Report of Science Advisors: *Supplement on Rangeland Management*
Solano County Habitat Conservation Plan and Natural Community Conservation Plan

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Draft: January 5, 2004

1. Introduction

This report supplements the "Report of Science Advisors, Solano County Natural Community Conservation Plan and Habitat Conservation Plan" (Noss et al. 2002), which was completed in November 2002. The Solano County Water Agency recognized the need for supplemental input regarding rangeland management, and recruited the authors after this date. Consequently, the authors did not have the opportunity to participate in the August 2002 workshop of the science advisors. This report uses a format similar to the science advisors' report, but does not repeat the background information.

This report summarizes an independent scientific review of the rangeland management issues associated with the conservation and resource management guidelines and specific information presented in the "Report of Science Advisors." This report focuses primarily on the scientific basis for management of the effects of livestock grazing on the special-status species covered by the Natural Community Conservation Plan and Habitat Conservation Plan (NCCP/HCP). It discusses how livestock grazing might affect other critical features of the ecosystems supporting these resources. Circumstances where grazing management can be useful in managing specified resources as well as situations where grazing may be problematic are addressed. The need for monitoring and a cautious approach to change, including removal of grazing, is emphasized. In addition, the report discusses rangeland management issues other than livestock grazing, including restoration of native grasslands, fire hazards, and oak woodlands.

2. Research Needs

It is important to recognize that the scientific literature and research record does not address conservation challenges associated with the special-status species of Solano County rangelands to the degree desirable for the design and planning of specific practices for their management and monitoring. In particular, we do not know the current "trend" for many of these species, and we have no way of knowing what the current vs. potential population levels might be. All we know from their "special status" designation is that they are either not widespread in the region,

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or few in number. In short, we do not know what effect current management practices are having on many of these species, positive or negative. We can speculate based on assumed relationships between habitat conditions and species welfare, and to some extent from research done elsewhere, but in fact habitat conditions are seldom considered on a landscape basis, in terms of the balance of diverse habitat conditions that may be found over a larger-scale and the populations that the landscape can support. A species that might use a dense woodland for breeding might use a more open habitat for foraging, and so forth. Considerable investment in changing one type of habitat may have little effect, or negative effect, if it reduces other types of habitat or if another habitat type is the limitation on the species. Further, enhancement of conditions for one species may cause declines in another.

Overall, a cautious and "adaptive" approach is appropriate, where changes in management regimes are tested prior to widespread adoption, and species response is monitored over time. Research and management should be done with controls adequate to determine the effect of management decisions on management targets over time. Because weather effects will overshadow most management activities on a short term basis, adequate time to evaluate long term effects is needed in most cases. The California Annual Grassland itself is a "disequilibrium" system, where weather patterns play a major and often overwhelming role in vegetation condition, quantity, and change. Weather patterns also interact with the relationship between grazers and the environment, influencing animal diet selection. In a dry year, woody species may be browsed more than in a wet year, and so on.

With respect to livestock grazing management, the literature on the effects of the manageable variables associated with livestock grazing or fire regimes (timing, severity, patchiness, and herbaceous and shrub height and biomass) is limited and sometimes conflicting. This reflects a relatively recent recognition of these challenges, a shortage of appropriately focused research, and in some cases, the specific site and weather conditions during the study (D'Antonio et al. ms). Consequently, such information is often absent or poorly represented in planning documents. In those documents, grazing is usually defined in vague terms. Grazing is often judged excessive ("over-grazed") when the residual herbaceous foliage has not in fact exceeded the recognized optimum (Bartolome et al. 2002). "Moderate" livestock grazing is often predicted to be neutral or beneficial, but very limited guidance is offered to the grazing planner and manager in prescribing grazing methods to benefit specific species or to minimize specific negative effects. In contrast, publications on the results of California research are available and more useful on the control of many of the high priority non-native invasive plants (Bossard, Randall, and Hoshovosky 2000), and on the protection of water quality from sediment and pathogen pollution (George 1996; Tate et al. 2000a; Tate et al. 2000b).

A primary research gap is the testing of prescribed grazing plans and practices for special-status species conservation. Numerous relevant management plans that employ grazing have been developed for these conservation purposes at Solano County sites, including Rockville Hills Regional Park (LSA Associates 2001) and Lagoon Valley Park Open Spaces (LSA Associates in progress). Grazed sites there, at Solano County Water Agency sites, Solano Land Trust conservation easement sites (Scott Planning Associates 2002), and Jepson Prairie (The Nature Conservancy) could be the subjects of long-term monitoring of the key grazing and grazing effects variables as well as experimentation.

Research should also examine modifications of grazing practices to reduce impacts on riparian woodlands. Riparian woodlands are conspicuously absent or reduced in canopy width and length along stream corridors in many parts of Solano County, yet they support at least 12 of the county's special-status species (refer to the Draft HCP Section, "Stream and Riparian Habitats"). In general, livestock grazing results in trampling and herbivory that has reduced the structural diversity and woody plant component of riparian woodlands in many settings. This effect is particularly evident at fenced boundaries where grazing has been excluded or reduced on the opposite side; mature woody vegetation (older taller trees and more structural diversity) is present where ungrazed, but absent, browsed more severely, or otherwise impacted where grazed. The characteristic grazed conditions have generally persisted for decades along with the special status species, and we have little information to fully evaluate the inter-linkages between grazing impacts and species persistence, at local, stream reach, or watershed scales. Experiments on the methods to reduce vegetation impacts should test the effects of specialized riparian grazing during the winter and spring when the deciduous trees are leafless. Relevant riparian studies (e.g. Ford, Ahlborn, and Dalen 2001) found that grazing before and after a specific leafless period resulted in significantly greater browsing and mortality of the riparian tree seedlings and saplings.

3. Conservation Grazing Management Issues

Environmental Impacts. A complete assessment of the environmental impacts associated with livestock grazing on rangelands should include the direct and indirect effects of herbivory and trampling. These include effects on the soil and on the germination environment through reduction of shading, nutrient re-distribution, and soil moisture changes. The sustainability and constraints of the livestock grazing industry and related infrastructure that carries out grazing should also be included in such an assessment. In addition, assessments should consider the impacts of livestock grazing introduction, removal, exclusion, or continuation. This latter point is significant because changes in livestock grazing regime can result in significant positive or negative changes in habitat quality for rodents, special-status species, and special natural communities, and in the structure of fire fuels and expected fire behaviors.

The impacts of livestock grazing on the natural vegetation and landscapes of the region have been broad (Painter 1995; Belsky, Matzke and Uselman 1999). Painter states that grazing impacts include the threat to 13 percent of the rare threatened and endangered plants of California, facilitation of the invasion of pest plants, reduction of the regeneration of woody plants, damage to wetland habitats, vegetation type conversion, soil degradation and erosion, and water pollution.

Table 1 summarizes some grazing impacts on habitat. Grazing impacts may benefit some species and suppress others. Most grazing impacts can be manipulated through management. Note that some of these impacts are concurrently caused by other factors, including weather, wildlife effects, and other routes of non-native species invasion.

Table 1. Grazing Impacts on Habitat.

