provides accounts that indicate grazing was effectively excluded from National Parks starting around the turn of the century (Vol II, Chap 3, pg. 42). Vankat and Major (1978) cite histories and early accounts to claim that sheep grazing was eliminated around the turn of the century within Sequoia National Park, with cattle grazing allowed only in certain areas until 1930. Sudworth (1900) states that grazing was eliminated from the Calaveras big tree grove for 30-40 years prior to his visit in 1900 (pg. 553), and that he was able to locate several other areas that had been protected for 15-20 years in the area of his survey. William Russell Dudley, professor of Botany at Stanford University, wrote after a tour of the Sierra in the late 1890's, "To pass from the trampled meadows of the reservation [Sierra Forest Reserve] to the protected meadows of the [Sequoia] National Park is a lesson in patriotism" (Dudley 1898). Dudley's observation from 1895 shows that the army had succeeded in gaining some control over sheep grazing in the National Parks by the turn of the century. Sudworth's comments about Calaveras might imply that the area was only grazed for a few years, if we take his comment, and the suggestion that grazing did not start in the Sierra until 1864, literally.

Several accounts from this time period are quoted in SNEP (Vol. II, Chap. 3, pg. 42) as testament to the destruction caused by sheep overgrazing in the late nineteenth century. Sudworth discusses the differences between the effects of sheep and cattle grazing, saying that sheep graze more closely, and unlike cattle, will browse conifers, among other things (1900, pg. 554). Anecdotal accounts, however, are shaped by the tenor of the times. Examining Dudley's full report for example, one comes across the following passage:

> To him [local farmers] the herder is a foreigner, a non-citizen, a parasite, who intends eventually to move back to France, Portugal, or Ireland, whence he came, and carry with him all his gains pilfered through sheep raising on land not his own (Dudley 1898).

Dudley's concentration on sheep and his earlier reference to patriotism no doubt reflects to some degree the anti-immigrant sentiments that were widespread in California at the time, as is evidenced by the passage of California's Chinese Exclusion Act in 1892. Sheepherders tended to be immigrants. Towards the close of the nineteenth century, they were commonly of Basque origin (Douglass 1970). Rowley (1985) states that the 1896 National Academy of Science Forest Committee report included the statement that sheep were often owned by foreigners, "who are temporary residents of this country." Lane (1974) documents what he terms the "public expression of an anti-Basque ideology" common to the period. He quotes one of Nevada's U.S. Senators, Key Pittman, as providing Congressional testimony that "there is neither reason nor excuse for granting a bonus to these laborers who are imported from the Pyrenees Mountains between Spain and France, admitting allegiance to neither one nor the other of those great countries—men who do not know what a home is, and do not recognize the authority of government; men of the lowest type and the most inferior intelligence, who rarely seek to become citizens of the country to which they are imported" (1913 Congressional Record as cited in Douglass and Bilbao 1975).

Douglass (1970) points out that the "tramp" or "gypsy" sheep bands so bemoaned in anecdotal accounts arose in large part when immigrant herders began herds of their own by taking ewes instead of cash for payment, a practice he attributes to the "Basque pattern of friendship, kinship, and ethnic ties." He points out that in the 1890's and up to 1934 many local and state laws were passed making it hard for sheepherders to use the public domain, including special taxes, cattlemen filing on all the water, and the regulations for acquiring National Forest permits which he argues were "designed to make the tramp-band operator move off of lands to which he had <u>as much legal claim as his persecutors</u>" (emphasis added). The Taylor Grazing Act of 1934 ended the nomadic herders in the western states, and from the Basque point of view discriminated against Basque enterprise (Douglass 1970). The Basque presence in Sierra was maintained by those who managed to acquire base properties (Douglass 1970), required by the Forest Service in order to obtain most grazing allotments. Forest Service base property requirements preceded the 1934 Taylor Grazing Act (Rowley 1985), which was applied to the remaining public domain grazing lands.

Early grazing and fire

Knowledge of fire history is important in evaluating the relationship between grazing, fire frequencies, and vegetation change over time. The more we know about how and why the vegetation has changed, the better chance we have of predicting the effects of current and potential management practices.

Dudley (1898) and others comment on evidence of fire in Sequoia groves. Dudley states that though most of the pines and firs he saw on his 1895 visit to the Sierra bore fire scars, for some years "no extensive fires had occurred in the region traversed." Leiberg's careful observations lead him to conclude that most of the fires in the Northern Sierra in the year of his visit were associated with sheep camps, but he finds that these are not as extensive as those he sees evidence of from the past, stating that "it is evident that during the last decade fires in this region have greatly diminished, and those which have covered the largest area during this period burned in chaparral" (1902, pg. 41). He suspects early miners and indigenous people of having set more influential past fires: "the aboriginal inhabitants undoubtedly started them at periodic intervals to keep down the young growth and the underbrush. When the miners came, fire followed them" (pg. 40). These observations lend support to the discussion in Skinner and Chang's chapter in SNEP about fire history (Vol II, Chap 38) where by correlating anecdotal accounts and tree ring studies it is hypothesized that high fire frequencies caused by indigenous burning were reduced by the destruction of Indian life in the mid-nineteenth century. They argue that burning by herders in the 1890s was not necessarily more frequent than that originally carried out by indigenous peoples, but was not as extensive, due to fuel reduction by grazing (Vol. II, Chap 38, pg. 1058). The statement is made that decreased fuel continuity reduced the spread of fire, so that in the tree ring fire record many areas show a reduction in fire during the late 1800s and an increase in tree density (Vankat and Major 1978, Mensing 1992). Sudworth illustrates with pictures the bare forest floor in grazed and burned areas, comparing them to protected areas with lots of understory shrubs and tree regeneration (Sudworth 1900). He observes several instances of sheepherders setting fires accidentally, and to clear brush to improve the forage supply and make herding easier, noting in one case that 17 fires had been set on the trail of one band of sheep over a distance of 10 miles (pg. 556). Leiberg (1902) attributes the continued existence of "grassy fire glades" to burning and grazing, and notes that when protected from grazing and fire, they rapidly become dense sapling stands (43). Vankat and Major (1978) cite the Report of the Acting Superintendent of Sequoia National Park, 1897, as stating that the amount of fires started by sheepherders had been overstated, and that lightning was the chief cause (Barrett 1935). Heady and Zinke (1978) suggest that indigenous people were a major factor in preventing tree regeneration during pre-settlement times.

Land tenure

At least one author in SNEP (Vol II. Chap 3, pg. 41), along with other authors too numerous to cite here but epitomized by Holechek et al. (1998), describe the property rights regime that led to extensive grazing abuses in the Sierra and elsewhere in the West in in the 1800s and early 1900s as a "tragedy of the commons." However, the situation cannot be characterized as having been a common property regime, at least not by the currently accepted definitions of such (Bruce 1993). It is instead an example of open access resources, where no clear ownership is established or enforced (Bruce 1993). Some resource economists and social scientists would argue that it could not be termed a commons either, because a commons does not involve unregulated use. All commons limit use because only community members (not outsiders) have a right to use them (Bruce 1993). Current widely accepted definitions are:

common property resource: A resource managed under a common property regime. Common property is a commons from which a community can exclude non-members and over which the community controls use. A commons is land or another natural resource used simultaneously or serially by the members of a community (Bruce 1993).

open access resource: A resource to which access is open and uncontrolled (Bruce 1993)

The public domain rangelands were open to all for use, with no set group of owners or community with rights of use, as in a commons, and no management regime, as in a common property resource.

The federal government asserted no control over grazing use of most of its lands in the Sierra until the twentieth century, and took direct action to maintain an open access regime, according to the accounts presented by all SNEP historians, and others. In much of the West, when ranchers attempted to exert control over public domain lands by fencing, for example, fences were removed by the federal government to keep the range open (Nelson 1995, pgs. 30-32). Yet the land allocation framework set out by the federal government for the western United States did not provide for private ownership of an adequate resource base for range livestock production (Nelson 1995). Ranchers came to depend on public lands to supplement private holdings.

Twentieth century history

Stocking on Sierra rangelands dropped with the establishment of the Forest Reserves and grazing management policy, and the exclusion of nomadic herds. It is difficult to assess the appropriateness of early stocking rates set by the government. After the turn of the century, historians in SNEP (Vol III, Chap 22 pg. 909)' (Skinner and Chang, Vol II Chap 38) and elsewhere (Pyne 1982) agree that fire suppression led to an increase in undergrowth and a gradual reduction in forage production in large areas of the Sierra. Range productive capacity has been a moving target throughout this century, and evaluating when AUMs allocated by the agencies and forage production capacity were brought "into balance" (asserted to be in the 80s or 90s in SNEP Vol III, Chap 22, pg. 910) is difficult to evaluate. Stocking rates were initially set on the basis of "traditional use" by the permittees, generally local landowners, and it is likely that the "traditional" stocking rates were optimistic.

Although it is sometimes argued that overstocking on federal lands was stimulated during both World Wars (SNEP Vol III, Chap 22, pg. 909), a prominent historian of the national forests, Bill Rowley, asserts that while widespread overstocking occurred in response to WWI, the Forest Service successfully argued against a similar increase in WWII (Rowley 1985). Forero (1998) conducted a painstaking study of stocking through the twentieth century on the Shasta-Trinity National Forest. Forero's (1998) analysis of grazing history on the Shasta-Trinity National Forest found only a small increase in numbers during

WWII, in contrast to a magnitudes greater peak during WWI. Rowley (1985) mentions that early in the twentieth century there was strong interest in providing allotments to new landowners, and to distributing grazing permits more equitably among permittees. In some cases attempts were made to reduce the permits of larger operators and redistribute them to smaller operators. Reducing permits was extremely difficult, and this created pressure to maintain high stocking rates to make room for newcomers (Rowley 1985, pg. 94). How much this social agenda affected stocking in the Sierra remains unknown.

Rowley (1985) discusses evidence that the Taylor Grazing Act of 1934, though it did not apply to National Forests, created a competing range management agency within the federal government, and caused the Forest Service to at least temporarily loosen grazing regulation during the mid-thirties.

Reductions in stocking rates, by way of reducing the number of livestock grazing or the duration of grazing, began fairly early on National Forest lands, and may have varied by forest. Forero (1998) found that concerns about stocking and season of use appear early in Forest Service documents for the Shasta-Trinity. The regional post-1905 histories provided in Chapter 22 of SNEP, do not provide specific detail or sources (Vol. II Chap 22). It cannot be discerned how the stocking rate estimates were determined, whether they were based on observations or actual data, and whether reductions in season of use were accounted for.

In the Mammoth-June Lake Ecosystem study grazing history presented in SNEP it is stated that an aggressive grazing adjustment program began in 1944, and that by 1950, AUMs had been reduced by over 40% (Vol II, Appendix 50.1, pg. 1311). Data for the Shasta-Trinity concurs with that reported above for the Mammoth-June Lake study in SNEP. The sharpest declines in stocking occurred in the 1920s through 1950 (Forero 1998). Forero (1998) shows a very marked peak in the 20s followed by a continual and relatively steep decline into the 70s, then a slower decline to the present. Permit changes were evaluated in terms of AUMs, taking into account changes in season of use and in the geography and extent of permits. This is important, as reductions in grazing during this time were reductions in duration of use, as much as in absolute numbers (Forero 1998; SNEP Vol II, Appendix 50.1, pg. 1311). It was found that at various times permits were lumped together with others, and at other times split into smaller permits, making the evaluation of this data difficult. Though sheep numbers were higher until about 1950, cattle AUMs have always been greater than sheep AUMs on the Shasta-Trinity. Duration of use has also declined over time, reaching a low during the drought of the 70s. These patterns follow what would be expected based on the work of well known historians of grazing on the National Forests (Rowley 1985). Data of similar accuracy and documentation would be desirable for the rest of Sierra.

Methodological problems described by Forero (1998) for the Shasta-Trinity National Forest may be of relevance to future work on stocking rates in the Sierra. He points out that “Ranger District Files,” and “Forest Level Files,” (both used as sources in SNEP Vol. III Chap 22), were often incomplete, had little information about grazing, and differed radically from District to District in quality and amount of information. Allotment Management Plans tended to be relatively recent, and not contemporaneous accounts.

A summation of the post-1905 history would be that stocking rates have declined overall from both pre-Forest Service unregulated grazing where large numbers of animals used the Sierra as an open access resource, and from highs achieved in response to increased demand during WWI. Sheep have been gradually replaced by cattle, though there are a number of viable sheep permits remaining. Much of the reduction has been by reducing the season of use, and by the elimination of some permits.

Current ranching and ecosystem management

The linkage between ranching and an ecosystem management approach that considers the role of public lands in conserving the Sierra ecosystem at a landscape scale is not directly addressed the SNEP report or in most others for that matter. Considerable acreage in the Sierra foothills is privately owned by ranchers who to some degree depend on access to public forage. On the west side of the Sierra, this land is largely foothill oak woodland, a type described in SNEP as severely threatened by development and lacking needed protections (Vol II, Chap. 11). In the SNEP document, Duane states, "…any factor influencing future patterns of human settlement has the potential to affect...the health and sustainability of Sierra Nevada ecosystems" (Vol II Chap 11, pg. 310). Ranching is one such factor.

Ranchers own a lot of land, and it is ecologically important (Ewing et al. 1988). The amount of land in the SNEP study area that is "range," land used for grazing, ranges from 4% in Shasta county, to 89% in Inyo County (Vol II, Chap 17, pg. 512). Smethurst (1997) found that in the Central Sierra, private land used for grazing is second only to land used for timber production. Johnson (1998) points out that "the future of these (foothill) woodlands lies almost entirely in the hands of individuals, whose separate, independent decisions about the disposition and management of their lands will cumulatively determine the future of California's oak woodlands." Unfortunately, not enough is known about the basis of rancher decisions and their possible response to various kinds of ecosystem-wide conservation initiatives. Most simply assume that the ranching community has no interest in conservation.

Attitudes and values of the ranching community and land use change

In the few studies that have been done in California, ranchers espouse values that rank environmental amenities highly. A variety of studies have shown that the majority of ranchers in California oak woodlands enjoy "living near natural beauty" (Huntsinger et al. 1997), and that one reason they keep ranching is because it makes them "feel close to the earth" (Huntsinger and Hopkinson 1996). Similar results have been found in other studies in the western U.S. (Smith and Martin 1972). Ranch fundamentalism, an idealization of the independent ranching lifestyle, and the benefits of ranching to family life, have been described by economists and others as major factors affecting the decision to ranch despite low profits from the enterprise (Smith and Martin 1972, Martin and

Jefferies 1966, Bartlett et al. 1989). Smith and Martin (1972) found that ranchers in Arizona resisted selling ranches at market prices far exceeding their value as livestock operations for reasons that included “love of the land,” and “love of rural values.” A recent Masters Thesis completed in El Dorado county’s Sierra foothills found that ranchers continue to ranch in the face of economic hardship and development pressure because they enjoy the tradition and the way of life and want their children to be able to ranch if they so choose (Hargrave 1993). Similarly, at least one researcher has described the ranch as a unit of consumption rather than production (Grisby 1976 & 1980).

Standiford et al. (Vol III Chap 15 pg. 638) assert that “voluntary educational programs have made dramatic progress in accomplishing sustainable management practices by ranchers.” Statewide, the percentage of ranchers who believe oaks are being lost in California, and who do not cut any living oaks, increased dramatically between 1985 and 1992 (Huntsinger et al. 1997). Numerous studies note that social factors, values, and attitudes, and not just profits strongly affect the decisions of range livestock producers (Grigsby 1976, Martin and Jefferies 1966, Shanks 1978, Smith and Martin 1972, Bartlett et al. 1989).

Many foothill woodland ownerships have been in place for a long time. Huntsinger et al. (1997) found that more than half of ranching families throughout California’s oak woodlands had owned their land for more than twenty years. Johnson (1998) found that in El Dorado and Amador foothill woodlands, 32% of active ranching families had owned their land for more than 100 years; 57% for more than 60 years. In Tulare County, McClaran and Bartolome (1985) found that 28% of ranches had been owned more than 60 years, and another 31% for more than 31 years. In a study of Central Sierra ranches, Smethurst (1997) found that ranchers have, over the decades, managed for an open oak woodland, and have shaped the foothill woodland environment.

A variety of studies have identified distinct ranching cultures around the globe that are recognized as historically significant (Adams 1967, Douglass and Bilbao 1975, Khazanov 1983, Marshall and Ahlborn 1980, Starrs and Huntsinger 1998, Starrs 1998). A reluctance to call on outside intervention to resolve disputes or environmental problems has been described as norms for California ranchers. Instead, western ranching culture has been found to rely heavily on tradition and customary law (Grigsby 1976, Ellickson 1986 & 1990, Huntsinger and Hopkinson 1996, Huntsinger et al. 1997). Statewide, more than 80% of oak woodland landowners with more than 20 acres agreed that “state regulation means a loss of liberties and freedom” (Huntsinger et al. 1997). A large majority of ranchers surveyed in Tehama county, California, reported that livestock trespass problems should be resolved by contacting the owner or herding the stock back to the owner, rather than involving any outside enforcement (Huntsinger and Hopkinson 1997).

