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Ecosystem Services from Keystone Species: Diversionary Seeding and Seed-Caching Desert Rodents Can Enhance Indian Ricegrass Seedling Establishment

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Abstract

Seeds of Indian ricegrass (*Achnatherum hymenoides*), a native bunchgrass common to sandy soils on arid western rangelands, are naturally dispersed by seed-caching rodent species, particularly *Dipodomys* spp. (kangaroo rats). These animals cache large quantities of seeds when mature seeds are available on or beneath plants and recover most of their caches for consumption during the remainder of the year. Unrecovered seeds in caches account for the vast majority of Indian ricegrass seedling recruitment. We applied three different densities of white millet (*Panicum miliaceum*) seeds as "diversionary foods" to plots at three Great Basin study sites in an attempt to reduce rodents' over-winter cache recovery so that more Indian ricegrass seeds would remain in soil seedbanks and potentially establish new seedlings. One year after diversionary seed application, a moderate level of Indian ricegrass seedling recruitment occurred at two of our study sites in western Nevada, although there was no recruitment at the third site in eastern California. At both Nevada sites, the number of Indian ricegrass seedlings sampled along transects was significantly greater on all plots treated with diversionary seeds than on non-seeded control plots. However, the density of diversionary seeds applied to plots had a marginally non-significant effect on seedling recruitment, and it was not correlated with recruitment patterns among plots. Results suggest that application of a diversionary seed type that is preferred by seed-caching rodents provides a promising passive restoration strategy for target plant species that are dispersed by these rodents.

Key words: ***Achnatherum hymenoides*, animal-mediated seed dispersal, *Dipodomys merriami*, Great Basin, heteromyid rodents, kangaroo rats, passive restoration, scatterhoarding.**

Introduction

Indian ricegrass (*Achnatherum hymenoides*) is a native bunchgrass common to sandy soils on arid desert rangelands of the western United States. It provides an important source of livestock forage on low-elevation sandy winter ranges of the Great Basin. Consequently, Indian ricegrass seeds are often included in arid land restoration efforts (Jones 1990). However, even with the release of cultivars selected specifically for reduced seed dormancy relative to seeds from wild-land plants, the success of Indian ricegrass seeding efforts has often been limited (Young et al. 1994).

Indian ricegrass seeds are dispersed primarily through seed caching by granivorous (i.e. seed-eating) heteromyid rodents (McAdoo et al. 1983; Longland et al. 2001), a New World family that reaches its maximum species diversity in the deserts of North America (Brown & Harney 1993). In a western Nevada study of Indian ricegrass seed fate, approximately 95% of seedling recruitment was attributable to seed caches made mainly by Merriam's kangaroo rat (*Dipodomys merriami*), one of five coexisting heteromyid species at the study site (Longland et al. 2001). In laboratory tests, Indian ricegrass seeds cached by heteromyids had very high germinability relative to native seeds collected in the field (McAdoo et al. 1983). Longland et al. (2001) reported that seedling recruitment of Indian ricegrass following caching by a single Merriam's kangaroo rat was significantly greater than for seeds not harvested by granivores or for those harvested by ants.

The Indian ricegrass example is not unique. Seed harvesting, consumption, and dispersal through caching by granivorous desert rodents have profound impacts on specific plant species and on species composition of arid plant communities. In another western Nevada study, Vander Wall (1994) found that superficially buried, scattered seed caches (scatterhoards) made

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by granivorous yellow pine chipmunks (*Tamias amoenus*) accounted for ≥99% of seedling production in antelope bitterbrush (*Purshia tridentata*). Both bitterbrush and Indian ricegrass are critical forage resources for livestock and wildlife, and in both examples a single rodent species provided the vast majority of seed-caching services. Ants and birds act exclusively as seed predators in both systems, as do some rodents. At a Chihuahuan Desert site in southeastern Arizona, Brown and Heske (1990) demonstrated that exclusion of a group of heteromyid species (kangaroo rats) from fenced plots shifted the dominant vegetation from shrubs to grasses, indicating that kangaroo rats functioned as keystone species.

