California Native Grasslands: A Historical Perspective

A Guide for Developing Realistic Restoration Objectives

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California's grasslands cover approximately 25% of the state, either in open grassland, oak woodland, or savanna. Although they are largely dominated by nonnative annual species, they provide essential hydrologic functions (capture, storage, and safe release of water), important wildlife habitats (Giusti et al. 1996), and repositories of native flora diversity. Around 90% of species listed in the Inventory of Rare and Endangered Species in California (Skinner and Pavlik 1994) inhabit California's grassland ecosystems. In addition to their important ecological values, California's grasslands provide forage for range livestock, a leading agricultural commodity in the state. Despite its value for native biological diversity and range livestock, California grassland habitat is increasingly reduced in acreage and quality not only because of conversion to cropland and residential and urban development, but also because of invasion by woody species and continued nonnative species invasion. Invasion by woody and nonnative species often occurs on conservation lands, which have been protected from grazing and other disturbances.

Conservation land managers are increasingly aware that acquisition alone doesn't necessarily result in conservation. They recognize that, without management, California grassland habitats can be degraded by accumulating mulch and domination of undesirable species, such as black mustard (*Brassica nigra*), fennel (*Foeniculum vulgare*), medusahead (*Taeniatherum caput-medusae*), coyote brush (*Baccharis pilularis*), or Harding grass (*Phalaris tuberosa*). Although these species can be controlled with mowing, prescribed fire, herbicides, cultivation, or livestock grazing, deciding on realistic management and restoration goals, followed by an effective management plan, are difficult first steps.

Here we review the history of animal and human impacts that led to the current composition and condition of California grasslands. We also include a history of restoration and management efforts on California grasslands. This history may help land managers recognize the difference between past uncontrolled grazing practices, which undoubtedly assisted in the invasion of our grasslands with nonnative species and degraded the resource as a whole, and today's use of managed grazing as a resource management tool. An understanding of California native grassland history should also help land managers identify realistic restoration goals. We conclude with a discussion of considerations to assist land managers in identifying measurable restoration and management objectives.

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Historical Perspective: Animal and Human Impact on California's Native Grasslands

For millions of years, California's original grasslands were grazed, browsed, and trampled by now-extinct megafauna, which included medium to large herbivores, such as ground sloth, bison, camel, horse, mammoth, mastodon, and ox (Edwards 1996). Undoubtedly, the combined influence of these large herbivores, the activity of smaller mammals, and fire played an important role in the development of California's native grassland species. When the megafauna became extinct some 10,000 years ago, pronghorn antelope (*Antilocapra americana*), black-tailed deer (*Odocoileus hemionus*), tule elk (*Cervus elaphus nannodes*), grizzly bear (*Ursus arctos*), and small mammals, such as California ground squirrel (*Spermophilus beecheyi*), gopher (*Thomomys* spp.), rabbit (*Sylvilagus* spp.), and kangaroo rat (*Dipodomys* spp.), continued to impact California's grasslands.

The Central Valley's early grassland landscape included significantly more wetlands, including riparian woodlands, freshwater marshes, and vernal pools.

Early reports from explorers indicate that vast herds of grazing animals in the Central Valley rivaled the numbers of bison on the Great Plains. McCullough (1971), for example, estimated a population of 500,000 tule elk in aboriginal central and western California. The specific impact of these grazing animals on the grasslands is difficult to discern, because these animals are not obligate grazers but rather browsers and/or grazers, consuming broadleaf plants, woody plants, and grasses (Wagner

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1989). Also, the Central Valley's early grassland landscape included significantly more wetlands, including riparian woodlands, freshwater marshes, and vernal pools. If, for example, tule elk, which prefer marshy areas, consumed large amounts of wetland plants, their impact on mesic native grassland species may have been limited (Wagner 1989).