Ranching as an enterprise to some degree relies on other ranchers and the rural community for social and economic reasons, for outside jobs, informal labor pools, and support services (Smith and Martin 1972, Ellickson 1991, Hart 1991). This has been described as the need for a “critical mass” of ranching operations to maintain a viable community (Huntsinger and Hopkinson 1996, Hart 1991). Estate taxes, conflicts between multiple heirs, and lucrative purchase offers for land may lead ranchers to sell their land to developers (Johnson 1998, Smethurst 1997, Hargrave 1993). In her study of ranches in El Dorado and Amador counties, Johnson points out that "a single ranch-owner's decision may spell the fate of many thousands of acres. Landowner decisions affect more than their own property, as nearby properties are also influenced through the fragmentation of land use, weakening of the agricultural infrastructure, changing land values, and the creation of new growth nodes in previously undeveloped areas (Johnson 1998, pg. 111). This type of effect has been noted by a number of researchers into land use change (Berry and Plaut 1978, Hart 1976, 1991). Berry and Plaut (1978) in their review of the land use change literature are perhaps the most succinct:

> At the local level the most remarkable feature of the urbanization process is its great dispersion over the landscape. Urban development proceeds by scatteration and some infilling rather than by accretion contiguous to past development.... it is evident that a relatively small amount of rural land converted to urban uses by this scatteration process will drastically alter the appearance of the landscape, making formerly rural areas neither truly rural nor truly urban...From the local perspective, then, it is not necessarily the volume of farmland or woodland conversion to urban uses that matters, but rather the dispersal of this development over the landscape. These visual effects are another of the "costs of sprawl."
>
> The effects of urbanization transcend the conversion of land from rural to urban uses--they also influence what the farmer does to the land....As this nonfarm population increases in size it is not surprising that the farmer's political and economic status in his community becomes relatively diminished and that nonfarm needs become politically important. ...Among those spillover effects that are political and economic in nature are 1. regulation of routine farming activities to suit urban neighbors; 2. acquisition of farmland to build roads, reservoirs, and other components of the urban infrastructure; 3. increase in property taxes and special district assessments to pay for new urban-oriented services. The increasing density of nonfarm population also may bring new problems for the farmer, such as damage to crops caused by air pollution, mischievous destruction of farm equipment or crops; or harassment of farm animals. Because spillover effects present the farmer with a set of managerial issues and expenses that he did not have to cope with before, it may become necessary to accommodate regulations of farming activity, to build new fences to keep children out of the orchards, to work at community relations explaining to non farmers that farming is a business, and so on. One would not expect all farmers to be equally able or willing to cope with these problems. Some farmers complain bitterly and talk about selling out, while others seem to have sufficiently mastered the art of community relations to continue farming successfully.

In rapidly developing counties, researchers have found that much ranch land is being held for development by speculators. McClaran et al. (1985) found that the Williamson Act as an incentive to reduce development was most effective in areas where development pressure was not yet high. Johnson (1998) found that foothill woodland owned by investors and developers was 52% at least and could be as high as 62% of the total in El Dorado and Amador Counties. Another 18% was owned by out of county owners, resulting in a total of 78% of foothill woodlands in unstable forms of ownership in El Dorado, and 51% in Amador. About 12% and 19% of the woodlands were owned by active ranch families, with another 29% in giant trust from a land grant in El Dorado. Smethurst (1998) concluded that the "Sierra is being transformed to an absentee-owned landscape, where natural resources such as water, timberland, and recreational assets are owned by those living outside the region. Residential development has increased, while ranching, farming, and hardwood rangeland have declined."

Johnson found that ranching families that want to remain (perhaps those who can cope as described by Berry and Plaut (1978) above) are often public lands users (pg. 126), and that all the ranchers she interviewed relied on finding sources of summer forage, and found that rentable private pasture was in short supply. She concludes that "every rancher who loses a lease on a high country pasture and seeks rentable pasture near the home ranch is heightening competition for a commodity already in short supply. These problems could well encourage ranchers to cut back herd size or just go out of business....Because livestock returns are such a small percentage of land value, it is unlikely land will be purchased for new ranches or purchased to be rented out for pasture; thus, development is the most likely future of land that is abandoned for ranching. In this way Federal land policies regarding grazing leases in high country locations can easily influence landowner management decisions on the home ranch miles away" (pgs. 152-3).

Smethurst (1997) argues that as foothill ranchers are linked with the forest economically, changes in access to resources in the forest will affect the base ranch as well. He comments that "in an effort to protect public lands from degradation due, allegedly, to grazing by cattle, proponents of regulations and fee increases have ignored the ecological links between private ranch lands and national forests. These regulation externalities could cause a shrinking of wildlife habitat and a corresponding decline in wildlife populations such as endangered spotted owls. Weakened property rights create uncertainty among ranchers about their long-term control over and access to forest lands that they must manage."

A large majority of ranchers surveyed in Tehama County agreed that "urbanization is a threat to ranching" (Huntsinger and Hopkinson 1997). Most wanted to see their land remain used for livestock production in the future. At the same time, they also perceived local and state land use planning as a threat. Conservation easements have been shown to be one viable option for maintaining ranching (Wright 1993, 1993b, 1994, & 1997; Barrett and Livermore 1983) because they can be structured as an integrated incentive that meets the needs of the larger society, and those of ranchers. Conservation easements can help ranch estates in two ways: first, by reducing the value of the estate and second, by generating substantial charitable deductions when given to qualified organizations (Johnson, 1998, pg. 214). Because ranches in the Sierra often rely on public forage, any large-scale efforts must be coordinated with the USFS. Trust, built on support for rancher needs and the voluntary nature of participation, is described as one element that can lead to successful efforts in landscape conservation through easements (Daggett 1996, Hart 1991). Beginning the process before development pressures are high seems likely to increase success.

Part VI: Social Impacts of Sierra Livestock Grazing on Forest Service Land

Abstract/summary

Grazing is generally seen as controversial on Forest Service and other public lands. There is little widely available or published recent work on this topic specific to the Sierra Nevada. Further study of these topics would be desirable.

There are indications that one fundamental basis for the polarization of views about the impacts of livestock grazing or about livestock grazing in general is different perceptions of what "environmental damage" consists of. Studies have shown that people of differing backgrounds, education, goals for use of public lands, and places of residence differ in their perceptions of scenic quality and environmental damage (Sanderson et al. 1986, Richards and Huntsinger 1994, Huntsinger and Heady 1988, Brunson and Steel 1994).

Both grazing by domestic livestock, and grazing by recreational packstock, can affect the experience of the recreational visitor.

<u>Overview of the Literature</u>

Impacts of grazing on recreation

Sandersen et al. (1986) found that their respondents in a study of recreationists in Malheur National Forest of eastern Oregon had a positive attitude toward range management practices including fencing and grazing overall. Fishermen viewed grazing with the most disfavor, preferring that it be kept out of riparian areas with fencing if necessary. They also viewed use of herbicides, and increased access for river recreationists, as problems. Hunters felt that grazing had little impact on their experience. Campers typically did not "mind looking at cows from a distance but wouldn't want to camp with them," and preferred that cattle be fenced out of campsites. Those who believed that the primary purpose of the National Forest was for preservation or recreation were unlikely to view grazing positively; those who lived in western Oregon or out of state were also more inclined to object to grazing and fences. Respondents who felt that the National Forests were for multiple use were highly unlikely to find grazing and fencing objectionable. All the survey respondents were those that had chosen to continue to recreate in this grazed area, yet most felt that an intensification of grazing or fencing would negatively effect their recreational use.

Mitchell et. al. (1996) found that without any cuing, 9% of all visitors surveyed in the Big Cimarron Watershed of the Uncompahgre National Forest in Colorado listed livestock as the most important source of interference in their experience. However, when surveyed and given a choice, the number of visitors indicating that range livestock (cattle) added to their stay (34%), was no different than the number stating a negative relationship (33%). In this study there was no consistent relationship between attitude toward livestock presence and home community size, or size of community where the respondent grew up. Visitors in dispersed campsites tended to be more critical of grazing than those in developed campgrounds, and visitors from rural areas (25% of the sample) were less likely to be critical of livestock grazing. Follow-up questions on desired changes in management found that 10% of visitors wanted cattle removed from the National Forest, while 60% could think of no needed changes.

Huntsinger and Heady (1988) found that local community members, BLM employees, grazing permittees, and members of Oregon environmental groups had very different views of the degree of environmental damage on Malheur County rangelands. Permittees thought the rangelands were in the best shape, and environmentalists the worst, with local residents and BLM employees in the middle. Permittees and environmental group members were also extremely polarized on the issue of whether there was "too much wilderness" in Malheur (almost all the permittees agreed, almost none of the environmentalists) or too much grazing (completely the inverse of the other question). Richards and Huntsinger (1994) found that among BLM employees in the area, length of service was related to views of grazing, with newer employees having a less favorable view.

Brunson and Steel (1994) used a nationwide phone survey to discern public attitudes toward public land management practices, including federal rangeland management. Most people were neutral on whether or not livestock grazing should be banned on federal lands (45%), and on whether federal range policy should emphasize livestock grazing (32%). About 60% agreed that federal range was overgrazed by cattle and sheep, 74% believed that most wildlife populations were declining on public lands, and only 17% believed that the extent of overgrazing on federal rangeland had decreased markedly in the last 50 years. Eighty-three percent agreed that a loss of streamside vegetation is a serious range problem. Respondents felt that "affected local communities" should be given the highest priority in federal management decisions, followed by national public opinion and then government natural resource agencies. Environmental groups and affected local industries were given almost identical rankings below. The authors concluded that the "relatively large number of noncommital responses" (as many as 45% of the sample), showed that public attitudes about federal rangelan management are shallow-rooted and vulnerable to strategies for inducing attitude change. They also conclude that there are "widespread misconceptions about the overall state of range resources on federal lands".

Impacts of packstock use

Grazing in the Sierra by packstock has a history longer than that of cattle or sheep grazing in the Sierra. Packstock were used to bring in supplies to mining camps, but after the Gold Rush use declined until it began to grow in popularity after WWI (Livermore 1947).

Travellers in the nineteenth century sometimes mention a lack of forage for packstock because of heavy use by cattle and sheep, but establishment of the National Parks, by excluding grazing, assured forage for packstock (McClaran 1989). At the same time, limits on hunting in the Parks were seen as a negative for the industry early on (Livermore 1947). By the 1930s recreational pack stock use in the entire Sierra Nevada increased significantly, and by the 40s there were 60 stations in operation with over 3000 horses and mules for hire (Livermore 1947). The Sierra Club sponsored their first annual high trip in 1901--250 people spent a month in the backcountry with more than 100 pack and saddle stock and 15-20 packers. After 42 trips, efforts were made to reduce the impacts by limiting the trip to 125 people in 1947. The trips were abandoned in 1974 (McClaran 1989).

To some, packstock enhance the pioneering experience of a visit, while others may find the smell of domestic animals and the sounds of their bells and neighing to be the antithesis of an experience predicated on escaping the sites and sounds of man (Moore and McClaran 1991). The sight of grazed vegetation, trampled soil, feces, hitchracks, and drift fences also influence the visitor's experience. The impact is greatest in camp and trail settings where backpackers and packstock users are in close proximity. In general, hiker satisfaction is reduced when they encounter packstock in wilderness (Lucas 1980). The impact has been found in one study to be greatest where there are little stock (Stankey 1979), indicating that impacts may be worse if packstock use is dispersed away from traditional areas (McClaran and Cole 1993).

The National Parks have been particularly concerned about the effects of packstock grazing and trails. There have been over 10,000 recreational pack stock nights per year in Sequoia and Kings Canyon National Parks since 1977 (McClaran 1989). Forty-three percent of the trips are from 17 commercial pack stations servicing riding and spot trips, 28% were private groups with own animals, and the rest were park trail crews and backcountry rangers. However, less than 5% of backcountry users use stock. Overuse by packstock was acknowledged in 1936 by the National Park Service, and an active management program that included closure of some meadows and other strategies characterized as “reactive” by McClaran (1989) began in 1958 (McClaran 1989). A more proactive approach was initiated with the completion of a comprehensive plan in 1986. Education of pack operators about minimum impact techniques, the publication of guidebooks, and user conferences help to minimize impacts (McClaran 1989).

Cole (1989) reviews the literature on recreational pack stock effects. In one study, trails produced by 1000 horse passes were 2 to 3 times as wide and 1.5 to 7 times as deep as trails produced by 1000 hiker passes. The bulk density of soils on horse trails increased 1.5 to 2 times as rapidly as on hiker trails. One half the vegetation cover was lost after 1000 hiker passes and 600 horse passes in a grassland and after 300 hiker passes and only 50 horse passes in a forest (Weaver and Dale 1978). Other studies have found that while hiker use tends to stabilize trail surfaces, horse use loosens the soil, making it more prone to erosion (Whittaker 1978).

In the Bob Marshall wilderness, Montana, stock sites were 6 times as large as backpacker sites, with more than 4 times the devegetated area, 11 times as many damaged trees, and

25 times as many trees with exposed roots. Stock sites had lost more of their organic horizons, were more compacted, had slower infiltration rates, and had been more extensively invaded by exotic plants (Cole 1983). Parties traveling with horses are larger and stay longer, and are more likely to use a wood fire and to visit during the fall (Lucas, 1985). If stock are dispersed, they are likely to have a greater impact on the ecosystem (Cole 1989).

Durable sites have been a time-honored approach to limit the extent of packstock effects, but they can be problematic: Provision of facilities and attempts to confine use are sometimes considered inconsistent with management goals. This appears to have made the provision of facilities to reduce packstock impacts unpopular with managers, except in National Parks (McClaran and Cole 1993). Research in wilderness areas showed that the impacts of packstock on visitors are usually concentrated at popular places in the wilderness, often near campsites and along trails in particularly scenic or accessible areas. For example, in the Eagle Cap Wilderness in Oregon, Cole (1981) estimated that grazing impacts were confined to less than 2 percent of the wilderness area. Cole concludes that wilderness-wide application of regulations may not be required, and may unnecessarily infringe on the visitor's wilderness experience (Cole 1990).

After a review of the literature and a survey of wilderness managers, McClaran and Cole (1993) conclude that regulations most limiting visitor freedom and access should be applied only where necessary, in a site-specific manner. Limits on numbers of animals and parties and on season of use are the packstock management actions most likely to interfere with freedom, and they are generally the most specifically applied by management.

Party-size limits may be more important to avoid conflict with backpacking groups. Such groups particularly dislike encountering large parties with stock (Stankey 1979). Restricting packstock to existing trails and prohibiting loose herding is important in preventing the destruction of existing trails, the development of new trails, and in preventing visitor conflicts caused by runaway animals (Cole 1989). Cole argues that in addition to knowing more about the ecological effects of grazing, needed areas of research include more about the effects of differing ways of restraining stock. Hobbles, pickets, hitchlines, and corrals are all used. More information is also needed about stock and wildlife interactions and the grazing behavior of stock, and the overall significance of their impacts.

Part VII: Summary

We have provided a brief glimpse into a large body of the literature relevant to Sierra Nevada ecosystems and livestock grazing. There is ample evidence to conclude that grazing as a process is rarely clearly defined, yet needs to be in order to judge ecosystem response. Abusive grazing is bad and results in unacceptable ecosystem response. Removal of all grazing results in ecosystem change.

What is missing is a comprehensive synthesis of what we know and don't know about different kinds of grazing based on experimental and other kinds of studies. Such a synthesis requires more time and additional expertise. Response will vary by spatial and temporal scale, and interpretation of effects will vary by area of expertise and values of individuals.

The social question of whether livestock belong as a use of public lands will not be answered by science. However, a critical synthesis of the literature provided in this report and elsewhere will provide the scientific base from which social/political decisions can be made. Our team, hopefully joined by others, will initiate such a synthesis over the next year.

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Appendix I: Evaluation of SNEP Statements about Livestock

The Sierra Nevada Ecosystem Project (SNEP) was an effort supported by Congress to conduct an independent science assessment of the conditions and trends in ecosystems and communities of the Sierra Nevada. The effort was enormous; more than 50 scientists authored or co-authored articles which pulled together information on the Sierra Nevada ranging from forest health and productivity to economic impacts of development and human population growth.

The original RST charter stated that the team would review the existing scientific basis for management decisions including a review of the SNEP report as it concerned livestock grazing. The team chose to review the SNEP and SNST reports and collect all statements made about effects of livestock grazing from the different chapters. A page-by-page review as well as electronic word-search review resulted in a compilation of 101 quotes. Team members then traced back the literature foundation for each quote starting with the literature cited in the quote.

In tracing SNEP cited literature (from a statement) back to the original sources, we found varying degrees of support for each statement. We have found citations that are valid interpretations of research work as well as citations that are completely irrelevant to the statement. We found citations that were based on the author's conjecture in the discussion section of a paper (not data), and we found SNEP authors offering opinions with no citations, and for which we found no experimental basis in the literature available to us. A key problem with the grazing literature cited in SNEP and SNST is that the authors do not always differentiate between peer-reviewed original research, non-peer-reviewed proceedings, editorials, position statements, or informational pamphlets, etc. when supporting statements.

The appendix is organized by major heading as in our review of the literature. Quotes are provided (in *italics*) and referenced to the Chapter and page in the SNEP or SNST document. Each quote is then followed with an evaluation of the cited literature.

Livestock and Water Resources

Statements concerning links between livestock and specific water resources issues (i.e. "grazing" impacts on infiltration, stream temperature, stream bank stability, etc.) are found throughout at least 7 chapters and 3 volumes of the document (Volume 2 Chapters 25, 30, 33, 36, Volume 3 Chapters 5 and 22), and in Appendix I of the SNST Report. Similar statements are grouped and discussed together as concepts of livestock linkages to specific water resources issues.

A break down of the ~62 references used in SNEP reveals that 14 (22.6%) are peer-reviewed journal articles, 21 (33.9%) are technical reports, 13 (21.0%) are proceedings papers, 1 (1.6%) is a thesis, 1 (1.6%), 1 is an unpublished report, 1 is a video tape, 2

(3.2%) are informational pamphlets, 5 (8.1%) are textbooks, and 4 (6.5%) are other SNEP Chapters.

The SNST Report Appendix I contains 22 citations in its handling of the subject. Of these 4 (18.2%) are peer-reviewed journal articles, 5 (22.7%) are technical reports, 1 (4.5%) are proceedings papers, 3 (13.6%) are thesis, 1 (4.5%) are informational pamphlets, and 8 (36.4%) are SNEP Chapters.