Granivorous animals do not make scatterhoard caches to benefit plants, but do this for the purpose of returning during seasons of natural resource shortages to later consume the cached seeds (Vander Wall 1990; Longland 1994). Despite the fact that seed cachers generally recover most caches, enough seeds escape this fate that many plant species have evolved strategies that capitalize on the seed dispersal and burial behavior exhibited by granivorous rodents (Vander Wall 1990, 2010). This raises the possibility of utilizing the seed dispersal services of native animals as a passive restoration strategy. The success of such an approach could be enhanced if the rate that rodents recover seed caches of plant species targeted for restoration was reduced, thus extending the time that caches remain in the soil seedbank and increasing the probability of germination.

Foraging granivores experience seeds in mixed-species seedbanks or seed neighborhoods where co-occurring seed species vary in terms of their desirability and numbers. The composition of the seed neighborhood can alter whether a seed is detected, selected, or ignored, so the likelihood of a seed being harvested depends on its own characteristics as well as those of co-occurring seeds (Veech 2001). Theory suggests that two outcomes are possible regarding harvest probability, associational resistance, and associational susceptibility (Barbosa et al. 2009). The former occurs when the focal species has reduced attraction when in mixed-species patches. This has been widely documented in studies of herbivore responses in diverse vegetation patches (Stiling et al. 2003; Barbosa et al. 2009; Bee et al. 2009). Alternatively, associational susceptibility occurs when a species suffers greater harvesting when in mixed patches than in single-species patches. In an applied context, the desired outcome is associational resistance, wherein the focal seed type is either undetected or ignored when present with a second (e.g. more preferred) "diversionary" seed. These associational effects have been demonstrated for North American granivorous rodents (Veech 2000, 2001), but have not yet been evaluated in an applied context.

We tested the feasibility of enhancing beneficial effects of seed-caching rodent species on a target plant species by providing inexpensive, commercially available, "diversionary" seeds that are highly desirable to granivorous rodents. We reasoned that under these circumstances rodents will cache both seed types—target and diversionary seeds—but will preferentially recover the diversionary seeds, sparing more target seeds from being consumed (Longland & Bateman 1998). Consequently, more target seeds would remain available for emergence as seedlings. In terms of the theoretical framework outlined above, we expected that associational susceptibility would result in rodents scatterhoarding both target and diversionary seeds during the caching phase, and we tested whether associational resistance benefits the target seed type as a result of vulnerability of the diversionary seed type during cache recovery.

In this study, we attempted to enhance the seed dispersal function of rodents for the plant species targeted for restoration by shifting a portion of seed predation to the alternate diversionary seed. We tested this strategy in efforts to restore Indian ricegrass to areas where its density has recently been reduced by cheatgrass (*Bromus tectorum*) invasion. Specifically, we tested the hypothesis that augmenting the food supply of scatterhoarding rodents through addition of diversionary seeds would increase Indian ricegrass seedling recruitment by reducing the number of ricegrass caches recovered by rodents for consumption over the winter.

Methods

Site Characteristics

Diversionary seeding was conducted at a field site in eastern California, Fish Slough (37°33′ N, 118°25′ W, Inyo County, CA, U.S.A.) and two sites in western Nevada, Flanigan (40°12′ N, 119°55′ W, Washoe County, NV, U.S.A.) and Hot Springs Mountains (39°40′ N, 119°05′ W, Churchill County, NV, U.S.A.). Indian ricegrass and heteromyid rodents occur at all these sites, where we have previously noted seedling emergence from caches, so we were confident that soil seedbanks included cached Indian ricegrass seeds. The Fish Slough site has a substrate of coarse sand that supports mixed desert saltbush scrub dominated by shadscale (*Atriplex confertifolia*) and four-wing saltbush (*A. canescens*). The Flanigan site has a deep sand substrate and was a desert shrub community dominated by basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) before a 1985 wildfire removed most of the shrubs. The Hot Springs site, a basaltic range covered to varying depths by fine sand, supports a diverse assemblage of sparsely distributed, salt-tolerant desert shrubs (Longland et al. 2001) and variable numbers of herbaceous plant species, including Indian ricegrass.

