IS COMMERCIAL LIVESTOCK GRAZING COMPATIBLE WITH PROTECTING OBJECTS OF BIOLOGICAL INTEREST IN THE CASCADE-SISKIYOU NATIONAL MONUMENT, SOUTHWEST OREGON?

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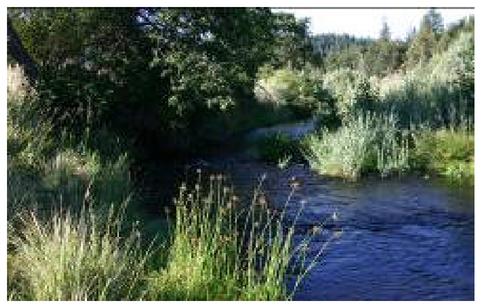

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EXECUTIVE SUMMARY:

The Cascade-Siskiyou National Monument was established in June 2000 for its nationally outstanding biodiversity. The Monument is the only high-elevation land bridge connecting the botanically unique Siskiyou Range with the Southern Cascades and is therefore important to the dispersal of numerous species. Additionally, the Monument is located in an overlap zone where several physiographic provinces converge, and thus it contains a rich assortment of plant communities, as well as exceptional concentrations of butterflies, rare aquatic mollusks, and endemic species of fish. The Bureau of Land Management (BLM) is legally required to oversee the Monument under terms specified in the Monument's authorizing Presidential Proclamation. Specific management details for the Monument are pending final approval of BLM's management plan anticipated this summer. As part of the legally binding terms of the Monument's Proclamation, however, the BLM is mandated to protect the *"objects of biological interest"* (e.g., particular species and community types) for which the Monument was designated and to sustain *"natural ecosystem dynamics"* and *"ecological integrity"* that those objects depend upon. Specifically, the authorizing Proclamation has four key provisions that direct BLM to protect the objects of biological interest:

1. *"… hereby set apart and reserves as the Cascade-Siskiyou National Monument, for the purpose of protecting the objects........."*
2. *"The Monument is home to a spectacular variety of rare and beautiful species of plants and animals, whose survival in this region depends upon its* ***continued ecological integrity"*** *(emphasis added).*
3. *"Study the impacts of livestock grazing on the objects of biological interest in the Monument with specific attention to* ***sustaining the natural ecosystem dynamics"*** *(emphasis added).*
4. *Should grazing be found incompatible with* ***protecting the objects of biological interest****, the Secretary shall retire the grazing allotments pursuant to the processes of applicable law" (emphasis added).*

BLM is in the process of making a determination on whether to continue commercial livestock grazing pending completion of its field studies (currently in peer review with the Ecological Society of America). The purpose of this report is to present three lines of evidence for why BLM should permanently retire grazing leases in the Monument: (1) multi-taxa field studies (peer-review in progress) conducted by a science team assembled by the World Wildlife Fund has documented extensive cattle impacts to biological objects; (2) comprehensive reviews of livestock grazing in related ecological systems demonstrates ecosystem integrity and natural ecosystem processes are typically altered or disrupted by cattle; and (3) extensive photos of the presence of livestock provides supplemental information on livestock related damages to objects of biological interest in the Monument. We note that BLM has agreed to consider peer-reviewed science, such as presented in this report and the related WWF studies, in making its grazing determinations (BLM 2005b).

Field studies – A multi-disciplinary team of researchers assembled by WWF conducted a multi-taxa study of livestock grazing within the 52,947 acre Cascade-Siskiyou National Monument, southwest Oregon, from spring through fall of 2003-06. Field studies were conducted (manuscripts in peer-review were submitted under separate cover to BLM) to assess effects of livestock on the objects of biological interest, which, according to the Monument's Proclamation, include examples of plants, wildlife, and general habitat and landscape features. Researchers examined a broad suite of species and habitat types across a range of grazing utilizations to determine whether livestock were compatible with the Proclamation's emphasis on **ecological integrity**, **natural ecosystem dynamics**, **and protection of the biological objects**. Compatibility was inferred by comparing species abundance and richness between heavily and lightly grazed study areas in mixed-conifer forests, oak woodlands, riparian areas, streams, and seeps. Results from field studies were supplemented with annotated bibliographies and photo documentation of livestock impacts in the Monument. Based on field studies alone, the following impacts of livestock grazing on the Monument's objects of biological interest were documented:

- Mixed conifers, oak woodlands, small seeps, and riparian areas showed signs of livestock damage from soil compaction, reduction of vegetation, increased sediment delivery to streams, and elevated temperatures and reduced oxygen levels in springs.
- Cumulative biomass and abundance of small mammals in heavily grazed sites were 62% and 80%, respectively, of that in lightly grazed sites with significantly fewer Harvest Mice (*Reithrodontomys megalotis)*, woodrats (*Neotoma cinerea*

and *N. fuscipes*), and Long-tailed Voles (*Microtus longicaudus*) in heavily versus lightly grazed sites and fewer Deer Mice (*Peromyscus maniculatus*) in heavily grazed oak woodlands (all *P* values < 0.05 in each of the studies).

- The negative effect from heavy grazing was greatest for Long-tailed Voles and Townsend's Voles near streams in mixed-conifer forests.
- Livestock may exert negative effects on predator-prey dynamics (i.e., natural ecosystem dynamics) by reducing abundance of small mammals and, in particular, woodrats and Deer Mice, important prey of the Northern Spotted Owl in southwest Oregon.
- Bird communities in heavily grazed areas had fewer long-distance migrants, foliage gleaners, and shrub-nesting species but higher numbers of ground nesters; thus, retiring grazing would be a net benefit to bird communities.
- Butterfly species that feed on grassy host-plants were less abundant at transects with higher intra-year grazing utilization. One of these species, the Great Basin wood nymph (*Cercyonis sthenele*), was 70% less abundant at higher grazing utilization sites.
- Stream and riparian area habitat quality were degraded by heavy livestock grazing, contributing to significantly greater levels of fine sediments in streams and decreased overhanging bank vegetation (grasses) important in ameliorating stream temperatures. However, no significant grazing effect was detected for aquatic macroinvertebrates.
- While there were no differences in presence of aquatic mollusks between grazed and ungrazed springs, small springs (discharge <0.03 cubic meters (<1 cubic ft) per second) with heavy livestock utilization had significantly greater temperature levels and lowered dissolved oxygen due presumably to vegetation trampling.

Comprehensive literature reviews and photo documentation - A comprehensive review of livestock grazing studies from similar habitat types and comparable regions provided extensive documentation that grazing typically alters natural ecosystem dynamics such as soil stability, porosity, and nutrient composition. The effects of livestock on weed invasions and fire regimes depend on site conditions, plant life-form, species and the grazing regime involved. Available evidence from the California floristic province, however, indicates that protection from livestock grazing is likely to favor native perennial bunchgrasses, though effects on native annual forb diversity differ among habitats. Livestock also likely result in a gradual decrease in infiltration, soil porosity, water holding capacity and soil biota. Additionally, livestock may alter predator-prey dynamics (as also noted above), destabilize stream banks and thereby contribute to fine sediment inputs in streams, and impact hydrological processes important to the integrity of springs and seeps. Photo documentation of livestock use in the Monument provided evidence of soil compaction, particularly near seeps, and extensive degradation of riparian areas where cattle and wildlife congregated.

Conclusions and recommendations - The weight of scientific evidence (hypothesis testing, literature reviews, and photo documentation) indicates compatibility problems exist between livestock and protection of the objects of biological interest in the Monument. Impacts were most pronounced where grazing occurred at relatively high levels and in areas where wildlife and cattle both congregate, such as oak woodlands, mixed conifers, small springs, streams, and riparian areas. It is unlikely that these impacts can be fully mitigated and, given the rugged terrain and remoteness of much of the Monument, it is very unlikely that commercial livestock grazing can be carefully controlled to reduce impacts or provide benefits to the objects of interest. Therefore, under the terms of the Proclamation, commercial livestock grazing allotments should be retired.

However, it appears to be BLM's position that as the Monument's managing agency, they have the authority to first attempt to modify the livestock grazing currently practiced if the agency finds it incompatible with the Proclamation's stated objectives regarding ecological integrity, natural ecosystem dynamics, and protection of biological objects (BLM 2005a). Contrary to the Proclamation's direction on grazing, BLM contends that only if it finds that <u>modified</u> grazing is still incompatible, must it end livestock grazing.

Changes in rangeland management practices involving more regulated and monitored livestock use may reduce but are not likely to eliminate grazing impacts. These management interventions could take the form of, for instance, stocking density reductions, long-term rest rotations, extensive fencing, permanent large, livestock exclosures, and adjustments in timing, duration, and intensity of livestock utilization. However, carefully controlling cattle will be difficult to achieve in practice due to steep terrain and remoteness of much of the Monument and prohibitive costs. **For instance, in order for BLM to more carefully manage ("modify") livestock grazing to reduce damage to the objects of biological interest and natural ecosystem dynamics, we estimate that ~148 miles of fencing would need to be installed to exclude cattle and the fencing would need periodic maintenance at an estimated cost of at least $4 million over a 10 year period. In comparison, BLM takes in ~$3,664 annually ($36,000 over 10 years) in grazing fees (2,714 AUMs x $1.35 per AUM[1]), representing nearly a $4 million cost savings if BLM retires grazing permanently rather than modifies it**. Further, any use of fencing would require a substantial increase in monitoring, maintenance, and enforcement as well as additional mitigation for potential wildlife impacts from the fencing. It is also likely that these figures underestimate costs associated with modified grazing as administrative costs would also be substantial due to extensive need for BLM specialists to monitor grazing impacts. An experimental grazing program would incur additional costs in support of new studies and BLM staff assigned to long-term monitoring to assess whether such changes achieve compatibility with protection of the objects of biological interest. As an example, the current BLM studies have cost over $1 million (P. Hosten, pers. commun.). Because effects of livestock grazing are cumulative and remain on the landscape over long periods (Marlow and Pogacnik 1985, Elmore and Beschta 1987 – full citations are in Appendix B unless otherwise noted), continuing grazing could further damage ecological integrity and delay or prohibit ecosystem recovery. Therefore, we recommend ending commercial livestock grazing in the Monument as the most ecologically appropriate and responsible management option to fulfill the Proclamation mandate in the long run.

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[1] The amount of forage required to sustain a cow and calf for one month (BLM 2005b:5) and AUM fees are based on 2007 amounts, although these may change slightly annually.

Finally, the Proclamation states that, in the case of incompatibility with protection, the commercial livestock grazing allotments must be retired. Under these circumstances, affected livestock grazing lessees would receive no compensation for their interest in grazing leases. Legislation was introduced into the United States Senate in September 2006 to allow Monument and nearby grazing lessees to waive their interest in federal grazing leases in exchange for compensation. This legislation was jointly requested by both the affected livestock interests and local conservation interests. Reintroduction is anticipated in 2007. **As part of legislation, the public cost of a buyout of ranchers holding leases in the Monument is estimated at ~$814,200 (~$300 per AUM x 2,714 AUMs), representing a net savings of more than $4 million[2] over estimated costs of modifying grazing,** should BLM elect to continue grazing in spite of significant evidence that it is incompatible with the Proclamation's protection mandate.

Key Words: aquatic mollusks, birds, butterflies, Cascade-Siskiyou National Monument, livestock grazing, macroinvertebrates, natural ecosystem dynamics, small mammals

[2] This may be a conservative estimate because it does not include all the costs of administering the grazing program, additional studies, and inevitable litigation costs involved in lawsuits defending or opposing BLM's grazing program.

CHAPTER 1: PROJECT OVERVIEW

Cascade-Siskiyou National Monument at a biological crossroads - Located at the juncture of the Cascade, Klamath, and Eastern Cascade Slope ecoregions, the 52,947 acre Cascade-Siskiyou National Monument ("Monument") in southwest Oregon is considered a unique "biological crossroads" (BLM 2002:16). Overlapping distributions of plants from distinct regions yield a rich mosaic of grasses and shrublands, oak woodlands (*Quercus garryana, Q. kelloggii*), juniper scablands, mixed-conifer and white fir (*Abies concolor*) forests, and wet meadows (BLM 2005a: Proclamation). Differences in species composition along environmental gradients (moisture, soil, elevation) are especially pronounced, resulting in high levels of beta-diversity (change in species composition along gradients) for which the Monument derives its nationally significant biodiversity.

A number of species in the Monument are listed as "peripheral," "naturally rare," "vulnerable," or "species of concern" as recognized by state and federal agencies. Thirty three plant species, 45 terrestrial animal species, and 8 special status aquatic animal species are on the Special Status Species list (see BLM 2005b: appendix B). Additional species of conservation importance include the federally threatened Northern Spotted Owl (*Strix occidentalis caurina*); Greene's Mariposa Lily (*Calochortus greeni*), restricted to the Monument's oak woodlands and shrublands south to Siskiyou County, CA; Redband Trout (*Oncorhynchus mykiss* spp), isolated by a waterfall in the lower section of Jenny Creek, southeastern portion of the Monument; Klamath Mardon Skipper (*Polites mardon klamathensis)*, 37 known sites located in just four geographic areas, including the Monument (Oregon Natural Heritage Program 2001); and nine endemic freshwater mollusks found primarily in the Monument's springs and streams (Frest and Johannes 1999). More specifically, the Jenny Creek portion of the Monument is a significant center of freshwater snail diversity (Frest and Johannes1999) and contains three endemic fish species (BLM 2005b: appendix B). The Monument also contains one of the highest numbers of butterfly species in the western United States with 114 species recorded (E. Runquist in prep.). Notably, the combinations of sympatric and synchronic butterfly species are nationally outstanding, owing to the contrasting ecoregions and corresponding plant communities that overlap within the Monument.

Proclamation mandate - The Monument was established on June 9, 2000 in recognition of its nationally outstanding ecological values (see BLM 2005b:7-8). The Proclamation specifically mandated the BLM to **protect** (emphasis added) the "*biological objects of interest*," which are both general, such as special plant communities like rosaceous chaparral and oak-juniper woodlands (BLM 2005a: appendix A), and specific, such as certain taxa as noted above (also see Odion and Frost 2001). The Monument's Proclamation shifted BLM's "multiple use" mandate, the agency's predominant management approach nation-wide across most of its 264 million acres, to an emphasis on protecting natural features and native species and sustaining natural ecosystem dynamics. Moreover, the President directed the Secretary of the Interior to:

> *"study the impacts of livestock grazing on the objects of biological interest in the Cascade-Siskiyou National Monument with specific attention to sustaining the natural ecosystem dynamics. Existing authorized permits or leases may continue with appropriate terms and conditions under existing laws and regulations.* ***Should grazing be found incompatible with protecting the objects of biological interest, the Secretary shall retire the grazing allotments pursuant to the processes of applicable law*** *(emphasis added)."*

In response to the Proclamation's grazing impact study mandate, BLM drafted a livestock grazing impacts study plan (BLM 2001) that was later revised (BLM 2005b) in response to peer review provided by scientists at Oregon State University and other institutions. The agency then put together a final study plan outlining several field studies and monitoring assessments of grazing effects, including the use of historical photo points, livestock grazing exclosures (11 exclosures of ~0.10 ha, 0.25-acre each), rangeland health assessments, and remote sensing of rangeland condition (Hyperspectral Light Detection and Ranging – LIDAR and Thematic Mapper Imagery, see BLM 2005b). During the peer review process, reviewers noted that the agency could do a more thorough job of meeting the Proclamation's direction by incorporating studies of "zoological objects of interest," or by using the results of studies under way through a multi-taxa, interdisciplinary field study organized by WWF[3] (see BLM 2005:3). In addition, a multi-stakeholder group consisting of ranchers, conservationists, and agency staff (collectively known as the Southwest Oregon Provincial Advisory Committee (PAC) working group on livestock grazing) and other citizens was assembled by BLM under the authorities deemed granted to it through the Northwest Forest Plan. The PAC requested that BLM include peer-reviewed studies, such as those conducted by WWF, in its final livestock determinations. Consequently, the agency agreed that it will evaluate the information contained in the studies summarized in this report, along with related peer-reviewed articles sent under separate cover, and other data when it makes its determination regarding livestock compatibility with protecting the Monument's biological objects in the coming year (BLM 2005b:1). Notably, the agency indicated that it will *"give more weight to studies that have been peer-reviewed*." Specifically, this report and the field studies it summarizes have gone through extensive scientific peer review that supported its scientific approach, conclusions, and applicability.