SNEP Statements Concerning Upland Soil Cover, Soil Compaction and Infiltration:

1. *Overgrazing can also influence soil compaction, erosion, and lowering of water tables.* Volume 1, Chapter 7, Page 115

2. *Soil moisture late in the growing season has decreased, and soil bulk density has increased due to compaction from higher herbivore densities.* Volume 1, Chapter 7, Page 120

3. *Gradually during this period (note 1900-1940), cattle began to replace sheep on many Sierran ranges, resulting in more soil compaction and increased effects on vegetation in riparian zones (Lux 1995).* Volume 2, Chapter 1, Page 14

4. *When insufficient vegetation remains after grazing, raindrop impact can change surface conditions and consequently reduce infiltration and increase runoff (Ellison 1945).* Volume 2, Chapter 30, Page 899

5. *Soil can become compacted by the repeated pressure of moving animals, especially if the soil is wet. The combination of soil exposure and compaction can decrease infiltration and increase surface runoff. If infiltration capacity is severely limited on a large fraction of a catchment, the extra runoff can quickly enter streams and generate higher peak flows (e.g. Davis 1977).* Volume 2, Chapter 30, Page 899

6. *If the animals remain in one place too long, and consume much more than about half the available forage, vegetative recovery may be impaired and an excessive amount of bare soil may be expose to erosive rainfall (Fleischner 1994; Committee on Rangeland Classification 1994).* Volume 2, Chapter 30, Page 899

7. *Removal of vegetation and compaction of soils by cattle can decrease infiltration and consequently increase surface runoff and augment local peak flows (Behnke and Raleigh 1979, Platts 1984).* Volume 3, Chapter 5, Page 221

8. *Livestock consume plants that hold the streambanks and soil together; mechanically alter the form, structure, and porosity of soils; and change the composition of the plant community.* Volume 3, Chapter 5, Page 212

9. *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 down-cutting, the relative abundance of grasslike and true grass species is an important indicator of this change. Volume 3, Chapter 22, Page 923

10. *Trampling compaction effects will naturally reverse themselves with natural freeze/thaw and wetting/drying annual cycles if sites are protected from grazing period 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.* Volume 3, Chapter 22, Page 397

11. *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.* Volume 3, Chapter 22, Page 936

12. *A large literature exists justifying plant community composition and bare soil exposure changes as indicators of grazing impacts (NRC 1994, 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*. Volume 3, Chapter 22, Page 922

13. *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 "increases" on mountain meadow rangelands are native forbs which can be substantially increased in abundance with frequent grazing (Ratliff 1985).* Volume 3, Chapter 22, Page 936

<u>A review of the Literature Cited in SNEP</u>

Lux (1995) is an appendix in a draft USFS environmental impact statement. This reference was not evaluated.

The paper (quote 4) by Ellison (1945) reviews the results of several experiments on the simulated effects of raindrop impacts and overland flow on infiltration capacity and sheet erosion. None of these studies, or Ellison's paper, focus on rangeland or grazing. Ellison does a reasonable job of summarizing the state of the knowledge on the physics of the raindrop soil surface interface, soil aggregate decomposition, infiltration, and sediment transport as overland flow in 1945. The case is clearly made that when left bare to rainfall the soil's surface is subject to extreme energy which will commence erosion and sediment transport, as well as to destroy soil surface structure reducing infiltration capacity. Given that it is not the objective of the paper, specific guidelines for the amount of cover required to protect rangeland soils, or any soils, are not given.

The paper (quote5) by Davis (1977) is in the proceedings of a conference, and does not appear to be peer-reviewed. The paper seems to focus on southwest riparian habitats. No original data or research is presented in the paper. Davis does state in several places in his paper that in his opinion, "Over grazing and the consequent loss of vegetative cover in the adjacent watersheds is probably the main reason for the frequency of high intensity floods resulting in drastic changes to the density and composition of riparian bottoms." Davis gives no references to support his statements, nor does he analyze any flood data to support the contention that the frequency of high intensity floods has increased on a particular southwestern rangeland watersheds, or rangeland watersheds in general.

Fleischner's paper (1994) is a review article discussing the general ecological impacts of over-grazing in western North America. While Fleischner does not discuss the 50% utilization definition for over-grazing as cited, he does give a very concise summary of the controversy over the definition of the term. He also points out that a large portion of the literature does not quantify grazing intensity, stocking rate, etc. making it very difficult to evaluate or interpret the work. In many cases he points out the inconsistent use of relative terms such as light, moderate or heavy grazing. With regard to bare soil (quote 6), Fleischner in turn cites Schulz and Leininger (1990), Ohmart and Anderson (1982), Cooperrider and Hendrix (1937), Davis (1977), Cottam and Evans (1945), Gardner (1950), Kauffman et al. (1983), and Ellison (1960). Despite his own argument, Fleischner does not define or describe the "grazing" reported in Schulz and Leininger (1990), Ohmart and Anderson (1982), or Cooperrider and Hendrixs (1937). He does state that Cottam and Evans (1945), Gardner (1950), Kauffman et al (1983), and Ellison (1960) are comparing "heavy grazing" and "overgrazing" to no grazing.

The Committee on Rangeland Classification (1994) does not seem to support the concept of overgrazing as cited in quote 6. The publication, Rangeland Health: New Methods to Classify, Inventory, and Monitor Rangelands, represents an effort by a committee composed of university scientists, federal land management agency staff, environmental organization representatives and ranchers. The Committee was convened by the Board of Agricultural of the National Research Council to address the complex issue of "rangeland health". The Committee provides a thoughtful discussion of the need to assess range condition from all perspectives, not just one focused on the condition of the range for livestock production (such as "take half, leave half). The Committee does discuss at length the importance of the soil resource to range health, making a strong case that soil erosion and thus bare soil should be one of the primary indicators of "range health", and citing several references in this context. No site specific values for adequate soil cover or utilization are given, nor would one expect them to be given from such an effort.

The proceedings paper by Behnke and Raleigh (1978, not 1979) is defined by its authors as "...the perspectives of two fisheries biologists on some of the issues raised at the forum and suggests some grazing management options to protect riparian/stream ecosystems from excessive grazing damage." The Behnke and Raleigh's paper is a proceedings paper discussing and citing papers from the proceedings of a previous meeting. It is not clear if either proceedings was subject to peer-review. With specific regard to the "removal of vegetation" portion of quote 7, Behnke and Raleigh (1978) state "It is primarily in arid and semi-arid regions that riparian vegetation is susceptible to overgrazing. Once the vegetation is removed, heavy rains are not absorbed by the soil and run overland causing erosion. When this occurs the amplitudes of peak runoffs are tremendously increased." There is no citation nor original data given in support of this series of statements. The paper seems to focus on riparian impacts rather than vegetation removal, increased overland flow, etc. and will be discussed in more detail in a later section of this report.

The paper by Platts (1984) is a proceedings paper on 7 years of research on the utilization of 17 riparian areas located in Idaho, Nevada, and Utah under continuous and rest rotation grazing by sheep and cattle grazing. Although Platts' initial literature review generally supports quote 7, the objective, focus and research in the paper is along a different line and is quite interesting. A major objective of the work is to identify and document riparian grazing management strategies which do and do not "balance forage and fish needs." Platts does identify some important future research needs to allow identification of riparian compatible grazing management. This paper will be discussed in a later section of this report.

SNEP Statements Concerning Channel Stability and In-stream Flow Processes:

14. *Wet and mesic meadow ecosystems, if overgrazed, show a trend of grass and legume composition increase at the expense of sedge and rush composition.* Volume 1, Chapter 7, Page 118

15. *Overgrazing and livestock concentration in riparian zones have altered stream morphology and vegetative composition in may areas throughout the Sierra Nevada.* Volume 1, Chapter 7, Page 129

16. *Consequently, riparian vegetation is overgrazed, banks are trampled and eroded back, and bed deposits are disturbed......Degradation of riparian vegetation permits bank erosion to accelerate under the more frequent peak flows that are caused by the decrease in infiltration capacity. About half of the channels in the Meiss allotment in the Upper Truckee River watershed were identified as being in fair or poor condition as a result of overgrazing (Lake Tahoe Basin Management Unit 1993). Changes in channel morphology have been related to overgrazing in headwater steams tributary to the Carson River (Overton et al 1994). Elimination of riparian vegetation by overgrazing in the broad alluvial valleys of the North Fork Feather River has led to rapid channel widening and massive sediment loads (Hughes 1934, Soil Conservation Service 1989). In other areas, such as meadows of the Kern Plateau and San Joaquin River Basin, downcutting has followed overgrazing (e.g. Hagberg 1995).* Volume 2, Chapter 30, Page 899

17. *Livestock grazing has decreased or eliminated riparian vegetation, broken stream banks, widened stream bottoms, increased sediment, decreased shade, and increased water temperature (Platts 1978, California State Lands Commission 1993, Li et al. 1994, Menke et al. 1996).* Volume 2, Chapter 35, Page 990

18. From Table 36.3 Volume 2, Chapter 36, Page 1014.

Ecological Consequence	Physical Effects	References
Livestock trample and compact banks	Prevent establishment of vegetation, crush amphibians	Armour et al. 1991 Chaney et al. 1990 Jennings 1996
Livestock hooves chisel banks	Destroy existing vegetation, destroy undercut banks, contribute to channel widening	USDA-FS 1995, Overton et al. 1994, Kondolf 1994c
Livestock browse seedlings	Recruitment of young woody riparian plants prevented	Platts 1991
Removal of vegetation, and compaction in watershed leads to increased peak runoff and erosion possible decreased base flow	Erosion of banks supporting riparian vegetation	Behnke and Raleigh 1979 Platts 1991, Dudley and Dietrich 1995
Previously listed factors lead to incision of channels especially in meadows	Water table drops, desiccating wetland species	Odion et al. 1990
Lack of bank vegetation and undercut banks, channel widening, and higher water temperatures	Reduced fish populations reduced invertebrate populations	Behnke and Raleigh 1979 Armour et al. 1991 Herbst and Knapp 1995

19. *Grazing throughout a watershed can increase peak runoff and erosion rates, leading to channel incision (and thus lowered alluvial water tables and desiccation of riparian plants), bank erosion, and increasing fine sediment content in channels (Behnke and Raleigh 1979).* Volume 2, Chapter 36, Page 1017

20. Grazing by livestock results in the trampling and compaction of riparian areas, the direct destruction of bank vegetation through the chiseling of banks by hooves, and *the elimination of recruitment of young woody riparian plants through browsing (Armour et al 1991, Platts 1991, Menke et al 1996).* Volume 2, Chapter 36, Page 1017

21. *The interrelated impacts commonly attributed to overgrazing include:*

reduction in vegetative cover

changes in species composition

introduction of exotics

reduction or elimination of regeneration

compaction and cutting of meadow sod

depletion or elimination of deeply rooted vegetation that strengthens banks

loss of litter and soil organic matter

erosion of stream banks, beds, and flood plains

loss of overhanging banks

destabilization of alluvial channels and transformation to wide shallow channels

initiation of gullies and headcuts

channel incision and consequent lowering or water tables

desiccation of meadows

increased water temperature during summer due to reduction of shade

increased freezing in winter from reduction of insulation and snow trapping efficiency

siltation of stream

bacterial and nutrient pollution

and decline of summer streamflow

(e.g. Platts 1984, Blackburn 1984, Kauffman and Krueger 1984,Skovlin 1984; Elmore and Beschta 1987, Armour et al. 1991, Platts 1991, Chaney et al. 1993) Volume 3, Chapter 5, Page 219

22. *A recent study of channel characteristics between pairs of currently grazed areas on National Forests and long-rested areas in National Parks in the Sierra Nevada found significant differences in bank angle, unstable banks, undercut banks, bed particle size, and pool frequency (US Forest Service 1995b). Significant differences in undercut banks and unstable banks were also observed between grazed areas and adjacent fenced exclosures with a few years of rest*. Volume 3, Chapter 5, Page 220

23. *Broken meadow sod, trampled streambanks, and widened streambeds are commonly documented in Sierra Nevada meadows under excessive grazing pressure (e.g. Allen 1989, Hagberg 1995, Range Watch 1995).* Volume 3, Chapter 5, Page 237

24. *Livestock consume plants that hold the streambanks and soil together; mechanically alter the form, structure, and porosity of soils; and change the composition of the plant community.* Volume 3, Chapter 5, Page 212

25. *A recent evaluation of a sample of 24 locations throughout the Sierra Nevada found 13 to be at risk of loss of critical functions and 4 to be not functioning (Menke et al. 1996).* Volume 3, Chapter 5, Page 220

<u>A review of the Literature Cited in SNEP</u>

The paper by the Lake Tahoe Basin Management Unit (1993) is an environmental assessment of a grazing allotment, Hughes (1934) is a USFS progress report, SCS (1989) is an erosion inventory report, and Hagberg (1995) is a thesis from Humboldt State University. Given time constraints, these publications were not evaluated.

The paper by Overton et al. (1994) is a U.S. Forest Service Technical Report. The paper reports the comparison of grazing excluded, horse grazed, cattle grazed, and stock corridor reaches on Rosgen "C" type reaches of Silver King and Coyote Creek on the Toiyabe National Forest in California to ungrazed "reference" reaches on Fishhook and Hell Roaring Creeks in Idaho. Grazing on Silver King and Coyote Creeks is by cattle in a deferred grazing system, with a 55% use of key forage plants grazing standard. No further definition of current grazing management is given. The age of all cattle grazing exclosures is reported as 5 years. Despite the authors assurances that the reaches in Idaho do indeed represent the "potential" and "future desired potential" of the California creeks, one must intuitively question this assumption. The streams in Idaho were indeed much different from those in California, regardless of management.

However, the comparisons between the differently grazed reaches on Silver King and Coyote Creeks (all within the same watershed, the same ecosystem, and the same State) are interesting. First, it is extremely important for the reader to note that there is no pre-treatment data for this comparison. Thus, any differences or similarities between reaches may well have existed prior to implementation of the grazing treatments. This has the potential to mask both positive and negative impacts of all treatments. Second, by the authors own admission, sample size is quite low (n < 10 transects for the majority of the means calculated for each reach). Third, the study is reach-based and any cumulative up-stream watershed effects could be masking or enhancing "treatment" effect.

Using the Forest Service's proposed R1/R4 fish habitat inventory procedures the authors measured the following channel morphological and in-stream sediment parameters for each habitat type; length, width, depth, maximum depth, surface fines, percent stable banks, percent under-cut banks. Width/depth ratio, width/maximum-depth ration, residual maximum depth, and residual pool volume were calculated. Habitat types were fast water (glide, run, riffle) and slow water (meander, pool, bend). For Silver King Creek, the authors report “little observable differences in means of habitat descriptors for the different sections (table 3).” Based upon analysis of variance and Tukey’s HSD mean separation, the authors report “Statistical comparisons of management types revealed few significant differences; those that were significant did not show a distinct break between the grazed and rested sections of Silver King Creek (figure 2).” For Coyote Creek, the authors do report statistically significant differences between grazed and rested stream sections for most parameters, with the rested streams falling closer to the “desired future condition” defined by the streams in Idaho. To aid in interpreting this conflicting data, one would like to know the exact grazing intensity on each of the grazed reaches and the amount of pre-treatment dissimilarity between comparison reaches. More thought should have been given to this case study prior to its implementation, the potential of this type of experiment is high.

Citing a long line of case studies and proceedings papers, the proceedings paper by Platts (1978) does support the statement as referenced. However, referring to these same papers, he states “The data and intuitive thinking these authors used to justify their conclusions lack the statistical strength needed to assign a high degree of validity to their findings.” In reviewing several of these papers, this becomes obvious to the reader. Platts goes on to state “However, it would be unreasonable to claim that a direct relationship between improper livestock grazing of streamsides and aquatic habitat degradation has yet to be proven.” There was indeed substantial qualitative and observational information to support this statement, and the author references most of it. Again, the issue lies in defining “improper” and “proper” grazing. In line with the primary objective of his paper, Platts goes on to discuss basic statistical considerations which must be addressed when planning studies to examine livestock-fisheries interactions.

The report by the California State Lands Commission (1993) contains 6 paragraphs on grazing found on page 334. It presents no original data, nor does it define “grazing” as overgrazing, current grazing, or past grazing. The report cites the AFS Position Statement by Armour et al. (1991) and the EPA informational pamphlet by Chaney et al. (1990) in support of their conclusions.

The paper by Li et al. (1994) is an article in the Transactions of the American Fisheries Society. This is a somewhat descriptive paper, but provides valid analysis of the specific hypothesis it set out to test. The authors conduct longitudinal stream surveys examining the effect of abundance and distribution of riparian canopy, watershed aspect, solar input, and water temperature on biomass and standing crops of algae, invertebrates, and rainbow trout. The authors choose a total of five, apparently grazed, creeks on the John Day River in Oregon. No quantitative description of the grazing management along any of the 5 creeks is given. The creeks had differing abundance of riparian vegetation, the mechanism causing this was not established experimentally. The authors appear to assume that the creeks with the lower abundance of riparian vegetation have achieved this state due to “overgrazing”. It is not clear what assumption the authors assign to explain those streams greater abundance of riparian vegetation. It would be very informative to know exactly which grazing strategies resulted in abundant riparian vegetation. The parameter "vegetation use" is measured by the authors. The measurement method is not defined, nor is "use" linked to grazing strategy. However, the paper did not scientifically determine what caused the differences in canopy of these streams. It simply documents the differences in the productivity of these streams. The authors found that watersheds with greater riparian canopy cover had higher standing crops of rainbow trout, lower daily maximum temperatures, and perennial flow. The mechanisms for increased perennial flow are not documented. Watershed aspect was a significant factor affecting trout biomass. Primary productivity was higher on open streams, but the authors express concern about maximum daily temperatures.

Menke et al. (1996) is Volume 3 Chapter 22 of SNEP. Menke et al. make at least two statements regarding grazing impacts on vegetation which would in part support quote 20 above. However, Menke et al. provide no references to support their own statements. This is an example of the circular references found throughout SNEP.