Whatever the impact of grazing animals on native grasslands following the extinction of the megafauna, human impact became significant when intensive management of grasslands, or prairies, began. Native Californians burned, dug, tilled, and pruned native vegetation to maintain the biological resources they used for food, medicine, and construction materials (Blackburn and Anderson 1993). Early expeditions in California made note of the open grasslands managed by the native Californians:

> *Within the forests, at all elevations from sea level to the top of the ridges, there were small open patches, known locally as "prairies," producing grass, fern, and various small plants. Most of these patches if left to themselves would doubtless soon have produced forests, but the Indians were accustomed to burn them annually so as to gather various seeds. These prairies were of incalculable value to the Indians, not alone for their vegetable products, but also for the game found upon them.*
>
> Summary of an encounter with remnant prairies in Humboldt County by R. Mc Kee expedition of 1851 (Loud 1918).

These open, productive prairies described by early explorers began to change with the arrival of Spanish settlers some 200 years ago. Fires were suppressed, livestock (i.e., cattle, horses, and sheep) were introduced, and hunting nearly exterminated the elk, pronghorn antelope, and deer. Although the Spaniards never extended their livestock management into the Central Valley, the Native Americans drove domestic livestock into the valley. By 1819, the native Californians were breeding their own stock and their herds started to grow. Many of their cattle and horses escaped and formed large uncontrolled herds of feral animals. Reports from the 1830s and 1840s mention the San Joaquin prairies swarming with wild horses and Sonoma County abounding with wild cattle and horses (Wagner 1989).

In most regions of the state, native species are only a minor component of the grassland flora, comprising less than 1% of the standing grassland crop.

An actual ranch industry in California did not develop until the discovery of gold in 1848. Ranchers began shooting wild horses, rounding up cattle and elk, and breeding their own herds. Herds of cattle were driven in from the east to build up numbers to support the growing demand for meat after the Gold Rush. From 1850 to 1880, excessive numbers of livestock grazed California's rangelands, including 3 million cattle, and 6 million sheep. These numbers decreased temporarily during a devastating drought from 1862 to 1864, when from 200,000 to 1,000,000 cattle may have starved (Wagner 1989). Although today the number of cattle on California's rangelands approaches the late 19th century population level (2.9 million), the number of sheep have substantially declined, to less than a half million.

A significant change in vegetation coincided with the arrival of domestic livestock and the growth of the ranching industry; nonnative grasses and forbs spread throughout California's coastal prairies, foothills, and valleys (Burcham 1956). Although nonnative species, such as the annual forb filaree (*Erodium cicutarium*) were present in California before settlement in 1769 (Mensing and Bynre 1998), the vast majority of nonnative species invaded and spread in the late 18th and early 19th centuries (Hendry 1931). Over the past 200 years, the nonnative species have become the most abundant plants across California's grasslands.

Although dominance of nonnative species and the accompanying decline in native grassland species have been attributed to uncontrolled livestock grazing, several other factors, including tillage for crop agriculture, fire suppression, elimination of land management by Native Americans, climate change, and competition from nonnative species have played an important role in the conversion. Some researchers have concluded that nonnative, annual grasses are so competitively superior that they could have displaced native grasses solely through competition and greater seed production (Heady 1977; Bartolome and Gemmill 1981; Murphy and Ehrlich 1989). Regardless of which factors were responsible for the decline of native-dominated grassland, in most regions of the state, native species are now only a minor component of the grassland flora, comprising less than 1% of the standing grassland crop.

Historical Perspective: Restoration Efforts and Management for California's Native Grasslands

Although efforts to restore native grasses to California's grasslands are relatively recent, beginning with the conservation movement of 1970s, range scientists and agronomists have long been interested in improving California's grasslands. University of California, Berkeley, agronomist Dr. P. B. Kennedy began testing native and exotic perennial grasses and legumes in 1912. He was searching for alternative forage species to improve California's rangelands for livestock production (Kay et al. 1981). His relative success with establishing nonnative perennials over native perennials led to the introduction of smilo grass (*Oryzopsis miliacea*) and Harding grass (*Phalaris tuberosa*) in California.

Sampson and McCarty (1930) were also interested in perennial grasses for rangeland improvement. They studied purple needlegrass (*Nassella pulchra*) because of its palatability, nutritional value when

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dry, and long green forage period. They also considered the impact of grazing on perennial grasses by conducting clipping studies. Based on their clipping studies, they concluded that purple needlegrass plants would fully recover and produce seed under moderate grazing intensity in the fall and winter, whereas late spring grazing could injure the plants.