WWF-led studies - From 2003-06, WWF coordinated a multi-taxa investigation of the potential effects of livestock grazing on the Monument's objects of biological interest. Scientists involved in these studies and their backgrounds are listed in Appendix A of this report. Field studies span a range of livestock utilizations from low to high (see Chapters 3 and 4) and cover several habitat types, including mixed-conifer forest, oak woodlands and grasslands, springs, riparian areas, and major creek drainages. Notably, the Jenny Creek watershed was included because of its importance to three endemic fish taxa, including the Jenny Creek Redband Trout, and their recognition in the Monument's Proclamation. The following taxa and habitat types were selected for study as representative biological objects of interest (as recognized in the Proclamation):

- bird monitoring stations along 25 point count routes in mixed conifer and oak woodlands;

[3] Completion of studies and reports is now the responsibility of the National Center for Conservation Science & Policy which took over this effort when WWF closed its Klamath-Siskiyou field office and staff and programs merged with Headwaters to form the newly created National Center.

- small-mammal live trapping in 16 study sites in mixed conifer and oak woodlands;
- aquatic snail distribution in 57 springs and seeps;
- stream and riparian habitat, water temperature, and aquatic invertebrates at six locations: Dutch Oven, East Fork Camp, Jenny, Keene, Mill, and South Fork Keene Creeks;
- Greene's Mariposa lily in more than 80 population clusters in oak woodlands[4];
- butterfly richness and composition along 27 transects in mixed conifer and oak woodlands; and
- natural ecosystem dynamics (see Chapter 2).

This report provides a synthesis of the literature on livestock grazing as it relates to the Proclamation's direction to study the impacts of commercial grazing on sustaining natural ecosystem dynamics (Chapter 2), key findings of the WWF field studies on objects of biological interest (Chapter 3), livestock utilization methodologies used in the field studies (Chapter 4), annotated bibliography of grazing effects (Appendix B1-B2), photo documentation of livestock impacts in the Monument (Appendix C), cost estimates associated with "modified" grazing programs (Appendix D1-D2), and recommendations to BLM regarding how best to protect for the Monument's objects of interest while sustaining natural ecosystem dynamics and ecological integrity (Chapter 5).

Notably, the field studies in this report were designed to test the "null" hypothesis (a statistical procedure whereby a hypothesis is set up to be nullified [refuted]) as it relates to the Monument's Proclamation. For example, using a null hypothesis approach, studies were designed to test the following hypothesis: *there are no detectable differences in abundance, species composition, and richness of specific taxa (i.e. objects) in relation to livestock utilization in mixed conifers, oak woodlands, streams, riparian areas, or springs.* Simply stated, the hypothesis posits that livestock grazing is compatible with protecting the objects of biological interest. The standard for determining compatibility in

[4] This study was jointly funded by WWF and BLM and is undergoing a separate independent peer review organized by BLM and was therefore not included in this report summary.

this report was therefore based on rejecting the null hypothesis, which was supplemented by the relevant literature and photo documentation. It is standard practice in scientific research to either reject the null hypothesis or conclude that evidence is insignificant to reject it at this time. Where there was significant evidence to reject the null hypothesis (as determined by statistical analysis), impacts were assessed and incompatibility with protection inferred. This was supported by the literature and supplemented by photo documentation wherever possible to provide visual examples of impacts.

For taxa where evidence is provided regarding incompatibility, it may be BLM's decision to mitigate grazing impacts by altering seasonality, frequency, duration, and intensity of grazing as often is done in rangeland management. However, these mitigation measures would increase management costs (Appendix D2), including the need for new studies and extensive fencing to protect the Monument's objects of biological interest. Additional measures to further restrict but permit livestock grazing (rather than retire it as required in the Proclamation) create potential inconsistencies with natural ecosystem dynamics and ecological integrity. Examples include the use of fencing to keep cattle away from sensitive areas, which could interfere with wildlife movements, and the continued diversion of the Monument's limited water to meet drinking water needs of cattle (see Chapter 5). We note that the Proclamation mandates BLM to maintain ***"a quantity of water sufficient to fulfill the purposes for which this monument is established."*** Therefore, diversions of water to accommodate livestock grazing present problems for the BLM in adhering to the Proclamation's protection mandate.

Rangeland vs. ecosystem studies - The scientific approach taken throughout this report differs from standard agency rangeland health assessments, which are governed by BLM's multiple-use management objectives elsewhere. For instance, most ecological studies document baseline conditions, defined as pristine areas or areas of relatively high ecological integrity (all species, processes, and functions operating within historic bounds) against which experimental treatments are assessed. Rangeland health assessments, on the other hand, begin from the assumption that livestock are part of the contemporary management regime of the area, and use various indices of "rangeland health" to determine whether rangeland is improving or deteriorating (compared to reference conditions). We maintain that the language in the Proclamation directing study of commercial livestock is best addressed by studies designed specifically to test whether livestock are compatible with protection of objects of biological interest rather than standard rangeland health assessments. Further, as stated by Freilich et al. (2003), the central question for rangeland scientists should be to determine exactly how different today's landscape is from historic conditions. This can best be determined by comparing grazed lands to large expanses of ungrazed areas. Additionally, researchers have consistently recommended the use of large exclosures (minimum size 2,500 ac) to monitor grazing response by plant, wildlife, and soil communities over decades of livestock exclusion (see Bock et al. 1993, Neff et al. 2005, OSU peer review cited in BLM 2005b:4).

Given that BLM permits livestock grazing on over 90 percent of its rangelands totaling 161 million acres (see http://www.geocommunicator.gov/GeoComm/landmin/home/landmin_range-allot.htm), large ungrazed areas to act as controls (e.g., large exclosures) are unavailable in most places (also see Bock et al. 1993). In fact, because livestock grazing is pervasive throughout the West, researchers have had to rely on lands historically isolated from cattle as *de facto* controls (e.g., along the tops of isolated mesas, see Madany and West 1983). Alternatively, retrospective studies of varying livestock utilization have been particularly useful in assessing grazing effects when large control areas are unavailable. Range improvement efforts, much like grazing itself, however, have been experiments without permanently ungrazed controls of sufficient size or replication (Bock et al. 1993).

In the Monument there were no true large "controls" except for the Box O Restoration Area. The 1,200 acre Box O is a unique habitat that was acquired by BLM in 1995 for riparian restoration, and since then livestock have been largely excluded.[5] For the small mammal study, the Box O provided a reasonable "control" for an area considered

[5] Recent observations of livestock or signs of livestock in the Box O Restoration Area have been noted by researchers involved in these studies and represent illegal trespass (see Appendix C photos).

ungrazed or lightly grazed. One Box O study site was on Jenny Creek and was similar in aspect and plant composition to heavily grazed sites in the Jenny Creek riparian pastures outside the Box O; the other Box O site was on Oregon Gulch and was similar to grazed sites on Skookum Creek outside Box O. For all other studies, however, the Box O's unique ecology, an ecocline between Ponderosa pine (*Pinus ponderosa*) and other community types, made it difficult to match up plant communities between lightly and heavily grazed areas due to dissimilarities in communities. Notably, the Box O area has been influenced by past and recent trespass grazing and is just now showing signs of riparian recovery (also see testimony by R. Drehbohl, August 31, 2005 – J. Walt and The Box D Ranch Appellants v. BLM OR-110-010-02). In addition, small (0.1 ha, 0.25 acre) livestock grazing exclosures developed by BLM for measuring plant community response also have been influenced by past grazing and recent trespass grazing (see Appendix C photos).

To compensate for the lack of ideal controls, the studies reported here made use of differences in livestock utilization against which wildlife response was measured while controlling for potential confounding effects. An additional complicating factor is that detecting a grazing effect from field studies conducted today may be confounded by a "legacy effect" from past practices (e.g., when grazing was much more intensive – see Borman 2005). The Monument has a history of livestock grazing dating back to the latter part of the 19th century. Cattle and sheep grazing are reported to have been much more extensive during the earlier years of this period. Grazing in the Monument continues today but is limited to authorized[6] active cattle use of 2,714 animal unit months (AUMs). Livestock in the Monument are managed on nine grazing allotments with 5 of these accounting for 97 percent of authorized use (BLM 2005b:9, Figure 1). Consequently, most (if not all) of the Monument has been influenced by livestock at some point during the past century at various intensities and frequencies.

[6] BLM estimates that livestock lessees used a total of 1,889 AUMs during the 2004 grazing season (70 percent of the AUMs authorized, see BLM 2005b:9). The ten year average of actual use according to BLM indicates that lessees used approximately 58% of authorized AUMs, although BLM is limited in its ability to determine whether this is actual use as agency numbers are based on self reporting by livestock operators that is largely unverified by BLM.

Despite these issues, the studies on wildlife response to varied grazing utilizations summarized in Chapter 3 indicate that livestock grazing effects were detectable as non-random signals originating at least in part from current practices, such effects were largely negative.

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CHAPTER 2: EFFECTS OF LIVESTOCK GRAZING ON ECOSYSTEM DYNAMICS IN GRASSLAND AND WOODLAND PLANT COMMUNITIES OF THE CALIFORNIA FLORISTIC PROVINCE: A REVIEW AND SYNTHESIS OF THE SCIENTIFIC LITERATURE

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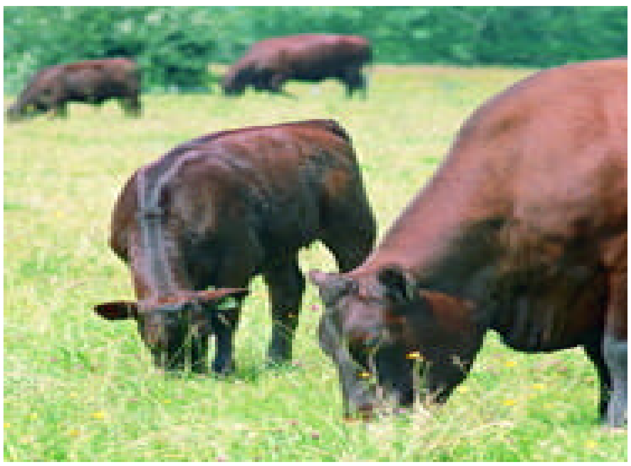


Executive Summary:

This report reviews the literature on livestock grazing in the western U.S., focusing on peer-reviewed studies from Mediterranean climate regions in California and southern Oregon. An annotated bibliography also is provided in Appendix B2 of this report. The purpose of the report is to summarize existing knowledge and uncertainty for use in evaluating how present and past grazing may be influencing natural processes in the Cascade-Siskiyou National Monument in southwest Oregon. The Monument is managed by the Bureau of Land Management. Cattle and sheep ranching became a significant land use in what is now the Monument during the latter half of the nineteenth century. It persists at lower levels today. The Presidential Proclamation that established the Monument required that the effects of ongoing grazing be documented through studies to determine how compatible they may be with maintaining the objects of interest the Monument is dedicated to protect. It directs these studies to provide specific attention to sustaining the natural ecosystem dynamics. Our report is therefore focused on what is known about how livestock grazing affects ecosystem dynamics. In the Monument and elsewhere on public lands, as exotic species increase, and natural disturbances like fire are modified, there is a need for managers to continue to evaluate existing grazing programs and the net effects of changing ecosystem dynamics.

In the first of three main sections of the report, we investigate grazing effects on plant community dynamics and invasive species. **We conclude that livestock grazing has widely varying effects on native vs. exotic plant species persistence and recovery. The specific effects depend on site conditions, soil types (serpentine vs. non-serpentine), plant life-form, species, and the grazing regime involved**. Grazing effects also vary from vernal pool to foothill sites, among grasses and forbs, annuals and perennials, and among native and exotic species. In many areas, grazing may cause and accelerate alien species invasions by increasing exotic seed dispersal and the frequency and intensity of disturbances that promote invasion. In other areas, such as sites that are heavily invaded by exotic annual grasses that contain a thick layer of their thatch (e.g., in grasslands strongly dominated by medusahead), carefully timed seasonal grazing may increase native annual forb abundance. In such sites, livestock removal is unlikely, in itself, to result in the recovery of native species, which is likely to require active restoration measures such as eradication and control of exotic species, controlled use of prescribed fire, and seeding or planting of native species.

The second section of the report concerns the effects of livestock grazing on soils and nutrient cycling. Again, much variation and uncertainty exists depending on the type of soil (especially its rockiness, texture) and on livestock management (especially stocking density, but also timing and duration), and a host of other factors. **Nonetheless, a variety of evidence indicates that livestock grazing typically results in loss of soil structure and alters nutrient cycles**. Significantly grazed lands tend to be characterized by soils that are more compacted, with lower rates of infiltration and soil water capacity and higher bulk density and rates of erosion. Grazing causes a net directional transport of nutrients to localized portions of the landscape where livestock congregate while causing reductions in levels of nutrients in other areas due to erosion, leaching, and removal of biomass**. Livestock grazing can also lower abundance and diversity of soil biota important to nutrient cycling, decomposition, and soil porosity, aeration, and water holding capacity.**

The third section concerns interactions among livestock gazing, vegetation dynamics and fire. **By removing grass biomass and damaging woody biomass, livestock grazing can reduce fireline intensity**. Thus, there is potential to use carefully controlled intensive livestock grazing strategically in proactive fire suppression approaches. **There are also fire hazard tradeoffs related to grazing**. In particular, by favoring annual grasses, fire spread rates can be increased. By eliminating perennial grasses, conifer density can be increased, leading to less frequent fire, but greater fireline intensity. Where grazing alters patterns of fire intensity that native species are adapted to, fire may favor non-native vegetation rather than native vegetation. Annual grass in particular can increase through the positive feedback loop involving both grazing and low severity fire, a combination to which most native species may be less adapted.

Unfortunately, most controlled quantitative studies of livestock are either of limited geographic scope, are confined to exotic annual rangeland or have poor experimental designs or other issues, making causation very difficult to infer. This is compounded by changes in other disturbances like fire and gopher activity, and difficulty in distinguishing between historic and contemporary grazing effects. Careful monitoring of spread of exotic species in relation to utilization of range by cattle can help identify current impacts. **Despite high levels of uncertainty, one key conclusion is that restoring natural ecosystem dynamics is likely to not only require removing non-native ungulate and human disturbances, but also returning natural disturbances, like fire, that have been lost.**

INTRODUCTION

The Cascade-Siskiyou National Monument, located in southwestern Oregon near the northern boundary of the California floristic province, contains a high diversity of plant and animal species (USDI BLM 2005). The Monument is also noted for its complex mosaic of vegetative communities, all of which were historically created and maintained by a range of ecological processes and natural disturbances, including fire. Many of these ecological processes have been altered to varying degrees by human activities. For example, fire has been almost completely excluded from the area in recent decades, and past logging has altered landscape and forest structure, as well as pathways of forest stand development (Sensenig 2004). The disturbance regime in non-forested areas also has changed due to the introduction of domestic livestock grazing, which has occurred at varying levels over the last ~150 years and continues today.

Cattle and sheep ranching became a significant land use in what is now the Cascade-Siskiyou National Monument during the latter half of the nineteenth century. This historic grazing was unregulated, occurred at much higher intensities than current levels and resulted in numerous ecological changes to local ecosystems (Galbraith and Anderson 1991). Major vegetation shifts became apparent to local observers in the late nineteenth and early twentieth centuries, including an increase in shrubs and trees and a decline in perennial grasses (USDI BLM 2002). Climate, fire suppression, the introduction of numerous non-native species and other variables also changed, confounding the ecological shifts that occurred during this time period. Because contemporary grazing occurs in the same landscape but under a very different environmental and management context, it is difficult to identify those ecological changes that are solely the result of current grazing practices (Borman 2005).

