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Managing exotic grasses and conserving declining species

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Abstract California's southern San Joaquin Valley, as with much of western North America, has been invaded by exotic plant species during the past 100–200 years. The herbaceous cover of these introduced grasses and forbs often creates an impenetrable thicket for small ground-dwelling vertebrates. Contrary to some earlier descriptions of upland habitat of the southern and western San Joaquin Valley as perennial grasslands, recent evidence suggests that most of this area was a desert vegetated by saltbush scrub with sparse cover of native annual grasses and forbs. Many of the small vertebrates that evolved in these habitats, some of which are listed as threatened or endangered, are desert-adapted. These species evolved in sparsely vegetated habitats and rely on open ground to forage and avoid predation. Preliminary research indicates that populations of giant kangaroo rats (*Dipodomys ingens*), San Joaquin kangaroo rats (*D. nitratoides*), San Joaquin antelope squirrels (*Ammospermophilus nelsoni*), and blunt-nosed leopard lizards (*Gambelia sila*), all listed as threatened or endangered, are affected negatively by thick herbaceous cover. This cover also may adversely affect several listed plant species. Removing anthropogenic disturbances does not reduce or eliminate these exotic plants. Fire is effective in reducing herbaceous cover but kills native saltbush and often is costly to implement or control. Although livestock may have contributed originally to habitat destruction and introduction of exotic plants, we believe that in some years, moderate to heavy grazing by livestock is the best way to decrease the dense cover created by these exotics. Recent decisions to decrease or eliminate livestock grazing on conservation lands without definitive studies of grazing in these habitats may lead to further declines of native species and possible local extinction of some listed plants and animals.

Key words conservation, endangered species, exotic plants, livestock grazing

Native species are often affected adversely and even displaced by exotic species (Wilcove and Chen 1998). Indeed, establishment of alien taxa is a leading cause of endangerment of native species worldwide, perhaps second only to direct loss of habitat (National Research Council 1995). Terrestrial communities are being invaded by exotic herbaceous plants throughout the world (D'Antonio and Vitousek 1992). Grasses in particular are colonizing areas that were formerly shrublands or forests. In some regions of the western United States, grasses were sown intentionally to increase forage for livestock, and in other areas of the West, exotic grasses have unintentionally become established, often in association with livestock or crop-seeding operations (Baker 1978, Mack 1986). In California, exotic grasses are established widely and constitute a major threat to the survival of many

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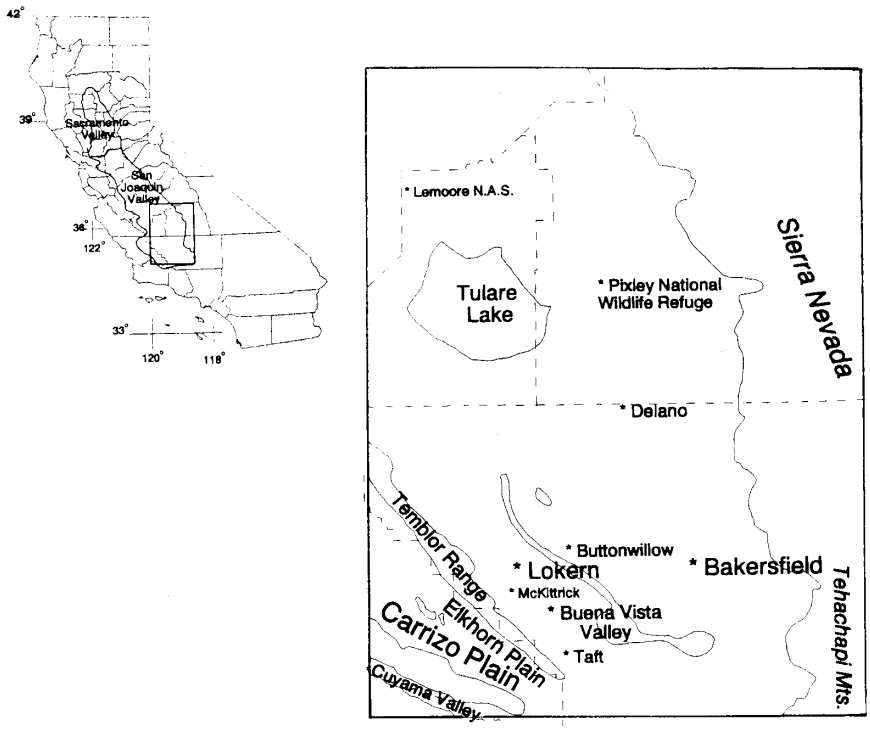