The University of California's interest in improving California's rangelands continued in the 1940s. The University of California, Davis, hired agronomist, R. M. Love to find replacement forage species, and he spent 15 years testing native perennial grass species, including *Nassella* spp., *Melica* spp., *Danthonia californica, Agrostis* spp., *Bromus* spp., *Elymus* spp., and *Sporobolus* spp. (Kay et al. 1981).

Love also considered the impact of grazing on these species. He seeded perennial grasses and legumes and studied the effect of spring grazing treatments with sheep. He found that early intensive grazing before the annuals headed out reduced the competition and resulted in the most vigorous perennials, which included purple needlegrass (*N. pulchra*) and nodding needlegrass (*N. cernua*) (Love 1944). He later devoted special attention to needlegrass species (Love 1951, 1954).

Examples of Measurable Objectives

Reduce medusahead to less than 15% of the groundcover. This objective will be achieved by burning pasture #3 late in May when medusahead is still green and most other annuals are dry. The burn will be conducted in cooperation with the California Department of Forestry and Fire Protection.

Maintain coyote brush cover at less than 5%. This objective will be achieved by maintaining a seasonal grazing program. Cow–calf pairs will graze the property from November to June.

Love's research led him to select two strains of purple needlegrass and nodding needlegrass to be certified by the California Crop Improvement Association in 1948 (Love 1948). Lack of interest in the public and private sectors kept these certified strains from being widely planted in California rangelands. Nonnative perennial grass species, such as Harding grass and orchard grass, proved to be easier to reseed and more palatable to livestock (Kay et al. 1981).

Meanwhile, other researchers acknowledged the naturalized annual-dominated grassland in California and began learning about appropriate grazing management practices for this grassland ecosystem (Bentley and Talbot 1951; Love 1945). They studied how to manage annual grasslands for vegetation composition (Heady 1956) and for soil protection and forage production (Bartolome et al. 1980). They also began studying grazing strategies to control invasive, less-desirable exotic species, such as foxtail barley (*Hordeum jubatum*), medusahead (*Taeniatherum caput-medusae*), and yellow starthistle (*Centaurea solstitialis*).

Interest in restoration has renewed interest in understanding how to establish and manage native California grassland species. Research projects focused on restoring native perennial grasses have reaffirmed the challenge of their establishment, especially from seed (Dyer et al. 1996; Stromberg and Kephart 1996). Other studies have determined that the more abundant and faster-growing annual grass species can form dense stands, monopolize resources, and restrict the growth and survival of perennial grass seedlings (Bartolome and Gemmill 1981; Dyer et al. 1996; Dyer and Rice 1997; Hamilton et al. 1999; Brown and Rice 2000). A comprehensive review of native grassland research conducted throughout California attempted to quantitatively evaluate the potential for use of grazing and prescribed fire as tools to enhance native grass populations (D'Antonio et al. 2001). Unfortunately, they found only a few studies that examined the impact of grazing and fire on native plants, and many of these studies lacked replication of treatment or controls to be included in a quantitative analysis.

Identifying Realistic Restoration Goals

Many conservation efforts on California grasslands have focused on the goal of restoring grasslands to some pre-settlement condition. This goal has proven to be unrealistic because not only is it difficult and costly to establish native perennial grasses,

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there is also uncertainty about the historical composition and extent of California native grasslands. One popular theory suggests that California's pristine prairie was dominated by purple needlegrass (*Nassella pulchra*) (Clements 1934). Clements came to this conclusion by observing nearly pure stands of purple needlegrass along railroad rights-of-way.

The theory that many of California's current grasslands were formerly dominated by woody vegetation and not "pristine" prairie (Cooper 1922) has been less popular, but is receiving growing scientific support (Hamilton 1997). Cooper noted numerous examples where repeated burning, often intentionally, was sufficient to eliminate woody vegetation and replace it with weedy annuals. Some annual grassland sites may have in fact previously been dominated by coastal scrub (Hopkinson and Huntsinger 2005) or native annuals (Solomeschch and Barbour 2004) and not perennial bunchgrasses.