Armour et al. (1991) is the American Fisheries Society's Position Statement on The Effects of Livestock Grazing on Riparian and Stream Ecosystems, published in Fisheries (quote 20 and 21). Some very interesting statements concerning livestock impacts on riparian areas as well as potential grazing management solutions to these problems are made throughout the document. Unfortunately, many of these statements are not referenced, making it impossible in many cases to separate position from scientific fact. A total of 29 references are cited in support of this position statement (5 peer-reviewed journal articles, 9 technical reports, 9 proceedings papers, 3 informational pamphlets, and 1 working paper). Armour et al. do state that "...the immediate effects of over grazing are loss of stream side vegetation and trampling of stream banks." They also state "It is our strong contention that when properly implemented and supervised, grazing could become an important management tool benefiting fish and riparian habitats." Specific supporting citations do not accompany either statement.

The proceedings paper (quote 18 and 19) by Behnke and Raleigh (1978, not 1979) is defined by its authors as "...the perspectives of two fisheries biologists on some of the issues raised at the forum and suggests some grazing management options to protect riparian/stream ecosystems from excessive grazing damage." The forum referred to was one held in Denver, CO on November 3-4, 1978. Thus, Behnke and Raleigh's paper is a proceedings paper discussing and citing papers from the proceedings of a previous meeting. It is not clear if either proceedings were subject to peer-review. They cite Dahlem (1978), Keller et al. (1978), Marcuson (1977), Martin (1978), Storch (1978), VanVelson (1978), and Winegar (1977) as supporting the following "Typical stream habitat changes associated with overgrazing....1. Widening and shallowing of the stream-bed, 2. Gradual stream channel trenching or braiding dependent upon soils and substrate composition, 3. Silt degradation of spawning and invertebrate food producing areas, 4. Loss of stream-side and in-stream cover, 5. Increased water temperatures and velocities,

6. Decreased terrestrial food inputs, and 7. Reduction of 3 to 4 fold in trout biomass in grazed versus ungrazed stream sections."

Dahlem (1978), Keller et al. (1978), Martin (1978), Storch (1978), and VanVelson (1978) are in the Proceedings of the Forum-Grazing and Riparian/Stream Ecosystems published by Trout Unlimited, Inc. Marcuson (1977) is a report on a Montana Department of Fish and Game project, and Winegar (1977) is a paper in the Rangeman's Journal. All are reports of case studies where "grazing" was removed from all or some portion of a stream system. Vegetation and habitat response are monitored within the exclosures and without for various time periods following fencing. While well-written, the papers do a poor job of quantifying grazing. The reader gets the sense that the grazing is "over grazing" and is indeed having a negative impact on the water resources of these particular streams. The authors also do a fairly poor job of classifying the stream types reported in these case studies. Given the lack of replication, no statistical analyses are made. However, it is made fairly clear by the trend data and photographs presented that these streams all responded positively, in just a few years, to the removal of the apparently "abusive grazing". Winegar (1977) gives evidence of enhanced sediment trapping ability in the excluded stream reach. Together, these case studies make a strong case that abused riparian areas will respond very rapidly to the removal of the abusive grazing. With increased vegetation, the potential to provide increased habitat, stream bank stability, and sediment trapping is clear. Although not mentioned in the SNEP report, Behnke and Raleigh (1978) identify some management practices they claim protect riparian areas from potential grazing impacts.

Chaney et al. (1990) is an informational pamphlet "aimed at the broad and growing audience of people interested in improved management of livestock grazing on western riparian areas and adjacent uplands." The pamphlet clearly and concisely describes the potential impacts of "overgrazing" on riparian functions and values. The pamphlet then illustrates 11 case studies where previously "overgrazed" and degraded riparian areas have been dramatically improved due to improved grazing management and upland watershed management (cedar control, road improvements, etc.). Grazing management strategies described in these case studies include rest-rotation, early season use, permanent stream fencing with improved upland pasture fencing and water development, 1-3 year rest from grazing followed by early season grazing, reduction in stocking rate to meet the carrying capacity of the watershed in conjunction with brush control and re-introduction of fire (no riparian fencing was used), and changes in season of use dependent upon reproductive needs of perennial grasses. While the description of overgrazing impacts on riparian areas presented in Chaney et al. (1990) supports the SNEP statement (quote 18 and 21), the authors conclude:

1. The case studies demonstrate that the productivity of degraded riparian areas can be restored, usually with a net gain in livestock forage.
2. These case studies also demonstrate that there is no cookbook of simple, universal recipes for successful riparian grazing strategies.

3. A successful riparian grazing strategy must be custom designed to fit the specific circumstances.
4. A clearly defined objective or desired future condition for the riparian area is the foundation of a successful grazing strategy.
5. In order to establish realistic objectives for riparian areas, it is important to know the vegetation potential for the site under proper grazing management.

The paper by Dudley and Deitrich (1995) is a research completion report to a granting agency, focusing on a 11 year old livestock exclosure on one-half mile of previously "heavily" grazed reach of the South Fork Kern River in the Golden Trout Wilderness Area. Quoting the abstract of this study: "Our objective was to assess the effectiveness of these cattle grazing exclosures in promoting resource recovery. Toward this objective, we focused on a cattle exclosure in Templeton Meadow which was installed in 1983. We (1) resurveyed ten stream cross sections originally measured in 1983 and surveyed and monumented thirty-seven additional stream cross-sections, (2) conducted infiltration tests on cattle trails, (3) monitored streambank erosion pins over winter, and (4) measured nitrogen dynamics in five stream side habitats. We have found little evidence of recovery inside the cattle exclosure. We were unable to find a difference in stream morphology attributable to the exclosure…We found no significant difference in bank erosion rates between locations inside and outside the exclosure. Nor did we find any significant difference in nitrogen dynamics between locations inside and outside the exclosure."

Herbst and Knapp (1995) is a paper in Bulletin of the North American Benthological Society. This paper was not acquired in time to be evaluated in this report, but the title Biomonitoring of Rangeland Streams under Differing Livestock Grazing Practices looks interesting and the interested reader should follow up on this paper.

Jennings (1996) is SNEP Volume 2 Chapter 31. Another example of the circular references found throughout SNEP.

Kondolf (1994) is a profile paper in Environmental Management. The paper seems to be a mesh of literature review, field monitoring of channel cross sections on grazed and ungrazed sections of a stream reach conducted during the drought of the mid to late 1980's, and the author's opinion about making public lands land use decisions in the face of scientific uncertainty. The paper profiles Cottonwood Creek Watershed in the White Mountains of California. Cottonwood Creek is home to the federally listed threatened Paiute cutthroat trout. This evaluation will limit itself to the literature review and field monitoring component of Kondolf's paper. In his literature review, Kondolf reiterates the potential negative effects overgrazing has on watershed scale hydrologic and riparian habitat parameters, heavily citing Armour et al. (1991) and Chaney et al. (1990). Despite an increasing population of trout (following chemical eradication of competing non-natives and hybrids in 1982 and reintroduction of pure-strain Paiutes), with a predictable die-off between 1988-91 (1260 adults and juveniles in 1988 and 670 in 1991) as a result of prolonged drought, it has been determined that habitat for the Paiute trout is limited by excessive amounts of fine sediments in the stream channel. Livestock grazing has been implicated as the cause for these fines. With regard to this, Kondolf states ".....the relationships between land use and sediment yield have not been conclusively determined, in large part because there are no historically ungrazed sites to serve as long-term controls." Cottonwood Basin is grazed 1 to 2 months in the summer by 200 head of cattle, and is a popular destination for hikers and fishermen given its natural beauty and access via a 4 wheel drive road. Evaluating stream cross sections and in-channel sediment conditions to identify sources of fine sediments, Kondolf states "Because no ungrazed meadows exist as controls and without major runoff in the basin during the study period, I could not directly measure the contribution of livestock grazing to sediment yield to the channel." Observing greater abundance of riparian vegetation outside livestock exclosures than within, but no significant differences in channel morphology within and without the same exclosures Kondolf concludes that channel morphology lags behind vegetative recovery within the exclosure. He also points out that the channel within the exclosure is still subject to influence from hydrologic impacts of grazing upstream. No reference or data is given to support this particular hypothesis. Thus, there is no field data in the paper by Kondolf (1994) to support the SNEP statement.

Platts (1991) is a chapter titled Livestock Grazing in an American Fisheries Society Special Publication titled Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. Reviewing proceedings from forums, seminars, symposia, workshops, and town hall sessions, Platts concludes:

1. Riparian habitats on grazed lands are degraded.
2. Solutions to land-use problems causing the degradation are not easily found.
3. The problems are most likely to be solved through an interdisciplinary approach.
4. Enough experience and knowledge exists to begin correcting the problems.
5. More research is needed to develop better understanding and provide solutions.

Platts provides a thorough review of the body of case study work and observations which indeed builds the strong case that "overgrazing" can lead to degradation of riparian areas and stream habitat. Although this body of evidence largely lacks statistical reliability, it gives scientists a place to focus research. The value of streamside vegetation and habitat are discussed. Platts evaluates various grazing strategies based upon his personal observations. Platts rates the various strategies in regard to fisheries compatibility, again based upon his observations. Ratings range from 1 to 10, 1 having little or no fishery compatibility and 10 being completely compatible with fishery needs. The strategies are defined by Platts, and the reader is referred there for details.

Platts (1991) provides no new data in support of the SNEP statement, but does review the case study literature documenting the negative effects of overgrazing.

Odion et al. (1990) is a proceedings paper in a symposium on plant biology of eastern California. It is not clear if the proceedings are peer-reviewed. The exact objective of this paper is not clear, no testable research hypothesis is stated. The authors measured vegetation along transects in Ramshaw and Templeton Meadows in the Golden Trout Wilderness Area on the South Fork of the Kern River. Transects were evenly split between grazed areas of the meadows and 2 year old ungrazed areas of the meadow. The authors define "increasers" as plants which increase with grazing and are "thus not important components of pristine meadow vegetation". They define "decreasers" as plants that decrease with grazing and are "thus important components of pristine meadow vegetation". Classification of "increaser" and "decreaser" species was determined from Ratliff (1985), that is based on Ratliff's opinion and long field experience. Ratliff (1985) also cautioned that one should not use his list of increasers and decreasers in other places. The conclusion, by Odion, that increaser plants have no value for riparian structure and function is fairly major, and perhaps not well founded. The assumption that the evolutionary theory developed by Dyksterhuis for grasslands of the Great Plains is applicable to 8,000+ foot meadows of the Sierra Nevada, is perhaps also not well founded. Particularly in light of work by Allen (1989) presented below. The authors also state earlier in their paper that both meadows have been historically grazed by native herbivores. It not clear how Odion et al. (1990) support the SNEP statement as referenced. Their survey determined the following:

Site	% Decreasers	% Increasers
Hydric	64	36
Mesic	34	66
Sagebrush	11	89
Streambanks	19	81

The reference, U.S. Forest Service (1995), is an unpublished report and so was not reviewed here.

A detailed account of Blackburn's (1984) review of grazing intensity and upland hydrologic process is given in this report (page 6).

The reference for Chaney et al. (1993) is essentially the same as Chaney et al. (1990), it is simply a new version of the same informational pamphlet, focusing even more so on educating ranchers on the principles of successful riparian grazing strategies.

The paper by Elmore and Beschta (1987) is a discussion paper in Rangelands. The paper provides no data or supporting references. The objectives of the paper are: 1) to promote awareness and discussion of riparian issues, 2) to identify the characteristics and benefits of productive riparian systems, and 3) to encourage managers to reconsider the effects of traditional grazing and structural channel control measures. The paper provides a good discussion of the issues it sets out, and does indeed point out the problems of "overgrazing". However, the intent of the paper is to foster action by land managers on two fronts: 1) careful consideration of current grazing in light of riparian needs, and 2) careful consideration of “quick-fix” in stream structures.

The paper by Kauffman and Krueger (1984) is a review (103 papers cited) of the literature on livestock impacts on riparian ecosystems and the resulting management implications. The importance of riparian areas to in-stream ecosystems, wildlife and livestock is discussed. The authors discuss the difficulty in interpreting science from opinion in the literature being reviewed. Kauffman and Krueger’s review reports on a substantial body papers which support the SNEP statement above, while at the same time presenting work finding little or no impacts from grazing. The authors do a very good job of referencing specific statements, and of reporting grazing management (stocking rate, season of use, etc) for as many of the studies as possible. Most of the papers cited on the negative impacts of overgrazing are the same ones cited by Platts (1984), Skovlin (1984), and Armour et al. (1991). The authors also review livestock impacts on terrestrial wildlife and riparian vegetation, both of which are discussed elsewhere in this report. Finally, the review focuses on the successes and failure of numerous case studies and research papers examining alternative management to restore, enhance and protect riparian areas. The reader is referred to Kauffman and Krueger for details. Alternative management reported include exclusion of livestock, alternative grazing strategies, changes in class and /or number of animals, riparian pastures, in-stream structures, and in-stream structures in conjunction with modified grazing management. Successes and failures are reported for almost each management option. The mechanisms for these successes and failures are not examined in detail.

The paper by Platts (1984) is a proceedings report on 7 years of research on the utilization of 17 riparian areas located in Idaho, Nevada, and Utah under continuous and rest rotation grazing by sheep and cattle. Although Platts’ initial literature review generally supports the statement, the objective, focus and research in the paper is along a different line and is quite interesting. A major objective of the work is to identify and document riparian grazing management strategies which “balance forage and fish needs”. Unfortunately, the author does a poor job in this paper of quantifying the grazing and grazing systems which were studied. The author gives the reader no definition of “light” or “heavy” grazing, nor does he provide any pre-treatment data to dispute the fact that the streams were potentially dissimilar prior to the grazing treatments. Grazing history is stated to be different for the streams. These are strong confounding factors which could either mask or enhance treatment effects. Under continuous sheep grazing on Horton Creek in Idaho, he reports a narrower (4X) and deeper (5X) stream channel, less bank alteration (15X), 7.6X greater fish density and 10.9X greater fish biomass in the “lightly” grazed compared to the “heavily” grazed pasture. Under rest-rotation grazing imposed by sheep herding, he reports 5% utilization on the riparian area and no significant impacts to the stream system. The comparison of continuous and rest-rotation grazing by cattle reported in this study must be considered carefully. The rest-rotation treatment was imposed on an area that had been excluded from grazing for an unspecified time, while the continuous grazing occurred on a long-term grazed site. Utilization levels in the rest-rotation treatments ranged from 25-80% while they ranged from 60-100% on the continuous grazed site. This level of utilization likely qualifies as “heavy”. After 2 years of rest-rotation grazing on the previously ungrazed area, no changes were detectable in any “water column or stream channel environmental conditions.”. The continuously grazed pastures were compared to adjacent rested pastures with results similar to those reported for continuous sheep grazing, but no supporting data was given. Platts points out that these are preliminary data and as much as an additional 6 years of data are required before strong conclusions are made.

Skovlin (1984) is titled Impacts of Grazing on Wetlands and Riparian Habitat: A Review of our Knowledge and is published in National Research Council/National Academy of Science text on developing strategies for range management. Responses to Skovlin’s review are provided by Platts and Raleigh in the same text. Skovlin cites at least 167 publications. Skovlin’s review taken together with Platts and Raleigh’s responses capture much of the case study, observational, opinion, and research-based literature on this issue in 1984. It is difficult to determine which citations are observation or opinion-based versus experimental-based. To determine this, that reader must revisit each original paper. Specific areas covered by Skovlin (1984) include responses of 1) trees, shrubs and herbaceous plants; 2) water quality, stream bank stability, and features of upland erosion; and 3) large and small mammals, birds, and invertebrate organisms to livestock grazing are reviewed. Grazing strategies to improve habitats are proposed. Skovlin states “In searching the literature for information on riparian habitats, an attempt was made to reach a comprehensive understanding of the effects of livestock grazing, not only of how grazing adversely affects habitats, but how grazing management can enhance habitats.” Both Skovlin’s review and Platts and Raleigh’s comments on it will be discussed further under Additional Literature. Basically, the review by Skovlin supports the SNEP list above, but as with many of the other papers referenced here, it contains much additional information.

Allen (1989) is a proceedings paper presented at the California Riparian Systems Conference. The paper discusses 10 years data from meadows used to evaluate range condition models for these types of rangeland. The author’s abstract is included: “Grazed Sierra Nevada stringer meadow systems were sampled on Blodgett Forest Research Station in northern California between 1977 and 1987 to determine cattle use, and to examine changes in production and species composition over time. Utilization of meadows species averaged 61 percent over 10 years, but increased to more than 80 percent utilization after 1985. Production averaged 2733 kg/ha, but has significantly declined in recent years. Relative species composition has not changed, nor has total vegetative cover between 1979 and 1986. Range condition models based on changes in species composition were not useful for assessing these stringer meadow systems. Managers should instead base livestock management on stream bank conditions and meadow productivity.” Allen also reports that application of the traditional range condition model based upon present composition of decreasers, increasers, and invaders would rate the meadow condition at both the beginning and end of the trial as fair to poor. Based upon bare ground, the meadow would be rated in excellent condition. Soil cover criteria (including litter) would rate the meadow condition as good. Despite these condition scores, Allen reports photographic evidence that indicates broken down stream banks, widened stream beds, and locally broken meadow sod. This evidence is what leads the author to conclude "Traditional range condition models are of little value either in assessing needs for improved management of these riparian systems, or evaluating the effectiveness of any newly developed practices."

Note that Allen's work brings into question the sensitivity of the work conducted by Odion et al. (1990) on the Golden Trout Wilderness.

Hagberg (1995) is a thesis from Humboldt State University, and was not evaluated due to time constraints.

Range Watch (1995) is a video tape. It was not evaluated for scientific merit in this review, so cannot be commented upon.

Menke et al. (1996) is Volume 3 Chapter 22 of SNEP. The statement above (quote 25) refers to a case study conducted during development of the Chapter to correlate meadow and riparian condition. In 1995, the authors re-read 24 existing Parker transects on 7 forests. The nearest stream reach was assessed using the USDI-BLM (1998) "Proper Functioning Condition" assessment method for lotic areas. The 17 parameters in USDI-BLM were estimated, as were elevation, width to depth ratio, presence of restoration project, and "function" and trend as estimated by USDI-BLM (1998). The authors report that 7 of the stream reaches were fully functioning (29%), 13 were functioning at risk (54%), and 4 were not functioning (17%). Given that USDI-BLM (1998) is not a tool to determine cause and effect, grazing could not be identified as the only factor leading to either functioning or not functioning status.