Specifically, the 52,947 acre Cascade-Siskiyou National Monument (hereafter abbreviated as CSNM) was designated by presidential decree in 2000 using powers granted to the president under the Antiquities Act of 1906. The Monument included a legally binding Proclamation that required the Bureau of Land Management (BLM), the federal agency overseeing the Monument, *"to study the impacts of livestock grazing on the Monument's objects of scientific interest…with specific attention to sustaining the natural ecosystem dynamics."* Objects of scientific interest stated in the Proclamation are both general (i.e., special plant communities) and specific species (USDI BLM 2005). The Proclamation requires the BLM to consider biological objects and ecosystem variables relative to the range of ecological processes occurring within the CSNM landscape. Because the disturbance regimes that currently affect the "objects of interest" are not the same as what they evolved with, it follows that some elements of the Monument's biological diversity may be at risk (Hobbs and Huenneke 1992, Pieper 1994, D'Antonio et al. 1999).

The objective of this report is to summarize available scientific evidence, primarily from the California Floristic Province, concerning the potential ecological effects of livestock grazing on four terrestrial-based ecological processes: 1) plant community dynamics; 2) exotic plant invasions; 3) soils and nutrient cycling; and (4) wildland fuels and fire regimes in grasslands and oak woodlands. Our goal was to make available in one document the most relevant studies for understanding the potential risks and benefits of livestock grazing on terrestrial ecosystem dynamics, for which pertinent published scientific data exist. We have purposefully omitted consideration of grazing effects on aquatic and riparian ecological processes, which, though very important ecologically, generally appear to be less region-specific and have already been thoroughly reviewed in the body of existing scientific literature (Kauffman and Krueger 1984, Armour et al. 1994, Fleischner 1994, Ohmart 1996, Belsky et al. 1999), including Chapter 5 of this report.

An attempt was made to include all research papers and literature reviews that concern the effects of livestock grazing either directly or indirectly on terrestrial ecosystem processes (see Appendix B2 for annotated bibliography). Wherever possible, we focus on evidence from inland and foothill plant communities of California, which are similar in many respects to vegetative communities that are represented in the CSNM and which are currently grazed by livestock. Where necessary due to lack of local data sources, and where applicable, we also include studies concerning grazing effects from grasslands and woodlands of (1) the California floristic province as a whole, and (2) the intermountain West. Readers should be aware that a substantial amount of research on these topics has been published from the Interior Columbia and Great Basins, which may also have relevance to management and conservation of the CSNM landscape.

METHODS

We searched the scientific literature for peer-reviewed empirical papers of the biological and physical effects of livestock grazing on ecosystem dynamics in California, and to a lesser degree, across the western USA. Because of the extensive literature on the subject, not all papers could be reviewed or cited. In choosing the papers to be included, we gave highest priority to recent papers in refereed journals. Secondary priority was given to descriptive or comparative studies. Where there was a paucity of data, we also used non-peer-reviewed reports, usually from government documents or symposia. In no case were our general conclusions drawn from un-refereed reports or from studies showing anomalous results. Instead, we based our conclusions on what emerged as the consensus of published literature in the field. We also identified and listed comprehensive review papers on each topic.

The literature review begins with a narrated overview and synthesis pertaining to each topic and discussed in the context of competing hypotheses about the effects of livestock grazing and evidence that supports or refutes these hypotheses. The remainder of the report includes abstracts of all bibliographic citations, formatted in accordance with the original works (see Appendix B2). Our intention is that this literature review will assist in evaluating a range of alternatives for managing livestock that might be applied to the CSNM as a means to maintain and restore natural ecosystem processes. The review is also intended to help identify gaps in our understanding of the potential effects of livestock grazing on ecosystem dynamics in this region, and to help direct future experimental work in this area.

I. GRAZING EFFECTS ON PLANT COMMUNITY DYNAMICS AND INVASIVE WEEDS

Hypothesis 1a: Grazing decreases the abundance of native species and increases the abundance of exotic species

Although there is support for this hypothesis from some studies (see below), grazing has generally been shown to increase the relative abundance of native vs. exotic species and native grassland recovery/restoration, while protection from grazing has been shown to decrease exotics (Table 1). For example, in vernal pool communities, grazing has reduced exotic grass cover and thatch (the layer of annual grass and forb litter) to the benefit of native plant species (Dyer and Rice 1997, Griggs 2000, Mawdsley 2000, Table 1). In the Vina Plains of the northern Central Valley, medusahead (*Taeniatherum caput-medusae*) increased in abundance following livestock removal, but decreased again following the restoration of seasonal cattle grazing (Griggs 2000). Researchers speculate that since medusahead does not accumulate a persistent soil seedbank, grazing appropriately timed to reduce its seed production can dramatically reduce, though not eliminate, infestations of this noxious weed, which is prevalent in the CSNM (Pollak and Kan 1996).

Numerous studies and reports concerning grazing effects on California ecosystems have found that the primary mechanisms by which grazing can benefit native (and exotic) annual forb abundance, and, in some cases bunchgrass reproduction (Menke 1992, Dyer and Rice 1997), are by (1) reducing thatch, thereby increasing light availability at ground level (Edwards 1992, Dyer and Rice 1997, Gerlach et al. 1998, Meyer and Schiffman 1999, Griggs 2000, Corbin et al. 2004), and (2) reducing the competitive influence and reproduction of exotic annual grasses (Pollak and Kan 1996, Dyer and Rice 1997, Table 1). Heady (1995) noted that thatch reduction by livestock (or by experimentation) may reduce the abundance of tall exotic annual grasses such as *Avena fatua* and *Bromus hordeaceus*, while increasing that of shorter native annual forbs (e.g., *Castilleja* spp.) and exotic annual grasses (e.g., *Aira* spp.) and forbs (e.g., *Trifolium*, *Erodium*, *Hypochaerus* spp). Baker (1992) cautioned, however, that the balance of evidence does not suggest that grazing is essential for maintaining native bunchgrass reproduction, and Hamilton et al. (2002) found that grazing or "management" was not necessary to perpetuate native bunchgrasses.

Thus, the effects of grazing versus protection from grazing on weed invasions and native community restoration/recovery appear to be site, life-form, and species specific, and have differed between serpentine and non-serpentine soils, vernal pool and foothill sites, grasses and forbs, annuals and perennials, and among individual native and exotic species (Merenlender et al. 2001, Gelbard and Harrison 2003, Harrison et al. 2003, Table 1). When carefully timed and controlled, livestock grazing has suppressed the seed production of weeds that are major problems in California grasslands and elsewhere in the West, such as yellow starthistle (*Centaurea solstitialis*) (Thomsen et al. 1993, DiTomaso 2000, Tu et al. 2001; Table 1) and medusahead (*Taeniatherum caput-medusae*) (Griggs 2000). In a recent review of scientific literature, D'Antonio et al. (2002) concluded that carefully timed grazing (especially by goats or sheep) can be used to generate short-term reductions in the reproduction and cover of some exotic species. However, the researchers did not find sufficient evidence to detect significant trends in the ability of grazing by cattle to effectively reduce weed populations or assist in the restoration of native grassland species.

Grazing may also reduce thatch to build-up that increases potential fire severity, while decreasing species diversity, as well as short-term forage availability. While properly timed prescribed fire can reduce the abundance of exotic species and increase that of natives (Menke 1992, Pollak and Kan 1996, DiTomaso et al. 1999, 2001, Corbin et al. 2004), grazing may reduce the risk of wildfires that are not properly timed to benefit native species, and which may therefore increase the abundance of exotic relative to native species, especially on relatively productive soil types (Harrison et al. 2003).

Hypothesis 1b: Grazing decreases the abundance of exotics and increases the abundance of native plants

A number of studies refute this hypothesis by finding that livestock grazing decreased native plant species and/or increased exotics (Appendix B2). Negative effects of livestock on the relative abundance of native vs. exotic species in California plant communities are believed to be rooted in the evolutionary vulnerability of many native species (especially perennials) to heavy grazing and trampling, due to an absence of high concentrations of large hoofed grazers in northern California and the Pacific Northwest since the Pleistocene (Baker 1978, Mack 1989, Wagner 1989, Milchunas and Lauenroth 1993, Heady 1995, Holland and Keil 1995, Painter 1995, Masters and Sheley 2001). As a result, many of California's native grassland species, especially perennial grasses, are believed to be more vulnerable to livestock impacts than many exotics (Baker 1978, Holland and Keil 1995; Seabloom et al. 2003; Corbin and D'Antonio 2004), and livestock are considered an exotic species themselves (Wagner 1989, Painter 1995).

Reviews by Hobbs and Humphries (1995), Belsky and Gelbard (2000), DiTomaso (2000), and Masters and Sheley (2001) have summarized a number of mechanisms by which livestock can cause and accelerate weed invasions, and prevent and/or retard the recovery and restoration of grasslands, shrublands, and woodlands:

- livestock act as vectors for exotic plant seeds by distributing them in their dung and coats;
- livestock selectively graze more palatable native (and exotic) species over weedy ones;

- the hoof action of livestock creates areas of bare and disturbed soil, and hoof prints act as microhabitats that hold water and increase exotic seed germination;
- livestock reduce fuel/biomass and disrupt native fire cycles; and
- livestock redistribute nutrients, resulting in (1) localized nutrient hot spots on areas where they congregate, such as under oaks, and near water sources; and (2) reductions in nutrient levels in areas where they consume biomass and then move on.

Evidence from the California Floristic Province suggests that the effects of grazing on plant community dynamics are variable (Corbin et al. 2004), and the likelihood that livestock will cause the above impacts depends not only on the stocking density, timing, duration, and type of grazing (Thomsen et al. 1993, Meyer and Schiffman 1999, DiTomaso 2000), but also on local environmental conditions such as soil and vegetation (Mack 1989, Milchunas and Lauenroth 1993, Safford and Harrison 2001, Harrison et al. 2003), the scale at which vegetation is sampled (Stromberg et al. 2001, Harrison et al. 2003), and the plant life form and individual species in question (Painter 1995, Harrison et al. 2003, Table 1). For example, researchers have shown that grazing may have negative effects on native species on non-serpentine soils, but positive effects on natives on infertile soils such as serpentine (Table 1). At the McLaughlin Reserve in California's inner Coast Range, Harrison et al. (2003) found that over four years, medusahead was more abundant on grazed than ungrazed sites on non-serpentine, but not serpentine, soils. Stromberg and Griffin (1996) found significantly fewer plant species in grazed than ungrazed inland *Nassella pulchra* stands based on areas of 0.1 ha, but when vegetation was sampled at a smaller scale (1-m^2), this pattern in species richness was reversed (Stromberg et al. 2001).

Although carefully timed and seasonal grazing have been shown to suppress seed production of yellow starthistle and medusahead, while avoiding negative impacts to native bunchgrasses and some sensitive vernal pool species (Menke 1992, Thomsen et al. 1993, DiTomaso 2000), The Nature Conservancy's weed control handbook cautions that **the degree of control required to achieve desirable results is rarely possible with**

commercial herds (Tu et al. 2001), and that such lack of control can result in overgrazing of desirable species. Where grazing is year-round continuous, as is the case in most California grasslands (Menke 1989), it may therefore favor less palatable exotic species over more palatable exotics and natives alike. This negative effect of continuous grazing may be less pronounced on infertile soils (Safford and Harrison 2001, Gelbard and Harrison 2003, Harrison et al. 2003), though the invasions of barbed goatgrass (*Aegilops triuncialis*) into a Napa Land Trust-owned site in Snell Valley, CA shortly after it was heavily grazed, as well as into the Payne Ranch at the junction of California Highways 16 and 20, and in Bear Valley (of Colusa County), have all provided evidence that grazed serpentine sites can still be vulnerable to invasion.

Conversely, protection from grazing has been shown to benefit native plant species, especially perennial bunchgrasses (Bartolome et al. 2004, Kimball and Schiffman 2003, Gelbard and Harrison 2003, Gelbard 2003, Harrison et al. 2003, Hamilton et al. 2002, Saenz and Sawyer 1986) (Table 1). Working in California coastal grasslands, Bartolome et al. (2004) reported a shift in plant community from more annual-dominated toward more perennial-dominated vegetation when grazing was removed, but individual perennial grass species responded differently. *Danthonia californica*, a common native grass in the CSNM, increased with grazing removal. Similarly, Saenz and Sawyer (1986) found greater perennial grass cover and higher native species diversity in coastal grasslands grazed for a partial season compared to a full season, and greater introduced annual grasses in more heavily grazed sites.

A handful of studies conducted in inland/foothill grassland communities have also reported increases in native grass cover when grazing is reduced or eliminated. Working across a wide range of grassland locations in northern California, Harrison et al. (2003), Gelbard and Harrison (2003), and Gelbard (2003) all found a negative correlation between livestock grazing and the abundance and/or diversity of native plant species (see Appendix B2). In remnant grasslands of the San Joaquin Valley, Kimball and Schiffman (2003) found that native grass species were negatively affected by experimental clipping, whereas alien species were unaffected. Overall, evidence from across the region indicates that pronounced vegetation changes are likely to require over a decade of protection from grazing, if not longer (Hamilton et al. 2002, Table 1). Although this may be achieved more rapidly if native species are seeded during years of favorable moisture (Seabloom et al. 2003).

The assertion that livestock removal may slow a yellow starthistle invasion has increasing support in the scientific literature. However, one study simulating grazing effects on starthistle invasion into bunchgrass stands suggested that ungrazed stands are considerably more resistant than grazed stands (Roche et al. 1994). Two recent studies provided evidence that stands of deep-rooted, late-season native species, including the native bunchgrass, *Nassella pulchra*, may resist starthistle invasion (Dukes 2002, Gelbard 2003); and stands dominated by seeded native bunchgrasses resisted reinvasion even by exotic annual grasses (Seabloom et al. 2003). The authors noted that in general, perennials are thought to be competitively superior to annuals in undisturbed environments and that undisturbed relict or restored stands of native perennial grasses are considered resistant to exotic annual invasion (Stromberg and Griffin 1996; Corbin and D'Antonio 2004). However, this tendency may be more pronounced in California coastal prairie than in interior grasslands (Corbin and D'Antonio 2004). Additional examples of findings on the relationship between livestock grazing, exotic weed invasions, and native restoration and recovery are summarized in Table 1.

Key Findings – Exotic Plants

The balance of evidence indicates that livestock grazing may have variable effects on exotic weed invasions and native plant species persistence, recovery, and restoration, which are likely to be specific to site, life-form, plant species and the grazing regime involved. There are important differences between serpentine and non-serpentine soils, vernal pool and foothill sites, grasses and forbs, annuals and perennials, and among individual native and exotic species (Merenlender et al. 2001, Gelbard and Harrison 2003, Harrison et al. 2003, Table 1). Notably, serpentine soils are not found in the Monument and therefore grazing response is more likely to resemble negative effects on native species reported for non-serpentinite soils. Additionally, in many areas, grazing may cause and accelerate weed invasions and slow recovery and restoration of native plant communities by increasing the (1) number of vectors of exotic seed dispersal and (2) frequency and intensity of disturbances that augment the vulnerability of plant communities to invasion. In other areas, such as sites that are heavily invaded by exotic annual grasses and forbs and contain a thick layer of thatch (e.g., in grasslands strongly dominated by medusahead), carefully timed seasonal grazing may increase native annual forb abundance. In such sites, livestock removal from highly invaded sites is unlikely, in itself, to result in the recovery of native species, which is likely to require active restoration measures such as eradication and control of exotic species, controlled use of prescribed fire, and reseeding or planting of natives.

II. LIVESTOCK GRAZING EFFECTS ON SOILS AND NUTRIENT CYCLING

Hypothesis 2a: Livestock grazing has no adverse effect on or improves soil conditions and nutrient cycling.