Given the uncertainty about the assemblage of native plants on a given site, restoration project planning must be characterized by clear thinking and fact-finding

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that leads to feasible goals and measurable objectives. Questions that might help planners define restoration goals and objectives include:

- What do you hope to achieve?
- Is your objective to maintain the native perennial species that currently exist on the site or is it to increase the vigor and density of the existing native perennial species?
- Are there native perennials that do not currently exist on the site that you would like to add?
- Are there specific exotic or woody species that should be targeted for control?

During fact-finding, project planners must determine if the goals and objectives are feasible based on current knowledge:

- Are your objectives achievable given the capabilities, constraints (soil depth, rainfall, etc.), and history of the site?
- Are there proven restoration practices that will allow the project to successfully reach restoration objectives?
- Can these practices be applied to the proposed restoration site?

Site capabilities and constraints. Vegetation stand establishment, productivity, and longevity are greatly influenced by site characteristics. Rainfall and soil moisture-holding capacity must be sufficient to support the establishment and maintenance of a native perennial stand. Although we may have incomplete knowledge of the rainfall requirements of native perennials, we know from rangeland improvement research in the 1940s and 1950s (Jones and Love 1945; Bentley et al. 1956) that seedings of native and exotic perennials and annuals have been more successful when annual rainfall exceeds 20 inches and soil depth is at least 24 inches. A shorter dry season (longer rainy season) may also improve perennial grass restoration success (Jackson and Roy 1986). To increase the chances of grassland restoration success, it may be prudent to focus restoration effort on coastal and upland sites, where rainfall and rainy season length are greater, and to avoid sites with shallow soils. Soil surveys, published by the USDA Natural Resources Conservation Service (NRCS), contain information about soils and ecological sites that can be helpful in determining site capabilities and constraints. NRCS offices throughout the state can be found under the U.S. Government listings in the telephone directory.

Site characteristics also influence the practices that can be applied to manage for native perennials. Native grass seed producers have proven that native grasses can be grown using normal farming practices (tillage, irrigation, fertilization, and weed and pest control). Dryland farming practices can also be used to grow native grass seed. However, many sites suffer from the "toos." They are too steep, too rocky, too dry, too salty, or too wet for application of normal farming practices. On these sites, seeding practices and weed and brush control practices become more limited. On some sites, vegetation management may be limited to manipulation of fire and grazing.

Increasing native grass cover on sites that have been cultivated may require reseeding as well as vegetation management. Because seeds of native perennials no longer reside in the seed bank on many annual-dominated sites, seeding or plug planting accompanied by management of invasive annual plants will be required on most sites, especially inland sites.

Site History. Knowledge of historical land uses may be helpful in understanding the site's herbaceous composition, including seed bank, and determining appropriate management practices. For example, on the Hastings Natural History Reservation near Monterey, the frequency of native perennials depends on whether the site has been cultivated. Few native perennials grow on sites that were cultivated before 1937; on sites that have not been cultivated, native perennials, such as purple needlegrass, comprise up to 37% of the total aboveground standing crop (White 1967). Increasing native grass cover on sites that have been cultivated may require reseeding as well as vegetation management. Because seeds of native perennials no longer reside in the seed bank on many annual-dominated sites (Rice 1989), seeding or plug planting accompanied by management of invasive annual plants will be required on most sites, especially inland sites.

Around 90% of species listed in the Inventory of Rare and Endangered Species in California inhabit California's grassland ecosystems.

Measurable objectives. Development of specific objectives will help project managers determine what practices to apply in the project; furthermore if the objectives are measurable, not only will be it be clear what should be monitored but also if progress is being achieved. For example some measurable objectives might be:

- Reduce medusahead to <15% of the groundcover.
- Eradicate Harding grass.
- Increase purple needlegrass cover to at least 20% of the groundcover.
- Maintain coyote brush cover at <5%.

With measurable objectives stated in this manner, project managers can develop a management plan, practices and strategies that have been shown to successfully reach these objectives (see "Examples of Measureable Objectives" sidebar). Past experience and science-based information should be the basis for selecting restoration practices. Measurable objectives also define what elements a manager needs to

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monitor to demonstrate practice effectiveness and project progress. Monitoring also helps the manager recognize the need to make management changes in response to changing conditions. With a restoration planning process that includes measurable objectives, implementation of effective practices, and monitoring, restoration projects can be successful.

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