Grazing Factor	Effects	Notes
A. Grazing Livestock Component:		
Trampling	Soil compaction; suppress development of shrubs; create bare areas and disturbance	Can influence soil moisture regimes, erosion rates, structure of stream banks, creation of terracettes, species richness
Browsing of woody vegetation	Suppress development of shrubs and trees; increase light to understory; reduce shading	Can enhance understory development, reduce fire hazard, reduce stream shading, prevent shrub invasion, reduce structural diversity; specific impacts to plants and animals include changes in nest sites and cover, constrain oak recruitment, improve understory development
Grazing of herbaceous vegetation	Reduce height of vegetation; create mosaic of vegetation density and heights; selectivity may lead to differing effects on different species; reduce litter; create bare areas	Reduced vegetation height may be desirable for some species, if invasive non-natives or annuals are selectively grazed; can benefit natives, etc.; can influence composition of rodent populations, cover, soil moisture and temperature; reduce some aspects of fire hazard; increase species diversity at intermediate levels; bare areas can facilitate invasions of non-natives and increase erosion rates
Nutrient redistribution and transformation	Concentrate some nutrients where feces and urine are deposited; volatilize nitrogen	Can reduce water quality, introduce pathogens; riparian buffers seem to prevent most impacts to water quality
Transport of seeds	Feces or fur may carry seeds from one area to another.	Can spread invasive non-native plants; research limited in this area (note: cattle feeding using hay may be more likely to transport seeds).
B. Livestock Operations Component:		
Construction, maintenance, and use of fencing, watering, and other livestock facilities; vehicle traffic	Similar to trampling on a more localized scale	Additional potential impacts include ground disturbance and impacts to cultural resources

In many cases, the negative impacts of livestock grazing justify a change in management. However, the choice to remove grazing is sometimes not an option and sometimes not desirable. In these cases, the planner should design practices to reduce the negative impacts to less than

significant levels, and consider opportunities to use grazing to achieve management goals. Management of rangelands dominated by California Annual Grassland and associated oak savanna should include Residual Dry Matter standards (Bartolome et al. 2002), water quality protection measures (George 1996; SWRCB 1995), fire hazard reduction methods, and prescriptions to maintain or improve any special-status resources.

Non-point Source Water Quality Planning. The Water Quality Control Plan for the San Francisco Bay Region, which includes Solano County, generally requires compliance with municipal water quality standards associated with pathogen pollution (CRWQB 2002). This generally does not apply to designated non-point sources, including rangeland livestock grazing. The California Rangeland Water Quality Management Plan (CRWQMP) for non-point source pollution associated with rangeland grazing applies to non-federal public and private grazing lands in California (SWRCB 1995). It is a formal multi-agency agreement with voluntary compliance by landowners, agencies, and resource managers. Rangeland management planners should follow the recommended grazing management planning and appropriate practices to prevent or minimize pathogen contamination and other pollution of waters.

Native Ungulate Grazing Regimes and Effects. Any considerations or plans for the mimicking of grazing regimes and effects of the pre-historic ungulate communities should begin with an investigation of those animals and how they probably behaved. Such an investigation will reveal the feasibility and promise of both the native animals and the livestock.

Prior to the first European settlements and introductions of livestock into Northern California (in the mid Eighteenth Century), there were two distinct periods with different groups of large grazing mammals (Edwards 1992). During the Pleistocene Epoch (which ended about 10,000 years ago) the lands of this region were grazed by very large native mammals, many of which became extinct, as well as smaller mammals that have persisted until today. The largest animals included mastodons, mammoths, ground sloths, bison, horses, camels, and oxen. Their teeth morphology, stomach contents, and fossils indicate these herbivores consumed primarily perennial grasses and woody forage. The evidence suggests a high diversity of feeding niches among ample grassland and savanna with grazing as a major activity, similar to East Africa today. Grazing and trampling were major forces shaping the structure and composition of the vegetation for about two million years. During this period most of our native grassland and savanna herbaceous plants evolved mechanisms to withstand grazing.

Since the end of the Pleistocene, and the extinction of the "megafauna," the region was grazed by a greatly reduced number of herbivores (Edwards 1992). The grasslands, savannas, and shrublands were grazed by roaming bands of tule elk (*Cervus elaphus nannodes*), mule deer (*Odocoileus hemionus columbianus*), and probably, pronghorn (*Antilocapra americana*). The California grizzly bear (*Ursus arctos californicus*) and some birds (particularly ducks and geese) probably utilized a significant amount of herbaceous forage too. The elk and deer are opportunistic in diet, utilizing more herbaceous forage during the growing season and more woody browse during other seasons.

Domesticated livestock, particularly cattle, sheep, goats, horses, and pigs, were introduced for food and fiber production and other economic purposes. The post-settlement transition severely

restricted the ranges of the remnant herds of elk, pronghorn, bear, and birds due to commercial hunting, fencing, and habitat loss. However, deer and numerous non-domesticated small mammals, such as rodents, continue to utilize significant herbaceous forage and shape the grassland and shrubland vegetation (Lidicker 1989). The conversion of the grasslands and oak savanna understory from native grasses to mostly annual grasses and forbs of European origin was also severe (discussed in the section on restoration of native grasslands). Disturbance associated with livestock is likely to have aided the invasion and helps maintain suitable conditions for persistence of some of the non-native opportunist plants.

The effects of livestock resemble the effects of the potential populations of native ungulates in terms of the reduction of height and biomass of the grassland herbaceous plants, reduced cover of native woody plants, trampling and soil compaction, and sources of pollutants. However, the behavioral patterns of livestock differ from the potential behavior of large groups of native ungulates, and consequently the timing, intensity, and spatial distribution of herbivory and trampling differs. Livestock grazing can be ecologically beneficial if careful strategies are devised to achieve specific conservation goals and to minimize the negative impacts based on the conditions of the grazed site (Edwards 1992; Ford 2001).

Native Ungulate Grazing Feasibility and Effectiveness. The building and maintaining of enclosures or exclosures of significant sizes for herds of any of the native grazing animals and their care and handling would be extraordinarily expensive. Adoption of native grazing animals by private sector landowners and livestock operators would pose other significant problems, including those extra costs, loss of conventional livestock production revenues, potential disease transmission, and possible genetic pollution. It seems very unlikely that any of the native animals could be enclosed or maintained in small herds to perform the desired vegetation management thoroughly and repeatedly in multiple fragmented sites. Wild grazers are unlikely to be available in sufficient numbers, or to be sufficiently controllable. Only the mule deer seems likely to be available in naturally occurring situations and relatively large numbers, but incorporating this wild animal into a prescribed grazing regime might require extensive exclosures or frequent moving between enclosures during critical seasons.

Livestock grazing is more likely to be the preferred management alternative because of the relative manageability of livestock, and because of the availability of livestock and the skilled personnel of the existing industry. Despite the dissimilarities of livestock grazing to that of the potential grazing of native ungulates, a careful program of prescribed livestock grazing is likely to be one of the most feasible and effective means available.

Prospects of Grazing Removal. The Intermediate Disturbance Hypothesis, the idea that moderate levels of disturbance enhance biodiversity, has been applied to Mediterranean annual grasslands and found to be useful in explaining enhanced biodiversity at moderate grazing levels (Perevolotsky and Seligman, 1999; Maestas et al. 2001). Further, the use of variable, heterogenic patterns of grazing to enhance biodiversity has been reported in grassland studies (Fuhlendorf and Engle 2001). Together with the long history of grazing in California annual grasslands, and the concurrent co-existence of a diverse array of flora and fauna in the grasslands and oak woodlands, caution in applying radical alterations of grazing regime is recommended. The linkages between patterns of grazing and the various species that have persisted in the

grazed landscape, despite radical changes in fire regimes, flora, and fauna that are historically and presently independent of grazing, are not fully understood. Anecdotes abound connecting presence of one species or another with grazing; certainly the removal of grazing has been found to have unanticipated negative consequences in some cases (refer to UCNRS 2002 for a classic case of denial in the case of grazing removal and the kit fox). Continued grazing at moderate levels using residue management guidelines (refer to the section on "environmental impacts"), resulting in an uneven distribution and subsequently diverse array of grazing impacts and floristic conditions, would minimize risk in the absence of complete information. Together with monitoring of areas or species of special concern, this will likely result in the best outcome for maintaining the biodiversity of these lands. In areas where grazing is believed to be a problem, careful testing of alternative regimes can be used. Even in riparian areas, rather than the full exclusion that is coming to be the "default management" for such areas, testing of exclusion in some areas to create a mosaic of conditions in riparian areas would seem a more conservative and risk-minimizing approach.