No scientific studies conducted in California grasslands were found that suggest positive effects of livestock grazing on soils and nutrient cycling, though light grazing has been observed to have minimal effects on soil properties (Dahlgren et al. 1997). Effects consistent with improvement of soils and nutrient cycling have been observed in the scientific and grazing management literature outside of California. In a text entitled *Grazing Management: An Ecological Perspective*, Archer and Smeins (1991) summarized how nutrient cycling via grazing animals can be important in enhancing or maintaining soil fertility (Floate 1981). They noted that cycling of nutrients through livestock may help keep a pool of readily mineralizable organic nutrients near the soil surface where they are more accessible to plants and microbes (Botkin and Wu 1981). Consumption of vegetation and subsequent defecation could also increase the turnover and availability of nutrients that would otherwise remain unavailable to plants. They noted, for example, that shoots of plants on grazed areas often have higher nutrient concentrations than plants from comparable ungrazed areas (Coppock et al. 1983), which may be a consequence of factors such as enhanced nutrient uptake by defoliated plants (Ruess 1984), and increased soil nutrient availability. Increased soil nutrient availability may result from: (1) input from dung and urine (inorganic N levels in soils of urine spots may remain elevated for up to 90 days and above-ground standing crop increased 3- to 7-fold); (2) enhanced microbial activity associated with higher soil temperature and moisture (Parton and Risser 1980); and (3) decreases in root biomass, which limits carbon availability to decomposers causing decreased microbial biomass and increased net mineralization (Holland and Detling 1990).

Savory (1999), in *Holistic Resource Management* (HRM), claims that grazing can have beneficial effects on soils and nutrient cycling by breaking up soil crusts, increasing aeration, aiding in the decomposition of plant litter, and fertilizing the soil with urine and dung. However, scientists have expressed skepticism at or even rejected HRM's claims about positive ecological effects of grazing, including on soils (e.g., Abdel-Magid et al. 1987, Holecheck et al. 2000). One review of HRM by an expert in the history and ecology of California grasslands raised doubts as to the scientific merits of Savory's methods (Bartolome 1989). In general, there is not yet evidence that the above "positive" effects of grazing on soils apply to California grasslands.

Hypothesis 2b: Livestock grazing adversely affects soil conditions and nutrient cycling.

The bulk of evidence concerning livestock grazing and soils generally supports this hypothesis. Numerous studies have documented significant grazing-related changes to soil structure, soil fertility, nutrient availability, soil biota and rates of erosion. First, livestock trample soils (an effect most pronounced on wet and/or fine-textured soils), resulting in compaction that damages plant roots (Watkins & Clements 1978, Hobbs and Huenneke 1992, Tisdale et al. 1985) and causes them to become concentrated near the soil surface (Menke 1989). Compaction also reduces water infiltration, percolation, aeration, and soil moisture storage (Menke 1989; Archer and Smeins 1991, Trimble and Mendel 1995, Dahlgren et al. 1997), increases overland flow, erosion, and topsoil loss, and dries out surface soils (Trimble and Mendel 1995), which may increase vulnerability to drought (Belnap 1995). The net result is that livestock-related compaction can lead to a loss of soil productivity.

Studies on grazing and soil compaction generally find that compaction increases with grazing intensity. At least one study has found no relationship between livestock stocking rate and bulk density (Warren et al. 1986c), however most have found significant increases in bulk density (soil compaction) with livestock grazing, particularly in finer textured soils and in surface soil layers (Abdel-Magid et al. 1987b, Bauer et al. 1987, Warren et al. 1986b, Firestone 1995, Ellison 1960). This effect is most pronounced with heavy grazing, but is also observed with moderate intensity grazing. Firestone (1995) observed a 13% increase in bulk density of grazed soils under oaks in northern California.

Working in oak woodlands of the Sierra Nevada, Dahlgren et al. (1997) reported significantly higher bulk density and higher levels of phosphorous in grazed areas than in matched ungrazed areas for 20 years, likely attributable both to direct trampling and to reductions in litter and organic matter, which increase soil porosity and protect soils from raindrop impact (see also Menke 1989). Gelbard (2003) found that soils in remote "grassland islands" (grassland patches surrounded by shrublands or oak woodlands) seldom visited by livestock contained significantly lower bulk density and higher porosity than grasslands contiguous with roads, which were considerably more disturbed by livestock. Likewise, Menke (1989) discussed the soft soils and high porosity of long-ungrazed areas that has been observed in several studies conducted at the Hopland and Sierra Foothill Range Field Stations, the San Joaquin Experimental Range, and the Hastings Natural History Museum, and concluded that trampling by herbivores may be depressing productivity throughout California grasslands.

Grazing can also alter nutrient cycles, both by causing increases and decreases in nutrient availability, and by altering the spatial distribution of nutrients in the soil. Grazing can also alter nutrient cycles, both by causing increases and decreases in nutrient availability, and by altering the spatial distribution of nutrients in the soil. As one example, Archer and Smeins (1991) found that grazing can result in considerable nutrient losses in grasslands where livestock consume seasonal biomass and are then moved off site.

Nutrient losses may also cause reductions in plant cover, especially that of perennials, resulting in (1) an overall reduction in N uptake, which after a brief pulse, could increase N loss from the system via nitrate leaching (Jackson et al. 1988, Seabloom et al. 2003), and (2) increased rates of erosion and topsoil loss (Archer and Smeins 1991). Livestock can also cause localized increases in soil fertility, especially in areas where they congregate such as near water sources and under trees (Mathews et al. 1994, Pieper 1994, Archer and Smeins 1991, Dalhgren et al. 1997, Harper et al. 1998). Vegetation within such nutrient hot spots tends to be dominated by exotic species, and these sites may act as foci for further invasion (Belsky and Gelbard 2000, Burke and Grime 1996). Grazing also appears to affect soil pH, which has been reported to be significantly lower in grazed compared to ungrazed areas (Ratliff 1985, Firestone 1995).

There is some variability in the scientific literature regarding the nature of the impact of livestock grazing on the total amounts of various nutrients in the soil. The effects of grazing vary depending on the nutrient studied, the location of the study and the grazing management system. However, most available evidence suggests that grazing changes soil nutrient status (Pieper 1994, Laurenroth et al. 1994). Nutrients are removed as livestock consume plants and convert them into livestock biomass that is transported off site. Nutrients are also lost through increased erosion of nutrient rich surface soil, accelerated decomposition of litter and organic matter, and leaching. Some nutrients are returned to the ecosystem in feces and urine. Tiedemann et al. (1986) calculated a net loss of 3.2 kg nitrogen per acre under moderate grazing compared to ungrazed areas in the Pacific Northwest (cited in Pieper 1994). Of that total, 0.9 kg nitrogen was estimated to be lost to volatilization during digestion, 2 kg was lost in livestock biomass, 0.7 kg was lost through increased erosion, and 0.22 kg was lost through increased leaching. Another study (Pieper 1977; cited in Ratliff 1985) estimated that 10.3% of nitrogen and 38.1% of phosphorous may be lost to the ecosystem under moderate grazing. Bauer et al. (1987) calculated that each 500 kg cow removes about 25 kg carbon and 4 kg nitrogen per hectare from grazed ecosystems.

Direct comparisons of grazed and ungrazed soils generally find that grazing tends to reduce total soil nutrient levels. Comparing an 80-year old exclosure with heavily and moderately grazed pastures, researchers found significantly more total soil nitrogen in the exclosure than in adjacent grazed areas. This nitrogen loss was observed down to 106.7 cm depth (Frank et al. 1995). Another study reports that soil nitrogen was reduced from 0.20% to 0.14% and soil carbon was reduced from 2.1% to 1.5% in heavily grazed soils compared with a 47-year old exclosure (Laurenroth et al. 1994). On the other hand, a study that examined 12 grazed and 12 ungrazed grasslands in North Dakota, found about 17% more total soil nitrogen in grazed areas. Carbon, however, showed the opposite trend, with grazed grasslands consistently showing lower total carbon levels than ungrazed areas (Bauer et al. 1987).

The effects of livestock grazing on soil nutrient availability (compared to total soil nutrient levels) have not been as well studied, but some evidence suggests grazing generally increases short-term soil nutrient availability by increasing rates of decomposition (Laurenroth et al. 1994). Afzal and Adams (1992) treated soil with cattle dung and simulated cattle urine. They found that the available nitrogen concentration in the soil was increased significantly under both types of excreta. Dahlgren and Singer (1991) found higher levels of highly available and mobile nitrate-nitrogen under oak canopies in grazed areas as opposed to ungrazed areas in California oak woodlands. Another California oak woodland study similarly found significantly greater levels of available nitrogen (ammonium and nitrate) under oaks in a grazed grassland than in an adjacent exclosure (Firestone 1995).

Grazed soils in semi-arid environments have also been observed to contain a lower diversity of soil biota (Bethlenfalvay and Dakessian 1984, Belnap 1995) and lower abundance of species important to soil turnover and aeration, including earthworms and gophers (Menke 1989), compared to untrampled soils. Soil biota such as arthropods, earthworms, microscopic bacteria, and fungi break up and then decompose plant and animal residues in all environments (Ingham et al. 1985). Brady and Weil (1999), authors of a leading textbook on soils, also discuss the importance of mammals in the decay process; they mention burrowing mammals such as gophers, which tend to occur in lower abundance in grazed than ungrazed California grasslands (Stromberg and Griffen 1996, Bernhardt and Sweicki 2000). Such changes to soil biota caused by livestock may influence not only nutrient cycling and soil structure, but also plant community composition (Egerton-Warburton and Allen 1999).

Key Findings – Soils and Nutrient Cycling

The balance of evidence indicated that livestock grazing has deleterious effects on soils and nutrient cycles. These effects may depend on the type of soil (especially its rockiness, texture) and on livestock management (especially stocking density, but also timing and duration). In most instances, grazed lands tend to be characterized by soils that (1) are more compacted, with lower rates of infiltration and soil water capacity and higher bulk density and rates of erosion; (2) have experienced a net directional transport of nutrients to localized portions of the landscape – livestock create localized nutrient hot spots that occur in areas where they congregate, but may cause reductions in levels of nutrients in other areas due to erosion, leaching, and removal of biomass; and (3) contain a lower abundance and diversity of soil biota important to nutrient cycling, decomposition, and soil porosity, aeration, and water holding capacity, compared to ungrazed sites.

III. INTERACTIONS AMONG LIVESTOCK GRAZING, VEGETATION DYNAMICS AND FIRE

Managers and researchers often focus on the effects of disturbances individually. In order to understand a disturbance like livestock grazing, it is necessary to consider how its effects interact with those of other disturbances, such as fire. Co-occurring novel disturbances often lead to ecological surprises (Paine et al. 1998). Because grazing modifies the amount and type of vegetation available for combustion, it can have important influences on fire regimes (Hobbs 1996). Alteration of fire regimes by land management actions is a major threat to biodiversity worldwide (Bond and van Wilgen 1996). Depending on vegetation type and other conditions, livestock grazing may result in either increasing or decreasing the frequency and intensity of fire. Here, we discuss alternative hypotheses about grazing effects on fire regimes, emphasizing that for biodiversity conservation and ecological integrity it is desirable to maintain and, where necessary, restore disturbance regimes to some semblance of those that have operated over evolutionary history.

Hypothesis 3a: Fire severity or frequency increases with livestock grazing

While there is some support for this hypothesis (see below), there are also some circumstances where livestock grazing is associated with decreasing fire hazard. In particular, intensive grazing of grassland vegetation can eliminate thatch, reduce forage height and biomass (see section I of this review; e.g. Edwards 1992, Dyer and Rice 1997, Gerlach et al. 1998, Meyer and Schiffman 1999, Griggs 2000, Corbin et al. 2004), and thus reduce fire-line intensity and flame length (Andrews and Rothermel 1983). Grazing may move grasslands that are in fuel model 3 (2-3 foot tall, dense grass) to fuel model 1 (one-foot tall, generally sparser grass, or a custom model for even shorter grass; see Anderson 1982 for a description of fuel models and expected fire behavior). With lower, and less dense grass, direct-attack-fire suppression efforts by hand crews is safer and easier (Andrews and Rothermel 1983).

Trampling and physical effects of livestock to shrubs may reduce fire-line intensity by reducing woody biomass, which may also aid fire suppression efforts, although spread rate may increase, producing the opposite effect. In conifer forests of the intermountain West and Sierra Nevada, grazing is believed to have reduced the frequency of fire by eliminating fine fuels that allow lightning ignitions to become spreading fires (Belsky and Blumenthal 1997). Present day gazing may help lower the likelihood of ignition where it eliminates fine fuels, but it is very difficult to separate present and past livestock grazing influences (Borman 2005).

Fire is presently uncommon in the Monument, making concerns about increased potential for fire due to grasses seem moot from an ecological perspective. However, managers may desire to reintroduce a greater influence of fire (USDI 2005). In addition, wildfires will eventually burn, despite fire suppression. When fires do not have the same patterns of intensity as those that burned over evolutionary history, they may not have the same ecological benefits in promoting native vegetation and instead may promote non-native species, opposite goals of protecting the objects of interest and ecological integrity in the Monument. Fire combined with grazing would be expected to exacerbate these effects, so fire restoration may need to be combined with protection from livestock.

Hypothesis 3b: Fire hazard decreases with livestock grazing

Although the intensity component of fire hazard may be reduced considerably by grazing, the spread component will increase under windy conditions (Anderson 1982). This follows from the principle that there is an inverse relation between the fuel loading per unit volume and the rate of spread as wind speed increases (Thomas 1972). Or, more simply, fire can spread very fast in porous fuels because fuel and biomass are a heat sink. Massive grass fires in the winter of 2006 in Texas, Oklahoma and Colorado on grazed lands (over 10,000 livestock were reportedly killed) illustrate the fire hazard problems associated with grass fuels and high rates of spread.

There are fire hazard tradeoffs that occur with increased annual grass vegetation and decreasing shrub vegetation resulting from grazing effects, which in turn can allow for greater fire frequency and fire spread. The opposite fire hazard tradeoffs exist in terms of grazing effects in forest vegetation; the frequency is likely to be lower, and the intensity higher, as a result of grazing. These two different pathways by which grazing can increase fire hazard will each be described below.

Grazing and Replacement of Shrubs with Annual Grasses - As described in previous sections, a principal effect of grazing in Mediterranean ecosystems is to promote exotic annual grasses (Keeley et al. 2003). Through positive feedback with fire, annual grasses can help favor their own invasion and displacement of woody plant communities (Mack and D'Antonio 1998). In fact, range managers have long known that a way to favor grasses over Mediterranean shrub vegetation to produce more forage for cattle is to use repeat burning (Sampson 1944, Tyler et al. 2007). Large areas of chaparral in northern California have been deliberately converted to annual grassland using this method. These grasslands can support more frequent fire, and grass promotes the fastest rates of fire spread of any vegetation. In many parts of southern California and the Great Basin, annual grasses are promoting more frequent fire and increased area burned unintentionally, thereby displacing native shrub vegetation (Brooks et al. 2004, Keeley 2005). This has caused concerns over safety, loss of native diversity, and has rendered fire suppression less effective in these non-forested ecosystems.

Because grazing in shrublands can help disperse grass seed and the trampling can open the shrub canopy, livestock help promote grass invasion, particularly if compounded with fire (Zedler et al. 1983). With the occurrence of a fire in shrublands affected by grazing, annual grasses can grow back in sufficient abundance to provide readily ignitable fuel allowing for reburns sooner than the natural vegetation would allow, and leading to complete type conversion from native shrub to exotic grass vegetation if the fire interval is 1-2 years (Zedler et al. 1983). If the reburn interval is longer, but before the shrub canopy has redeveloped, grass invasion may still be facilitated, leading to a partial type conversion that may be completed with the occurrence of subsequent fires (Keeley 2001, Tyler et al. 2007).

