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Restoration is Best for Wildlife, Right?

Lessons learned and applications to grassland habitat management

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Introduction

Intact native grasslands are some of the rarest ecosystems in the world and wildlife species associated with grasslands have declined precipitously over the last 200 years (Samson and Knopf 1994). California's grasslands are one of the most invaded ecosystems globally (Huenneke 1989), with over 98% dominated by non-native forbs and grasses (Barbour et al. 2007). Some grassland habitats have been restored with grasses and forbs thought to be native to the Central Valley, with the goal of restoring biodiversity and ecosystem services that have been lost due to exotic species invasion, overgrazing, and other factors (see Seabloom et al. 2003). Grassland restoration is thought to increase floral and faunal native species richness, wildlife diversity and abundance, forage for livestock, and aesthetic value. However, restoration projects are expensive and time-consuming, and post-restoration monitoring is heavily constrained by limited resources (Majer 2009). Wildlife monitoring can be particularly intensive, and impacts of restoration on wildlife are not commonly monitored (Bash and Ryan 2002, Golet et al. 2008). In many cases when monitoring is conducted, only one or a few taxa are included on a limited spatiotemporal basis, the results of which may not be applicable across years or locations (Magurran et al. 2010).

In California, the diverse assemblage of wildlife that reflects the state's great variety of climates and habitats is now greatly reduced in abundance and diversity (Vander Zanden et al. 2006). One of the goals of habitat restoration and management is the provision of wildlife habitat and increased biodiversity, which extends to impacts on food webs. Beschta and Ripple (2009) concluded, for example, that the removal of large predators (e.g., wolves) in the western United States resulted in drastic changes to native plant communities. When wolves were no longer present to control elk and other large herbivores, this resulted in overgrazing by wildlife and a sweeping change to plant communities. In such cases, restoration of native flora is likely necessary for the recovery of former ecosystem services. However, while the restoration of historic

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Western yellow-bellied racer (*Coluber constrictor mormon*) under coverboard in Esparto, CA. *Photo: Kristina Wolf*

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plant community assemblages is often assumed to provide increased resource availability for other trophic levels, how well this objective is met is rarely monitored (Boyd and Svejcar 2009).

Plants sit at the base of all other trophic levels, providing necessary habitat requirements for a variety of guilds. For example, rodents rely on plants for cover and food, and rodents are an important food source for a number of higher trophic levels, including snakes, raptors, and intermediate predators (e.g., coyotes, raccoons). Thus, the resource base provided by plants can cascade up to other trophic levels beyond rodents and influence wildlife species abundance and diversity (Terborgh et al. 2010). Grassland restoration creates at least initial disturbances and alters plant communities and cover, thereby causing a ripple of effects into wildlife communities. Theoretically, wildlife will respond by utilizing these areas more or less, depending on their habitat requirements, and as such, "utilization" may act as a proxy for changes in wildlife "abundance." However, while restoration generally assumes an increase in suitable habitat, it is still not clear how many different wildlife species respond to restoration (Majer 2009), particularly in grasslands.

Methods

We conducted a natural experiment in which we monitored plant community structure (physical attributes, including height and cover), and rodent, snake, and raptor diversity and utilization in paired restored (native perennial) grasslands, and unrestored (exotic annual) grasslands at four locations over a full year to elucidate the impacts of restoration. Our experiment was multi-season, multi-species, and multi-trophic and included sites that spanned California's heavily invaded Central Valley

The four study locations were chosen for the availability of paired restored and unrestored sites with similar soil types, topography, land-use history, grazing regimes (if any), and management. Data were collected over a 30-day period in April 2014 (spring), July 2014 (summer), and October 2014 (fall), and over a two-month period from February-March 2015 (winter). At two locations, restored sites were planted in 1992, while restored sites at the other two locations were planted in 2003.

We used a combination of live trapping at night and coverboard surveys during the day to monitor rodent populations each season. Eleven live traps were laid along each of four transects at each site, baited with oats and/or peanut butter, set at dusk, and opened at dawn. Over the course of the experiment, we totaled 8,360 trap nights.