Potential Conservation Benefits of Prescribed Grazing. The negative impacts of livestock grazing are well recognized (discussed in the section on "environmental impacts") and criticisms of grazing in California are often justified. However, its potential uses as a conservation tool are not well recognized, particularly among other disciplines and professions, and should be tested and applied where appropriate:

Habitat of Special-Status Animals

- Reduction of tall grass cover, and associated increase in habitat quality for sensitive wildlife species that depend on low grass height.
- Increase in small-scale diversity of patch height and age in grassland and shrub habitat for wildlife associated with varying grazing prescriptions among grazing units.

Special-Status Plants and Natural Communities

- Less damage to oak seedlings (with spring grazing) compared to fire.
- Reduction of tall annual grass cover, and associated decrease in habitat quality of mice and other small rodents, which cause herbivory damage on oak seedlings.
- Reduction of tall annual grass cover and moisture competition, and associated increase in habitat quality for native perennial grasses (with grazing terminated before native grass flowering)
- Reduction of tall annual grass cover and moisture competition, and associated increase in habitat quality for oak sapling growth (with spring grazing and/or tree shelters)
- Reduction of excessive grass litter mulch and shading, and associated increase in species diversity of associated grassland forbs.
- Increase in small-scale plant species richness associated with variation in grazing within grazing units and different grazing prescriptions among grazing units.
- Minimized impacts to wetland vegetation and banks (with spring grazing)
- Reduction of shrub encroachment into grasslands (where edaphic conditions are appropriate for such encroachment).

Fire Hazard

- Reduction of fire hazard associated with fine fuel biomass.

- Replacement of fire as a vegetation management tool where fire is inappropriate and livestock grazing does not cause conflicts with other resource management objectives.

Income That Can Contribute to Conservation Projects
- Lease rates can be high in this area, providing annual income for conservation projects.
- Leasing forage may contribute to stability of surrounding land ownerships

Shift from Conventional to Conservation Grazing. One of the fundamental goals of land management under the NCCP/HCP will the conservation of the habitat for the special-status species and natural communities that could be affected by livestock grazing, where that land use is appropriate. Where existing livestock grazing will continue or be modified, or where it will be introduced, the purposes and practices of that grazing will need to shift to include new specific conservation objectives as well as the conventional livestock production and other related ranch goals. Livestock grazing will continue as a primary management tool with a new focus on ecosystem qualities and functions, including habitat for the special-status resources.

It is possible that a conservation-oriented grazing management plan will shift the grazing systems from traditional year-long or late fall through late spring periods to more intensified seasonal grazing periods with more movement of the animals and adjustments of the stocking rates.

The cooperative relationship between the Livestock Operator and the agency responsible for administering and supervising the conservation agreements under the NCCP/HCP will be vital to both the effective operation of the conservation agreement and the resulting grazing programs. It will also be vital to the continual improvement of property management through adaptation based on monitoring and evaluation. Assigning the primary responsibilities for monitoring and proposals for adaptations of grazing plans to the Operator could add the significant opportunity to discover new information and to improve management. That responsibility would also provide an incentive to the Operator to find better ways to achieve the conservation goals. Compensation for voluntary reductions in stocking rates during emergencies or unconventional costs associated with conservation, such as weight losses, structural improvements, building and maintaining exclosures, and controlling invasive non-native pest plants will also provide incentives to the Operator. Such compensation could be either reduction of grazing lease fees or reimbursement for the unconventional costs. The supervising agency's provision of information, including manuals and reference documents, invitations to technical workshops, and personal contact with technical representatives to discuss new ideas and scientific development will serve as incentives to the Operator to study and improve management practices.

The Operator's responsibilities should be guided by specific performance objectives and standards described in formal Grazing Management Plan for each property. The Operator should be provided a direct link to an equally or better skilled representative of the supervising agency who can provide technical assistance as a fellow professional and who has the authority to intercede if the results are not appropriate. These incentives will give the Operator the opportunity to take pride and financial reward in cooperating to achieve the conservation goals.

Grazing Management Planning for Conservation. With the shift from conventional grazing to conservation, grazing management plans will need to address such goals as maintaining biological diversity, controlling non-native pest plants, minimizing the negative impacts of grazing, and maintaining and improving rangeland ecosystem health, including water quality. In all cases, it is important to keep in mind that weather effects will often overshadow management effects in the short term. At the same time, if a viable livestock operation is to succeed, the goals of grazing management will include maintaining and improving forage quality and quantity. Planning will involve the prescription of grazing animal kinds, animal numbers, grazing periods, standard ranges of effects, and adjustments based on thresholds. The complex of different target resources and optimal grazing specifications is likely to pose some conflicts that will require determination of most desirable options, potential to avoid or mitigate negative effects, and re-thinking of the grazing plans.

Unique characteristics of a grazing management plan for such conservation purposes might include:

- Specific prescriptions of the expected grazing effects on the required habitat qualities of the target special status species and natural communities, non-native pest plant infestations, fire hazards, and sources of livestock-borne pathogens
- Permanent and temporary sub-division of grazed areas for application of specialized grazing systems to achieve different purposes in some areas
- Unconventional infrastructure requirements, such as exclosures and temporary fencing
- Adaptability during episodes of drought, fire, or late growth and the associated reduction of forage--alternative pasture ("grass banks") and intra- and inter-annual adjustments of stocking rates
- Methods for monitoring of key variables and decision diagrams for adaptive management

Sustainability and Availability of the Regional Livestock Industry to Perform Grazing Services. At the same time, it will be important to remember the constraints that face livestock operators in developing grazing plans. Forage resources are not easily replaceable, and reductions in grazing can result in greatly increased costs to the operator. Often operators have little flexibility in herd size over the short term. A maximum degree of stability will result in the best relationships with the operator, and planning for flexibility will be helpful in developing grazing scenarios. In general, with the increasing conversion of lands, many operators are facing forage shortages. This should improve the market for leasing on Solano County lands, and make it possible to get a good price for leases. Developing long term, mutually satisfying relationships with local ranchers that are good cooperators can also contribute to keeping more ranch lands in open space, by contributing to the sustainability of the industry in the area. We recommend reviewing grazing permitting programs in similar environments (such as those of the East Bay Regional Park District) to determine what improvements might be made to current Solano County leasing programs or prices.