There are a number of reasons high frequency fire can eliminate shrub vegetation (Tyler et al. 2007). While annual grasses can recover following fire and reach reproductive maturity in one growing season, the recovery of shrub vegetation is generally more gradual. It often takes 10-20 years for chaparral shrub canopies to redevelop (Keeley 2001), and it may take longer for seed banks to establish, and many shrubs rely on accumulating a persistent seed bank in order to regenerate after fire (reviewed in Odion and Tyler 2002). Shrubs that do not resprout (e.g. most species of *Arctostaphylos* and *Ceanothus*) must grow from seed. However, both sprouting and non-sprouting shrub life history types are sensitive to fire at intervals of less than about 20 years (Keeley 2001, 2006). Sprouters often have very high mortality if reburned within 1-2 years (Zedler et al. 1983). Young seedlings established after fire are typically killed by an early reburn and they remain sensitive for several years if they are sprouting species. Germination and mortality associated with fire results in little or no carry-over of the seed bank that was present prior to the first of two sequential burns. In some Mediterranean grasslands, removal of livestock grazing leads to native shrub reestablishment or encroachment (Keeley 2001, Tyler et al. 2007). However, many chaparral species (i.e. evergreen sclerophylls such as *Arctostaphylos* and *Ceanothus*) have life histories that are poorly suited for reclaiming habitat lost to annual grasses. This is influenced by the lower fire severity that grazing and annual vegetation combines to promote. A dormant soil seed bank stimulated to grow by high severity fire is particularly important in the establishment of many chaparral shrubs (Odion and Davis 2000). Even if seed of these chaparral shrubs is dispersed into the grassland, it may never receive sufficient heat or other stimuli from combustion byproducts (Keeley 1991) to allow germination. Conversely, with less shrub vegetation, fire severity may be low enough to allow for survival of grass seeds, which do not typically survive the high-intensity fire that characterizes shrublands with relatively closed canopies (Keeley 2001). Thus, reduction in fire intensity can be an important stabilizing feedback for annual grasses that occurs with frequent fire and grass invasion (Tyler et al. 2007). Once grassland is established, mechanical damage to shrub seedlings from livestock, and their late season utilization of slightly palatable shrubs (Sampson and Jesperson 1963) can also help stabilize and maintain grasslands. In order to prevent or minimize invasion by grasses and other light-demanding exotics, maintaining an intact shrub canopy is recommended for chaparral systems (Keeley 2001, 2006).

As mentioned above, in existing grasslands of any origin, grazing can reduce the intensity and severity of fire by removing biomass that would otherwise burn. This may favor exotic annual grasses over not only shrubs, but also perennial grasses. Perennial bunchgrasses in the western U.S. such as *Nassella* are well adapted to fire (reviewed by Wright and Bailey 1982), and historically fires occurred in the western USA where combustible grass biomass was not removed by ungulates (Wagner 1989). Native perennial grasses can be quite tolerant of relatively severe fire (Wright and Bailey 1982). In fact, some (*Koeleria, Nassella*) were found to survive and resprout following chaparral fires (Odion and Davis 2000). Moreover, some species, such as members of the genus *Nasella*, have self-planting seeds (Bartolome and Gemmill 1981). Burial of these seeds in soil can help them survive fire. Many native bulb plants are stimulated to grow with fire, taking advantage of a pulse of nutrients and flowering in profusion (Bond and van Wilgen 1996). One species in California may not reproduce in the absence of relatively severe fire (Tyler and Borchert 2002). In short, a regime of reduced fire intensity as a result of biomass removal by livestock may select against native grassland species, which are fire adapted, and favor exotic species, which are sensitive to fire, but well adapted to grazing.

Annual grasses are now important components of oak woodland vegetation. In contrast to many chaparral species, oaks do not have fire-dependent reproduction. In fact, along with conifers, they can replace some types of chaparral vegetation in the absence of fire, a dynamic noted in SW Oregon (Detling 1961). Grazing and annual grasses can have complex, profound, but difficult to separate effects on oak regeneration (reviewed by Tyler et al. 2006 2007. While adults and established saplings of some oak species are capable of resprouting following low intensity fire, frequent or severe fire kills seedlings and may cause sapling mortality. Swiecki et al (2002) reported that frequent fire was negatively associated with blue oak (*Quercus douglasii*) sapling recruitment. Mensing (1998) examined pollen deposits in Santa Barbara County and found that lack of fire correlated significantly with an increase in oak in the last 100 years when fires have been less frequent. In sum, minimizing both fire and grazing are likely to favor establishment of oaks, and their return in grasslands where they may have been reduced, but the annual grasses may prevent this. In addition, lack of fire can lead to increased conifer growth in more mesic oak woodlands (Swieki and Barnhardt 2002), which may be facilitated by grazing, as described below.

Grazing and Conifer Regeneration - In dry, open conifer vegetation of the intermountain West, intensive historic cattle grazing has been an important causal factor in the loss of the native bunchgrass understory (reviewed by Belsky and Blumenthal 1997). This grazing impact is opposite to the effect of grazing in shrublands: it has reduced the frequency and increased the intensity of fire in dry forests. While it is commonly believed that altered fire regimes are due to filling in of formerly open forests due to fire suppression, studies that have been able to identify locations that were never grazed have found that no infill of conifers occurred (e.g. Rummel 1951, Mudany and West 1983, Neuschwander and Zimmerman 1984). Others have noted that alteration of interior ponderosa pine (*Pinus ponderosa*) forests and their fire regimes commenced at different times that coincided with intensive grazing by sheep (Savage and Swetnam 1990). Without livestock, native perennial grasses that are naturally abundant in stands of widely spaced ponderosa pine continued to flourish and prevent conifer seedling establishment even though fire was excluded. It is also generally understood that historic cattle grazing helped reduce the influence of fire in these forests by reducing fine fuel that allowed ignitions of widely spaced tress to become spreading fires (Belsky and Blumenthal 1997).

Key Findings

By removing grass biomass and damaging woody biomass, livestock grazing can reduce fire-line intensity. There is potential to therefore use carefully controlled livestock grazing strategically and proactively in fire suppression planning, much like controlling bad exotic species infestations. However, for the Monument, the same management difficulties of carefully controlling and confining grazing to specific locations and forage apply in both cases. There are also increases in fire hazard that grazing may generally facilitate. By favoring annual grasses in the landscape, fire spread rates can be increased. By eliminating perennial grasses, conifer density can be increased, leading to less frequent fire, but greater fire-line intensity. When fires do not have the same patterns of intensity as those that burned over evolutionary history, they may not promote native vegetation and instead non-native vegetation may prosper. Annual grass in particular can increase through positive feedback with not only grazing, but low severity fire that most native species are less favored by. Conversely, annuals are sensitive to higher fire severity that characterizes native vegetation, particularly sclerophyllous shrub vegetation.

CONCLUSIONS

Livestock grazing has been implicated as one of the predominant causes of decline of native grassland species in California. At the same time, grazing has been promoted as a means of enhancing native species diversity. In our review of grazing in California rangelands, we examined the quantitative evidence of how livestock grazing affects ecosystem processes. Unfortunately, most controlled quantitative studies of livestock in California ecosystems are either of limited geographic scope, are confined to exotic, annual rangeland species or have poor experimental designs, making causation very difficult to infer.

Maintaining interior foothill and lower montane landscapes such as those found within the Monument without livestock grazing is likely to slow the spread of invasive weeds such as yellow starthistle, which currently is abundant primarily along roadsides and in more heavily disturbed habitats of the area. In addition, the balance of evidence suggests that protection from grazing is likely, in the long-term, to favor the recovery of native perennial bunchgrasses, especially in more mesic sites and areas still containing native seed sources, and where fire and protection from grazing can be used together. Protection from grazing is highly unlikely, in itself, to result in the recovery of heavily invaded communities, especially where native grass species and seed sources have been largely eliminated. Heavy infestations may instead be reduced by careful use of livestock grazing, but there does not appear to be potential for this in most of the Monument due to the rugged terrain and the resources necessary to achieve proper control.

Available evidence from the California floristic province suggests that protection is likely to favor dominance of grasses relative to forbs (both native and exotic) and perennial grasses relative to annual grasses, though its effects on native annual forb diversity may differ between habitats. Protection is likely to also result in a gradual increase in infiltration, soil porosity, water holding capacity and soil biota.

In summary, if the management goal of the Cascade-Siskiyou National Monument is to maintain and/or restore natural ecosystem dynamics, it follows that protection from livestock grazing, or light seasonal grazing under specific controlled conditions, would be optimal land uses. However, targeted grazing may be a useful management tool under specific circumstances, such as in heavily invaded areas where grazing may suppress exotics, or as part of fire management by reducing fireline intensity in accessible areas targeted for fire suppression where the tradeoff of increased spread rate is not a concern.

CHAPTER 3: IN THE FIELD – AN OVERVIEW AND SYNTHESIS



PURPOSE AND NEED

Beginning in 2002, WWF[7] assembled a multi-taxa team of scientific experts (see Appendix A) to examine two fundamental questions related to the Monument's Proclamation: (1) are livestock compatible with protection of the objects of biological interest for which the Monument was established; and (2) are livestock compatible with sustaining "*natural ecosystem dynamics*" essential to these objects (see Chapter 2 and 5 for more detailed discussion of natural ecosystem dynamics)?

While the Proclamation directed the BLM to conduct scientific studies with the explicit purpose of a compatibility-with-protection determination regarding grazing, the multi-taxa studies summarized here were designed by WWF to be submitted to BLM as part of field studies on grazing effects by researchers in the Monument. A review of BLM's study plan by scientists from Oregon State University indicated that the agency would benefit from analysis of additional objects of biological interest, particularly zoological ones covered in the WWF studies, but not addressed in the BLM studies.

Over a three-year period (including a pilot study conducted on birds in 2002), WWF supported six field studies and the BLM conducted 18 separate studies (to be reported on separately by BLM). The WWF sampling effort represents a comprehensive assessment of grazing effects in the Monument as numerous taxa were investigated using comparable experimental designs and hypothesis testing through a coordinated, interdisciplinary and rigorous approach. Field studies combined with literature reviews supplemented with

[7] The National Center for Conservation Science & Policy is now administering the completion of these studies with the July 2006 closing of the WWF Klamath-Siskiyou field office.

photo documentation (see Appendix C) provide a detailed investigation of whether livestock grazing is compatible with the Monument's protection mandate.

The purpose of this chapter is to summarize key findings of the field studies coordinated by WWF in the Monument. Each of the individual studies is undergoing external peer-review by scientific journals (draft manuscripts sent under separate cover to BLM) and final manuscripts will not be available until this peer-review process is complete (~August-November 2007). The following taxa and habitat types were studied as biological objects and were examined under a range of livestock utilizations:

- Small-mammal live trapping in 16 study sites in mixed conifer and oak woodlands;
- bird monitoring stations along 25 point count routes in mixed conifer and oak woodlands;
- butterfly species richness and composition along 27 transects in mixed conifer and oak woodlands;
- aquatic snail distribution in 57 springs across the Monument;
- stream and riparian habitat, water temperature, and aquatic invertebrate diversity in two small watershed pairs (Dutch Oven and East Fork Camp creeks and Mill and South Fork Keene creeks); and
- distribution of Greene's Mariposa lily across more than 80 population clusters[8].

SUMMARY OF EXPERIMENTAL APPROACH AND KEY FINDINGS

- **Relative Abundance and Habitat Associations of Small Mammals in Two Forest Types in Southern Oregon (Master's Thesis – Aaron Johnson; Thesis Advisor – Dr. Robert Anthony, Oregon State University – two manuscripts currently in review with scientific journals – thesis available on line –** http://ir.library.oregonstate.edu/dspace/bitstream/1957/2140/1/THESIS.pdf**).**

[8] the Mariposa lily manuscript is undergoing a separate, independent peer review requested by the BLM of the Ecological Society of America.

Summary – Small mammals were live-trapped in early October to mid-November 2003 and 2004 within 16 study sites (light vs. heavily grazed) located in the mixed-conifer forests and oak woodlands of the Cascade-Siskiyou National Monument, southwest Oregon (Figure 2). Specific objectives were to: (1) compare small mammal communities between habitat types; (2) identify riparian affiliated species; (3) describe micro-habitat associations; and (4) test the null hypothesis that grazing does not influence small-mammal communities by comparing sites of low and high grazing utilization. Over a two-year period, 1,617 individual small mammals representing 20 species were live-trapped. Mixed-conifer forests had greater species richness and abundances than oak woodlands. Harvest Mice (*Reithrodontomys megalotis*), Long-tailed Voles (*Microtus longicaudus*), and Townsend's Voles (*M. townsendii*) were affiliated with, but not restricted, to riparian zones within the major forest types. No significant differences (*P*>0.05) in species richness, diversity, and evenness of small mammals were found between grazing intensities. However, cumulative biomass and abundance of small mammals in heavily grazed sites were 62% and 80%, respectively, of that in lightly grazed sites. Significantly fewer (all *P* values < 0.05) Harvest Mice (*Reithrodontomys megalotis),* woodrats (*Neotoma cinerea* and *N. fuscipes*), and Long-tailed Voles (*M. longicaudus*) occurred in heavily versus lightly grazed sites and fewer Deer Mice (*Peromyscus maniculatus*) were found in heavily grazed oak woodlands. Notably, woodrats and Deer Mice are important prey of the threatened Northern Spotted Owl (*Strix occidentalis caurina*) in southwest Oregon (Forsman et al. 2004) and the abundance of prey is known to influence owl reproduction (Rosenberg et al. 2003). Thus, cattle may interfere with predator-prey dynamics by lowering abundance of important prey within owl territories. The overall effect of grazing on woodrats was the clearing of clutter (i.e. shrubs, debris, grass cover) from grazed areas, which may have an adverse affect on woodrats given their habitat associations. Additionally, there was little or no detectable effect on species associated with exposed habitats, such as chipmunks (*Tamias* spp.). However, those that preferred heavy herbaceous cover (e.g., *Microtus spp* and *Reithrodontomys spp*.) were likely impacted by the removal and trampling of herbaceous cover by cattle, which may increase competition for resources and exposure to predation.

- **Association of Grazing Utilization and Bird Communities in the Cascade-Siskiyou National Monument, southwest Oregon (John Alexander, Jaime Stephens, and Nat Seavy– manuscript in review with a scientific journal)**

Summary – Bird communities and bird species of special conservation status were studied in association with livestock grazing along 25 point count routes in 2003 and 2004 in mixed-conifer forests and oak woodlands of the Cascade-Siskiyou National Monument, southwest Oregon (Figure 3). Sampling was stratified by habitat type (mixed-conifer forest vs. oak woodland; upland vs. riparian) and comparisons of bird communities were made using a continuous measure of grazing utilization. Enhanced BLM grazing utilization protocols were used to measure utilization and avian routes were categorized by low (0-40%) and high (>40%) utilization classes (see Chapter 4 for methods). The specific objectives of this study were to: (1) compare bird community composition among habitat types; (2) test the null hypothesis that avian species richness, composition, and abundance are unrelated to livestock grazing effects; and (3) provide recommendations regarding conservation of bird species, which are identified in the Monument's Proclamation as an "object of biological interest." Differences in bird community composition were detected between mixed conifer and oak woodland, but no differences in avian communities were detected in mixed conifer in association with different levels of livestock utilization (i.e., no grazing effects "signal" was detected). In contrast, grazing influenced bird community composition in both riparian and upland areas of oak woodlands. In general, avian communities associated with high grazing utilization had fewer shrub-nesting, foliage-gleaning, and long-distance migratory species, but higher numbers of ground nesters. Long-distance migrants accounted for 10 of the 24 oak woodland bird species, and 3 of 6 Partners-In-Flight oak focal species included in the analysis. The shrub nesters made up 3 of the 24 oak woodland species, none of which were focal species. The Foliage gleaners made up 10 of the 24 avian species, including 1 focal species. The ground nesters made up 3 of the 24 oak species and 1 focal species. In addition, there were 2 bark gleaners, neither of which were focal species. Thus, if grazing is reduced or eliminated in the Monument it would likely provide net benefits to avian species of conservation concern. Notably, oak woodlands are among the most threatened habitats in southern Oregon and eliminating grazing or limiting grazing periods and density of livestock is consistent with recommendations of the *Partners In Flight* program concerning conservation of bird species associated with this declining habitat type.