We monitored coverboards of two materials (galvanized metal roofing and untreated plywood) in mornings for snakes and rodents. Two coverboards (one of each material) were placed next to each other at 75 m intervals along a parallel transect. A total of 12 coverboard pairs were located at each site, and were surveyed 1-8

Native deer mouse (*Peromyscus maniculatus*) under coverboard in Zamora, CA. *Photo: Kristina Wolf*

times per location, site, and season for a total of 1,608 surveys during the monitoring year.

We monitored raptor diversity and foraging behavior using a sampling approach where all individual raptors within the site boundaries were observed, and distinct hunting behaviors were recorded. We conducted surveys for 1-1.5 hours per site at each of the four locations for 5-7 days in July 2014, October 2014, and July 2015, for a total of 164 survey hours. Surveys began approximately 30 minutes after sunrise and were not conducted during high wind or heavy rainfall. For each raptor, we recorded species, age, sex when possible, time spent hunting, number of attacks on prey, and the result of each attack.

We monitored vegetation at the start of each trapping season at each site in 0.5-m^2 quadrats adjacent to each live trap along each transect. We recorded all plant species present, as well as percent cover of bare ground, litter, native and exotic forbs, and both native and exotic grasses. We estimated vertical cover using a visual obstruction method from a viewpoint approximately 1-m from the soil surface.

Results

Plant Communities

Across all seasons, unrestored sites had slightly (but not significantly) more bare ground (9%) than restored sites (8%), and more litter as well (59% unrestored, 48% restored). As expected, restored sites had more native perennial grass cover (14.5%) and forb cover (3.3%) than unrestored sites (0% native grass and 1.1% native forb). Exotic grass cover was not different between the two site types (18%), but exotic forb cover was higher at unrestored sites (25%) in the growing season (winter, spring) than at restored sites (18%).

Rodents

We captured 2,732 rodents, of which 1,738 were unique individuals each season (not recaptures). The number of rodents utilizing unrestored sites was higher by about 28% than at restored sites (Fig. 1), although this difference was driven solely by differences in the

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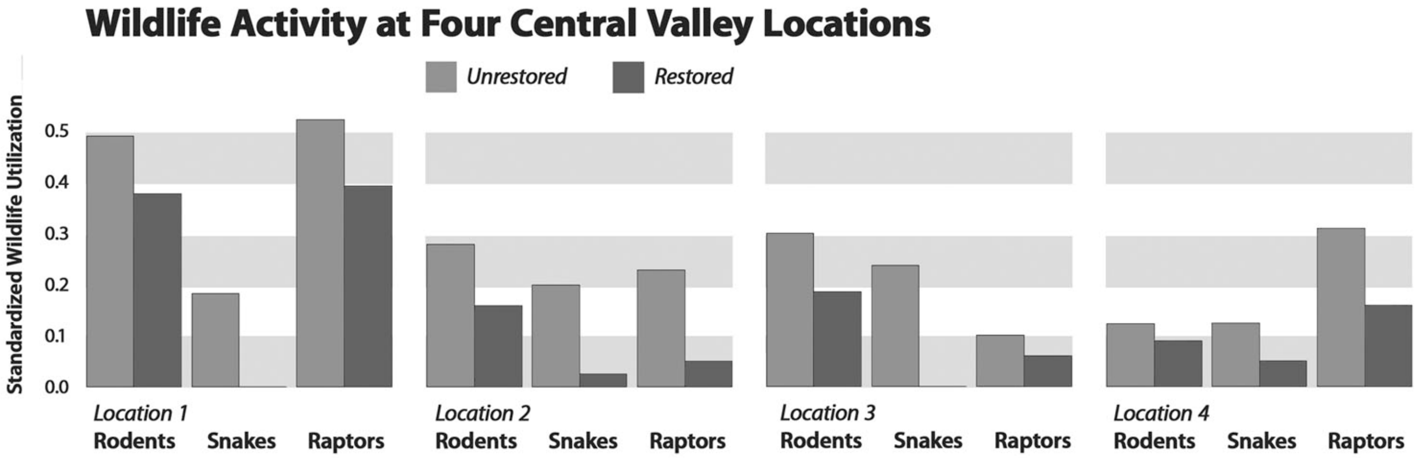

Figure 1. Standardized wildlife activity at four locations in paired unrestored and restored grassland sites in California's Central Valley by location, site, and vertebrate group.