4. Effects of Livestock Grazing on Special-Status Species Covered in the HCP/NCCP

The draft NCCP/HCP identified 82 species of plants and animals of Solano County for special-status consideration (SCWA 2002; SWCA 2003). The Science Advisors identified 24 key species (18 animals and 6 plants) of sufficient potential threats of urban development to warrant

special consideration and development of specific conservation measures (Noss et al. 2002). Of the 82 species in the draft NCCP/HCP, 63 (30 animals and 33 plants) occur in or could be affected by management of wildland habitats potentially managed with livestock grazing (grasslands, woodlands, savanna, riparian communities, and scrub). Wetland and aquatic habitat will presumably be excluded from grazing or managed separately with temporary access. Of the 24 species identified by the Science Advisors, 11 are included in the total that occur in or could be affected by management of wildland habitats potentially managed with livestock grazing. Eighteen animals (Table 2) and ten plants (Table 3) warrant special consideration and development of specific grazing management measures to favor potential beneficial effects and/or to minimize potential negative effects. Documentation of potential grazing impacts was not found for five of the animals and 19 of the plants.

These tables summarize reliable information about the special status species, including the characteristics and habitat parameters related to livestock grazing, vulnerabilities to grazing, and the potential negative and beneficial impacts of grazing. Sources are cited. If publications were not available, the information is summarized from interviews of wildlife biologists and plant ecologists with expertise in the individual species or from personal observations. Absence of reliable information is so noted. Before proceeding with grazing activities in key habitat areas, additional information should be collected based on further interviews about those species for which little reliable information is available and a potential threat is identified.

Table 2. Potential Effects of Livestock Grazing on Key Special-Status Animals of Solano County, CA.

Species[1]	Habitat and Occurrence[1]	Potential Effects of Livestock Grazing and Associated Threats[2]	Significant Grazing Concern
Aleutian Canada goose *Branta canadensis leucopareia*	Grassland	Biological Opinion determined project not likely to adversely affect. Reliable information on grazing effects was not found.	?
Osprey *Pandion haliaetus*	Oak woodland, riparian woodland, scrub/chaparral Uses large trees, snags, and dead-topped trees in open forest habitats for cover and nesting	Significant impacts would typically be [to] a nest site and conservation measures best addressed on a project specific basis. Probably unaffected by conventional livestock grazing.	None
Cooper's Hawk *Accipiter cooperii*	Grassland, oak woodland, oak savanna, riparian scrub, riparian woodland, scrub/chaparral Prefers dense trees or patchy woodland habitats; nesting and foraging usually occur near open water or riparian	Potential for development impacts; May require additional conservation measures for oak woodland and savanna. Probably unaffected by conventional livestock grazing.	None

Species[1]	Habitat and Occurrence[1]	Potential Effects of Livestock Grazing and Associated Threats[2]	Significant Grazing Concern
	vegetation; nesting in oak woodlands March-August, with peak May-July.		
Sharp-shinned Hawk *Accipiter striatus*	Grassland, oak woodland, oak savanna, riparian woodland, scrub/chaparral A common migrant and winter resident in dense woodlands; nest and forage in oak woodland; breeds April-August, with peak late May-July.	Potential for development impacts; May require additional conservation measures for oak woodland. Probably unaffected by conventional livestock grazing.	None
Peregrine falcon *Falco peregrinus*	Grassland, oak woodland, oak savanna, riparian scrub, riparian woodland, scrub/chaparral Requires protected cliffs, ledges, or artificial structures for cover and nesting.	Biological Opinion determined project not likely to adversely affect species or critical habitat. Probably unaffected by conventional livestock grazing.	None
Prairie falcon *Falco mexicanus*	Grassland, oak woodland, oak savanna, riparian scrub, riparian woodland, scrub/chaparral Uses open terrain for foraging; nests in open terrain with canyons, cliffs, escarpments, and rock outcrops.	Primary concern is for direct impacts to nest sites and conservation measures best addressed on a project specific basis. Probably unaffected by conventional livestock grazing.	None
Northern Harrier *Circus cyaneaus*	Grassland, riparian scrub Common year-round in grasslands or shrubs; roosts and nests on the ground in open grassland or edges of freshwater emergent wetlands; nests April-September, with peak June-July.	Could generally be covered by conservation actions for other required species. Management to maintain or improve habitat for the ground squirrel would benefit the raptors that prey on these and other rodents; management to maintain or improve the open qualities of the grasslands and minimize encroachment of shrubs would benefit this grassland dependent species; nests could be affected adversely by livestock traffic during nesting season April-September.	Vulnerable ground nests; otherwise beneficial
Swainson's Hawk[4] *Buteo swainsoni*	Grassland, oak savanna, riparian scrub, riparian woodland Roosts in large trees, but will roost on ground if none available; typical habitat is open grassland	Concern for development and O&M activities in much of County. Management to maintain or improve habitat for the ground squirrel would benefit the raptors that prey on these and other rodents; management to maintain or improve the open qualities of the grasslands and minimize encroachment of shrubs	Vulnerable ground nests; otherwise beneficial

Species[1]	Habitat and Occurrence[1]	Potential Effects of Livestock Grazing and Associated Threats[2]	Significant Grazing Concern
	containing scattered large trees or small groves; nests March to August, with peak May to July.	would benefit this grassland dependent species; nests could be affected adversely by livestock traffic during nesting season March to August.	
Golden Eagle *Aquila chrysaetos*	Grassland, oak woodland, oak savanna, riparian scrub, riparian woodland, scrub/chaparral Often a year-round resident of rolling foothills with grassland and oak savanna. Secluded cliffs with overhanging ledges and large trees used for cover; nests on cliffs of all heights and in large trees in open areas	Conservation actions for many required species would be applicable to conserving foraging habitat; may require additional measures to address nest sites. Management to maintain or improve habitat for the ground squirrel would benefit the raptors that prey on these and other rodents; management to maintain or improve the open qualities of the grasslands and minimize encroachment of shrubs would benefit this grassland dependent species. Zeiner, et al. 1988-90: Nest desertion if disturbed by humans.	Vulnerable tree nests; otherwise beneficial
Bald Eagle *Haliaeetus leucocephalus*	Grassland, riparian scrub, riparian woodland, scrub/chaparral Requires large, old-growth trees or snags in remote, mixed stands near water; nests in large, old-growth, or dominant live tree with open branchwork	Biological Opinion determined project not likely to adversely affect species. Probably unaffected by conventional livestock grazing.	None
Mountain Plover *Charadrius montanus*	Grassland Winter migrant to region Frequents open plains with low, herbaceous or scattered shrub vegetation.	Concerns for population based on nesting; winter habitat conservation if necessary could be addressed through conservation measures for other required/recommended species. Management to maintain or improve the open qualities of the grasslands and minimize encroachment of shrubs would benefit this grassland dependent species.	Beneficial
Burrowing Owl[4] *Athene cunicularia*	Grassland, oak savanna, riparian scrub Found in open, dry grazed grasslands and ruderal areas; requires suitable burrows for nesting and shelter, usually dug by ground squirrels; breeds March-August, with peak April-May; semi-colonial; perches on rock outcrops.	Potential for impacts and potential species for future federal and state listing; nest sites protected by existing state and federal laws. Management to maintain or improve habitat for the ground squirrel would benefit the availability of shelter and presence of prey; management to maintain or improve the open qualities of the grasslands and minimize encroachment of shrubs would benefit this grassland dependent species. Zeiner, et al. 1988-90: Poisoning of ground squirrels have contributed to owl population declines.	Beneficial