The SNEP statement (quote 25, Appendix I) does not explore the data from the case study to its limits. Another interpretation of the date presented in Menke (1996) could be:

1. Twenty of the 24 stream reaches (83%) are currently functioning,

2. Thirteen (54%) of these stream reaches are functioning but at risk,

3. Of the 13 functioning at risk reaches, 6 (46%) are in an upward trend, 4 (31%) had no apparent trend, and 3 (23%) were in a downward trend,

4. A watershed assessment needs to be conducted on the 3 functioning at risk/downward trend, the 4 functioning at risk/no apparent trend, and the 4 not functioning reaches to determine the causes and possible solutions,

5. Long term monitoring on these same 11 reaches needs to be established to formally document trend.

Digging deeper into the data collected via USDI-BLM (Volume 3, Chapter 22, Page 958, Table 11) the reader discovers that Menke et al. lump the categories "No" and "N/A" when reporting their results for the 17 parameters assessed under the "Proper Functioning Condition" method. Under the method presented in USDI-BLM (1998) these categories have very different meanings. Thus, it is impossible to determine if the stream reach was "not supporting" of the function or if the function was simply "not applicable" for the specific reach. Only the positive responses can be interpreted, realizing that a score of "not supporting" could actually mean "N/A" and visa versa. Examining the data provided (quote 25) in Table 11 from Menke (1996) one could calculate the following:

1. 54 % of the floodplains are inundated in relatively frequent events.
2. 8% of the reaches have active/stable beaver dams.
3. 67% of the reaches have sinuosity, width/depth ratio, and gradient in balance with landscape setting.
4. 8% have a widening riparian zone. 8% have a "somewhat" widening riparian zone.
5. 63% have upland watershed not contributing to riparian degradation.
6. 67% have diverse age structure of vegetation.
7. 88% have a diverse composition of vegetation.
8. 79% have species present which indicate maintenance of riparian soil moisture characteristics, a 4% "somewhat have species present which indicate maintenance of riparian soil moisture characteristics.
9. 67% have riparian plants with root mass to old banks.
10. 92% have riparian vegetation exhibiting high vigor.
11. 58 % have adequate cover to protect banks and dissipate energy during high flows.
12. 25% have plant communities with an adequate supply of coarse and large woody debris.
13. 54% have floodplain or channel characteristics adequate to dissipate energy.
14. 88% have point bars which are revegetating, and 4% "somewhat" have point bars which are revegetating.
15. 67% have lateral stream movement associated with natural sinuosity.
15. 79% have vertically stable stream beds.
16. 67% have are in balance with the water and sediment being supplied by the watershed.

There is a wealth of information in these data that were never addressed within SNEP. The relatively high values for many of these critical functions paints a bit more positive picture that does either Menke et al. or Kattleman and Embury in SNEP. Obviously, there is room for improvement in these numbers and the functions they represent.

SNEP Statements Related to Pathogens and Nutrients

26. *Congregation of cattle in and around streams provides a direct pathway for nutrients and pathogens to degrade water quality (Springer and Gifford 1980, Kunkle 1970).* Volume 2, Chapter 30, Page 900

27. *Cattle grazing in backcountry areas provides a source of Giardia cysts (Suk et al. 1985).* Volume 2, Chapter 30, Page 900

<u>A review of the Literature Cited in SNEP</u>

Springer and Gifford (1980) is a proceedings paper reviewing unconfined grazing and bacterial water pollution. The paper focuses on indicator bacteria such as total coliforms (TC), fecal coliforms (FC), and fecal streptoccocci (FS) as indicators of pollution from grazing animals. The authors report on several studies attempting to determine “background” indicator counts from ungrazed watersheds. Bacterial indicators are present in waters from ungrazed watersheds, indicating wildlife can be a significant source. The literature clearly shows a relationship between coliform counts, streamflow, and turbidity. This indicates that bacterial indicators are “flushed” from the watershed both within season and within storm. This pattern was evident in both grazed and ungrazed watersheds. Many of the studies cited indicate an higher in bacterial indicators in streams draining grazed than ungrazed pastures/watersheds. The review also discusses the temporal and spatial of livestock manure deposition on watersheds, as well as bacteria survivability.

Kunkle et al. (1970) was not evaluated in this report.

Suk et al. (1985) is a proceedings paper reporting surveys for Giardia in the Sierra Nevada. From the author’s abstract: “ Cysts of Giardia sp. were detected in 27 of 78 water samples collected at remote streams in California’s Sierra Nevada range. The data suggest that intensity of human recreational use may play a significant role and/or be a useful indicator in the contamination of surface water with Giardia. Cysts of Giardia spp. were detected in 26 of 309 fecal samples collected from cattle grazing in back-country areas in the Sierra Nevada.”

SNEP Statements Concerning Water Temperature

28. *Removal of riparian vegetation and channel widening by grazing expose the stream to much more sunlight. Therefore stream temperatures in summer may be several degrees higher than if shade remained. These artificial changes in temperature impact aquatic organisms that rely on a more natural temperature regime*. Volume 2, Chapter 30, Page 900

29. *Livestock grazing has decreased or eliminated riparian vegetation, broken stream banks, widened stream bottoms, increased sediment, decreased shade, and increased water temperature (Platts 1978, California State Lands Commission 1993, Li et al 1994, Menke et al 1996).* Volume 2, Chapter 35, Page 990

30. From Table 36.3 Volume 2, Chapter 36, Page 1014.

Ecological Consequence	Physical Effects	References
Lack of bank vegetation and undercut banks, channel widening, and higher water temperatures	Reduced fish populations reduced invertebrate populations	Behnke and Raleigh 1979 Armour et al. 1991 Herbst and Knapp 1995

A review of the Literature Cited in SNEP

These references are reviewed in the Stream Channel Stability and In-stream Flow Processes.

Livestock and Plant Resources

SNEP Statements Concerning Meadow and Riparian Resources

31. *Livestock consume plants that hold the streambanks and soil together; mechanically alter the form, structure, and porosity of soils; and change the composition of the plant community* (Volume 3, Chapter 5, page 212)

32. *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)* Volume 3, Chapter 22, page 936).

33. *Ratliff (1985) has compiled an extensive list of species responses to grazing in Sierran meadows.* (Volume 3, Chapter 22, page 936)

34. *Some observers attribute the reduction of native perennials and their replacement by more aggressive annual species in upper elevation grassy hillsides and higher elevation meadow systems to this unregulated sheep grazing (Muir 1894, Douglass and Bilbao 1975, Rowley 1985, Beesley 1985)* (Volume 2, Chapter 1, page 7).

35. *Wet and mesic meadow ecosystems, if overgrazed, show a trend of grass and legume composition increase at the expense of sedge and rush composition*. (Volume 1, Chapter 7, page 118).

36. *Overgrazing and livestock concentration in riparian zones have altered stream morphology and vegetative composition in many areas of the Sierra Nevada* (Volume 1, Chapter 7, page 129).

37. *Livestock grazing has been implicated in plant compositional and structural changes in foothill community types, meadows, and riparian systems, and grazing is the primary factor affecting the viability of native Sierran land bird populations* (Volume 1, Chapter 5, page 74).

38. *Moderate grazing usually increases native plant species' diversity in wet and mesic meadow, but can suppress 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.* (Volume 3, Chapter 22, page 936)

39. *...wet meadows converted to dry terraces above an incised stream as a result of overgrazing may not recover even over a century without active restoration work. Riparian vegetation tends to become reestablished within a few years after chronic disturbance is eliminated, but readjustment of channel morphology to a natural shape may require decades. Although disturbances such as a single timber harvest or a fire may have severe short-term effects, natural recovery from them generally occurs at a much faster rate than recovery from chronic disturbances.* (Volume 1, Chapter 7, page 130).

40. *Overgrazing and livestock concentration in riparian zones have altered stream morphology and vegetative composition in many areas throughout the Sierra Nevada.* (Volume 1, Chapter 7, page 129).

41. *Overgrazing has altered riparian communities throughout much of the Sierra Nevada*.(Volume 3, Chapter 5, page 203).

42. *Riparian areas often suffer from overgrazing because their vegetation tends to be grazed more heavily than upland vegetation because of consumption preference and availability of water and shade.* (Volume3, Chapter 5, page 220).

43. *A prime problem with respect to grazing is that areas degraded in past decades have never had a chance to recover, even though grazing intensity may have greatly diminished. Such areas have to be rested for a t least a few years if recovery is to begin.* (Volume 3, Chapter 5, page 241).

44. *Riparian vegetation degraded by overgrazing generally recovers within a decade once grazing pressure is removed (e.g. Platts and Nelson 1985, Chaney et al. 1993, Nelson et al. 1994).* (Volume 3, Chapter 5, page 221).

A review of the Literature Cited in SNEP

Ratliff (1985) is frequently cited in SNEP. It is a compendium of research and experience in Sierran mountain meadows over the career of the author. The publication presents a classification of meadow types, meadow productivity values, management problems and meadow condition and trend. It describes the diversity of meadows across gradients of elevation, moisture, and hydrologic condition. The statement (quote 32) that increasers on mountain meadow rangelands are native forbs which can be substantially increased in abundance as attributed to Ratliff (1985) was not found although this statement certainly follows the Range Condition Model. It is true that Ratliff (1985) has compiled an extensive list of species responses to grazing but response to grazing is not based on experimental evidence. Rather the list is his own observations along with information gleaned from Dayton 1960, Hayes and Garrison 1960, Hermann 1966, 1970, 1975, Hitchcock 1950, Munz and Keck 1959, USDA Forest Service 1937, Weeden 1981.

The idea of native perennial displacement by exotic annuals is highly controversial (See Foothill Oak Woodland, this report, page 61). There is little evidence that the California grassland was dominantly native perennials (Hamilton 1997).. Muir (1894) and Douglass and Bilbao (1975) are non-scientific narratives. Rowley (1985) is a review of Forest Service grazing history. We did not find Beesley (1985).

Platts and Nelson (1985) is a Rangelands article that does not mention recovery rates. Instead they compared 3 grazing systems and found that streamsides were more heavily utilized than the uplands. They also found streamside zones were not heavily used early in the season, but received greater use later in the season. Chaney et al. (1993) is a non-peer reviewed report at the Information Center Inc. in Eagle, ID. Nelson et al. (1994) is in the Ecological Support Team Workshop Proceedings for the California Spotted Owl Environmental Impact Statement, on file at the USFS Pacific Southwest Station, San Francisco. The workshop proceedings report the opinions of group of scientists and professionals and do not address recovery rates.

SNEP Statements Concerning Blue oak

45. *Allen-Diaz and Bartolome (1992) looked at blue oak seedling establishment and mortality with the treatments of grazing and prescribed burning in coastal areas of hardwood rangelands. Neither of these treatments significantly affected oak seedling density nor the probability of mortality when compared to unburned and ungrazed areas, suggesting that seedling establishment is compatible with grazing and fire*. Volume 3, Chapter 15, page 660.

46. *Perhaps the importance of fire on oak regeneration is explained by the enhanced postfire oak sprout growth documented by Bartolome and McClaran (1989). They concluded that in areas of moderate grazing with fire intervals around 7 years, seedlings taking up to 18 to 20 years to exceed the browse line (around 5 feet) would survive to become saplings and persist in the stand. In heavily grazed areas, only those trees that exceeded the browse line in 10 to 13 years would be recruited.* Volume 3, Chapter 15, page 660.

47. *For the blue oak, livestock grazing has been proposed for the cause for their increase in density. Livestock grazing removes herbaceous competition for blue oak seedlings and decreased fuel levels, so fires are less intense and thus less detrimental (Vankat and Major, 1978).* Volume 2, Chapter 39, page 1083

48. *When grazing pressures and plant competition are minimal (along roadsides beyond pastures) or where micro-habitat is favorable, pioneer establishment of blue oaks in open sites can occur.* Volume 3, Chapter 15, page 655.

49. *From the period 1932 to 1992, the canopy density and basal area of blue oak woodlands at the stand level has increased under typical livestock grazing practices, and fire exclusion policies (Holzman, 1993).* Volume 3, Chapter 15, page 649

<u>A review of the Literature Cited in SNEP</u>

Allen-Diaz and Bartolome (1992) found no significant difference among the grazing and prescribed burning treatments on seedling establishment and mortality.

McClaran and Bartolome (1989) did document enhanced postfire oak sprout growth, supporting their hypothesis that fire stimulated sprouting is beneficial to blue oak recruitment. The statement about time requirements to exceed the browse line should be taken in the context they present it: "Recognizing the absence of replicated observations and our inability to measure variables such as fire season and intensity effects on postfire sprouting, we offer the following interpretation. With heavier livestock browsing pressure, only plants that surpass the browse line in approximately 10-13 years will be recruited. This applies to both postfire sprouts and true seedlings. However, under lighter browsing pressure, nonfire-related seedling will be recruited even in surpassing the browse line requires approximately 18-20 years."

Long term changes in blue oak stands was investigated in 4 biogeographical regions by re-sampling plots established in the 1930s (Holzman, 1993). The results were a significant increase in the mean total basal area of blue oaks. This was attributed to the growth of trees existing in the 30s, as well as the introduction of new trees (average of 3 trees per .2 acre plot) into the stand. These results were consistent across grazed and ungrazed plots (54% and 46% of the sample plots, respectively). These results stand in contrast to a model predicting widespread lack of blue oak recruitment developed by Swiecki et al (1997b).

The statement (quote 47) attributed to Vankat and Major (1978) is contained in a review article without stated references for support. The statement used is an adaptation of "Thus, we hypothesize that intense livestock grazing in the nineteenth century initiated the density increase by removing herbaceous competition for Q. douglasii seedlings and decreasing fuel levels, so that fires were less intense." The other statement (quote 48), that without grazing pressure or plant competition establishment of blue oaks in open sites can occur, is true and supported by research (Adams et al, 1992; Adams et al, 1997;

McCreary and Tecklin, 1997). However, it implies that with grazing and competition establishment of blue oak is not possible, which is not supported by research (see following).

SNEP Statements Concerning Oak Woodland Vegetation Community Change

50. *With the introduction of domestic livestock and exotic annuals during the Spanish mission days, hardwood rangeland ecosystems have changed dramatically. The herbaceous layer changed from a perennial layer to an annual layer (Crampton, 1974). Fire intervals have increased dramatically and fire intensity has also increased (McClaran and Bartolome, 1989). The overstory layer, if not converted to another land use, has generally increased (Holzman and Allen, 1991). Soil moisture late in the growing season has decreased, and bulk density has increased due to compaction from higher herbivore densities (Gordon et al, 1989). Riparian zones are now less dense and diverse (Tietje et al, 1991).* Volume 3, Chapter 15, page 650

51. *The combination of poor grazing practices and extended periods of drought contributed to the conversion of Sierra foothills from perennial to annual grasslands.* Volume 1, Chapter 7, page 114

52. *Perennial grasses were dominant in the grassland communities, although exotic annuals had begun their invasion even before the arrival of the first missions in 1769.* Volume 2, Chapter 3, page 42

53. It is thought that the native grasses were replaced by grazing-tolerant non-native annual grasses (Mack, 1989) Volume 2, Chapter 47, page 1206

54. *Impacts of overgrazing are considered on second to dams and river regulation as causing degradation of riparian areas in the Sierra Nevada foothills (Nelson et al, 1994).* Volume 3, Chapter 5, page 218

<u>A review of the Literature Cited in SNEP</u>

McClaran and Bartolome (1989) concluded that "between 1848 and 1948, fires were three times more frequent than between 1681 and 1848. The limitations of fire scar evidence should be considered before concluding the ignitions were more frequent after Anglo-American settlement. Ignitions before Anglo-American settlement may have been very frequent and therefore of such low intensity that scarring was not likely, an trees harboring older fire scars may be dead or rare." They concluded that fire frequency increased on one of their two sites after 1948. They did not relate this phenomena to livestock grazing, but did note that the site with the increased fire frequency also had "traditionally less livestock grazing" than the site where they could not conclude that fire frequencies had increased.

The statement that the overstory layer, if not converted to another use, has generally increased is supported by Holzman and Allen (1991), and further substantiated by

Holzman (1993). Long term changes in blue oak stands were investigated in 4 biogeographical regions by re-sampling plots established in the 1930's. The results were a significant increase in the mean total basal area of blue oaks. This was attributed to the growth of trees existing in the 30's, as well as the introduction of new trees (average of 3 trees per .2 acre plot) into the stand. These results were consistent across grazed and ungrazed plots (54% and 46% of the sample plots, respectively)

Gordon et al (1989) conducted a trial examining the effects of 2 annual species (Bromus diandrus and Erodium botrys) on soil water potential and blue oak seedling growth and water relations. They found higher soils water potentials, greater dry weights, and longer growing seasons for oak seedlings with Erodium competition and the control container (no competing plants) than in those with Bromus competition. They suggested that the competition for soil water with annual species contributes to blue oak seedling mortality. They found that soil water depletion occurred most rapidly in the high density Bromus planting, with the low density Bromus planting reaching a similar water potential soon afterwards. Erodium plantings had significantly greater soil water potential throughout the summer growing period than in the Bromus plantings, and there was no observed change in soils water potential when oaks were planted alone. However, there was no investigation into the effect of compaction from higher herbivore densities on soil moisture late in the growing season, nor on bulk density.

The statement (quote 50) that riparian areas are now less dense and diverse, attributed to Tietje et al (1991) is a misquote. While the authors did refer to differences in species diversity of two riparian communities at different locations, they did make any claims about prior riparian communities. We did not find other supporting research literature, either general or specifically in regards to livestock grazing.

Mack (1989) in a review article that addresses changes in the Central Valley states that "the huge numbers of cattle and sheep recorded for the Central Valley from the mid-19th century onward testify to the tremendous grazing and trampling these animals must have exerted on the communities dominated by caespitose grasses," citing Burcham (1982[1957]) as the source. (See following for additional discussion)

The statement (quote 54) about the impact of overgrazing on riparian areas in the Sierra Nevada foothills by Nelson et al (1994) appears in a non-peer reviewed document without any supporting documentation. The statement occurs in one of two paragraphs (pages 5 and 12) which summarize the authors opinion of livestock grazing impacts in riparian areas. We found no other literature to support this statement.