Seeding Treatments

We broadcast seeded white millet as a diversionary seed on 8 December 2008 at Hot Springs, 14 January 2009 at Flanigan, and 28 January 2009 at Fish Slough, a period when winter-active rodents would have been utilizing seed caches made during the previous season of growth. Millet seeds were broadcast on three 100 × 100−m (i.e. 1-ha) plots at each site using a hand-held (Even-Flo®) rotary spreader along five 100-m-long parallel transects. Transects extended from one edge of a plot at the 10-, 30-, 50-, 70-, and 90-m points to the same points at the

opposite edge. At each site, we allocated seeds among the three plots as follows: (1) a low-density seed plot with 34.1 kg/ha of seed (approximately 6.8 kg/transect line), (2) a medium-density plot with 68.2 kg/ha (approximately 13.6 kg/transect line), and (3) a high-density plot with 102.3 kg/ha (approximately 20.5 kg/transect line). We attempted to spread seeds evenly over each transect line. Seeds propelled up to approximately 5 m on either side of the spreader, so the end result was that seeds were distributed across each plot in five strips, each approximately 10 m wide. Some of the millet seeds were easily found still lying on the soil surface of all plots 2 weeks after broadcasting them, but after 4 weeks seeds were only still apparent on the high-density plots. Three non-seeded control plots of the same size were also established to compare Indian ricegrass emergence to seeded plots; in sum, six plots were established in two rows of three plots at each of the three sites with a 50-m buffer zone between neighboring plots. Seed density treatments and non-seeded controls were randomly assigned to plots at each site.

Seedling Emergence Sampling

Indian ricegrass seeds typically germinate in late winter or early spring at our sites, but no seedling establishment occurred in winter 2008–2009 likely because of lack of appropriately timed precipitation. However, in March 2010 (i.e. winter 2009–2010), we noted considerable establishment of Indian ricegrass seedlings at the two Nevada sites, which we then sampled after allowing a few months of growth. Seedling emergence for Indian ricegrass was not detected at the Fish Slough site during visits in 2008–2009 or 2009–2010, and therefore, we focus on results from the Nevada sites. We sampled Indian ricegrass seedlings on 10 May 2010 at Hot Springs and on 9 June 2010 at Flanigan along the same 100-m transects used for applying diversionary seeds to plots. The area sampled extended 1 m to both sides of each transect line, so each transect included an area of 200 m^2 (i.e. 100 m $\times$ 2 m), and each plot included a total sampling area of 1,000 m^2 (i.e. 200 m^2/transect $\times$ 5 transects/plot). We conducted the same sampling protocol on non-seeded control plots at each site.

Data Analyses

We used PROC MIXED (SAS 2002) to test effects of sites and diversionary seeding treatments on seedling establishment in a mixed-model analysis of variance (ANOVA). We included data for both seeded and control plots to test for effects of two categorical variables, site and seeding density (either "low," "medium," or "high" for seeded plots and "none" for non-seeded control plots), on numbers of seedlings counted on the five transects per plot. Plot nested within site was a random term in the model, and the Satterthwaite method was used to adjust error degrees of freedom. We included a planned comparison in this model to contrast seeded and control plots and test for effects of diversionary seeding on Indian ricegrass recruitment independent of seeding density.

Small Mammal Community

Granivorous small mammals at both Nevada sites are primarily heteromyid rodent species. During previous studies, Merriam's kangaroo rat was the numerically dominant species, constituting >50% of trap captures at both sites (Longland 1995; Longland et al. 2001). Near the time that plots were sampled for Indian ricegrass seedlings, we conducted live trapping in the immediate vicinity of study plots at each Nevada site to determine if contemporary small mammal species composition remains similar to these historical patterns. Two 5 $\times$ 10–station trapping grids separated by $\geq$300 m were established at each site. Rows within each grid and adjacent stations along each row were spaced 15 m apart. A single Sherman® live trap was placed at each trap station, baited with bird seed mix, activated in late afternoon, and checked early the following morning. Captured animals were identified by species and sex, fitted with a uniquely numbered ear tag, and released at the site of capture after a short handling period, usually <2 minutes. We trapped each site for three consecutive nights (2–4 June 2010 at Hot Springs and 27–29 July 2010 at Flanigan) yielding a sampling effort of 300 trap nights per site (2 grids $\times$ 50 traps/grid $\times$ 3 nights).