Figure 1. Location of the San Joaquin Valley in California. Localities referenced in the text are shown.

native plants (Mooney et al. 1986, Schierenbeck 1995). In the San Joaquin Valley of California (Figure 1), exotic annual grasses have become the dominant herbaceous component in many habitats (Biswell 1956, Heady 1977). In particular, red brome (*Bromus rubens madritensis*), mouse-tail fescue (*Vulpia myuros*), Arabian grass (*Schismus arabicus*), foxtail (*Hordium murinum glaucum*), ripgut brome (*Bromus diandrus*), and soft chess (*Bromus hordeaceus*) have become ubiquitous.

The western and southern portions of the San Joaquin Valley are inhabited by numerous native, desert-adapted animal and plant species. Many of these taxa are endemic to the valley and are protected by state or federal regulations. Animals include the giant kangaroo rat (*Dipodomys ingens*), Tipton kangaroo rat (*D. nitratoides nitratoides*), and Fresno kangaroo rat (*D. n. exilis*), which are state and federally listed as endangered; the San Joaquin antelope squirrel (*Ammospermophilus nelsoni*), which is state-listed as threatened; and the blunt-nosed leopard lizard (*Gambelia sila*), which is state and federally listed as endangered. Plants include Kern mallow (*Eremalche kernesis*), San Joaquin woolly-threads (*Lembertia congdonii*), California jewelflower (*Caulanthus californicus*), and Bakersfield cactus (*Opuntia treleasi*), all of which are federally listed as endangered, and Hoover's woolly-star (*Eriastrum hooveri*), which is federally listed as threatened. Numerous other plants and animals in the area are declining and not formally protected.

Much of the nonforested or nonshrubland habitat west of the Sierra Nevada in California is often considered native grassland (Clements 1920, Biswell 1956, Küchler 1977). This is particularly true of the San Joaquin Valley, which has been classified as a bunchgrass prairie, except for marshes, riparian habitats, and a small area of alkali sink habitat on the valley floor (Heady 1977, Küchler 1977, Baker 1978). Recent analyses, however, cast doubt on the classification of most of the San Joaquin Valley as a perennial grassland (Wester 1981, Hamilton 1997). Based on the plant and animal species of this area, Hawbecker (1958) classified this part of the valley as a desert. Axelrod (1966) and Hafner and Riddle (1997) also argued convincingly that this area is a desert, equal in biotic composition and structure to other North American deserts.

In this paper we argue that many of the plants and animals native to this area are adapted to relatively open habitats and therefore are morphologically, behaviorally, and physiologically ill-equipped to live in dense grass. We also present evidence that the dense cover of exotic annual grasses is having a significant negative effect on these plants and animals and that the structure of the habitats occupied by these species must be kept relatively clear of dense herbaceous plant growth to ensure their survival. Lastly, we develop our hypothesis that well-managed grazing by livestock may be used to reduce these exotic grasses and thus sustain populations of the native plants and animals that are at risk of becoming endangered or extinct.

Habitats of native animals and plants

Kangaroo rats

Perhaps the most visible members of the terrestrial vertebrate community on natural lands in the San Joaquin Valley, at least in their ground-disturbing activity, are 3 species of kangaroo rats. The giant kangaroo rat is the largest (up to 180 g) and occurs along the western side of the valley, including the Carrizo and Elkhorn plains and Cuyama Valley (Figure 1, Grinnell 1932, Williams and Kilburn 1991). This species often reaches high densities and acts as a keystone species (Williams and Kilburn 1991). The Heermann's kangaroo rat (*Dipodomys heermanni*) is smaller (60–80 g), occurs throughout the valley, and is not threatened or endangered. The San Joaquin kangaroo rat (*D. nitratoides*) is the smallest (30–45 g) and has 3 recognized subspecies: *D. n. exilis* occurs in the central portion of the valley floor, *D. n. nitratoides* is found on the southern portion of the valley floor, and the short-nosed kangaroo rat (*D. n. brevinasus*) occurs along the western and southern sides of the valley (Williams and Kilburn 1992). The last is not listed as threatened or endangered, although its numbers also are declining.