Species[1]	Habitat and Occurrence[1]	Potential Effects of Livestock Grazing and Associated Threats[2]	Significant Grazing Concern
Short-eared Owl *Asio flammeus*	Grassland, riparian scrub Found in open, treeless areas with elevated sites for perches, and dense vegetation for roosting and nesting; nests on dry ground in a depression concealed in vegetation	Could generally be covered under conservation strategies for other required species. Management to maintain or improve habitat for rodents would benefit the raptors; management to maintain or improve the open qualities of the grasslands and minimize encroachment of shrubs would benefit this grassland dependent species; nests could be affected adversely by livestock traffic during nesting season April to July.	Vulnerable ground nests; otherwise beneficial
Salt Marsh Common Yellowthroat *Geothlypis trichas sinuosa*	Riparian scrub Frequents low, dense vegetation near water; many brushy habitats used in migration; nest usually placed on or close above ground; breeds from early April to mid-July, with peak activity in May and June	Could generally be covered under conservation strategies for other required species. Management to maintain riparian woody vegetation would benefit this species.	Vulnerable ground nests; riparian woody cover
Yellow-breasted Chat *Icteria virens*	Riparian scrub, riparian woodland Frequents dense, brushy thickets and tangles near water, and thick understory in riparian woodland; nests usually 0.6 to 2.4m above ground in dense shrubs along a stream or river	Could generally be covered under conservation strategies for other required species. Management to maintain riparian woody vegetation would benefit this species.	Vulnerable riparian woody cover
Tricolored Blackbird *Agelaius tricolor*	Grassland, riparian scrub Common local resident of near freshwater emergent wetlands near grasslands and croplands; colonial nesters; nests in cattails, tules, trees, or shrubs mid-April to late July.	Some overlap with conservation strategies for other required species; may require additional measures. Zeiner, et al. 1988-90: colonies vulnerable to massive nest destruction by mammalian and avian predators Management to maintain or improve the open qualities of the grasslands and minimize encroachment of shrubs would benefit this grassland dependent species.	Vulnerable wetland emergent vegetation and riparian woody cover
California Tiger Salamander[3] *Ambystoma californiense*	Grassland, oak savanna Grasslands and oak savanna with rodent burrows are used for summer retreats and/or breeding; adults live in	Sensitive to livestock traffic and excess grass height (hindering movement) primarily during key periods of above-ground activity in 1km band around temporary ponds-- movement of adults from burrows to breed in ponds November-March and movements of juveniles from ponds to burrows March-August; sensitive	Vulnerable to trampling; otherwise beneficial

Species[1]	Habitat and Occurrence[1]	Potential Effects of Livestock Grazing and Associated Threats[2]	Significant Grazing Concern
	subterranean refugia for most of year, then move to ponds with first rains of season, usually November; migrate during rainy season to seasonal wetlands, vernal pools, stock ponds, or slow streams that hold water through May; breeding occurs from December to early February; larvae transform in water by early July; post-metamorphic juveniles disperse from breeding sites in late spring to early summer.	to drawing down of pond breeding sites in spring; indirectly sensitive to reduced populations of burrowing rodents; management to maintain or improve habitat for the ground squirrel would be beneficial to this and other species that have persisted in the region as a group because of the presence of common habitat requirements, including dependence on surface water in ponds and streams and on active populations of the ground squirrel, which constructs burrows subsequently used for refuge; requires access across the open grasslands, thus insufficient grazing, and associated grass height elevation and shrub encroachment, would reduce habitat quality.	
California Red-legged Frog[4] *Rana aurora draytonii*	Grassland, oak woodland, oak savanna, riparian scrub, riparian woodland Common residents using streams, marshes, and stock ponds, preferring pools or slow waters with dense overhanging shrub or emergent vegetation; also use ephemeral streams with pools; attach eggs to emergent vegetation; use upland grassland habitats and refuges of rodent burrows and woody litter up to one mile from breeding areas during movements prior to breeding or for post-metamorphic juvenile dispersal November-March and July-October.	Sensitive to livestock traffic and herbivory (degrading or removing vegetation) at stream and pond edges November-March; sensitive to hoof traffic in streams, wetlands, and ponds November-March. Sensitive to livestock traffic and excess grass height in upland grasslands (hindering movement) during key periods of movement prior to breeding or for post-metamorphic juvenile dispersal November-March and July-October; management to maintain or improve habitat for the ground squirrel would be beneficial to this and other species that have persisted in the region as a group because of the presence of common habitat requirements, including dependence on surface water in ponds and streams and on active populations of the ground squirrel, which constructs burrows subsequently used for refuge; requires access across the open grasslands, thus insufficient grazing, and associated grass height elevation and shrub encroachment, would reduce habitat quality. EBMUD 2001: Moderately vulnerable to livestock impacts—trampling, heavy grazing, and browsing on essential breeding and sheltering habitat, including emergent aquatic plants and dense riparian herbaceous and willow cover at ponds and streams; partial permanent exclusion or extended deferment of livestock use of pond and streams from fall to mid-spring for optimal protection or recovery of degraded sites; tolerant of light to moderate grazing in upland grassland that maintains habitat and prey base.	Vulnerable riparian woody and herbaceous cover and trampling; otherwise beneficial
Western Pond Turtle *Clemmys*	Grassland, riparian scrub, riparian woodland	Conservation actions will likely be addressed through other required species.	Vulnerable to trampling;

Species[1]	Habitat and Occurrence[1]	Potential Effects of Livestock Grazing and Associated Threats[2]	Significant Grazing Concern
marmorata	Open slow-moving water of streams and permanent ponds with rocks, floating vegetation, logs, or open mud banks for basking; females move overland into upland grasslands during spring to early summer or when waters dry; eggs laid March-August; incubation and hatchling movements June to November.	Sensitive to hoof traffic around permanent waters where adults and juveniles move between water and nests; March-November; management to maintain or improve habitat for the ground squirrel would be beneficial to this and other species that have persisted in the region as a group because of the presence of common habitat requirements, including dependence on surface water in ponds and streams and on active populations of the ground squirrel, which constructs burrows subsequently used for refuge; requires access across the open grasslands, thus insufficient grazing, and associated grass height elevation and shrub encroachment, would reduce habitat quality. CDFG 1994: Some population declines are in part due to impacts on and alterations of nesting habitat by the activity of livestock. EBMUD 2001: Highly vulnerable to livestock impacts—trampling of nests and burrows and incubating eggs within one quarter mile of feeding habitat in waters; optimal protection by complete exclusion of grazing from critical habitat from April-November.	otherwise beneficial
Western Spadefoot Toad Spea hammondii	Grasslands with shallow temporary pools; spends most time in burrows; surface movements from fall to early spring	Management to maintain or improve the open qualities of the grasslands and minimize encroachment of shrubs would benefit this grassland dependent species.	Beneficial
Salt Marsh Harvest Mouse *Reithrodontomys raviventris halicoetes*	Grassland Pickleweed in saltmarsh is the primary habitat, but non-submerged, salt-tolerant vegetation for escape during highest tides is essential; nests on ground	Reliable information on grazing effects was not found.	?
Valley Elderberry Longhorn Beetle[4] *Desmocerus californicus dimorphus*	Riparian scrub, riparian woodland	Noss et al. 2002: The beetle and its host plant, elderberry (*Sambucus* sp.) occur in many riparian and scrub habitats in Solano County. Livestock browse elderberry, and can cause a visible "browse-line" on the plants when occurring in open habitat, such as grassland, but moderate seasonal grazing is not expected to eliminate or reduce the number of plants. USFWS Undated; Virginia Polytechnic Institute and State University 1996: Inappropriate or excessive grazing of elderberry habitat was identified as a threat to survival of the Valley elderberry longhorn beetle by the U.S. Fish and	Vulnerable stands of host plant