Livestock and Wildlife Resources

SNEP Statements Concerning Amphibians

55. *"There are waters where native amphibians are still surviving. In the foothills, these tend to be small streams that have a dense riparian canopy, that are free of*

introduced species, and that have not been disturbed by grazing and other impacts." Volume 1, Chapter 7, Page 128

56. "*The causes of frog and toad population declines are not wholly understood and differ depending on latitude, altitude, and species. Low elevation species, such as foothill yellow-legged frog (Rana boylii) and the California red-legged frog (R. aurora draytonii) have been most impacted by alteration of streams and wetland habitats as a result of grazing, mining, reservoir construction, and urbanization."* Volume 2, Chapter 31, Page 939; SNST, Page 39

57. *"Grazing has been implicated as a major factor affecting the habitat of the leopard frog and the recent drought has exacerbated already tenuous conditions (Jennings and Hayes 1994)."* (SNST, Page 39)

58. "*Specific examples of factors contributing to this degradation [note: of riparian habitat for amphibians] are livestock grazing, road building, reservoir construction, and recreation (Jennings and Hayes 1994). The most obvious reasons for the demise of native amphibians due to these factors are: (1) increased dehydration and increased predation due to loss of vegetative cover; (2) changes in the structure and composition of the flora (thus affecting important food resources); and (3) the crushing or removal of small or cryptic individuals due to trampling, vehicles, or the results of human activity. Specific examples include (1) increased dehydration rates for slender salamanders in habitats where the riparian cover was removed (see Ray 1958); (2) the loss of riparian willow (Salix spp), which resulted in increased predation on California red-legged frogs by raccoons (Procyon lotor) (Miller 1994); (3) the loss of important food resources that are critical for the growth and survival of juvenile frogs and toads, due to the removal of vegetation upon which invertebrates feed (Jennings and Hayes 1994); and (4) the crushing of individuals by livestock grazing in alpine meadows, which resulted in trampled larval and juvenile Yosemite toads (D. Martin, Maring, Canorus, Ltd., letter to the author, May 12, 1991), or by motorcycle use in riparian zones, which crushed juvenile and adult foothill yellow-legged frogs and garter snakes (personal observations by the author [M. R. Jennings] 1986-90)."* Volume 2, Chapter 31, Page 939

59. *"The more open vegetation resulting from grazing may expose amphibians to predation and desiccation. Direct trampling by livestock may be an important cause of amphibian mortality."* Volume 3, Chapter 5, Page 220

<u>A review of the Literature Cited in SNEP</u>

Literature other than SNEP documents referenced by the above quotes include Ray (1958), Jennings and Hayes (1994), and Miller (1994). Ray (1958) showed experimentally that slender salamanders in captivity could be killed by dehydration in a desiccation chamber. Nevertheless, the SNEP author is simply speculating that removal of riparian vegetation could result in mortality of salamanders. Jenning and Hayes (1994) produced a major review of all amphibians and reptiles suspected of warranting "special concern" by the California Department of Fish and Game because they were rare, threatened or likely to become so. This report is important, and likely the best information available to that date, but it is not a refereed publication in the traditional sense. Miller (1994) refers to a document placed into the Congressional Record by Congressman Miller proposing to list the California red-legged frog as endangered. There is no reference in Miller (1994) to support the statement that raccoons may prey on red-legged frogs.

SNEP Statements Concerning Birds

The following statements from SNEP and the USFS Science Team Review indicate some of the issues and concerns regarding the influences of the livestock industry on native birds in the Sierra Nevada. Some statements are located under the headings for highlighted species.

60. *"Livestock grazing has been implicated in plant compositional and structural changes in foothill community types, meadows and riparian systems, and grazing is the primary negative factor affecting the viability of native Sierran bird populations."* Volume 1, Chapter 5, Page 74

61. *"The extinction of least Bell's vireo in the Sierra appears most likely related to nest parasitism by brown-headed cowbirds, although destruction of willow-dominated riparian corridors, which were fragmented by grazing, greatly reduced its habitat.* Volume 1, Chapter 5, Page 79

62. *"Among the potential risks faced by Sierran land birds, grazing and its secondary effects appear to be the single most significant negative factor. Montane meadows and montane riparian habitats are extremely important for Sierran birds; by midsummer, montane meadows may be the single most critical Sierran habitat requirement for may species that do not use this habitat during the actual breeding season. Grazing catalyzes changes in meadow plant species and cover, with cascading effects on birds. Changes in herbaceous and shrubby growth in meadows potentially alter the levels of prey insects, change use patterns by predatory birds, alter nest-building opportunities, and change the water relations of meadows, which sometimes leads ultimately to loss of meadow area."* Volume 1, Chapter 5, Page 82

63. *"Grazing has also been implicated in the decline of great gray owls outside of Yosemite National Park; great gray owls do not forage in grazed meadows, perhaps because grazed meadows are attractive to great horned owls which exclude them (Gaines 1988), or because of changes in prey populations."* Volume 2, Chapter 25, Page 717

64. "The major deleterious effects of grazing on montane meadows are decrease in the density and height of herbaceous growth in the meadow. Many of the landbird species utilizing these meadows depend upon insects that either live on the *herbaceous growth or depend upon the primary productivity of the herbaceous growth for sustenance. (The dense concentrations of aphids on lupines and corn lilies in these meadows is one example.) A decrease in the quantity of this herbaceous growth will result in a decrease in the food sources of landbirds that use the meadow."* Volume 2, Chapter 25, Page 717

All the above statements are undocumented except for the reference to Gaines (1988). This is the earlier version of a bird guide to the Yosemite area that was revised in 1992. The later edition also contains Gaines' comments regarding great gray owls' preference for ungrazed areas inside Yosemite. These comments fall under the category of speculation from observations. Great gray owls do forage outside Yosemite Park (R.H. Barrett, personal observation).

We found comparative (e.g. Dobkin et al. 1998) but no experimental scientific reports on the response of bird species to livestock grazing (Appendix 2). Some bird species respond positively to livestock grazing while others respond negatively. Great gray owls (*Strix nebulosa*) are rare in the Sierra Nevada, and may well prefer ungrazed meadows for feeding, but this is undocumented in peer-reviewed scientific literature. The least Bell's vireo (*Vireo bellii pusillus*) has been extirpated from the Sierra Nevada, and livestock grazing has been hypothesized to be a factor at least indirectly in the opinion of one author (Goldwasser et al. 1980).

The following sections consider two bird species for which more than speculation or expert opinion is available regarding their response to livestock grazing.

Willow flycatcher

65. *"Grazing of Sierran habitats, particularly mountain meadow and montane riparian habitats, may constitute a significant threat to Sierran landbirds. Grazing of montane meadows has been implicated as a major cause of the drastic decline of willow flycatchers; Gaines (1988) claims that willow flycatchers do not nest in willows whose lowermost foliage has been denuded by livestock."* Volume 2, Chapter 25, Page 717

66. *"Overgrazing of meadows has been suggested as a major cause of the decline of Willow Flycatchers (Ohmart 1994). Cattle can directly disturb Willow Flycatchers and other birds nesting in montane meadows by knocking over nests in willows or crushing eggs on the ground (Sanders and Flett 1989)."* Volume 3, Chapter 5, Page 208

67. *"Declines [note: in willow flycatcher] are believed to be related to direct degradation of nesting and foraging habitat from livestock grazing in meadows and loss of riparian habitat (Serena 1982, Harris et al. 1987, Harris et al. 1988)."* (SNST Page 42)

Four out of the five citations in the above quotes deal with willow flycatchers in the Sierra Nevada (Serena 1982, Harris et al. 1987, Harris et al. 1988, Gaines 1988, Sanders and Flett 1989) and are discussed below. Ohmart (1994) is a comprehensive (57 citations) review paper on the impacts of livestock grazing on birds focusing primarily on southwestern riparian habitats. Ohmart (1996) is a more comprehensive work (237 references) covering all wildlife in which he reviewed Taylor's work (Taylor 1986, Taylor and Littlefield 1986) on willow flycatchers in Oregon (see below). Ohmart (1996) and Skovlin (1984) are the only two comprehensive reviews of the links between wildlife and livestock in western riparian habitats.

Brown-headed cowbird

68. *"The most serious effects [note: of non-native species] have been produced by the brown-headed cowbird, which was self-introduced early in the century. The spread of this nest-parasitizing bird in the Sierra (and the West in general) has mirrored the spread of farmland, livestock grazing, clearcut logging, and suburban development. Cowbirds are directly implicated in or directly charged with the decline of several songbirds in the Sierra Nevada, especially the willow flycatcher, least Bell's vireo, yellow warbler, chipping sparrow, and song sparrow."* Volume 1, Chapter 5, Page 80

69. *"Preferred foraging areas for cowbirds in the Sierra include heavily grazed meadows, recent clear-cuts (especially those that are grazed), open forest with short grass understory, pack stations and stables, picnic areas and campgrounds, lawns and golf courses, and residential areas with bird feeders."* Volume 1, Chapter 5, Page 80

70. *"Grazing may increase nest parasitism by non-native cowbirds, although grazing itself is not as important to the spread of cowbirds as are agricultural practices and feedlot distribution in the regions adjacent to the Sierra. Local cowbird-control programs related to grazing practices and aimed at certain critical meadows and riparian habitats may be necessary to protect remnant populations of some rare Sierran birds and already show promise where they have been tried. In recent decades cowbird populations on the Sierran transects have been declining, perhaps from reductions in grazing and logging disturbances where those transects occur."* Volume 1, Chapter 5, Page 82

71. *"The most serious effects [note: of alien species] have been produced by the brown-headed cowbird. The spread of this brood parasite in the Sierra Nevada (and the west in general) has mirrored farming, livestock grazing, clear-cut logging, and suburban development (Gaines 1977, Rothstein et al. 1980, Verner and Ritter 1983, Airola 1986, Coker and Capen 1995). Preferred foraging habitats in the Sierra include heavily grazed meadows, recent clear-cuts, especially those that are grazed, open forest with short grass understory, pack stations and stables, picnic areas and campgrounds, lawns and golf courses, and residential areas with bird feeders.*

Closed-canopy and multi-layered forests, forests with shrub understory, tall-grass meadows, and clear-cuts after shrubs and trees are established do not provide cowbird foraging habitat (Laymon 1995).” Volume 2, Chapter 25, Page 713

72. *“And finally, the grazing of montane meadows promotes contact between cowbirds (which are attracted to grazing livestock) and a high density of nearby nests of many host species, including both those that nest in the meadow itself and those that nest, often in higher than average numbers, in the adjacent forest.”* Volume 2, Chapter 25, Page 718

73. *“The amount of grazing in the Sierra, at least at mid- and higher elevations, has been decreasing in recent years. Perhaps related to this, BBS indicates cowbird populations seem to be decreasing as well (DeSante 1995). However, at the present time grazing and its secondary effects may well be the single most significant negative factor in the maintenance of native Sierran landbird populations.”* Volume 2, Chapter 25, Page 718

74. *“In all cases, grazing tends to decrease the amount of herbaceous plant growth present in the forest, woodland, and brushland habitats, thereby negatively affecting the food resources of many granivorous and some insectivorous [bird] species, and tends to increase the contact between cowbirds and their host species.* Volume 2, Chapter 25, Page 718

75. *“Cowbird invasion into the mountains is favored by livestock grazing, clear-cutting, and disturbances such as pack stations, picnic areas, and campgrounds (Rothstein et al. 1980, Verner and Ritter 1983).”*(SNST Page 42)

<u>A review of the Literature Cited in SNEP</u>

Of the seven citations in the above quotes, six are observational or comparative field studies in the Sierra Nevada (Gaines 1977, Rothstein et al. 1980, Verner and Ritter 1983, Airola 1986, DeSante 1995, Laymon 1995). Gaines (1977) and DeSante (1995) are non-refereed documents, but they contain large amounts of personal observation by these expert ornithologists. Coker and Capen (1995) is a peer-reviewed study of the cowbird habitat preferences in Vermont.

Historic and Current Ranching Use

76. “*Livestock were introduced into the Sierra in the mid-1700s following settlement by the Spanish”* (Vol. 3, Chap 22, pg. 909). We found no evidence to support this statement.

77. “Grazing was perhaps the most ubiquitous impact, as cattle and sheep were driven virtually everywhere in the Sierra Nevada that forage was available” (see Menke et al 1996; Kinney 1996) (Vol II, Chap 30, pg. 866; Vol III, Chap 5 pg. 215)

78. "*Grazing by sheep and cattle is widely believed to have been virtually ubiquitous throughout the Sierra Nevada before 1930" (Vankat and Major 1978; McKelvy and Johnston 1992; Kinney 1996)... (Vol III Chap 5 pg. 218)*

79. "*Virtually all the Sierra Nevada has been grazed at some time (Kinney 1996, Menke et al 1996)"*

80. "Grazing by livestock was virtually ubiquitous in the Sierra Nevada from the nineteenth century through 1930 (Vankat and Major 1978, McKelvy and Johnston 1992, Kinney 1996) (Vol II Chap 36 pg. 1017-8)"

The exact distribution of historic grazing in the Sierra has not been evaluated in any comprehensive sense, but it is often stated as "ubiquitous" in SNEP. A review of these comments reveals that they lack full documentation. This reviewer did not find these claims made by Kinney 1996, particularly with reference to cattle. Though Menke found accounts of heavy grazing in each of the regions he examined, he does not make the claim that the livestock "grazed everywhere that forage was available," and quotes Kinney for information about pre-1900 grazing. Kinney documents that there were high numbers of sheep and cattle in California, and numerous compelling anecdotal accounts of overgrazing, but also does not attempt to argue that grazing took place "everywhere that forage was available." Vankat and Major (1978) cite histories and early accounts to claim that "cattle were widespread," but restrict their claims that livestock grazing was "ubiquitous" to Sequoia National Park. They also state that sheep grazing was eliminated around the turn of the century within the Park, with cattle grazing allowed only in certain areas until 1930. McKelvy and Johnston (1992) is part of an apparently unpublished report on the spotted owl and was not reviewed. The significance here is that it may be possible to find areas of the Sierra that are so difficult of access that they have not been grazed, and that the amount, timing, and type of grazing that has taken place in various areas may vary. Further discussion of distribution of historic grazing can be found within this text.

81. "*Most cattle, especially those associated with dairying, were kept on lower elevation, higher quality, and often fenced ranges. Sheep grazed on all other rangelands*"(Sudworth, 1900; Leiberg, 1902) (Vol II Chap 1 pg. 8)

Review of Leiberg and Sudworth does not find support for this attribution. Only on the east-side basin of Long Valley do sheep seem to be more extensive than cattle according to Leiberg. Near Truckee only does he describe a pattern where cattle use the "levels" and sheep the slopes and summit – but even the "levels" in the Truckee area are at a high elevation. In west slope basins the following is more typical: "…all through portions of the high regions are cattle and sheep" (pg.69, and "…cattle roam throughout the region, sheep are confined chiefly to the eastern and more mountainous tracts" (pg. 98). However, it is probably not fair to generalize from Leiberg's observations too much; his objective was not after all to fully describe the range of either cattle or sheep in the Sierra.

82. *As it related to livestock, fire had its greatest effect from 1880 to 1910 when sheepherders apparently set large brush fires every fall as they left the public lands* (Vol. III Chap 22, pg. 909).

83. *Again, the sheepherders' fires impacted the foothills more than grazing* (Vol. III, Chap 22, pg. 915).

84. *This greater impact (of sheep grazing) was mainly due to the higher numbers of sheep over a longer summer season and to the sheepherder's burning practices, which were evidently more frequent and extensive than those of Native Californians* (Vol II, Chap 3, pg. 40).

The statements are not attributed to any source, and do not seem to be supported by the review of historical literature within this document.

85. *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--Sheepman Fires by Thomas West 1932*) (Vol III, Chap 22, pg. 915)

86. "The historical accounts...seem to agree that sheep grazing, as conducted during this period, affected rangeland condition more than cattle grazing" (Vol 2 Chap 3 pg. 40).

A full citation for the attribution is not provided for this statement, and it was not found in the UC Berkeley libraries or database.

87. "*Under a system of common ownership of a resource, with no regulation of individual use, the so-called "tragedy of the commons" occurs. In economic terms, <u>the common property resource, here the public rangelands,</u> are overused, because no individual user has any incentive to conserve or steward the resource; any reduction in his use is quickly captured by other users (Howe 1979). Sierra Nevada grazing in the late 1800s is a classic example of this type of market failure...*" (Vol II. Chap 3, pg. 41*)* (emphasis added*).*

Public domain rangelands do not fit well-accepted definitions of the term common property resource (Bruce, 1993), as elaborated in the review.

88. "*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 at a much more limited scale, never attaining the size of the areas opened to grazing as in the past"* (Vol III, Chap 22, pg. 909).

This statement is unattributed and contradicts evidence presented elsewhere in SNEP, which argue that increases in shrub and woodland density were well underway by 1900 (Skinner and Chang).

89. "*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"* (Vol III, Chap 22, pg. 909).

No source is given for this assertion. A prominent historian of the national forests, Bill Rowley, asserts that while widespread overstocking occurred in response to WWI, the Forest Service successfully argued against a similar increase in WWII (Rowley, 1985).

90. *"Until the 1934 Taylor Grazing Act very little attention was given to grazing carrying capacity limits [on the Modoc National Forest]"* (Vol III, Chap 22, pg. 910).

91. *"During this period [1908-1946] grazing was allowed in the high Sierra on National Forest land, but only by local ranchers holding "base property" according to the Taylor Grazing Act*" (Vol III, Chap 22, pg. 910).

Assertions are made about the Taylor Grazing Act's influence on Forest Service practice in SNEP, but no citations are given, and they seem derive from a mistaken idea that the Act applied to Forest Service lands.