In general, small mammals have declined precipitously in the southern San Joaquin Valley since 1994 (Single et al. 1996). The actual mechanism causing the decline is not known, but factors likely include greater than normal rainfall and associated dense grass growth that probably makes foraging harder and leads to increased risks of predation. Also, dense grass growth and high levels of precipitation may keep soil moister than normal (Single et al. 1996). Because many kangaroo rats cache seeds, damp winter soils may cause seeds to become infected by molds, some of which are toxic (Frank 1988). Additionally, abnormally wet periods may cause some kangaroo rats to develop fatal respiratory problems, as was seen in captive Tipton kangaroo rats during an abnormally rainy February in 1995 (D. Germano, unpublished data).

Kangaroo rats generally prefer open habitats that allow them to travel unimpeded (Bartholomew and Caswell 1951, Price 1978, Goldingay et al. 1997). The adverse effects of dense grass cover to kangaroo rat populations has been shown for Stephen's kangaroo rat (*Dipodomys stephensi*, O'Farrell and Uptain 1987, Price et al. 1994), Merriam's kangaroo rat (*D. merriami*, Reynolds 1950), and chisel-toothed kangaroo rat (*D. microps*, Rowland and Turner 1964). There also are numerous anecdotal observations showing that abundance of giant kangaroo rats increases as grass and forb cover decreases, such as around livestock watering points, sheep bedding areas, and in prescribed burn areas (Grinnell 1932; Shaw 1934; Williams and Kilburn 1991; D. Germano and L. Saslaw, unpublished data). Similarly, Fresno and Tipton kangaroo rats appear intolerant of dense grass cover (Williams and Germano 1992; D. Germano, unpublished data; C. Uptain, unpublished data). Most Fresno kangaroo rat habitat has been lost to agricultural crops and urbanization (Williams and Kilburn 1992), but habitat alteration also is a problem. For example, one of the few known sites that supported a population of *D. n. exilis* was the Alkali Sink Preserve in Fresno County, which was created to protect this species. When cattle grazing was stopped in 1979, however, exotic grasses soon dominated the preserve and the population of kangaroo rats declined and virtually disappeared by 1982. No animals have been found at the preserve since 1992, when only a single individual was caught, which suggests strongly that cessation of grazing and the subsequent habitat conversion from desert scrub to grassland was responsible (Williams and Germano 1992, United States Fish and Wildlife Service 1997).

Antelope squirrel

San Joaquin antelope squirrels weigh about 150 g and are well adapted to arid environments with scattered cover provided by bushes (Hawbecker 1975, Best et al. 1990). This species was listed as threatened by the state because it is intolerant of agricultural cultivation (Grinnell and Dixon 1918, Williams and Kilburn 1992). There also is growing evidence that habitat conversion from desert shrublands to dense grassland also is associated with declining numbers, probably for reasons similar to those cited above for kangaroo rats. For example, on the Carrizo Plain (Figure 1), squirrels were most abundant in open habitats associated with grazed pastures, prescribed burns, and roadside shoulders, where the cover and density of exotic grasses were reduced (G. Rathbun, unpublished data).