- **Butterfly Diversity, Environmental Variation, and Cattle Grazing in the Cascade-Siskiyou National Monument (Erik Runquist, Ph.D. Candidate, University of California, Davis – manuscript in review with a scientific journal)**

Summary - Butterfly assemblages were studied from April through September of 2003 and 2004 along 27 transects located within mixed-conifer forests and oak woodlands of the Cascade-Siskiyou National Monument (Figure 4). Specific hypotheses tested included: (1) cattle grazing utilization does not affect local butterfly species richness, butterfly species evenness, and total butterfly density; (2) life history characteristics do not interact with cattle grazing utilization or other variables to affect butterfly abundances; and (3) individual butterfly species, including those of conservation concern, do not vary in their responses to cattle grazing utilization or other environmental variables. Grazing utilization was initially estimated using a GIS map of utilization constructed by the BLM and later ground-truthed at transects with observed historic grazing in the fall of 2004 using a combination of the key species and stubble height methods. Comparisons of richness, evenness, and butterfly species composition were made across a gradient of increasing grazing utilization. Intra-year grazing utilization level at these transects ranged from low (0-15%) to high (60-74.9%) on a 5-point scale.
Multiple environmental variables predicted butterfly diversity better than grazing utilization with the most significant trends in butterfly numbers and composition related to elevation (and therefore habitat type), the presence or absence of water, percent vegetation cover, and plant species richness. Cattle grazing utilization appears to be a relatively minor predictor of butterfly diversity and abundance, as few trends were

statistically significant and others were inconsistent between years. However, when butterflies were categorized by life history characteristics, analysis revealed that species with grassy host-plants had significantly ($P<0.001$) lower abundance at higher livestock utilization. One of these grass-feeders, the Great Basin wood nymph (*Cercyonis sthenele*), was 70% less abundant ($P = 0.007$, power = 0.902) at high grazing utilization transects than low grazing utilization transects, and no plant richness or cover variable predicted abundance. Management and conservation of butterflies, a recognized "object of biological interest" for which the Monument was established, might best be served by concentrating on environmental factors that are highly correlated with butterfly habitat such as plant species richness and maintenance of grass species for butterflies impacted by grazing such as the wood nymph.

- **Association of Pebblesnail Distribution and Spring Water Quality and Livestock Grazing Utilization in the Cascade-Siskiyou National Monument, Southwest Oregon (Brian R. Barr – National Center for Conservation Science & Policy, Terrence J. Frest, Ph.D. and Edward J. Johannes – Deixis Consultants – manuscript in review with scientific journal)**

Summary – Pebblensail (genus *Fluminicola*) distribution and water quality was studied in springs within and immediately adjacent to the Cascade-Siskiyou National Monument, southwest Oregon (Figure 5). The high diversity of aquatic mollusks and the level of endemism exhibited in this area warranted explicit mention of these taxa as "objects of biological interest" in the Monument's Proclamation. Pebblesnails, in particular, are sensitive to subtle differences in water and habitat quality, requiring clean, cool, oxygen-rich waters and complex habitats. We tested several hypotheses to determine if livestock were compatible with protecting aquatic mollusks: 1) presence of pebblesnails in seeps is independent of livestock utilization; 2) presence of pebblesnails in seeps is independent of stock pond and pump chance development; 3) there is no difference in water temperature of springs across livestock use levels; and 4) there is no difference in dissolved oxygen concentrations in springs across livestock use levels. During 2003 and 2004, we collected aquatic mollusks, water quality data, and livestock utilization measures at 57 headspring sites. Livestock utilization was estimated using a modified BLM protocol consistent with the Klamath Bird Observatory's utilization protocol (see Chapter 4). Springs were stratified into "ungrazed" (utilization = 10%), moderately grazed (utilization >10 to 40%) and heavily grazed (utilization $> 40\%$). We also identified the presence of stock pond and pump chance (for fire suppression) development along each spring system from headspring to stream. Pebblesnail presence was independent of both livestock use and stock pond/pump chance development. Water temperatures were similar across the three livestock utilization categories; however, ungrazed springs showed marginally significantly ($P=0.069$) higher levels of dissolved oxygen. More detailed examination of pebblesnail distribution showed dependence on spring size ($P = 0.024$) with presence at a lower proportion of small springs (defined as springs with a discharge of <0.03 cubic meters [<1 cubic ft] per second) compared to large springs. Water temperature was significantly lower ($P = 0.031$) and dissolved oxygen concentration was significantly higher ($P = 0.044$) for ungrazed small springs, compared to springs with grazing (40 of the 57 springs were considered small based on discharge levels). To maintain water quality in these headwater areas, we recommend that BLM protect smaller springs and their spring brooks by fencing them from cattle or otherwise implementing management actions to retire or limit cattle use within these narrow wetland and riparian areas.

- **Factors Affecting Streams and Watershed Conditions in the Cascade-Siskiyou National Monument, Oregon (Brian R. Barr, National Center for Conservation Science and Policy, Jack E. Williams, Trout Unlimited, Randa Horton, Southern Oregon University, and Michael S. Parker, Southern Oregon University)**

Summary – Differences in stream habitat, riparian habitat, and benthic macroinvertebrate diversity and integrity were investigated in two small watershed pairs (Dutch Oven and East Fork Camp creeks and Mill and South Fork Keene creeks) within the Cascade-Siskiyou National Monument, southwest Oregon. We chose watersheds such that physical characteristics (drainage area, aspect, elevation range, soils, and vegetation) within each pair were similar but the degree of anthropogenic disturbance (grazing activity, roads, and timber management) differed. Riparian habitats, Redband Trout (*Oncorhynchus mykiss*), Jenny Creek Sucker (*Catostomus rimiculus*), and pebblesnails were all designated as "objects of biological interest" in the Monument Proclamation. The effects of livestock grazing are difficult to isolate from the many natural and anthropogenic factors that shape stream and riparian habitats in the Monument. Thus, in addition to livestock grazing, we examined road density, road stream crossings, timber management activities, mining, wildfire events, and soils and erosion hazard within each of the watersheds. Macroinvertebrate samples were collected at 2-3 locations, spread longitudinally throughout each stream during spring and summer. Riparian and stream habitat measures were collected during each macroinvertebrate sampling session. Additional riparian and stream habitat samples were collected during the summer at random locations in Dutch Oven and East Fork Camp creeks, which displayed the greatest discrepancy in grazing use but also had large discrepancies in road densities, road/stream crossings, and percent area recently logged. Livestock utilization and road density were higher in both South Fork Keene and Mill creeks compared to the other pair of streams. South Fork Keene Creek was the most heavily impacted watershed and Dutch Oven Creek was the least impacted watershed examined. Statistical comparisons of stream and riparian habitat conditions showed significantly less surface fine sediments ($P = 0.024$) and significantly greater overhanging grass cover ($P = 0.046$) in Dutch Oven Creek (least impacted by grazing) compared to East Fork Camp Creek (high grazing impacts). Although lacking sufficient sample size for statistical analysis, South Fork Keene Creek (high grazing impacts) had the highest percentage of surface fine sediments, the lowest percentage of riparian vegetation cover, the lowest percentage of overhanging grasses, and the lowest percentage of overhanging woody vegetation. High levels of fine sediments are detrimental for spawning and incubating trout and for the production of benthic macroinvertebrates, a key source of food for predators in aquatic and riparian habitats (Karr 1999). Low levels of overhanging vegetation leads to warming and decreased availability of food for aquatic and riparian predators. Macroinvertebrate diversity documented in our surveys was among the highest recorded by the National

Aquatic Monitoring Center at Utah State University, which provided taxonomic analyses of samples. High diversity occurred in all streams except South Fork Keene Creek. South Fork Keene Creek (high grazing impacts) also displayed the lowest scores in metrics that show high stream integrity. Stream and riparian habitat conditions and macroinvertebrate metric scores all point to South Fork Keene Creek as the least healthy of the watersheds examined. The watershed-level assessment of disturbances suggests Mill Creek and South Fork Keene Creek as being the most impacted, as evidenced by livestock use, proximity to roads, and road stream crossings. Site-level disturbances appear to be more influential than watershed scale conditions in many areas of the watersheds. Attempts to determine a single cause for degraded stream conditions proved problematic. However, roads, timber harvest, and livestock grazing are interdependent upon each other. The high density of roads was created to facilitate timber harvest and is now used as travel corridors by cattle, allowing efficient distribution in the roaded portions of the Monument. Direct restoration actions can be taken relative to both livestock grazing and the road network to address impacts to overhanging vegetation and fine sediment input. The BLM should focus restoration needs on reducing sediment input from roads and retiring or restricting livestock grazing where improvements in stream conditions are especially warranted.

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CHAPTER 4: LIVESTOCK GRAZING UTILIZATION IN THE CASCADE-SISKIYOU NATIONAL MONUMENT

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INTRODUCTION

In partnership with the World Wildlife Fund, Bureau of Land Management Medford District, Oregon State University, University of California at Davis, and other organizations, the Klamath Bird Observatory conducted scientific studies exploring interactions between livestock grazing and five different taxonomic groups in the Cascade-Siskiyou National Monument. Experimental design and study site placement relied on Bureau of Land Management's (BLM) existing assessments of livestock grazing utilization across the monument landscape. While the BLM data on grazing utilization are likely accurate on a landscape scale, they are not sufficiently detailed for describing the utilization at a particular study site. The analysis of data collected as part of our 5-taxa study require grazing utilization information specific to the site scale, particularly for species that exhibit limited mobility (plants, aquatic mollusks, perhaps some butterflies and mammals). Watershed scale information about utilization, based on site-specific measures, are needed for verifying landscape level utilization measures collected by the BLM using more generalized techniques.

METHODS

In order to acquire site-specific grazing utilization data, cooperators completed Herbaceous Removal - Key Species transects at a variety of study sites within the Monument during 2003 and 2004 following standard methods (Alexander et al 2003; Cooperative Extension Service et al. 1999). Key Species were employed along 50 point transects. Some transects varied in number of points based on availability of homogeneous habitat. Transects were marked using GPS units with location readings collected at the beginning and end of each transect and at points where transects deviated from a straight line. Before each transect was read the key species was determined by choosing the dominant palatable grass species at the study site. A reference plant, that showed no evidence of herbivory, was collected, measured and weighed to develop a height and mass table to be used for estimating percent utilization for the key species at each point along the transect.

Fifty meter-tape measures were stretched along each transect and points were established every meter. Surveyors recorded utilization estimates at each point for the transect's key species by measuring the height of the individual specimen that was closest to each point. Estimates of utilization for each transect were obtained using procedures outlined in Cooperative Extension Service manual (1996). Data from 2003 and 2004 were combined and analyzed together. In all cases when transects were repeated, only the most recent transect was incorporated in the analysis, and others were disregarded. For each utilization transect, a reference specimen (one that showed no sign of herbivory) of the key species was collected at each transect. The plant was then cut into segments and each segment weighed. These data were used to generate a height-mass curve that was then used to calculate the volume utilized (percent of plan mass eaten) based on height measurements collected for individuals of that species along the transect. Key species stubble height at each point along the transect was translated into a percentage height removed. In order to avoid negative percent height removed values, reference plant height was raised to match the tallest key species height on the transect. Percent phytomass removed was estimated by plugging percent height removed into the formula relating height and weight for each key species. The mean of all points' percent phytomass removed was calculated to give an overall utilization estimate for each transect. Transects were then grouped by the 7^{th}-field watersheds in which they were established and the transect-level utilization estimates were averages to provide a landscape level scale measure of utilization.

RESULTS

Data were analyzed for 156 transects (Table 2, Figure 7). Number of points per transect varied between 9 and 100 though the majority of transects (n = 99) were made up of 50 points. Among all transects, the mean transect utilization averaged 46% ranging from 9.7% to 97.6%. The standard deviation of mean transect utilization, which is a measure of utilization variability within transects, averaged 25.1 ranging from 4.2 to 59.4. Figure 8 displays a histogram showing the distribution of mean transect utilization for all transects.

Data were analyzed for 35 7th-field watersheds (Table 3, Figure 9). Number of transect per watershed varied between 1 and 15 averaging 4.4 transects per watershed. Among the watersheds the transect-level utilization estimates within each watershed averaged 43.9% ranging from 10.8% to 69.8%. The standard deviation of transect-level utilization estimates (within watersheds containing more than one transect), which is a measure of utilization variability within a watershed, averaged 16.2 ranging from 6.4 to 33.2.

DISCUSSION

This report provides a measurement of mean utilization along Herbaceous Removal - Key Species Transects that were collected as part of a study investigating interactions between livestock grazing and five different taxonomic groups in the Cascade-Siskiyou National Monument. Each transect in Table 2 is geo-referenced allowing investigators to associate site specific utilization measurements with the various sites included in this study. Additionally, landscape-level measurements of utilization are provided based on the 7th-field watershed scale. Each watershed is listed in Table 3 with unique watershed identifiers. These data can also be compared with landscape level utilization maps that have been provided by the Bureau of Land Management.

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CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS RELATED TO THE MONUMENT'S PROCLAMATION

> *"The Monument is home to a spectacular variety of rare and beautiful species of plants and animals, whose survival in this region depends upon its* ***continued ecological integrity"*** *(emphasis added).*
>
> *"Study the impacts of livestock grazing on the objects of biological interest in the Monument with specific attention to* ***sustaining the natural ecosystem dynamics"*** *(emphasis added).*
>
> *Should grazing be found incompatible with* ***protecting the objects of biological interest****, the Secretary shall retire the grazing allotments pursuant to the processes of applicable law" (emphasis added).*
>
> *"…hereby set apart and reserves as the Cascade-Siskiyou National Monument, for the purpose of* ***protecting the objects****..........(emphasis added)"*
>
> *Presidential Proclamation – Cascade-Siskiyou National Monument*

In this section, we evaluate livestock management options against three key Proclamation provisions: **(1) continuing ecological integrity**; **(2) sustaining natural ecosystem dynamics**; and **(3) protecting the objects of biological interest**. Based on the evidence summarized in this report and these Proclamation mandates, we conclude that livestock grazing impacts are incompatible with protecting the Monument's objects of biological interest and sustaining natural ecosystem dynamics. Thus, retirement of grazing leases is the most ecologically appropriate means to meet the Proclamation's protection mandate.

Continuing ecological integrity - the concept of "ecological integrity," though complex and difficult to define, has gained broad acceptance in scientific and regulatory communities (Davis 1995, Karr 1992, Pimentel et al. 2000, Slosser et al. 2005) and thus the Proclamation's emphasis on integrity is scientifically sound. Karr and Dudley (1981) provide perhaps one of the most widely cited definitions of ecological integrity:

> *"The ability of an ecosystem to support and maintain a balanced, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region."*

Integrity implies not only continuity of function and ecosystem productivity but also "*an unimpaired condition or the quality or state of being complete or undivided*" and "*correspondence with some* ***original condition***" or "***naturally evolved state***" (emphasis added; Karr 1992).

We interpret ecological integrity to mean providing for composition, structure, and function of ecosystems within the context of "*unimpaired*" or "*undivided*" conditions and corresponding to some original state (reference condition) or naturally evolved set of conditions. In Chapters 2 and 3, we concluded that livestock management was incompatible with the Proclamation's emphasis on protection of biological objects and natural ecosystem dynamics. Based on ecological integrity concepts, the ability of the ecosystem to support and maintain a balanced, adaptive community of organisms is therefore constrained by introduced, non-native commercial livestock, as their continued presence favors some species at the expense of others and interferes with natural ecosystem dynamics.