Rangeland History

Many documents cited in the SNEP history (Vol. II Chap 22) are undated, and it cannot be determined if they are primary data or a rehash of anecdotal accounts. The term "uneconomical" is used frequently with reference to why permits were discontinued or ranches closed down, but is never really explained or defined. It cannot be discerned how the stocking rate estimates were determined, whether based on observations or actual data, and whether reductions in season of use were accounted for. It is important to know if stocking was evaluated in terms of AUMs or just livestock numbers, but this is not made clear.

Reviewing grazing records for the Mammoth area, the authors reported in SNEP that

92. *"…this reduction was achieved not so much by a reduction in actual animal numbers, but by a reduction in the number of days animals were allowed on a given range*" (Vol II, Appendix 50.1, pg. 1311.)

This concurs with results for the Shasta-Trinity National Forest (Forero, 1998).

Analysis of demographic and land use trends in the Sierra leads Duane to the following conclusions:

93. *"The rapid population growth being experienced in some rural areas has the potential to transform radically the physical and the social environments of those regions, including significant fragmentation of habitat and the likely loss of native biological diversity"* (Vol II Chap 11, pg. 246).

94. *"Existing institutional arrangements for land use and environmental planning in the Sierra Nevada appear inadequate for managing rapid population growth and the land conversion process associated with human settlement"* (Vol II Chap 11, pg. 236).

95. *"Innovative growth management strategies to coordinate and consolidate development across these parcels may...be...necessary if the impacts of future population growth are to be mitigated"* (Vol II Chap 11, pg. 236*).*

In the Chapter "Range Assessment" (Vol III Chap 22), Menke adds:

96. *"... housing development continues to reduce the contribution of oak trees to foothill ecosystem function"* (Vol II, Chap 22, pg. 905).

This supports efforts in the review to look at grazing in its ecosystem context.

97. *"The increased values associated with the amenity benefits of open space lands are not easily captured by landowners"* (Vol II, Chap 11, pg. 279), and,

98. *"Agriculturists beyond the range of speculative development are ...likely to support such efforts (preservation of agricultural lands), for they yield marginal benefits at very low opportunity cost. large landowners within the range of speculative development are likely to oppose such preservation efforts despite a long family history in agriculture and/or natural resources and a commitment to agricultural preservation. Their children often do not want to continue in this difficult line of work..."(Vol II, Chap 11, pg. 279).*

No citations or research results were provided to support these statements.

Appendix II: Supplement to Part IV: Livestock and Wildlife

The following table lists approximately 115 citations about livestock and various species of wildlife. The articles range from opinion pieces in SNEP chapters or journals to experimental studies. Only 9 of the articles provide an estimate of livestock grazing intensity in the paper. Fourteen citations are about experiments with 10 of these papers citing negative effects on bighorn sheep, small mammals or deer; 3 papers are reviews of experiments and 1 paper reported no effect. Of the ~115 citations, ~24 took place in the Sierra Nevada.

The table is organized by taxa. For each paper, a relevant quote about livestock and wildlife is listed to provide a context for our evaluation of whether the article provides an opinion, a comparative study, or an experiment. If the quote is from SNEP, the V (volume): C (chapter): and P (page) is provided.

Although a totally comprehensive review of literature available on livestock and wildlife was not possible in the time frame for this study, this table does point out the need for more Sierra Nevada based experimental research on wildlife. It also points out the need for a comprehensive synthesis of existing experimental and “gray” literature for the Sierra Nevada.

Appendix 2: Wildlife literature reviewed in this study (including literature cited in SNEP SNST reports. The SNEP quotes are also referenced by V (volume):C (chapter), P (page).

Wildlife	Location	Livestock	Intensity	Season	Authors	Date	SNEP-V:C:P	Opinion	Comparison	Experiment	Quote from this reference
amphibians	Other				Ray	1958		N/A			"Various species of amphibians show a range of water loss tolerance of from 7 to almost 50% in terms of the percentage of their total weight lost during desiccation."
amphibians	Sierra	cattle		Year	Jennings and Hayes	1994		negative			"
amphibians	Sierra	cattle		Summer	Graber	1996	3:5:220	negative			"The more open vegetation resulting from grazing may expose amphibians to predation and dessication. Direct trampling by livestock may be an important cause of amphibian mortality."
amphibians	Sierra	cattle		Year	Jennings	1996	2:31:939a	negative			"…factors contributing to this degradation [of riparia for amphibians] are livestock grazing, road building, reservoir construction and recreation."
amphibians	Sierra	cattle		Year	Jennings	1996	2:31:939b	negative			"The most obvious reasons for the demise of native amphibians…are (1) increased dehydration and incre vegetative cover; (2) changes in the…flora, and (3) the crushing or removal of…individuals…"
amphibians	Sierra	cattle		Year	Jennings	1996	2:31:939c	negative			"…examples include…increased dehydration rates for slender salamanders in habitats where riparian cover was removed."
amphibians	Sierra	cattle		Year	Jennings	1996	2:31:939d	negative			"…examples include…the loss of riparian willow wh
amphibians	Sierra	cattle		Year	Jennings	1996	2:31:939e	negative			"…examples include…the crushing of individuals by grazing in alpine meadows, which resulted in trampled larval and juvenile Yosemite toads…"
amphibians	Sierra	cattle		Year	SNEP	1996	1:8:128	negative			"In the foothills, [native amphibians are still surviving in] small streams that have a dense riparian canopy, that are free of introduced species, and that have not been disturbed by grazing…"
bighorn	Other	cattle		Summer	Bissonette and Steinkamp	1966			negative		"The core areas used by bighorn and distances to escape terrain generally decreased as cattle moved closer to sheep. Likewise, sheep moved from cattle as cattle approached them."
bighorn	Other	sheep		Year	Foreyt and Jessup	1982		negative			"…acute fibrinopurulent bronchopneumonia resulted Washington. Circumstantial evidence indicated that the apparently healthy domestic sheep transmitted pathogenic bacteria to the bighorns..."
bighorn	Sierra	sheep		Year	Jessup	1985		negative			-bighorn sheep populations can be devastated by pneumonia contracted from domestic sheep-
bighorn	Other	sheep		Year	Coggins	1988		negative			"…two-thirds of 100 bighorn sheep…died…circumstantial evidence linked the die-off to contact with domestic sheep."
bighorn	Other	sheep		Year	Onderka and Wishart	1988				negative	-contact between bighorn and clinically normal domestic sheep caused fatal pneumonia in Rocky Mountain bighorn-
bighorn	Other	sheep		Year	Weaver and Clark	1988		negative			"The death of >50 bighorn sheep was probably caused by 1 stray domestic ewe that introduced a severely pathogenic strain of bacterial pneumonia [to the Warner Mountains].
bighorn	Other	sheep		Year	Foreyt	1989		negative			-confirmed that clinically normal domestic sheep carried bacterium responsible for dieoff of bighorn-
bighorn					Bleich et al.	1990					"…[in 1989] California bighorn [numbered] 300 in the Sierra Nevada…"

Appendix 2: Wildlife literature reviewed in this study (including literature cited in SNEP SNST reports. The SNEP quotes are also referenced by V (volume):C (chapter), P (page).

Wildlife	Location	Livestock	Intensity	Season	Authors	Date	SNEP-V:C:P	Opinion	Comparison	Experiment	Quote from this reference
bighorn	Other	sheep		Year	Foreyt	1990		negative			"…domestic sheep and bighorn sheep should be separ4ated or bighorns may die from pneumonia."
bighorn	Other	sheep		Year	Jaworski et al.	1993				N/A	"…ribotyping…procedures have the discriminatory c monitor the transmission of specific strains of bacteria within and between animal populations."
bighorn	Other	sheep		Year	Foreyt	1994				negative	"…all bighorn sheep died from acute bronchopneumonia after contact with dometic sheep and mouflon sheep."
bighorn	Other	sheep		Year	Foreyt et al.	1994				negative	"…a relatively nonpathogenic and common isolate of healthy domestic sheep was lethal in bighorn sheep under experimental conditions."
bighorn	Other	sheep		Summer	Pybus et al.	1994		N/A			"…there is ample evidence that some bighorn sheep declined subsequent to introduction of domestic sheep onto traditional bighorn ranges."
bighorn	Other	none		Year	Fitzsimmons et al.	1995			N/A		"By the end of year eight, more heterozygous rams had 13% higher horn volumes than less heterozygous rams."
bighorn	Other	none		Year	Ramey	1995			N/A		"Significant differences in mtDNA haplotype distributions over short distances and high values of Nst on a local scale appear to be a result of the tendency of female mountain sheep to disperse less frequently and over shorter distances than males."
bighorn	Sierra	none		Year	Wehausen	1996			N/A		"Mountain lions effectivelyhalted a previously successful restoration program for bighorn sheep in the Sierra Nevada and reversed the overall population trend."
birds	Other	cattle		Year	Wiens	1973			negative		"Local plot-to-plot differences, associated with grazing intensity, were considerably more important than the regional differences [in bird community composition]."
birds	Other			Year	Desante and George	1994		negative			"…75 native landbird species decreased…destructior grasslands, shooting, overgrazing, logging…, and cowbird parasitism where the major factors responsible…"
birds	Other	cattle		Year	Johnson and Jehl	1994		negative			"The later activity [livestock grazing] continues to be the most pervasive current threat to [western] riparian habitats and their avifauna."
birds	Other	none			Johnson and Jehl	1994		N/A			"Without trustworthy temporal baselines, it is premature to invoke processes responsible for patterns of abundance…causation remains as elusive as ever."
birds	Sierra	cattle		Summer	Graber	1996	2:25:717	negative			"Grazing of Sierran habitats, particularly mountain meadow and montane riparian habitats, may constitute a significant threat to Sierran landbirds."
birds	Sierra	cattle		Summer	Graber	1996	2:25:718	negative			"…grazing tends to decrease the amount of herbaceo woodland, and brushland habitsts, thereby negatively affecing the food resources of many granivorous and some insectivorous [birds]…"
birds	Sierra	cattle		Summer	SNEP	1996	1:5:79	negative			"…grazing is the primary negative factor affecting the viability of native Sierran bird populations."

Appendix 2: Wildlife literature reviewed in this study (including literature cited in SNEP SNST reports. The SNEP quotes are also referenced by V (volume):C (chapter), P (page).

Wildlife	Location	Livestock	Intensity	Season	Authors	Date	SNEP-V:C:P	Opinion	Comparison	Experiment	Quote from this reference
birds	Sierra	cattle		Summer	SNEP	1996	1:5:82	negative			"Among the potential risks facd by Sierran land birds, grazing and its secondary effects appear to be the single most significant negative factor."
birds	Sierra	cattle		Summer	SNEP	1996	2:25:717	negative			"Grazing of Sierran habitats, particularly mountain meadow and montane riparian habitats, may constitute a significant threat to Sierran landbirds."
birds	Sierra	cattle		Year	Verner et al.	1997			no effect		"Overall, results of this study do not show that grazinghas led to the loss of any bird species that regularly nests in this foothill oak-pine woodland."
birds	Other	cattle		Year	Dobkin et al.	1998			negative		"Avian species richness and relative abundances were greater on [plolts ungrazed for 30 years]…[ung were dominated by wetland and riparian birds [versus upland birds]."
bobwhite	Other	cattle		Year	Kiel	1976		negative			"The establishment of large blocks of solid stands of buffelgrass, coastal bermudagrass, and bluestem [for cattle] is not favorable for bobwhite quail."
bobwhite	Other	cattle		Year	Hammerquist-Wilson and Crawford	1981				no effect	Found no significant differences in relative abundance of bobwhite among three different grazing systems on the Welder Wildlife Refuge.
bobwhite	Other	cattle		Year	Murray	1958		negative			"The [bobwhite] population varied directly with the acreage in cultivation and inversely with the acreage grazed [bobwhite declined when grazing intensified]."
cowbird	Sierra	horse		Summer	Rothstein et al.	1980			negative		"Cowbirds apparently exploit horse corrals and other human developments for group foraging during midday, scattering by evening or early morning to dispersed breeding sites."
cowbird	Sierra	horse		Summer	Verner and Ritter	1983			negative		"Cowbirds strongly prefer meadow edges as breeding habitats…cowbird abundance declined rapi from...pack stations…abundance of warbling vireos was negatively correlated with that of cowbirds."
cowbird	Sierra	horse		Summer	Rothstein et al.	1984			negative		"[cowbirds] spent mornings in host-rich habitats such as forests and then commuted 2.1-6.7 km to one or more prime feeding sites such as horse corrals and bird feeders…"
cowbird	Sierra	cattle		Summer	Airola	1986			negative		"Parasitism was strongly associated with habitat disturbance… Hosts that prefer riparian habitats are most likely to decline due to cowbird parasitism."
cowbird	Other				Beezley and Rieger	1987					-removal of cowbirds by trapping resulted in increased least Bell's vireo numbers-
cowbird	Sierra	sheep		Summer	Flett and Sanders	1987		negative			"…sheep were always accompanied by flocks of 5-5 cowbirds that foraged in the immediate vicinity of the flock…"
cowbird	Other				Laymon	1987		N/A			-concluded from model that cowbird parasitism over 48% would lead to least Bell's vireo extinction in short time-
cowbird					Sedgwick and Knopf	1988		N/A			"…at least 11/15 pairs (73.3%) [of willow flycatchers in Colorado] were parasitized [by cowbirds]."
cowbird	Sierra				Harris	1991		N/A			-13 of 19 willow flycatcher nests (68%) on 7 of 8 territories (88%) were parasitized by cowbirds; a percentage sufficient to cause decline in host-

Appendix 2: Wildlife literature reviewed in this study (including literature cited in SNEP SNST reports. The SNEP quotes are also referenced by V (volume):C (chapter), P (page).

Wildlife	Location	Livestock	Intensity	Season	Authors	Date	SNEP-V:C:P	Opinion	Comparison	Experiment	Quote from this reference
cowbird	Sierra	horse		Summer	Gaines	1992		negative			"Brown-headed cowbirds dine at stables, campgrounds,, picnic areas and meadows, but search forests and thickets for foster parents to raise their young. Every horse corral and stable supports a summer flock."
cowbird	Sierra	horse		Summer	Rothstein	1994		negative			"Habitat restoration, not cowbird control, holds the most promise for the long-term management of these hosts [least Bell's vireo; willow flycatcher]."
cowbird	Other	cattle		Summer	Coker and Capen	1995			negative		"The model that best predicted patches used by cowbirds [used] area of the patch, distance to closest chronic disturbance patch, and number of livestock areas within 7 km of the patch."
cowbird	Sierra	cattle		Summer	Graber	1996	2:25:713	negative			"The most serious effects [of alien species] have been produced by the brown-headed cowbird. The spread of this brood parasite in the Sierra Nevada…h farming, livestock grazing, clear-cut logging and suburban development."
cowbird	Sierra	cattle		Summer	Graber	1996	2:25:718	negative			"…grazing of montane meadows promotes contact b attracted to grazing livestock) and a high density of nearby nests of many host species…"
cowbird	Sierra	cattle		Summer	SNEP	1996	1:5:80a	negative			"Cowbirds are directly implicated in or directly charged with the decline of several songbirds in the Sierra Navada…"
cowbird	Sierra	cattle		Summer	SNEP	1996	1:5:80b	negative			"Preferred foraging areas for cowbirds in the Sierra include heavily grazed meadows, recent clearcuts (especially those that are grazed), …pack stations
cowbird	Sierra	cattle		Summer	SNEP	1996	1:5:82a	negative			"Nest parasitism by non-native cowbirds may be increased by grazing, although grazing itself is not as important to the spread of sowbirds as are agricultural practices and feedlot distribution in the regions adjacent to the Sierra."
cowbird	Sierra	cattle		Summer	SNEP	1996	1:5:82b	negative			"In recent decades cowbird populations on the Sierran transets have been declining, perhaps from reductions in grazing and logging disturbances where those transects occur."
cowbird	Sierra	cattle		Year	Verner et al.	1997			negative		"It is almost certainly true that the number of cowbirds in these woodlands is highter with cattle present than would be the case without them."
cowbird	Other	cattle		Year	Ortega	1998	p269	negative			"Minimizing interspersion of cowbird feeding areas is an important step in conservation efforts (Thopmson 1994)"
cowbird	Sierra	cattle		Summer	STR	1998	p42	negative			"Cowbird invasion into the mountains is favored by livestock grazing, clear-cutting, and disturbances such as pack stations, picnic areas and campgrounds."
deer	Other	sheep		Summer	Jensen et al.	1972		positive			"Sheep grazing on winter ranges is compatible with big game [deer] use in this type of forage mix [northern Utah] provided it is restricted to the early gowing season [May-June] before bitterbrush twigs are growing rapidly."
deer	Other	cattle		Summer	Anderson et al.	1975		no effect			A rotational grazing system improved an southeastern Oregon winter range for elk but had no effect on mule deer.