Lizards

The blunt-nosed leopard lizard is relatively large (40–50 g) and preys on arthropods and other lizards (Montanucci 1965, Tollestrup 1982, Germano and Williams 1992). In turn, it is prey for a

Figure 2. This blunt-nosed leopard lizard, an endangered species, was approached easily in this dense thicket of exotic grass. For lizards and small rodents, grass is a major barrier to forage and escape from predators. Photograph by B. L. Cypher.

variety of mammals, birds, and snakes (Montanucci 1965, Germano et al. 1994, Germano and Carter 1995), which it avoids by swift cursorial (often bipedal) flight into small mammal burrows. One indication of how poorly these lizards are adapted to dense grassland situations is the ease of capturing them by hand in dense grass (Figure 2), compared to more open habitats (B. Cypher, personal communication; D. Germano and L. Saslaw, personal observation). Visual transect surveys (D. Germano, unpublished data; D. Williams, personal observation) and radiotracking studies (Warrick et al. 1998) have shown their preference for open habitats, including dirt roads and roadsides, arroyos, and grazed pastures with reduced grass density.

The coast horned lizard (*Phrynosoma coronatum*) is small (25–30 g) and has relatively weak legs, which restricts it to open habitats. Increasing exotic grass has been associated with a decline of horned lizard abundance at the Pixlie National Wildlife Refuge (M. Davis, unpublished data) and may have contributed to their decline throughout the San Joaquin Valley. The impacts of habitat alterations are not restricted to leopard and horned lizards. For example, declines in abundance of the lesser earless lizard (*Holbrookia maculata*) and the eastern fence lizard (*Sceloporus undulatus*) in Nebraska were associated with increased grass cover after cattle grazing was stopped (Ballinger and Watts 1995).

Birds

Although the mobility of ground birds makes them less susceptible than reptiles and rodents to negative effects of habitat conversion, some species in the San Joaquin Valley have been affected. The mountain plover (*Charadrius montanus*), which is a declining species (Knopf 1994) and has been proposed for federal listing, breeds in the western Great Plains of North America, but many winter in and near the San Joaquin Valley. They spend most of their time in intensively grazed pastures, burned fields, or plowed farmland (Grinnell and Miller 1944, Knopf and Miller 1994, Knopf and Rupert 1995), but they abandon these areas when herbaceous plant cover exceeds about 10 cm in height (S. Fitton, personal communication).

Plants

Kern mallow, California jewelflower, Hoover's woolly-star, and California woolly-threads are annual species that germinate in late winter and usually set seed by April or May (Taylor and Davilla 1986, United States Fish and Wildlife Service 1997), similar to many annual grasses. The invasion by nonnative herbaceous plants, notably the grass *Bromus madritensis rubens*, has forced these native annuals to compete for light and soil moisture with exotic plants that are capable of 100% ground cover and heights of 50 cm. The Kern mallow seems to be particularly susceptible to competition from dense exotic grasses (E. Cypher, unpublished data; L. Saslaw, personal observation). An obvious consequence of this aggressive competition is the collapse of the massive spring wildflower "shows" so characteristic of many desert areas, including the southwestern San Joaquin Valley. The perennial Bakersfield cactus also can be harmed by extensive grass accumulation, which increases damage from fire, promotes decay organisms, and can harbor damaging insects (United States Fish and Wildlife Service 1997).

Managing exotic grasses

Biological communities in the San Joaquin Valley have been altered significantly in the past century, particularly by introduced plants, and we believe that management actions are necessary to avert the decline and eventual extinction of a variety of endemic species in the valley. As Brown and McDonald (1995) pointed out, we can never go back to the West of pre-European times. We need to find a way to manage communities now dominated by exotics so that declining species are not eliminated. Possible methods to decrease the cover of alien grasses are removing all disturbances to the system, using prescribed fire, applying mechanical or chemical treatments, and grazing livestock.

Because cattle and sheep likely contributed to the spread of exotic weed plants in the West (Young et al. 1972, Baker 1978, Mack 1986), some authors believe that eliminating livestock from upland habitats could allow these areas to recover to presettlement conditions (implicit in papers by Fleischner 1994, Noss 1994). If native perennial grasses are released from the damaging effects of grazing, some people believe the perennials will eventually outcompete exotic annual plants. Studies conducted in California, however, do not support this idea. Absence of livestock grazing does not eliminate exotic annuals (Biswell 1956, Heady 1977, George et al. 1992, Stebbins 1992) or allow perennial grasses to regain dominance (Bartolome and Gemmill 1981, Keeley 1990). Indeed, it is likely that cessation of grazing only exacerbates the problem in habitats where annual exotic grasses are naturalized. Also, it may be that some nonnative plants arrived in California before livestock grazing began (Mensing and Byrne 1999), indicating an ecological predisposition of some alien plants to California habitats, regardless of disturbance.