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non-native house mouse (*Mus musculus*). There were no significant differences in activity of the native deer mouse (*Peromyscus maniculatus*) or western harvest mouse (*Reithrodontomys megalotis*), and rodent species diversity was not different between sites. California voles (*Microtus californicus*) were rarely live-trapped, so their abundance was assessed under coverboards. Voles did not utilize coverboards differently between the two sites. Mice (not to species) were also surveyed under coverboards, and mouse observations were higher at unrestored sites, corroborating live trapping data.

Snakes

Like rodents, snakes utilized unrestored sites more than restored sites by about 90% (Fig. 1). As predators of rodents, it is plausible that higher snake utilization of unrestored sites is related to higher rodent utilization at unrestored sites. There were also twice as many species of snakes at unrestored sites than at restored sites.

Raptors

Like rodents and snakes, raptors utilized unrestored sites more than restored sites by about 36% (Fig. 1). Raptors spent more time in unrestored sites, attempted prey captures at higher rates in unrestored sites, and captured more prey items in unrestored sites. Again, it is possible that higher raptor utilization of unrestored sites is directly related to higher rodent and/or snake abundance. All observations of raptors successfully catching a prey item were of insects or rodents (not snakes), and the higher raptor utilization was of a similar magnitude as rodent utilization at unrestored sites. It may be that raptors utilize unrestored sites more due to higher rodent abundance than to higher snake abundance.

Conclusions and Implications

Despite some substantial differences between study locations in topography, land use history, time since restoration, seeded and exotic species, presence of livestock and wild pigs, and management regimes, the observed trend in rodent, snake, and raptor utilization of paired unrestored and restored sites was remarkably consistent. All three wildlife groups utilized unrestored sites significantly more than restored sites. The lower activity in restored sites could be due to legacy effects of disturbances associated with restoration, such as tillage, drill-seeding, compaction, and fire (Montalvo et al. 2002), yet wildlife utilization trends at each location were consistent despite differences in time since restoration.

Differences in habitat resources (cover, insects, seeds) may also contribute to differences in wildlife activity (Morrison 2002). Annual Mediterranean grasses common in California's invaded landscapes produce a far greater abundance of seed and biomass at different times than native grasses (Seabloom et al. 2003) and may support larger seed- and leaf-eating wildlife populations than native grass communities. Historical data regarding wildlife utilization of native grasslands prior to invasion are not available for comparison, but it is possible that our native grasslands did not support as abundant wildlife populations as do the current heavily invaded annual grasslands that now dominate California's landscapes. While we certainly do not contest that wildlife abundance was historically greater than it is today, the reduction in total habitat due to habitat conversion, fragmentation, pollution, climate change, and other human activities has reduced *total* suitable wildlife habitat, such that total abundance of some wildlife species is now substantially reduced (Marzluff and Ewing 2001, Burdett et al. 2010).

Restoration of native plant communities has merit on its own; the ecosystem services provided by native plants (e.g., pollinator habitat, livestock forage, biodiversity, aesthetic appreciation) are vitally important to retain in highly invaded California (Ehrlich and Mooney 1983). However, restoration with native plants may not automatically confer increased wildlife diversity or abundance. When a major goal of restoration is an increase in wildlife habitat, the specific habitat requirements of targeted wildlife species must be carefully considered (Miller and Hobbs 2007), as native plant restorations that seed or plant with the "usual suspects" may not actually boost wildlife habitat, at least in the eyes of the wildlife species of interest. Food webs are highly complex, and a focus on

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just plants, rodents, snakes, and raptors does not likely tell the full story (Terborgh et al. 2010), while herbivores also likely impact plant communities in ways we did not assess (Marquis 2010). Wildlife restoration via native plant community restoration may thus be more nuanced than we once thought. Future analyses accounting for trophic interactions are likely to enrich and clarify our understanding of how and why different wildlife species respond to the resources present in each habitat type.

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Northern mockingbird (*Mimus polyglottos*) harassing a juvenile white-tailed kite (*Elanus leucurus)* in Elk Grove, CA. *Photo: Ryan Bourbour*