Species[1]	Habitat and Occurrence[1]	Potential Effects of Livestock Grazing and Associated Threats[2]	Significant Grazing Concern
		Wildlife Service.	
Sacramento Anthicid Beetle *Anthicus sacramento*	Riparian scrub	Conservation measures would be best addressed on a project specific basis. Reliable information on grazing effects was not found.	?
Ricksecker's Water Beetle[3] *Hydrochara rickseckeri*	Riparian scrub	Conservation actions can likely be addressed through [measures taken for] other required species. Reliable information on grazing effects was not found.	?
Callippe Silverspot Butterfly[4] *Speyeria callippe callippe*	Grassland	Noss et al. 2002: The butterfly and its larval food and nectar plants occur in grassland habitat in Solano County. Management to maintain or improve the open qualities of the grasslands and minimize encroachment of shrubs would benefit this grassland dependent species; control of non-native nectar plants would be detrimental. Reliable information on grazing effects was not found.	?
Chinook Salmon - Winter-run *Oncorhynchus tshawtyscha*	Riparian scrub, riparian woodland	Primary concerns are for passage/movement and water quality. Management to maintain riparian woody vegetation would benefit this species.	Vulnerable water quality and riparian vegetation
Chinook Salmon-Central Valley fall/late fall-run ESU *Oncorhynchus tshawtyscha*	Riparian scrub, riparian woodland Some potential breeding habitat.	Concerns for water quality, passage, and riparian habitat protection. Management to maintain riparian woody vegetation would benefit this species.	Vulnerable water quality and riparian vegetation
Chinook Salmon - Spring-run *Oncorhynchus tshawtyscha*	Riparian scrub, riparian woodland	Primary concerns are for passage/movement and water quality. Management to maintain riparian woody vegetation would benefit this species.	Vulnerable water quality and riparian vegetation
Steelhead - Central California Coast ESU *Oncorhynchus mykiss*	Riparian scrub, riparian woodland Breeding habitat present; many streams in County may qualify as critical habitat	Concerns for water quality, passage, and riparian habitat protection. Management to maintain riparian woody vegetation would benefit this species.	Vulnerable water quality and riparian vegetation
Steelhead - Central Valley ESU[4] *Oncorhynchus*	Riparian scrub, riparian woodland Breeding habitat present;	Concerns for water quality, passage, and riparian habitat protection. Management to maintain riparian woody	Vulnerable water quality and riparian vegetation

Species[1]	Habitat and Occurrence[1]	Potential Effects of Livestock Grazing and Associated Threats[2]	Significant Grazing Concern
mykiss	many streams in County may qualify as critical habitat	vegetation would benefit this species.	

[1] Summarized from SWCA 2002 (http://www.scwa2.com/HCP/Species-Habitat%20Associations.doc) and Zeiner et al. 1988-90.

[2] Summarized from SWCA 2002 (http://www.scwa2.com/HCP/Species-Habitat%20Associations.doc); potential grazing effects and associated threats summarized by L. Ford from personal interviews of relevant expert wildlife biologists and personal observations unless from cited source.

[3] Noss et al. (2002) found limited potential direct impact from urban growth/development.

[4] Noss et al. (2002) found potential direct impact from urban growth/development.

Table 3. Potential Effects of Livestock Grazing on Key Special-Status Plants of Solano County, CA.

Species[1]	Habitat and Occurrence[1]	Potential Effects of Livestock Grazing and Associated Threats[2]	Significant Grazing Concern
Alkali Milk-vetch *Astragalus tener* var. *tener*	Grassland	CNPS 2003: Threatened by habitat destruction, especially agricultural conversion. Reliable information on grazing effects was not found.	?
Heartscale *Atriplex cordulata*	Grassland, chenopode scrub	Reliable information on grazing effects was not found.	?
Crownscale *Atriplex coronata var. coronata*	Grassland, chenopode scrub	Occurs in vernal pools on alkali soils; conservation measures could likely be incorporated with other required species. Reliable information on grazing effects was not found.	?
Brittlescale *Atriplex depressa*	Grassland, chenopode scrub	CNPS 2003: Threatened by grazing and trampling.	Vulnerable
Big-scale Balsamroot *Balsamorhiza macrolepis* var. *macrolepis*	Grassland, oak woodland, oak savanna, scrub/chaparral	U.S. Forest Service 2003: Other herbaceous species in this genus are palatable and nutritious forage for livestock and wildlife Reliable information on grazing effects was not found.	?
Big Tarplant *Blepharizonia plumosa* ssp. *plumosa*	Grassland	CNPS 2003: Historical occurrences probably extirpated by agriculture and non-native plants Reliable information on grazing effects was not found.	?
Mt. Diablo Fairy-lantern *Calochortus pulchellus*	Grassland, oak woodland, oak savanna, riparian woodland, scrub/chaparral	CNPS 2003: Threatened by grazing. EBMUD 2001: Moderate impact of grazing: genus of 20-30% palatability, early foliage; highest use by goats, and least by horses;	Vulnerable

Species[1]	Habitat and Occurrence[1]	Potential Effects of Livestock Grazing and Associated Threats[2]	Significant Grazing Concern
		monitoring of grazing impact and management or protection justified.	
Holly-leaved Ceanothus *Ceanothus purpureus*	Oak woodland, scrub/chaparral	CNPS 2003: Threatened by agriculture and alteration of fire regimes. U.S. Forest Service 2003: Other species in this genus are palatable and nutritious forage for livestock and wildlife, and recover from grazing	Not likely
Congdon's Tarplant *Centromadia parryi* ssp. *congdonii*	Grassland	CNPS 2003: severely threatened by development Reliable information on grazing effects was not found.	?
Recurved Larkspur *Delphinium recurvatum*	Grassland, oak woodland, oak savanna	CNPS 2003: Threatened by grazing. U.S. Forest Service 2003: Other species in this genus are palatable and nutritious forage for wildlife, but can be poisonous to cattle; some species recover and increase where grazed	Possibly vulnerable
Round-leaved Filaree *Erodium macrophyllum*	Grassland, oak woodland, oak savanna, scrub/chaparral	CNPS 2003: Threatened by urbanization and non-native plants. U.S. Forest Service 2003: Other species in this genus are palatable and nutritious forage for livestock and wildlife, and recover from grazing	Not likely
Streamside Daisy *Erigeron biolettii*	Oak woodland, oak savanna	Reliable information on grazing effects was not found.	?
Fragrant Fritillary *Fritillaria liliacea*	Grassland, oak woodland, oak savanna	CNPS 2003: Threatened by grazing, agriculture, urbanization, and non-native plants.	Vulnerable
Adobe-lily *Fritillaria pluriflora*	Grassland, oak woodland, oak savanna, scrub/chaparral Generally associated with serpentine or high clay soils with limited grass cover	CNPS 2003: Threatened by grazing.	Vulnerable
Brewer's Western flax *Hesperolinon breweri*	Grassland, oak woodland, oak savanna, scrub/chaparral	Reliable information on grazing effects was not found.	?
Carquinez Goldenbush *Isocoma arguta*	Grassland	Reliable information on grazing effects was not found.	?
Northern California Black Walnut *Juglans californica* var. *hindsii*	Riparian scrub, riparian woodland Although black walnut is common in County, pure native stands are of limited	EBMUD 2001: No potential grazing impact: no documented palatability of genus to livestock. CNPS 2003: Threatened by urbanization and conversion to agriculture.	None