From an evolutionary and ecological perspective, livestock are a recent and exotic (Wagner 1989, Painter 1995) addition to the West in general and to the Monument's native flora and fauna in particular. Likely negative effects of livestock on the Monument's plant communities inferred from the literature (see Chapter 2) may be due to the lack of adaptations by some native species (e.g., native perennial bunch grasses) to large hoofed ungulates that have not been part of the *evolutionary history* or ecology of the region since at least the late Pleistocene (10,000 years ago). Further, cattle do not contribute to an "*original condition*" or a "*naturally evolved state*" since their large size, foraging methods (i.e. close cropping of plants), and foraging behavior (e.g., high concentrations for long periods in riparian and shaded areas) are markedly different than native ungulates (see Chapter 2). Thus, livestock are incompatible with ecological integrity as they were never part of the indigenous fauna of the area and have significantly altered biological communities and natural processes as noted below.

Natural ecosystem dynamics - We defined natural ecosystem dynamics as ecological processes integral to the health and resiliency of landscapes, including fire, floods, natural herbivory, and other natural disturbances that interact with the objects of biological interest and upon which the objects depend.

Despite varied effects of livestock grazing on ecosystem processes (Chapter 2), it is clear that the preponderance of evidence demonstrates that livestock grazing differs in many ways from grazing by native ungulates, and that livestock alter biological communities and natural processes in ways that are degrading to ecological integrity. While grazing benefits have been reported in the literature under certain conditions, the degree of control required to achieve desirable effects in terms of exotic species and grassy fuel reductions is rarely possible with commercial herds and may actually result in overgrazing of desirable species (Tu et al. 2001). Rugged terrain and remoteness in the Monument make careful control of livestock both costly (see below) and unlikely to be achieved in practice, particularly given real-world staff and budget limitations.

Disruption of ecosystem dynamics by livestock were inferred from the literature or detected in our studies (terrestrial and aquatic – see Chapter 3) and are summarized as follows:

- <u>Alteration of riparian and stream processes</u> – While riparian areas represent less than 1% of the landscapes of the West, including the Monument, they are used disproportionately by wildlife (Kauffman et al. 2001). They also are places where livestock congregate particularly in dry regions where water is limited and in steep terrain where riparian areas may represent the only suitable area for livestock. For example, in a grazing allotment within the Blue Mountains, Oregon, the riparian zone comprised only 2% of the allotment area, but produced 21% of the available forage and 81% of forage consumed by cattle (Roath and

Krueger 1982 cited in Belsky et al. 1999). In fact, cattle spend 5-30 times as much time in these cool, productive zones than would be predicted from surface area alone (Roath and Krueger 1982 in Belsky et al. 1999). Consequently, concentrations of livestock in these areas alter riparian ecosystem processes, a phenomenon widely documented across western landscapes (Fleishner et al. 1994, Knapp and Matthews 1996, Belsky et al. 1999, Kauffman et al. 2001, Krueper et al. 2003, Stevenson 2004). Cattle degrade riparian areas through the effects of forage removal, soil compaction, streambank trampling, and introduction of exotics (Kauffman et al. 2001 – also see below illustration). Livestock use generally has been noted by BLM as extensive in riparian areas throughout the Monument (BLM 2005; Box O testimony of R. Drehobl, August 31, 2005). Likewise, we documented significant impacts from livestock grazing along stream banks that included reduction of overhanging bank vegetation, increased fine sediments in riffles and pool tail-outs, and decline in abundance of riparian associated small mammals (see Chapter 3 summaries). Such changes to riparian ecosystem dynamics are known to impact native coldwater fish by increasing stream temperatures and reducing spawning success (Li et al. 1994, Waters 1995, Lee et al.1997). Notably, the Jenny Creek area is a water-quality (temperature) listed stream as determined by the State of Oregon, and livestock-related water quality problems have been noted by the BLM for this particular stream (Box O testimony by R. Drehobl, August 31, 2005 – J. Walt and The Box D Ranch Appellants v. BLM OR-110-010-02) as well as many others in the Monument (BLM 2005).

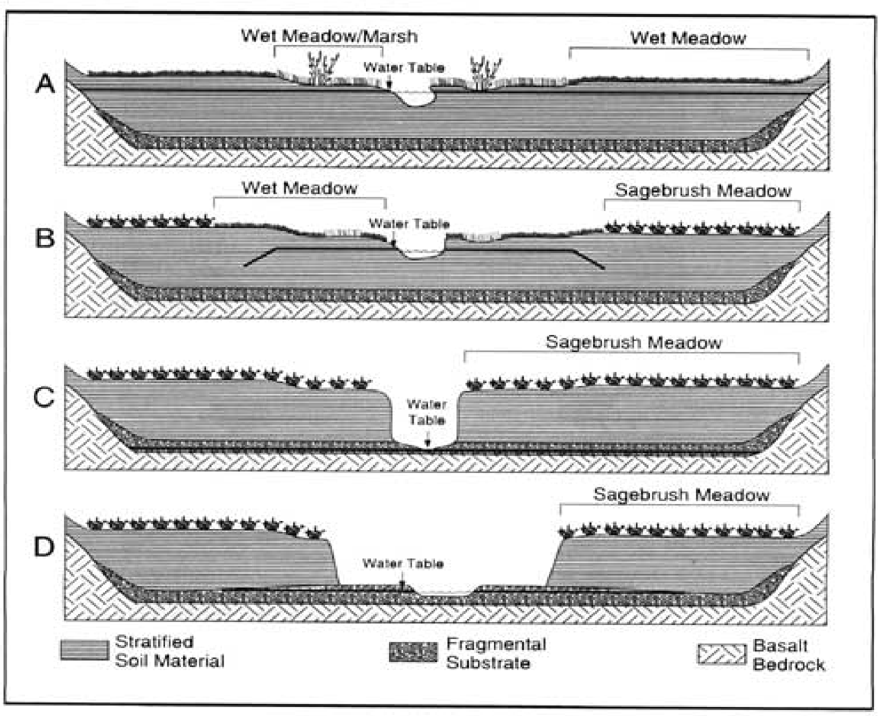
- Disruption of hydrologic processes, water quality and quantity in springs – Springs are an important component to biodiversity in the arid West, providing habitat to many unique plants and animals. In particular, all of the Special Status snails found in the Monument are spring obligates. Management of the landscape for livestock grazing interacts with springs in several ways. Livestock often concentrate around springs as these habitats provide a consistent source of water, cover, and palatable forage (also see Box O testimony by R. Drehbohl, August 31, 2005 – J. Walt and The Box D Ranch Appellants v. BLM OR-110-010-02). This concentrated activity results in the consumption and trampling of the vegetation surrounding springs and increased deposition of nutrients from animal waste (see photos in Appendix C and illustration below). These two factors allow greater amounts of silt and nutrients to enter spring systems during precipitation events (Thomas and Toweill 1982, Kauffman and Krueger 1984, Fleischner 1994). Our studies (see Chapter 3) found that small springs with heavy livestock utilization had lower dissolved oxygen and higher temperatures. Since many of these springs are in headwater areas they present potential water quality problems that can migrate down stream. In addition, stock ponds and pump chance ponds (used for fire suppression) in the Monument impound water from springs and therefore may violate the Monument's Proclamation regarding "***a quantity of water sufficient to fulfill the purposes for which this monument is established (emphasis added).***" Decreasing flows in springs through diversion is likely to result in greater water temperature variation, including greater high and more extreme low temperatures (Sada et al. 2001) such as those observed in our study. Livestock related diversions also disrupt hydrological connectivity, altering natural ecosystem dynamics of aquatic systems.

- <u>Alteration of predator-prey dynamics</u> – Small mammals are important prey for several raptors that occur in the Monument, including Golden Eagle (*Aquila chrysaetos*), Red-tailed Hawk (*Buteo jamaicensis*), Northern Goshawk (*Accipiter gentilis*), and several owls (Barred Owl (*Strix varia*), Northern Pygmy-Owl (*Glaucidium gnoma*), Great Gray Owl (*S. nebulosa*), Western Screech-Owl (*Otus kennicottii*) and Northern Spotted Owl). Small mammals are also important prey for many other mammals that occur or possibly occur in the Monument, including Pine Marten (*Martes martes*), Ermine (*Mustela* spp.), Long-tailed Weasel (*M. frenata*), Skunk (*Mephitis mephitis* and *Spilogale gracilis*), Mink (*Mustela vison*), Raccoon (*Procyon lotor*), Coyote (*Canis latrans*), Bobcat (*Felis rufus*), and Mountain Lion (*F. concolor*), as well as several reptiles (rattlesnake, gopher snake, etc). The alteration of food-web dynamics by livestock has been previously documented in the literature (Freilich et al. 2003), and our field studies documented lower abundance of woodrats and Deer Mice in heavily grazed mixed-conifer forests and oak woodlands (Chapter 3). Woodrats and Deer Mice, in particular, are important prey for the Northern Spotted Owl in southern Oregon (Forsman et al. 2004) and abundance of Deer Mice has been positively associated with owl reproduction in the Oregon Cascades (Rosenberg et al. 2003). Livestock, therefore, may alter predator-prey dynamics to some degree for this federally protected owl as well as other predaceous species in the Monument.

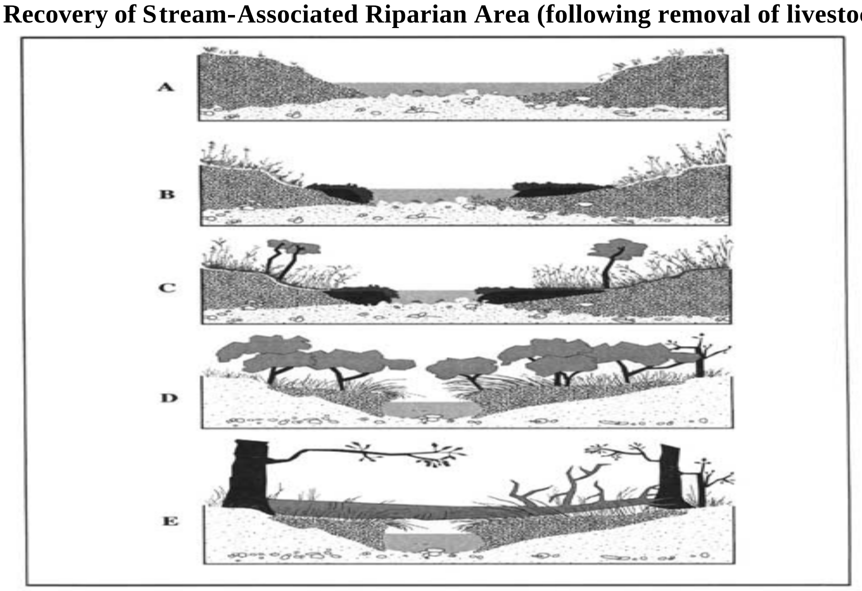
- Facilitation of weedy invasions, disruption of soil processes, and alteration of fire regimes – The weight of evidence presented in Chapter 2 on livestock grazing effects and the difficulty in carefully controlling livestock to reduce weedy invasions and grassy fuels (especially in remote areas) indicates that their removal would have net benefits to ecosystem processes and biological objects in the Monument. Livestock removal would likely: (1) slow weed spread (particularly yellow star thistle which is advancing from the south); (2) favor recovery of native bunchgrasses in the long run; and (3) restore infiltration, soil porosity, water holding capacity, and soil biota. In places in the Monument where native plant populations persist as islands embedded in a "sea" of weeds (e.g., along roads, the southern section of the Monument, and many other places where weeds are especially evident), livestock tilt the competitive advantage to weedy species, which, in turn, overtakes native plant populations. In addition, photo evidence presented in Appendix C illustrate soil damage was extensive in places where livestock congregated especially in riparian areas (this contributes to sediment deposition to streams), road side bank cuts used as travel corridors by livestock, stock ponds, and seeps.

- Degradation of riparian areas by cattle – Because riparian areas are disproportionately used by both cattle and wildlife and significant grazing impacts were detected in our field studies for this particular object of interest, we have provided the following illustration from a report by the Forest Service and BLM of how cattle alter stream channel dynamics:

Sequential Degrading of Stream Channel by Livestock



Recovery of Stream-Associated Riparian Area (following removal of livestock)



"Heavy grazing by livestock most severely affects the stream channel. Livestock tend to spend a large portion of their time within the riparian community where they trample riparian vegetation and streambanks. Eventually protective riparian vegetation is lost. Streambanks are sheared off through trampling and become erodible. As riparian areas are degraded, accelerated erosion incises stream channels, lowering water tables and restricting historically wide floodplains to narrow riparian communities in wash bottoms. Once streambanks are broken down and eroded, streams are left wide and shallow with significantly less living space or hiding cover for fish. Wide streams have huge surface areas exposed and susceptible to increased water temperatures and rapid evaporation. Eroding streambanks contribute excessive sand and silt accumulation over the stream bottom, decreasing aquatic invertebrates (fish food) production and smothering fish eggs in spawning areas."

USDI-BLM and USDA-Forest Service. 1995. Rangeland Reform '94 Draft Environmental Impact Statement. BLM. Washington, DC: 3-46 (citing USDI-BLM. 1993. Riparian area management: process for assessing proper functioning condition. Tech. Ref. 1737-9. Bureau of Land Management, Service Center, Denver.

Riparian degradation by cattle is currently occurring throughout the Monument as riparian areas contain forage and shade that concentrate livestock (see photos in Appendix C and studies in Chapter 3). Therefore, livestock are negatively impacting natural ecosystem dynamics within the Monument's riparian areas. Recovery similar to that depicted in the above illustration, however, is taking place in the Box O where cattle have been largely restricted since 1995. It follows that the benefits to riparian areas and ecosystem dynamics from livestock removal occurring in the Box O are transferable to other riparian areas in the Monument if livestock are similarly removed.

Objects of Biological Interest - Based on field studies we conducted, there is sufficient evidence to conclude that livestock grazing is incompatible with protecting the following objects of biological interest:

- small mammal communities and, in particular, those that are important prey items for the Northern Spotted Owl (e.g., woodrats, Deer Mice);
- shrub nesting, foliage gleaning, and neotropical migratory birds (although ground nesters were positively associated);
- butterflies associated with grass host plants (e.g., Great Basin wood nymph – although butterflies as a community responded more to habitat than grazing);
- streamside (riparian) vegetation and related ecological processes, including grasses, overhanging bank vegetation, and sedimentation;
- water quality properties (dissolved oxygen and temperature) and water quantity problems in springs through diversion of headwater areas for stock ponds; and
- mixed conifers and oak woodlands where impacts were observed for several taxa.

The continued presence of livestock therefore is tilting the competitive balance of biological objects in favor of species more adapted to grazing at the expense of natural ecosystem dynamics and native species less adapted to grazing. Ongoing livestock related impacts, therefore, present significant challenges to BLM in upholding the Proclamation's protection mandate.

EVALUATION OF GRAZING MANAGEMENT OPTIONS

The Monument Proclamation specifies that grazing must end if BLM finds it to be incompatible with the Monument's protection mandate. BLM, however, has ostensibly taken the position that if current grazing is incompatible with protection then it may modify grazing practices in an attempt to make this activity compatible (BLM 2005). There is no mention of "*modify*" in the Proclamation. Therefore, whether the Monument Proclamation leaves the agency with discretion to "*modify grazing*," rather than to end it, will likely be decided by the courts. Since BLM is likely to consider a modified grazing regime (BLM 2005), however, we examine this option here despite its absence from the Proclamation's direction.

Rangeland ecosystem management traditionally has relied on altering stocking densities, timing, duration, and seasonality of cattle to manipulate the quality of rangeland conditions primarily for livestock. Other techniques such as livestock exclosures, fencing, herding, and permanent removal of livestock have been used to restrict livestock and allow for ecosystems to recover. We examine some typical livestock management approaches and present a case for ending livestock grazing as the most cost effective and ecologically appropriate means for meeting the Proclamation's protection mandate.