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Wildlife	Location	Livestock	Intensity	Season	Authors	Date	SNEP-V:C:P	Opinion	Comparison	Experiment	Quote from this reference
deer	Other	cattle		Year	Reardon et al.	1978		negative			"White-tailed deer definitely preferred a rangeland grazed under a system which included a systematic rotational deferment, and the more frequent the deferment the higher the preference."
deer	Other	sheep		Summer	Smith et al.	1979			positive		"…quality of deer [winter] diets [in northern Utah] w detrimentally affected where sheep had grazed [moderately] during the preceding spring…"
deer	Other	cattle		Year	Bryant et al.	1981		positive			"The Merrill 4-pasture grazing system appeared to increase the availabilty and use by deer of grass regrowth."
deer	Other	cattle		Year	Holechek	1982		positive			"Heaving grazing by livestock between 1880 and 1930 resulted in a large scale increase in several shurbs and trees…[beneficial to mule deer in the Intermountain West]."
deer	Other	cattle		Year	Urness	1982		positive			Bitterbrush for deer can be stimulated by heavy grazing of grasses by livestock, especially horses, in spring and early summer.
deer	Other	cattle		Year	Warren and Krysl	1983		negative			"…livestock grazing must be controlled to maintain a of nutritional status in the econimically important white-tailed deer of central Texas."
deer	Other	cattle		Year	Bowyer and Bleich	1984			negative		"…found significantly fewer…deer…in meadows wh occurred than in similar areas where cattle were prohibited."
deer	Sierra	cattle		Summer	Kie et al.	1987			negative		Increasing cattle stocking intensity decreased deer hiding cover.
deer	Other	cattle		Year	Urness	1990		positive			"…reduction or outright removal of livestock set in tr condition [more grass less browse] and decreased deer carrying capacity along the Wasatch Front."
deer	Sierra	cattle	<1.5AUM/ha	Summer	Kie et al.	1991				negative	"Deer spent more time feeding and less time resting with increased cattle stocking rates." "Time spent feeding by deer was negatively correlated with standing crop of herbaceous forage…"
deer	Sierra	cattle	<1.5AUM/ha	Summer	Loft et al.	1991				negative	"In the absence of grazing, meadow-riparian habitat comprised a greater proportion of deer home ranges…" "Within home ranges, deer preferred meadow-riparian habitat…"
deer	Sierra	cattle	<1.5AUM/ha	Summer	Loomis et al.	1991				negative	"The incremental benefits of deer hunting gained under the 2-years-of, 1-year-on grazing system is greater than the lost net economic value of the forage to the rancher…"
deer	Sierra	cattle	<1.5AUM/ha	Summer	Loft et al.	1993				negative	"Deer home ranges increased in area as cattle grazing level increased." "…deer and cattle were attr distributed meadow-riparian and aspen habitats where herbaceous forage was most available…"
deer	Other	cattle		Year	Bernardo et al.	1994		negative			"…net returns are maximized from cattle grazing wit habitat. Low to moderate deer and quail habitat ratings are associated with this plan."
deer	Sierra	cattle	<1.5AUM/ha	Summer	Kie	1996				negative	-increased cattle grazing increased doe foraging time beyond the preferred crepuscular activity period-
ducks	Other	cattle		Year	Gjersing	1975		negative			"[Duck] pair populations generally increased in pastures excluded from cattle grazing the previous year and decreased in pastures grazed in the fall of the previous year."

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frogs	Sierra				Moyle	1973		negative			"The disappearance of *R. aurora* from the region, and the continuing reduction in range of *R. boylii*, is attributed to habitat alteration coupled with predation and competition from *R. catesbeiana*."
frogs	Sierra	none	0		Bradford et al.	1993		N/A			"…[The mountain yellow-legged frog] was eliminate this century in many of the lakes and streams in Sequoia and Kings Canyon National Parks…"
frogs	Sierra	none	0		Fellers and Drost	1993		N/A			"The almost complete disappearance of Rana cascadae from the Lassen National Park area does not appear to be caused by any single factor."
frogs	Sierra	none	0		Sherman and Morton	1993		N/A			
frogs	Sierra	none	0		Bradford et al.	1994		N/A			"…survey…failed to reveal significant differences in chemistry parameters between sites with and sites without each of the three [frog] species."
frogs	Other				Miller	1994		negative			"
frogs	Sierra	none	0		Drost and Fellers	1996		N/A			
frogs	Sierra	cattle		Year	STR	1998	p39a	negative			"Low elevation [frogs] have been most impacted by alteration of streams and wetland habitats as a result of grazing, mining, reservoir construction and urbanization."
frogs	Sierra	cattle		Year	STR	1998	p39b	negative			"Grazing has been implicated as a major factor affecting the habitat of the leopard frog…"
great gray owl	Sierra	cattle		Summer	Gaines	1992		negative			"…great gray owls rarely forage in grazed meadows; reason they rarely stray outside the [Yosemite] park boundaries."
great gray owl	Sierra	cattle		Summer	Graber	1996	2:25:717	negative			"…great gray owls do not forage in grazed meadows, because grazed meadows are attractive to great horned owls which exclude them."
jack rabbit	Other	cattle		Year	Taylor et al.	1935		positive			"A preference [by jack rabbits] was found for areas on which livestock grazing had reduced the vegetative stand, provided a moderate forage supply was still available."
least Bell's vireo	Sierra	cattle		Year	Goldwasser et al.	1980		negative			"Populations of least Bell's vireo have declined substantially throughout Califonria."
least Bell's vireo	Sierra	cattle		Summer	SNEP	1996	1:5:74	negative			"…extinction of least Bell's vireo in the Sierra appear cowbirds, although destruction of willow-dominated riparian corridors, which were fragmented by grazing, greatly reduced its habitat."
lizards	Other	sheep		Year	Bury and Busack	1974		negative			Found an inverse relationship between sheep grazing in the Mohave Desert and lizard population
lizards	Other	cattle		Year	Jones	1981			negative		"Lizard populations sampled on heavily grazed…con lower relative abundance and species diversity indices than those of similar, lightly grazed sites."
N/A	Other	cattle	1.5ha/AUM	Fall	Kauffman et al.	1983				N/A	"…erosion related to livestock grazing and trampling to create significantly greater annual streambank losses when compared to ungrazed areas."
N/A	Other	cattle	1.5ha/AUM	Fall	Kauffman et al.	1983				N/A	"Shrub use was generally light except on willow…on bars…[where] succession appeared to be retarded by grazing."
pheasant	Other	cattle		Year	Koerth et al.	1983		negative			"…there is no reason for concern that short duration with cattle will increase trampling loss of ground nests over continuous grazing."

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Wildlife	**Location**	**Livestock**	**Intensity**	**Season**	**Authors**	**Date**	**SNEP-V:C:P**	**Opinion**	**Comparison**	**Experiment**	**Quote from this reference**
prairie chicken	Other	cattle		Year	Jackson and DeArment	1963		negative			"Changing land-use practices are responsible for keeping lesser prairie chickens at low population levels in the Texas Panhandle. The more important of these are overgrazing of cattle range…"
small mammals	Other	cattle		Year	Grant et al.	1982			negative		Biomass of small mammals was lower at grazed sites than ungrazed sites in three of four grassland types.
small mammals	Other	cattle		Year	Hanley and Page	1982			variable		"Microtine rodents were consistently found in lower abundance in livestock-grazed than -ungrazed comunities. Other species…appeared to act as "decreasers" in zeric haitats and "increasers" in mesic habitats."
small mammals	Other	cattle	2.0ha/AUM	Fall	Kauffman and Krueger	1984				negative	"Livestock grazing and the subsequent removal of forage…cause[d] significant short-term decreases in small mammal composition and densities."
small mammals	Other	cattle		Year	Hayward et al.	1997				negative	"…small mammals were 50% more abundant on plot from which livestock were excluded [for 10 years]."
small mammals	Other	cattle		Year	Uresk et al.	1982		positive			"Blacktail prairie dogs were more abundant in areas of southwestern South Dakota heavily grazed by cattle than in areas were cattle were excluded."
snake	Sierra	none			Jennings et al.	1992			N/A		"Reasons for the declines of B. canorus and R. muscosa are not clear…[but] T. elegans should not be declines of Bc and Rm because it appears more strongly associated with P. regilla than these species…"
turkey	Other	cattle		Year	Baker	1978			negative		"…these findings emphasize the benefits of rotationa success. [Turkey nest] survival rate was significantly higher in the pasture deferred longer."
waterfowl					Kantrud	1990		positive			"Nearly all previous studies indicate that reductions in height and density of tall, emergent hydrophytes by fire and grazing (unless very intensive) generally benefit breeding waterfowl."
waterfowl	Other	cattle		Summer	Sedivec et al.	1990			positive		"Nesting success [of prairie ducks] on nongrazed prairie was consistently lower than the [short duration] grazing treatments."
waterfowl					Payne	1992	p289a	positive			"The purpose of livestock grazing as an aquatic and semiaquatic habitat modification technique is to open up dense patches of cover to improve composition so that diving ducks and other waterbirds can penetrate it for nesting."
waterfowl					Payne	1992	p289b	positive			"Trampling and smashing of vegetation and moderate grazing are recommended for marsh edges with solid stands of tall, rank vegetation such as cattail, pharagmites, bulrush, cordgrasses, and willows…"
waterfowl					Payne	1992	p289c				"Ideally, cattle should be used for 2 to 3 months in late winter and early spring…Cattle should be excluded from …marshes during [nesting] July, August, and September."
waterfowl					Payne	1992	p294	negative			"Grazing generally impacts nesting waterfowl negatively…As a general rule, use by cattle and duck [winter] grazing removes only one-half the average amount of the primary forage plants produced annually."

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wildlife	Other	cattle		Year	Storer	1932		negative			"Grazing is, and has been, practiced in all suitable areas of the state [California] from the earliest times [and has had a major impact on wildlife].
wildlife	Other	cattle		Year	Carothers	1977		negative			"…the most insidious threat to the riparian habitat [for wildlife] today is domestic livestock grazing."
wildlife					Holechek et al.	1982		positive			"Specialized grazing systems show potential for amelioration of negative impacts of livestock grazing on wildlife habitat."
wildlife	Other	cattle			Heady	1985		negative			"The long-used management ofone kind of animal [cattle] and the existence of others [wildlife] will continue to be practiced in most situations."
wildlife					Anderson et al.	1990		positive			"Livestock and wildlife can be compatible on the same range provided that management of each is coordinated with the objectives for the area, phenology and physiology of key forage species, and ecological capability of the resources."
wildlife					Guthery et al.	1990		positive			"[Short duration grazing] could be used in management of wildlife species inhibited by ground cover that is too tall and dense."
wildlife					Kie and Loft	1990		positive			"Livestock can open up dense stands of shrub vegetation such as willow thickets and improve access for several species of wildlife through trampling and browsing."
wildlife					Kie	1991		variable			"Livestock grazing affects different species of wildlife in different ways, and the effects depend on how those livestock are managed."
wildlife					Payne	1992	p290a				"Riparian habitat is probably the single most important, least abundant, and most abused plant community for wildlife…"
wildlife					Payne	1992	p290b	positive			"…cattle can improve structural diversity by creating through the [dense riparian] brush…But mostly, riparian habitat should be fenced and ungrazed."
wildlife					Payne	1992	p290c				"…the four-pasture rest-rotation system seems best ii single grazing strategy for riparian areas functions well under all situations…[provides 13 guidelines]"
wildlife					Kie et al.	1994	p663a				"Management of public rangelands in the United Sates is constrained by both federal and state laws, and those laws require managers to address the impact of livestock grazing on all wildlife."
wildlife					Kie et al.	1994	p663b				"…impacts of livestock grazing can vary widely fron vegetatiion conditions also can be extreme. Therefore, much of the existing literature may seem contradictory."
wildlife					Kie et al.	1994	p664				"…the range condition terms excellent, good, fair, an differ greatly among species…the terms excellent, gc seral..."

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Wildlife	Location	Livestock	Intensity	Season	Authors	Date	SNEP-V:C:P	Opinion	Comparison	Experiment	Quote from this reference
wildlife					Kie et al.	1994	p665a	negative			"Heavy livestock grazing has been detrimental to many wildlife species in western North America…W adverse impacts occur, elimination of livestock can improve habitat conditions…"
wildlife					Kie et al.	1994	p665b	positive			"When properly managed, livestock grazing can be used to improve habitat for wildlife species dependdent on early-seral stage plant communities."
wildlife					Kie et al.	1994	p665c				"The relationship between grazing and wildlife habitat is complex."
wildlife					Kie et al.	1994	p666				"Livestock management practices that can affect wildlife habitats and populations include livestock numbers, timing and duration of grazing, animal distribution, livestock types, and specialized grazing system. These practices can be modified to reduce or eliimiate adverse effects on wildlife, and sometimes to enhance wildlife habitats..."
wildlife					Kie et al.	1994	p667a				"Livestock effects on wildlife become more pronounced with increasing stocking rates, and the relationship is often nonlinear…"
wildlife					Kie et al.	1994	p667b				"…a range manager's traditional definition of proper livestock forage and preventing soil erosion. Optimal livestock densities for wildlife may occur at different, and often lower, stocking rates."
wildlife					Kie et al.	1994	p670				"[among all grazing systems] Rest-rotation grazing may have the most potential to provide benefits to wildlife [e.g. graze 2 out of 3 years]."
wildlife					Kie et al.	1994	p671a				"Using livestock to maintain a plant community in an early seal stage often will benefit those wildlife species dependent on such habitat, while at the same time adversely affect species associated with climax communities."
wildlife					Kie et al.	1994	p671b	negative			"Maximizing benefits to wildlife from prescribed grazing almost always will involve reducing livestock numbers and shortening grazing seasons compared to management plans designed to maximize livestock production."
wildlife					Kie et al.	1994	p617c				"…managers should avoid generalizations and evalua habitats independently for each species [of wildlife], grazing plan, and management situation."
wildlife					Kie et al.	1994	p617d				"Wildlife use riparian zones disproportionately more than any other habitat type."
wildlife					Kie et al.	1994	p671e				"Little information is avaiilable on wildlife/riparian interactions. In general, this resuits in wildlife management considerations being excluded from land use plans."
wildlife					Kie et al.	1994	p673a				"Management of riparian areas needs to be considered for two locations: (1) onsite or within the riparian zone, and (2) offsite or outside the riparian zone, which accounts for all adjacent uplands that exert influence over the watershed."

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wildlife					Kie et al.	1994	p673b	negative			"Livestock grazing is perhaps the greatest biological threat to riparian habitats in the West, given that about 91% of the total rangeland is grazed…"
wildlife					Kie et al.	1994	p673c				"Isolated case studies have demonstrated that revised grazing management improved conditions, but the condition of riparian habitats [in the West] continues to decline…"
wildlife					Kie et al.	1994	p673d				"…riparian areas are as badly deteriorated today as a reason may be because the number of cattle on western rangelands has steadily increased since 1875."
wildlife					Kie et al.	1994	p674a				"Riparian vegetation usually improves from grazing relief within 4-6 years, depending on severity of use…Areas with severe overuse require greater periods of time (>15 years)…"
wildlife					Kie et al.	1994	p674b				"…riparian vegetation should be managed as the most sensitive and most productive North American wildlife habitat."
wildlife					Kie et al.	1994	p674c				"The best management strategy for sustaining rangeland riparian areas is one that (1) maintains the productivity of the vegetation…(2) maintains the inte and (3) recognizes that several factors interact to maintain a dynamic equilibrium..."
wildlife	Other	cattle		Year	Moore and Terry	1979		positive			"Short periods of intensive grazing followed by long rest periods show potential for improving wildlife habitat [in Florida].
willow flycatcher	Sierra	cattle		Summer	Serena	1982			negative		"Willow flycatchers were...absent from otherwise...suitable areas where the lower branches of willows had been stripped of leaves and twigs or were missing entirely due to livestock."
willow flycatcher	Sierra	cattle		Summer	Stafford and Valentine	1985		negative			"Results to date suggest that willow flycatcher production may not be affected by cowbird parasitism, but may be by the acitivities of range cattle."
willow flycatcher	Other	cattle	<1.7AUM/ha	Year	Taylor	1986			negative		-passerine species richness, including willow flycatchers, increased as shrub volume increased and grazing decreased-
willow flycatcher	Other	cattle		Year	Taylor and Littlefield	1986			negative		"…willow flycatchers were found in high numbers o transects undisturbed or rarely used by cattle and with high shrub volume."
willow flycatcher	Sierra	cattle		Summer	Flett and Sanders	1987		negative			"…the placement of [willow flycatcher] nests in willo potentially vulnerable…because they were built near the edge...and low enough to be knocked over by cattle."
willow flycatcher	Sierra	cattle		Summer	Harris et al.	1987			negative		"The Kern River [willow flycatcher] population appears to have increased steadily…and evenly over the area [since grazing was eliminated]..."
willow flycatcher	Sierra	cattle		Year	Unitt	1987		negative			"The available evidence indicates that the [willow flycatcher] has declined precipitously and…is now rarer than many other birds formally designated as endangered."
willow flycatcher	Sierra	cattle		Summer	Harris et al.	1988			negative		"The Kern River [willow flycatcher] population appears to have increased steadily…and evenly over the area [since grazing was eliminated]..."

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willow flycatcher	Sierra	cattle		Summer	Valentine et al.	1988			negative		"From 1983 through 1986, four of 20 studied nests were destroyed by livestock prior to the young fledging. During 1987 no nests were upset by cattle [with reduced cattle stocking]."
willow flycatcher	Sierra	cattle		Summer	Sanders and Flett	1989		negative			"Cattle can disturb willow flycatchers and other birds nesting in montane meadows by knocking over nests in willows or crushing eggs on the
willow flycatcher	Sierra	cattle		Summer	Gaines	1992		negative			"In the Sierra…grazing may be the major factor [limiting willow flycatcher populations]."
willow flycatcher	Other	cattle		Year	Ohmart	1994		negative			"The resiliency of riparian habitats is remarkable after only eight years of cattle exclusion…in experier healing process is extended at least three of four times what it would be with total exclusion."
willow flycatcher	Sierra	cattle		Summer	Rothstein	1994		negative			"…breeding meadows are grazed by livestock which [willow flycatcher] nests and consume the lower foliage of willows."
willow flycatcher	Sierra	cattle		Summer	Graber	1996	2:25:717	negative			"Declines [in the willow flycatcher] are believed to be related to direct degradation of nesting and foraging habitat from livestock grazing in
willow flycatcher	Sierra	cattle		Summer	Kattelmann and Embury	1996	3:5:208	negative			"Overgrazing of meadows has been suggested as a major cause of the decline of willow flycatchers."
willow flycatcher	Sierra	cattle		Summer	SNEP	1996	3:6:208	negative			"Cattle can disturb willow flycatchers and other birds nesting in montane meadows by knocking over nests in willows or crushing eggs on the
willow flycatcher	Sierra	cattle		Summer	STR	1998	p42	negative			"Declines [in the willow flycatcher] are believed to be related to direct degradation of nesting and foraging habitat from livestock grazing in meadows and loss of riparian habitat."