Species[1]	Habitat and Occurrence[1]	Potential Effects of Livestock Grazing and Associated Threats[2]	Significant Grazing Concern
	distribution and there are no known stands are in County.		
Contra Costa Goldfields[3] *Lasthenia conjugens*	Oak savanna	Moderate grazing in the late spring can help control exotic plant invasions into vernal pool habitat CNPS 2003: Threatened by overgrazing and non-native plants.	Vulnerable
Woolly-headed Lessingia *Lessingia hololeuca*	Grassland, oak woodland, oak savanna Generally in serpentine soils	CNPS 2003: Possibly threatened by grazing. Reliable information on grazing effects was not found.	Possibly vulnerable
Delta Mudwort *Limosella subulata*	Riparian scrub	CNPS 2003: Threatened by habitat destruction. Reliable information on grazing effects was not found.	?
Napa Lomatium *Lomatium repostum*	Oak woodland, scrub/chaparral Typically associated with serpentine soils	Limited potential impact. Reliable information on grazing effects was not found.	?
Mt. Diablo Cottonweed *Micropus amphibolus*	Grassland, oak woodland, oak savanna	Limited potential impact. Reliable information on grazing effects was not found.	?
Sylvan Microseris *Microseris sylvatica*	Grassland, oak woodland, oak savanna, scrub/chaparral	Limited potential impact and likely insufficient information to make conservation decisions. CNPS 2003: Threatened by grazing and agriculture.	Vulnerable
Green Monardella *Monardella viridis ssp. viridis*	oak woodland, scrub/chaparral	Limited potential impact. Reliable information on grazing effects was not found.	?
Little Mousetail *Myosurus minimus ssp. apus*	Grassland Occurs in vernal pool habitats	CNPS 2003: Reduced by vernal pool habitat loss; threatened by grazing, development, and agriculture.	Vulnerable
Cotula Navarretia *Navarretia cotulifolia*	Grassland, oak woodland, oak savanna, scrub/chaparral Occurs in vernal pool habitats	CNPS 2003: Threatened by non-native plants. Reliable information on grazing effects was not found.	?
Baker's Navarretia *Navarretia leucocephala*	Grassland, oak woodland, oak savanna	CNPS 2003: Threatened by development and agriculture. Reliable information on grazing effects was not	?

Species[1]	Habitat and Occurrence[1]	Potential Effects of Livestock Grazing and Associated Threats[2]	Significant Grazing Concern
ssp. *Bakeri*		found.	
Gairdner's Yampah *Perideridia gairdneri ssp. gairdneri*	Grassland, oak woodland, oak savanna, scrub/chaparral Typically occurs around vernal pools and other seasonally wet areas.	CNPS 2003: Threatened by agriculture. Reliable information on grazing effects was not found.	?
Lobb's Aquatic Buttercup *Ranunculus lobbii*	Oak woodland, oak savanna Typically occurs around vernal pools and other seasonally wet areas.	CNPS 2003: Threatened by agriculture. U.S. Forest Service 2003: Other species in this genus are palatable and nutritious forage for wildlife, but can be poisonous to livestock. Reliable information on grazing effects was not found.	?
Victor's Gooseberry *Ribes victoris*	Oak woodland, riparian scrub, riparian woodland, scrub/chaparral	Likely insufficient information to make conservation decisions. U.S. Forest Service 2003: Forage of other species in this genus have fair palatability and nutrition for wildlife and livestock; decrease with livestock grazing	Possibly vulnerable
Rayless Ragwort *Senecio aphanactis*	Grassland, oak woodland, oak savanna, scrub/chaparral Generally associated with alkaline soils and seasonal wetlands	Reliable information on grazing effects was not found.	?
Showy Indian Clover *Trifolium amoenum*	Grassland Natural populations likely extinct in County	CNPS 2003: Historical habitat lost to urbanization and agriculture. U.S. Forest Service 2003: Other species in this genus are very palatable and nutritious forage for wildlife and livestock; effect of grazing depends on competition with grasses.	Not likely
Dark-mouthed Triteleia *Triteleia lugens*	Oak woodland, oak savanna, scrub/chaparral	Reliable information on grazing effects was not found.	?

[1] Summarized from SWCA 2002 (http://www.scwa2.com/HCP/Species-Habitat%20Associations.doc)
[2] Summarized from SWCA 2002 (http://www.scwa2.com/HCP/Species-Habitat%20Associations.doc) and Noss et al. 2002; potential grazing effects and associated threats summarized by L. Ford from personal interviews of relevant expert plant ecologists and personal observations unless from cited source.
[3] Noss et al. (2002) found potential direct impact from urban growth/development.

5. Rangeland Management Issues Other Than (But Related to) Grazing

Restoration of Native Grasses and Native Grasslands. Native species are quite often present in the California Annual Grassland, although most commonly scattered in a matrix of non-native species. On some soils, natives may be prominent. Research indicates that prospects for large-scale restoration of native species to dominance in California Annual Grasslands are negligible for several reasons. Success of restoration projects, whether manipulating fire regimes or livestock grazing, is almost always more closely linked to climatic conditions than to manipulative treatments. Climatic fluctuations, and the highly competitive characteristics of the introduced exotic species, are largely responsible for the success of exotics and research has shown that removal of grazing is generally not sufficient to restore native species dominance. Interspecific competititon, low recruitment rates of native species, annual variation in climate, impacts of non-native mammals including feral pigs, and fire all play a role in making restoration at a broad scale highly risky and unpredictable (D'Antonio et al. unpub. ms).

Perennial bunchgrasses were most likely dominant in wetter areas prior to European contact, while drier sites were dominated by annual grasses, forbs, and perhaps shrubs (Hamilton 1997; Schiffman 1997). The decline of native grassland species has been attributed to several causes. There was no livestock grazing or plowing in the pre-contact California grassland (Heady 1977; Heady et al. 1977; Mack and Thompson 1982) compared to a long history of intensive livestock grazing and cultivation in Europe, where most invading exotic plants originated (Jackson 1985). This could have played a role in favoring European species as livestock production was introduced and intensified and land was cleared and plowed for crops. It has also been suggested that exotic annual grasses are competitively superior to many native species with or without livestock grazing or plowing and could have replaced the natives solely through competition and greater seed production (D'Antonio unpub. ms; Heady et al. 1977; Bartolome and Gemmill 1981; Murphy and Ehrlich 1989). The role of livestock grazing in this conversion is the subject of continuing study and debate (Heady 1977; Jackson 1985; Edwards 1992; Blumler 1992; Hamilton 1997).

Interest in native forbs, and in particular legumes, has increased in recent years, but as yet little research has been conducted on their response to common management regimes. Recent research has indicated that in the mesic grasslands, creating a matrix of disturbance regimes through grazing contributes significantly to maintaining the suite of native species. Research on California Coastal Prairie found more exotic annual grass and forb cover at grazed sites, but also greater native annual forb species richness and cover, concomitant with reduced vegetation height and litter depth (Hayes and Holl 2003). Concerns about the impacts of herbicides used to control invasive non-native plants on these species, for example the impact of the herbicide *Transline* on native legumes, indicate a cautious approach is needed.