Results

Site had a significant effect on Indian ricegrass seedling recruitment in the mixed-model ANOVA ($F_{[1,4]} = 36.35$, $p = 0.004$), because mean recruitment was considerably greater among all plots at Hot Springs than at Flanigan (Fig. 1). Seeding density had a marginally non-significant effect on recruitment ($F_{[3,4]} = 5.88$, $p = 0.060$), which was consistent between the two sites (site $\times$ density interaction term: $F_{[3,4]} = 1.46$, $p = 0.351$). However, the contrast between seeded and non-seeded plots independent of seeding density was

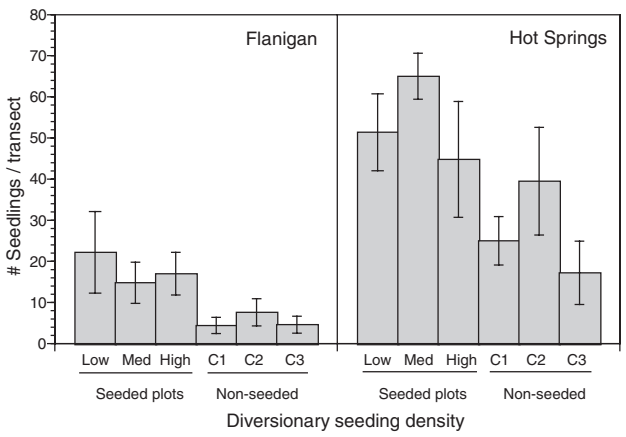

Figure 1. Mean (±SE) number of Indian ricegrass seedlings counted per 200-m^2 transect on six 1-ha plots at two western Nevada field sites (i.e. Flanigan and Hot Springs). Each plot was sampled along five such transects. At each site, diversionary seeds (millet) were applied to three plots, one at each of three seeding densities ("Low" = 34.1 kg/ha seed, "Med" = 68.2 kg/ha, and "High" = 102.3 kg/ha). Three non-seeded 1-ha control plots (C1, C2, and C3) were also sampled at each site.

Table 1. Number (and %) of individual animals and trap captures (including recaptures) of rodent species at two diversionary seeding study sites.

		2010 Trapping		*Historical Trapping*
Site	*Species*	*# Individuals (%)*	*# Trap Captures (%)*	*% Trap Captures*
Flanigan	*Ammospermophilus leucurus*	1 (2.4)	2 (2.7)	0.2
	Dipodomys deserti	0	0	3.0
	Dipodomys merriami	8 (19.5)	16 (21.6)	54.7
	Dipodomys ordii	32 (78.0)	56 (75.7)	26.9
	Dipodomys panamintinus	0	0	12.1
	Perognathus longimembris	0	0	3.2
Hot Springs	*A. leucurus*	3 (8.8)	3 (6.4)	11.3
	D. deserti	0	0	10.8
	D. merriami	25 (73.5)	38 (80.9)	52.1
	Microdipodops pallidus	2 (5.9)	2 (4.3)	12.2
	P. longimembris	4 (11.8)	4 (8.5)	13.6

Each site was live trapped for 300 trap nights (i.e. 100 traps × 3 nights) shortly after plots were sampled for Indian ricegrass seedlings (Flanigan trapped 27–29 July 2010 and Hot Springs trapped 2–4 June 2010). Historical trapping data (% captures) are also shown for each site from previous studies (Flanigan: Longland 1995; Hot Springs: Longland et al. 2001). Historical data are based on 1,400 trap nights and 439 captures at Flanigan during 1988–1990 and on 6,600 trap nights and 1,645 captures during 1994–1996 at Hot Springs.

significant ($F_{[1,4]} = 16.42$, $p = 0.015$), as more seedlings recruited on all plots seeded with diversionary seeds than on control plots (Fig. 1).