State and transition models (Westoby et al. 1989) are useful to understand the transition from the original saltbush shrubland of the San Joaquin Valley to the nonnative annual grassland that is now dominant. Vegetational changes within California's annual grasslands have been evaluated using nonequilibrium ecological theory to better understand observed irreversible transitions and alternative stable states (George et al. 1992). These nonnative grasslands appear to be resistant to disturbances and resilient in their ability to maintain their dominance. Without management action, these grasslands will persist, even if the original stable state was a desert scrubland.

Burning of natural habitats is known to temporarily decrease herbaceous exotic plant cover, and some plant communities have evolved with a regular fire regime (Mooney and Conrad 1977, Conrad and Oeschel 1982, Keeley 1995). Fire can remove annual grasses and forbs, at least until the next rain, but as pointed out by Young et al. (1972), many exotic grasses are reproductively well adapted to fire. We have seen that wildfires and prescribed burns in San Joaquin Valley habitats temporarily promote an increase in abundance of terrestrial vertebrate populations. Nevertheless, desert habitats in general are not fire-adapted (Kearney et al. 1914, Brown and Minnich 1986). Grasses, which are the fine fuels that carry fires, were not a major component of most desert systems. In fact, fire now maintains alien grasslands in habitats throughout the world, including the San Joaquin Valley, at the expense of native plant communities (D'Antonio and Vitousek 1992).

The major drawback of prescribed burning in the San Joaquin Valley is that fire often completely kills native saltbush. We conducted a test of the effects of fire on saltbush on the Lokern Natural Area (Figure 1) in 1997 and 1998. We used 4 (replicated) grids 300 m on a side with 225 cells each 20×20 m. We randomly selected 10 cells in each of the 4 grids and counted the number of live saltbushes before and after an August 1997 prescribed burn. We found 83.9% of saltbush alive before the fire, compared to only 0.2% afterwards. During an August 1998 follow-up survey, none of the dead saltbushes had resprouted from their base. Saltbushes provide potentially important cover to the diurnal antelope squirrels and lizards and they represent a major component of the natural landscape of the desert environment that is important to other species in this community, such as the Le Conte's thrasher (*Toxostoma lecontei*) and sage sparrow (*Amphispiza belli*).

Another drawback to prescribed burning is the high cost to manage fires (Wilcove and Chen 1998). For example, in 1996 a 259-ha prescribed burn on the Carrizo Plain became uncontrolled, burning an additional 445 ha and costing $44,500 to contain (L. R. Saslaw, personal observation). If structures had been accidentally burned, the costs would have been much greater. Additionally, in many areas, including the San Joaquin Valley, air-quality standards restrict prescribed burning. For these reasons, we do not believe that fire, except on a limited basis, is a practical or even desirable way to manage exotic

plants on a landscape basis in the desert areas of the San Joaquin Valley.

The control of exotic grasses and the production of open spaces may be possible by removing plants mechanically or by broadcasting herbicides. Although these methods can be effective in small areas, they are too costly over the landscapes necessary to benefit endangered plants and animals in the San Joaquin Valley. Also, the indirect effects may be unacceptably large. For example, the application of herbicides can negatively affect nontarget plants and could depress numbers of invertebrates, some of which are important prey to the species of concern. Mechanical treatments would likely crush burrows used by the species of concern.