Restoring native plant diversity and abundance (or dominance) in California grasslands to their full potential requires the setting of realistic targets with species specificity, and the application and testing of workable management practices. Invasion by exotic species and climatic fluctuations have probably played important roles in the loss of native species, but these factors are neither controllable nor testable. Fire and grazing, on the other hand, probably contributed to the change in grasslands and can be manipulated at appropriate scales in an effort to change the

balance of native and non-native species. However their effects vary with climatic and edaphic factors, are context specific, complex, and effect different species differently. Currently, both are being used and promoted as a means of enhancing native grassland diversity in different parts of the state (D'Antonio unpub. ms; DiTomaso et al. 1999; Meyer and Schiffman 1999; Edwards 1995, 1996; Reeves 2001; Fehmi and Bartolome 2003).

Numerous studies have shown that removal of grazing did not lead to increased native dominance even after several decades (White 1967; Bartolome and Gemmill 1981; Stromberg and Griffin 1996). The relationship between livestock grazing and native grassland has not been clearly established. The existing data show that the interactions among livestock, exotic plants, and native plants are complex and variable across regions and years. Grazing has been shown to benefit some native plant populations but the positive response to grazing is not universal among native species or across locales for any one species.

Fire regime manipulation also does not result in a straightforward increase in native vegetation or consistent decrease in exotic cover, although elements of the native vegetation can benefit in some contexts (D'Antonio et al. upub. ms; Fehmi and Bartolome 2003). Climate, particularly total precipitation, is generally more important than the type of burning treatment in influencing the response of native perennial grasses and forbs to fire.

There are two general approaches for native grassland restoration that seem to be indicated:

1. Identify specific sites with edaphic factors that favor native species, and manage those sites adaptively to test various methods of increasing the presence of native species. This might include testing, with controls, presence or absence of various grazing regimes, reintroduction of burning, or seeding with native species. The most reliable indicator of such sites is a currently high presence of native species.

2. Intensive management and investment in small areas that can be planted, weeded, and monitored over time as a "native species garden." The target for such a site might be to provide examples or refugia for certain species.

An excellent review of native grassland restoration is presented by D'Antonio (unpub. ms).

Oak Woodlands. Two of Solano County's oaks (Blue oak [*Quercus douglasii*] and Valley oak [*Q. lobata*]) are commonly found with poor recruitment in California (Pavlik et al. 1991:125). While only one cause of oak suppression among many, livestock grazing can contribute to oak seedling mortality through trampling and selective herbivory, especially during the summer and fall when grass forage declines in relative quality.

In making management decisions about oak woodlands it is important to determine current trends in the existing woodlands. Is recruitment adequate to maintain the current woodland? Would increased canopy cover be desirable? Livestock grazing adds to a long list of factors, including the shift to annual grassland understory, that typically limit oak recruitment in California oak woodlands (Allen-Diaz et al. 1999). Observing fenced road cuts or other fenced sites within or near the study area can provide some insight into the role livestock might be

playing in this particular area. Often there is no difference, indicating that weather, deer, insects, rodents, disease, soils, or other factors are playing the larger role. The presence of many sapling-sized oaks in fenced areas, on the other hand, indicates that altering grazing regime may promote recruitment. Sometimes oak recruitment will flourish on specific soils regardless of grazing regime or weather patterns. Aspect and soil moisture levels are also influential. Getting to know the specific situation on the site is critical to developing management targets and methods.

It is also important to remember that oaks live a long time. This should be factored in to calculations of the replacement rate needed to maintain oak stocking. Some research has indicated that many oak woodlands in the past have experienced a "pulse" of regeneration, often attributed to changes in weather, fire, or land use. Overstory-understory relationships, the interaction of oaks with the changing grasslands, are not well understood.

Under almost any conditions, it is possible to regenerate oaks with intensive management. Acorns collected from as nearby as possible can be planted and protected with well established techniques, many of which will protect young oaks from normal wildlife and livestock grazing (McCreary 2001). If it is determined that such steps are necessary, there are often volunteers eager to plant oaks.

Fire Hazards. Reduction of fire hazards associated with fuel loads in the grasslands, woodlands, and scrub of Solano County is an important goal that can be influenced by grazing. Accumulations of highly flammable herbaceous fuels in California Annual Grasslands are a well-known problem during the dry seasons. In this case, livestock grazing is the preferred alternative, among the common methods of fuel reduction. Mowing is expensive and impractical in uneven terrain. Prescribed fire causes smoke pollution and can escape to cause severe damage to property and human health. Both of these latter practices would pose conflicts (reduction of prey habitat quality and abundance, risk of soil erosion due to machinery tracks, and risk of injury) with the management of habitat quality for special-status animals and their associates.

The fire hazard reduction benefit alone is enough incentive for many grassland managers to employ grazing on their lands. The risk of direct and indirect damage by wildfire can be severe. However, it is important to note that grazing of California Annual Grasslands at proper levels has been shown to reduce the hazard of fuel loads and to alter the behavior of wildfires, but *not* to significantly reduce the risk of fire ignition and its spread (Stechman 1983). More severe grazing is often required to achieve fire hazard reduction objectives in grassland fuels. Alternatively, in terms of longer-term fire management objectives, grazing reduces invasion of shrubs (McBride and Heady 1968), which pose a different fire hazard. Calculation of fire risks involves identification of ignition sources, probabilities, and the proximity of property and persons subject to the risk.

The fire hazard represented by grazeable herbaceous forage and the associated dense woody fuels of the Oak Woodlands and Scrub is very significant due to the complexity of vegetation. The large amount of woody "ladder" fuels and the density of trees and shrubs in the woodlands and scrub make the combination of fuel types more dangerous than grassland alone. The grassland herbaceous fuels would be likely to carry a wildfire very quickly during the dry seasons, and potentially carry the fire to the woody fuels, which pose the added potential for a major fire in the tree crowns and shrubs. Although the herbaceous fuel loads fluctuate from year to year associated

with weather conditions, the risks posed by these grazeable fuels are usually severe most years if not reduced by grazing or other means to low amounts. Year 2003 demonstrated this because of the above-normal precipitation, and associated high herbaceous growth. Regular livestock grazing can help reduce the risks associated with wildfire because the grazing will generally limit the annual buildup of herbaceous fire fuels to low levels before the dry season begins. As a further precaution, fuel breaks should be disked or mowed several times during the spring and early summer at the margins of wildland properties where this is not harmful to species of concern. However, disking can stimulate invasion of invasive non-native plants, accelerate erosion on slopes, disturb the soil, destroy wildlife habitat, and reduce wildland viewshed values, so it should be minimized when possible.

Brush Encroachment into Grasslands. Brush encroachment into grasslands (and associated increases in fire hazard) is occurring in many places where grazing has been reduced or removed, and fire has been suppressed. Brush invasion of grassland, particularly coyote brush (*Baccharis pilularis*), can develop particularly near existing stands of scrub on the more productive soils, and during years of above-normal precipitation. McBride and Heady (1968) and Heady et al. (1977) described the ecology of grassland succession to Northern Coastal Scrub. Continued grazing will assist in limiting this in areas where it is a problem, but conventional livestock grazing is less effective where the woody vegetation is well developed. Consideration should be given to the use of goats to control woody species in particular areas. A program of prescribed burning followed by grazing can be effective in areas where burning is feasible. Repeated prescribed burning alone can also be effective.

Professional Licensing Requirement. The California Board of Forestry and Fire Protection requires a licensed "Certified Rangeland Manager" for the conduct of rangeland management, planning, and conservation activities on non-federal wildlands that support or have the potential to support at least 10% cover of woodland, including riparian woodland (SRM 2000). This means that agencies and consultants conducting such work for non-federal grazing lands and other rangelands in Solano County are required to employ a licensed professional to supervise that work.

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