Merriam's kangaroo rat remained the most common rodent species at Hot Springs as in a 1994–1996 study, but increased in abundance, comprising 73.5% of individual animals captured at the completion of this study (Table 1). At Flanigan, the rodent species composition shifted considerably relative to that present during a 1988–1990 study; Merriam's kangaroo rat comprised only 19.5% of individuals captured in 2010 after seedling sampling (Table 1). By contrast, Ord's kangaroo rat (*Dipodomys ordii*), the second most common species in the previous study at 26.9% of captures, comprised 78.0% of individuals captured in 2010 (Table 1). White-tailed antelope ground squirrel (*Ammospermophilus leucurus*) represented <7% of captures at either site and was the only diurnal species and the only non-heteromyid species captured.

Discussion

Indian ricegrass seedling recruitment was significantly greater on plots where we had applied millet as a diversionary seed for granivorous rodents than on non-seeded plots. This difference between seeded and control plots yielded a marginally non-significant seeding density effect, implying that enhanced seedling recruitment of Indian ricegrass on diversionary seeding plots was independent of seeding density. Moreover, seedling recruitment was clearly uncorrelated with seeding density, because high-density plots did not yield maximum recruitment among seeded plots at either site. Our results thus suggest that costs of this passive restoration strategy can be kept relatively low because low-density plots yielded similar success to those that used higher diversionary seeding densities. At the price we paid for white millet seeds ($0.36/lb = $0.79/kg), the cost for our 1-ha low-density seedings was $24/plot. At a typical recommended seeding rate of 9.0 kg pure live seed/ha for Indian ricegrass seed (USDA, NRCS 2000) and a cost for Indian ricegrass seed of $8.80/kg (lowest current cost among three available cultivars; Granite Seed Co., Lehi, UT, U.S.A.), it would cost substantially more than this for restoration via direct seeding. It should be noted, however, that appropriate diversionary seeding densities are likely to vary spatially and temporally depending on relative availabilities of target seeds. If diversionary seeds are too scarce compared with natural densities of target seeds, they would have little effect on the dynamics of seedling recruitment. Of course, overall cost effectiveness depends on the relative success of diversionary seeding versus direct seeding of target plants, which are both likely to be highly variable in arid systems.

A measurable response to our diversionary seeding treatments was delayed by a year relative to the time we seeded plots in winter 2008–2009, but this is not surprising. Winter precipitation is essential to successful Indian ricegrass seedling establishment (Young et al. 1994). The nearest weather stations to the study sites with continuous records available for the relevant winter months are in Doyle, California (approximately 27 linear km from the Flanigan site), Fallon, Nevada (approximately 32 km from Hot Springs), and Bishop, California (approximately 21 km from Fish Slough). Records from each station indicate that cumulative precipitation was greater by a factor of >2 between 1 December 2009 and 1 April 2010 than during the same period the previous year (Fig. 2; National Oceanic and Atmospheric Administration 2011). Thus, the timing and/or amount of precipitation did not permit Indian ricegrass establishment in 2009, but a moderate level of recruitment occurred at the Nevada sites in 2010. It is unclear whether the lack of recruitment at our California site was due to this site receiving lower winter precipitation. Because 2009–2010 winter precipitation at this site was only slightly lower than at Hot Springs (Fig. 2), where seedling recruitment was greatest, recruitment failure at the California site is more likely attributable to other factors, such as timing of precipitation events.