- *Exclosures and rest rotations* – Most livestock exclosure studies suggest that livestock operate as keystone species: they determine which species thrive and diminish and therefore alter biological communities. Some exclosures, however, have not resulted in significant or lasting ecosystem changes following livestock removal because (a) certain grasslands have a very tight evolutionary association with native grazers (Great Plains) while others do not (e.g., the Monument) and therefore response to livestock varies based, in part, on an evolutionary predisposition to grazing (Baker 1978, Mack 1989, Wagner 1989, Heady et al. 1988, Painter 1995); (b) landscapes have been so altered historically by livestock grazing that they cannot return to an original condition or higher ecological integrity (e.g., desert grasslands of the Southwest; Neff et al. 2005); (c) insufficient time has elapsed for detecting post-grazing changes (Marlow and Pogacnik 1985, Elmore and Beschta 1987); and (d) most exclosures are too small to pick up ecosystem changes or function as intact ecosystems. Bock et al. (1993) recommended that exclosure programs include 20% of each parcel of land with a minimum size of 2,500 acres located so they are representative of major habitats. According to Bock et al. (1993), "***sensitive species in western landscapes have nearly always been reduced by even intermediate levels of livestock grazing, while grazing-tolerant species come to predominate, even if pastures were "rested" on a rotational basis*" **(emphasis added)**. They concluded that range improvement efforts, *much like grazing itself*, have been experiments without permanently ungrazed controls and thus require large ungrazed landscapes (e.g., several Box O size controls are needed for proper experimental design). Thus, restricting grazing through the use of exclosures is more likely to provide significant benefits to biological objects if exclosures are sufficiently large

(>2,500 ac), replicated across major plant communities, particularly those sensitive to grazing (e.g., riparian areas, wetlands, oak woodlands), and maintained over long periods (at least a decade – longer for restoring sensitive soils and related processes). We note that although large livestock exclosures are preferred over smaller ones, exclosures are not fool proof methods for restricting livestock. Livestock or their presence were observed and reported to the BLM on several occasions by researchers in this study. Enforcement problems have been noted by BLM staff for fenced areas like the Box O, and gates have been frequently left open and fence lines cut (see Box O testimony by R. Drehbohl, August 31, 2005 – J. Walt and The Box D Ranch Appellants v. BLM OR-110-010-02). Thus, if fencing or exclosures are used, BLM will need to bolster monitoring and enforcement efforts in order to ensure that exclosures (large or small) truly restrict livestock entry. This will require substantial increases in budget and staff levels over time that BLM does not have now nor can guarantee in the future. Furthermore, even if areas are fenced to prevent riparian trampling, BLM may continue diverting water for cattle, disrupting aquatic processes (Freilich et al. 2003) and competing with water demands of aquatic wildlife. Diversion of water for livestock appears to violate the Monument's Proclamation related to maintaining "***a quantity of water sufficient to fulfill the purposes for which this monument is established.***"

- *Fencing and associated costs* –Fencing, whether as part of exclosures or riparian fence lines, including electrical wiring, may be useful (although these too have enforcement and monitoring problems) in restricting livestock access to sensitive areas, particularly wetlands and riparian areas. Fencing would reduce impacts in places where livestock congregate or where impacts were noted by field studies, such as riparian areas, small seeps, mixed-conifer forests, and oak woodlands. Using GIS (see Appendix D1 for methods), we estimated a total of 148 miles of fencing would be needed to minimize livestock damage to the biological objects within oak woodlands, mixed-conifer forests (older forest types), small springs, and streamside areas (Table 4, Figure 10). Of this, 41 miles of fencing would be needed along streams and small springs. However, because there was considerable overlap between aquatic areas and terrestrial areas already recommended for fencing, we included only 7 additional miles of fencing along streams and seeps in this estimate (Table 4). Additional fencing in these areas was recommended for ten springs outside of fenced terrestrial areas. Two of these were in the Dixie allotment (on the southeastern edge of the Monument) that required 0.8 miles of fencing, and the remaining eight were in the Keene Creek allotment that required 3.2 miles of fencing (see Figure 10). We recommend excluding cattle from seeps by using 0.10 mile of fencing on each side of the seep**.** However, site conditions may call for either a larger or smaller exclosure based on slope and soil types with steeper slopes and less erodible soils calling for smaller fenced areas. In addition, 3 stream segments were recommended for fencing outside of proposed oak woodlands and mixed-conifer areas also requiring fencing. These segments include upper Mill Creek (1,250 feet in length) within Keene Creek Pasture of the Soda Mountain Allotment, lower Jenny Creek (1,500 feet in length) within the North Pasture of the Jenny Creek Allotment, and upper Beaver Creek (2,750 feet in length) within Keene Creek Allotment. Each of these fenced segments should be ~250 feet wide.

Based on estimated installation costs of $25,000 per mile plus annual maintenance costs, the use of fencing to reduce impacts to objects of interest is ~$4.8 million for the first ten years (Appendix D2). These costs do not include new studies needed to monitor experimental grazing regimes (if attempted with or without fencing), and enforcement of gate closures and fence lines (fences break down or are occasionally cut – see photos in Appendix C). As an example, BLM spent ~$1 million on its grazing studies in the Monument and studies would need to be repeated if modified grazing were chosen by BLM. Additionally, the use of fencing may restrict wildlife movements, presenting problems regarding natural ecosystem dynamics and ecological integrity. This is in comparison to ~$36,000 (at ~$3,664 per year) of revenues generated by Monument grazing fees over a ten year period.

- *Permanent livestock removal vs. livestock reductions* - In numerous studies of riparian grazing effects, investigators concluded that total removal of livestock is necessary to restore ecosystem functions (see Krueper et al. 2003, Freilich et al. 2003 for reviews). Reductions in grazing stocking densities, in comparison, have been shown to have limited benefits (Fleishner 1994). Kauffman et al. (2004) noted that if their entire study area were excluded from livestock, the top surface of 10 cm of soil in restored meadows alone could potentially store $16.6x10^6$ times the amount of water available compared to grazed areas, making water more available for fish and wildlife species. Thus, removing cattle would better enable BLM to meet the water quantity requirements of the Monument's Proclamation. Knapp and Matthews (1996) concluded that restricting or eliminating grazing in the Sierra Nevada Range, California would increase meadow stability, improve habitat for trout, and enhance conditions for a wide range of other riparian species. Further, Earnest et al. (2004) indicated that of 51 avian species studied in the Columbia Plateau, 71% exhibited a positive trend in detections and 76% of species with significant change (either positive or negative) increased following permanent livestock removals. In particular, aspen and willow communities exhibited dramatic increases in cover (riparian vegetation also has been improving dramatically along Jenny Creek in the Box O area due to tree planting and exclusion of livestock – testimony by R. Drehbohl, August 31, 2005 – J. Walt and The Box D Ranch Appellants v. BLM OR-110-010-02). Kreuper et al. (2003) noted a 4-6 fold increase in riparian vegetation in southeastern Arizona, immediately following removal of cattle. Removal of cattle led to rapid and substantial recovery of riparian and mesquite vegetation and bird populations, including several species of high conservation concern. Popolizio et al. (1994) studied four grazing treatments in montane riparian forests of north-central Colorado: long-term grazing, protection from grazing since 1956, recent protection following long-term grazing, and recent livestock grazing following protection. They reported that differences resulting from grazing vs. protected treatments became more apparent when less frequent and rare species were considered. In particular, the recovery of ecosystems following grazing can take decades (Marlow and Pogacnik 1985, Elmore and Beschta 1987 also see Appendix B2); therefore, permanent removal is preferred over temporary restrictions (such as flash grazing, seasonal restrictions, etc). Neff et al. (2005) noted that even 30 years after livestock grazing was prohibited in Canyonlands National Park (southeastern Utah), surface soils in the historically grazed area had 38-43% less silt and 14-51% less total elemental soil content relative to soils that had never been exposed to livestock disturbances. Differences in nutrient levels were related to wind erosion of soil fine particles still evident decades after historical disturbance by livestock.

CONCLUSIONS AND FINAL RECOMMENDATIONS RELATED TO THE PROCLAMATION'S PROTECTION MANDATE ("*SET APART FOR THE PUROSE OF PROTECTING THE OBJECTS*")

We provided three lines of evidence that together document incompatibility between livestock grazing and protection of the Monument's objects of interest: (1) field studies documenting multiple impacts of grazing across taxa (objects); (2) literature reviews from comparable regions and habitat types on livestock impacts to natural ecosystem dynamics, especially in areas of high conservation concern that are also biological objects (e.g., riparian areas, small springs, mixed conifers, and oak woodlands); and (3) photo documentation of livestock grazing impacts in the Monument. Moreover, we review relevant case law that supports a higher standard for the Monument than other BLM lands where livestock grazing is typically monitored through rangeland health assessments and modified according to local management objectives as noted below.

Case law - Relevant case law (TWS vs U.S. Fish & Wildlife Service, 316 F.3d 913) defines "**compatible use**" as a "**wildlife-dependent recreational use or any other use of a refuge that, in the sound professional judgment of the Director, will not materially interfere from the fulfillment of the mission of the System or the purposes of the refuge."** The Refuge Act permits uses within a Refuge only if they "*are* *compatible with the major purposes*" for which the area was established (16 U.S.C. § 668dd(d)(1)(A)). Further, the Refuge Act defines "compatible use" as a use that "*will not materially interfere from the fulfillment of the mission of the System or the purposes of the refuge*" (16 U.S.C. § 668ee(1)). Notably, the Monument's Proclamation carries a higher standard than even the National Wildlife Refuge compatibility determination, which, in this case, was based on a recreation rather than a protection mandate. Consequently, the Proclamation's compatibility requirement is more analogous to the Wild and Scenic Rivers Act, which requires BLM to "*protect and enhance the values which caused it to be included" as a Wild and Scenic River* (16 U.S.C. § 1281(a)[9]). Interpretation of case law supports the notion that livestock materially interfere with the fulfillment of the Monument's Proclamation mandate. Thus, based on comparable case law regarding compatibility determinations and the extensive documentation presented in this report, BLM should retire grazing in order to best comply with the Proclamation.

Although many view ranching as relatively innocuous, and as a culturally and historically valuable legacy of the Old West, the results summarized in this report and the weight of scientific evidence (e.g., Bock et al. 1993, Fleishner et al. 1994, Belsky et al. 1999, Freilich et al. 2003, Kauffman et al. 2004) demonstrate that ranching is not an ecologically benign activity. The Monument's Proclamation provides unambiguous guidance to BLM that *"should grazing be found incompatible with* ***protecting the objects of biological interest****, the Secretary* ***shall retire*** *the grazing allotments pursuant to the processes of applicable law (emphasis added)."* Moreover, because the single purpose for the Monument's designation was to protect the objects of interest, the standard for determining compatibility needs to be higher (such as for Wild & Scenic Rivers) than in places where BLM's mandate is multiple-use management. Should BLM decide to modify grazing to mitigate impacts rather than retire it as an incompatible activity, additional livestock restrictions such as fencing could cost ~$4 million to continue a

[9] Oregon Natural Desert Association v. Singleton, 47 F. Supp. 2d 1182, 1192 (D. Or. 1998) rejected BLM's contention that grazing in Wild and Scenic River corridor was presumptively allowed unless such use was demonstrated to result in a "substantial likelihood" of "substantial degradation" of river values. Oregon Natural Desert Association v. Green, 953 F. Supp. 1133, 1144-45 (D. Or. 1997) also rejected BLM's contention that it was required to restrict grazing "only where grazing would "substantially interfere" with the public's enjoyment of Wild and Scenic river corridor."

program that yields only ~$3,664 annually in grazing receipts (~ $40,000 over ten years). The substantial costs of fencing coupled with terrain and remoteness plus enforcement and monitoring problems associated with intensively managing livestock in order to mitigate impacts or provide some ecosystem benefits (i.e., under specific conditions – see Chapter 2) make "modified" grazing far less likely (and therefore incompatible) than retirement to achieve the higher standard of protection required by the Proclamation.

Ecosystem restoration needs – Livestock grazing has taken place in the Monument area for over a century and, based on the results of the studies presented here, continues to negatively impact riparian areas, springs, oak woodlands, mixed conifers and wildlife communities. Even if livestock were removed immediately, it would take decades to restore ecosystem integrity. This is especially the case as livestock are one of many factors that over time have contributed to diminished integrity in the Monument, which has a history of logging, road building, fire exclusion, and seeding with non-native species. Thus, we recommend the following restoration activities be coupled with livestock removal:

- *Restore hydrological function and connectivity to springs altered by livestock management in order to better meet the Monument's Proclamation regarding a sufficient quantity of water* – Fifty-seven seeps were located in the Monument (see Chapter 3 and Figure 5); many of which were degraded by diversion (berms) of flows for pump chances and stock ponds. The hydrology of seeps needs to be restored by reconnecting flows diverted for livestock and removing barriers (such as berms – also see Box O testimony of R. Drehobl, August 31, 2005). This is particularly important in headwater areas where diversion of flows can disrupt the continuity and ecology of the seep throughout its downstream hydrology. Notably, the Jenny Creek watershed is already constrained by diversions that transfer 1/3 of the water from the drainage to Bear Creek and therefore livestock represent a cumulative impact to water quantity that otherwise would be available to the biological objects.

- *Restore riparian vegetation and stream bank morphology* – Grazing along streams has disrupted bank stability and altered vegetation communities. Planting willows and other riparian species, as for example, the outstanding restoration taking place along Jenny Creek on the Box O, would stabilize banks and restore vegetation and this exemplary work should be replicated across the Monument.
- *Aggressively contain and, if possible, eradicate invasive species* – Livestock act both as vectors of weed spread and also may feed on weeds and limit spread (see Chapter 2). However, in places where source pools of native plants persist, the removal of livestock would allow native populations to eventually recover, particularly if other weed containment measures are supplemented. Weed eradication other than livestock grazing should be experimentally introduced using an adaptive management approach.
- *Experimentally reintroduce fire through prescribed burning and prescribed wildland fire* – Many places in the Monument have experienced shifts in plant communities associated not only with livestock grazing, but with fire exclusion. Fire is a key ecosystem process that is integral to the persistence and viability of fire-dependent biological objects in the Monument (e.g., oak woodlands, chaparral communities – see Chapter 2). In the northern section of the Monument, where private lands and BLM lands abut, management should focus on treating near surface and ladder fuels prior to reintroduction of fire within the appropriate Plant Association Groups. BLM should expand outreach to private landowners regarding defensible space management. In contrast, wildland fire should generally be prescribed in the southern more remote sections of the Monument, particularly in chaparral where high severity fire is the norm and mid to upper elevation mixed-conifer forests where mixed severity fire is part of the historic fire regime of the area (some of these areas may require ladder fuel reductions and small tree thinning prior to re-introduction of fire due to suppression history).
- *Enforce grazing restrictions that prohibit cattle trespass in the Monument* -BLM needs to tighten enforcement of grazing restrictions to ensure that if leases are permanently retired trespass will be regulated or if leases are continued it is capable of enforcing restrictions given the well documented problems with

trespass. In addition to exclosure and Box O violations, cattle trespass occurs in the southern portion of the Monument across the state line from California and enforcement measures need to be tightened. Fencing along the state line should be part of efforts to restrict livestock from entering the Monument from the south.

In conclusion, the Proclamation requires a compatibility determination. *"Should grazing be found* ***incompatible with protecting the objects of biological interest****, the Secretary* ***shall retire*** *the grazing allotments pursuant to the processes of applicable law (emphasis added)."* Based on field studies, literature reviews, and photo evidence presented in this report, grazing appears incompatible with the Monument's protection emphasis as indicated in the authorizing Proclamation. Thus, in order to fulfill the Proclamation's protection mandate and the specific language with regard to grazing impacts, BLM should retire commercial livestock grazing allotments in the Cascade-Siskiyou National Monument.

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