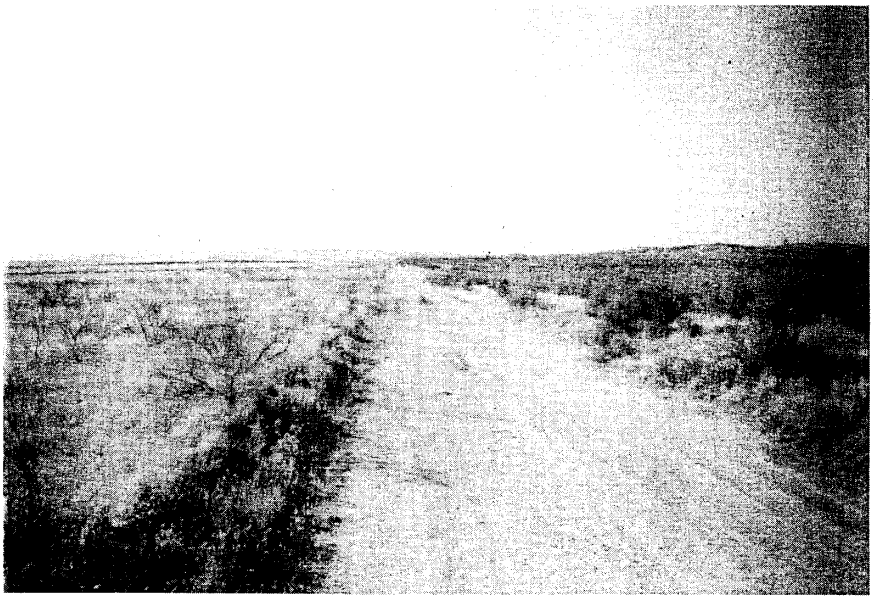

Figure 3. In the past 100 years, saltbush scrub habitat in the San Joaquin Valley has been invaded by alien grasses that now form thick cover between shrubs in wet years. The area on the left side of this photograph had recently burned and was covered with dense exotic grasses. Photograph by D. J. Germano.

Recently, the topic of livestock grazing has become a concern of conservation biologists (Noss 1994), who focus largely on documenting the widespread detrimental ecological effects that livestock grazing has had on western lands (Fleischner 1994). We do not argue with the fact that in many situations poorly managed livestock grazing has been detrimental to vast areas of the West. However, alien plants are increasingly colonizing the arid West, and well-managed livestock grazing may be the most practical way to maintain habitat structure for some species.

Brown and McDonald (1995) point out that not all livestock grazing in the West is necessarily bad. Certain vertebrate species, especially, are greatly aided by the actions of large herbivores. We believe this is now the case in the San Joaquin Valley. We are not advocating overgrazing, or grazing all remaining arid lands. However, we believe that a mosaic of patches with different management regimes, on a landscape scale, would accommodate a wide variety of native plant and animal communities in the region. A large proportion of these patches should be managed so that exotic grasses in upland desert habitats are maintained at low stature during the growing season. This can be done without greatly affecting native perennial plants or soils by prescribed grazing and carefully monitoring livestock. We recognize that in some years of low rainfall, grazing may not be desirable. During average or above-average rainfall years, however, exotic grasses can form thick carpets (Figure 3). Management prescriptions should include the ability to alter the dates and stocking rates of livestock to respond to annual plant production so that nonnative grass does not dominate a site. Besides the ability of managed livestock to limit the growth of grass and accumulated dry matter, livestock operations can produce income, which makes livestock use easy to implement. We recognize that livestock may have some direct negative effects, such as trampling cryptogamic soil crusts and damaging some individual rodent burrows and individual native plants. We believe these negative effects will be outweighed by a general improvement of habitat conditions for populations of declining species.

Conclusions and management recommendations

Environmental groups have effectively developed the public perception that livestock dung and bare ground are "bad." The fallacy of this view is that some arid western lands may not "function well" when the

objective is solely to make lands "look good." A habitat that is visually less appealing, yet preserves endangered native species, is preferable to a pleasant view that largely supports only alien taxa and precludes small vertebrates and native annuals.

We recognize the need to experimentally determine the effect of grazing on at-risk species, and we are in the process of gathering these data. Convincing data from these studies, however, will likely take many years to gather. In the interim, the San Joaquin Valley may lose populations of endangered species due to land-use policies that are counterproductive because they allow thick grass cover to persist. While quantitative information required to develop land-use methods that are compatible with recovering declining species on arid lands in the West is gathered, we recommend that at least some of the conservation lands in the San Joaquin Valley be grazed by well-managed herds of livestock.

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