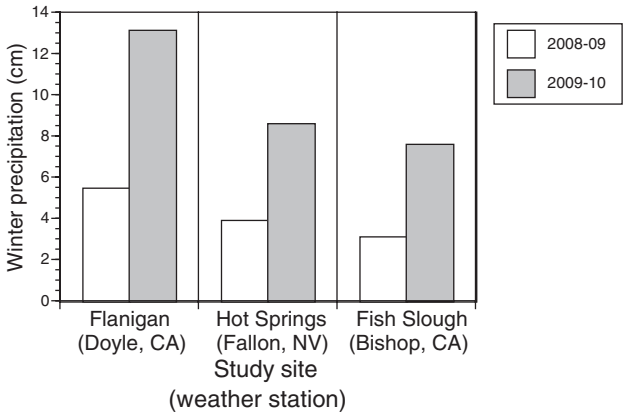

Figure 2. Cumulative winter precipitation records (1 December 2008 to 1 April 2009 and 1 December 2009 to 1 April 2010) at weather stations near the three study sites.

We consider the delayed response to diversionary seeding at the Nevada sites to be encouraging, because it suggests that the window of opportunity for such efforts to produce favorable results extends beyond the growth season immediately following deployment of diversionary seeds. Germination and establishment of seeds of desert plant species, including Indian ricegrass, are highly variable in both space and time. This was illustrated in this study by between-year differences in seedling recruitment that we witnessed at our Nevada sites and by the contrast in seedling recruitment between our California site and the Nevada sites in 2010. This variability limits the potential success of arid land restoration efforts such as the diversionary seeding concept. Any among-year carryover of diversionary seeding on seedbank reserve extends the opportunity for a favorable response by target plant species.

The species composition of the granivorous rodent communities at our study sites differed in 2010, when we sampled Indian ricegrass seedling recruitment, compared with 1994–1996 trapping data from Hot Springs and 1988–1990 data from Flanigan. Merriam's kangaroo rat, the rodent species previously identified at Hot Springs as the primary dispersers of Indian ricegrass seeds (Longland et al. 2001), remains the numerically dominant species at this site and may have even increased in relative abundance. At Flanigan, however, relative abundances of Merriam's kangaroo rat and two additional congeneric species decreased, whereas Ord's kangaroo rat has increased dramatically. Whether or not this shift in species abundance might affect potential success of the diversionary seeding strategy is unclear. Both Merriam's and Ord's kangaroo rats cache seeds in scatterhoards (Longland 1994), but a laboratory study suggested that Ord's kangaroo rat may cache relatively more seeds in burrows (larderhoarding) and fewer in surface scatterhoards than Merriam's kangaroo rat (Jenkins & Breck 1998).

Differential seed dispersal and predation are widely recognized as two of the most critical processes to plant population regeneration, community diversity, and spatial structuring (Schupp et al. 2002). In some systems, plant regeneration is limited by high rates of seed predation (Kauffman & Maron 2006; Doust 2011) and in others by low rates of seed dispersal (Makana & Thomas 2004). Among three commonly cited advantages of seed dispersal—escape from high levels of mortality near parent plants, colonization of new suitable sites, and directed dispersal to specific microsites favoring seedling establishment and survival—the latter offers the most clear advantages to plants and is likely to be far more common in nature than implied by the small number of documented examples (Wenny 2001).

The importance of animal-mediated seed dispersal has been emphasized for many environments and for a diversity of plant species. Much of this literature focuses on dispersal by fruit-eating animals via gut passage of seeds (i.e. endozoochory), usually involving woody plants dispersed by birds or bats in tropical systems (Medellin & Gaona 1999) or by birds in temperate systems (Garcia et al. 2010). Attempts to manipulate dispersers to enhance endozoochory in such systems generally involve attraction of birds and/or bats to disturbed areas through the establishment of tree islands (Carriere et al. 2002; Zahawi & Augspurger 2006; Herrera & Garcia 2010) or artificial perches (Holl 1998; Shiels & Walker 2003; Zanini & Ganade 2005; Kelm & von Helversen 2007). An innovative approach to enhancing tropical forest restoration was suggested by Mikich et al. (2003), who demonstrated that frugivorous bats could be attracted to specific sites with an essential oil extracted from fruits of a bat-dispersed tree.

We believe that our study represents the first example in the literature of attempting to enhance seed dispersal and seedling recruitment of a target plant species by manipulating the seed-caching and cache recovery behavior of granivores. The concept and terminology surrounding the use of diversionary foods, including seeds, were developed for forest systems in attempting to reduce rodent predation on pine seedlings (Sullivan & Klenner 1993; Sullivan et al. 2001). In this study, we attempted to carry this concept further than simply reducing predation by intervening in the natural seed-caching and cache recovery activities of rodents that constitute both seed predators and dispersers. Indian ricegrass may be an ideal candidate as a target species for such efforts, as Wenny (2001) suggested that directed dispersal is particularly likely for animal-dispersed plants in arid ecosystems.

It is easy to imagine variations on how to apply a diversionary seeding strategy. In this study, we simply added diversionary seeds to soil seedbanks that were already stocked with native Indian ricegrass seeds. The timing of diversionary seeding could be varied relative to the seed production phenology of the target plant species. Perhaps seeding earlier than in our study, for example immediately after target plants produce seeds, could reduce the number of target seed caches recovered for consumption and enhance seedling recruitment further. At sites supporting a low density of a desirable plant species that is dispersed by rodents, it may be possible to increase seedling recruitment of such a target plant by either simultaneous or consecutive broadcast seeding of both target and diversionary seeds and allowing rodents to cache both. Diversionary seeding could also be superimposed on other restoration efforts, such

as in an area that has been drill seeded to restore a target plant. In this case, easily accessible diversionary seeds on the soil surface would be both more detectable and more efficiently harvested than the buried target seeds, which should reduce the rate at which rodents excavate target seeds and redistribute them in caches. Although caching can certainly benefit plants that naturally emerge from scatterhoards, in the latter example the goal would be to discourage caching of target seeds so that they remain distributed as intended.

There may be commercial varieties of seeds available that would be superior to millet as diversionary seed candidates. Although millet seed is very desirable to heteromyid rodents, its preference ranking by rodents relative to Indian ricegrass seems to vary. In field studies, Kelrick et al. (1986) found evidence that granivorous rodents preferred millet over Indian ricegrass, but in laboratory cafeteria tests, heteromyid species that occurred at our study sites showed no consistent preference when given a choice between these two seed types (Longland & Bateman 1998). Consequently, we suspect that more Indian ricegrass caches were recovered for consumption by rodents using millet as a diversionary seed than if we had used a seed type that is consistently preferred over Indian ricegrass. We chose to use millet because it is readily available as bird seed, inexpensive, desirable to rodents, and it will not establish and persist in desert environments. To date, we have not found a commercial seed type that is consistently preferred to Indian ricegrass by rodents in laboratory tests, but will continue to test potential candidate seeds. In the meantime, there are numerous native range plants in addition to Indian ricegrass that establish seedlings from rodent scatterhoards (Longland 1994). As a bet-hedging strategy due to the uncertain nature of the next seed production event, granivorous desert rodents cache any seeds that they may eventually consume, even those that have low preference rankings (Vander Wall 1990; Longland 1994). If a desirable diversionary seed, such as millet, was deployed in such a system, preferential recovery of diversionary seed caches by rodents could significantly improve recruitment of target species seedlings.

Implications for Practice

- Diversionary seeding may be useful for restoring plant species that are dispersed by seed-caching rodents in addition to Indian ricegrass. For a given plant species, determining the frequency that seedlings emerge in clumps from rodent scatterhoards may indicate the potential utility of attempting diversionary seeding to enhance seedling recruitment.
- Utilization of a highly preferred diversionary seed should increase the probability of a favorable seedling recruitment response by the target plant species. Therefore, prior knowledge of rodents' preference rankings for potential diversionary seed candidates relative to seeds of target plant species should enhance the success of the diversionary seeding concept.
- Similarly, prior knowledge of species-specific roles of rodent species in dispersing seeds of a particular target plant species combined with knowledge of relative abundances of these rodent species in the local community may reflect the probability of successfully applying the diversionary seeding concept.

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