Rodents show species-specific seed preferences but consume native and non-native seeds equally in a desert ecosystem

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Abstract

Novel fire regimes are expanding in North American deserts with significant potential for ecological state changes defined by the loss of native plant cover and the expansion of invasive plants. Rodents are active seed predators that can strongly influence post-fire plant community assembly in desert ecosystems. Using rodent fencing and experimental burns in a full factorial design, we examined how rodent exclusion and fire impacted the seed persistence of seven common native and three dominant invasive plant species in the Mojave Desert. We placed a known quantity of seeds in dishes in each experimental treatment plot in a randomized order. When averaged across all species, seed persistence dropped from 80% in the rodent exclusion plots to 33% in rodent allowed plots over seven days. Rodents removed some seeds of all species but had a particularly strong preference for blackbrush (*Coleogyne ramosissima* Torr.) and Joshua tree (*Yucca brevifolia* Engelm.) seeds. Rodents targeted native and invasive species equally, independent of the burn conditions. Rodents' seed preferences were not strongly correlated with seed size, moisture, or nitrogen content. Fire did not have a strong or consistent effect on seed removal by rodents, likely because it did not influence rodent abundance. Our results demonstrate that rodents are effective at locating and removing common native and invasive seeds in the Mojave Desert, which likely has significant implications for post-fire plant community assembly and plant invasions.

Introduction

The life-history traits of plant invaders (Callaway and Ridenour 2004; Rejmánek and Richardson 1996) and the characteristics of an ecosystem influence patterns of invasion (Enders et al. 2019; Levine et al. 2004). Non-native annual grasses native to Eurasia, particularly in the genus *Bromus*, have spread broadly across the North American continent and are particularly problematic in desert ecosystems (Knapp 1996). These annual grasses are strong competitors for soil resources, leading to rapid growth and prolific seed production that have driven invasive grass expansion (Knapp 1996; Leffler et al. 2011). Native plant communities create biotic resistance to invasion by competing for space and resources (Knapp 1996; St.Clair et al. 2016). In addition, native consumers can reduce non-native plant establishment (Allington et al. 2013; St.Clair et al. 2016).

The enemy release hypothesis outlines mechanisms by which non-native species perform better in their introduced range due to a lack of natural enemies (Callaway and Ridenour 2004; Keane and Crawley 2002; Keane and Crawley 2002). Supporting this hypothesis are studies showing herbivores more strongly suppressing native plants than invasive plant species (Adams et al. 2009; Lucero et al. 2019; Vila et al. 2005), highlighting how a lack of shared co-evolutionary history with potential enemies could give non-native plants an advantage in their introduced range.

Rodents exert top-down control on plant community assembly and confer biotic resistance against invasion (Connolly et al. 2014; Parker et al. 2006; Pearson et al. 2012), including aggressive invasive annual grasses in North American deserts (Pyke 1986; St.Clair et al. 2016). Seeds have the highest

caloric value of any plant material, and rodents target them as a preferred food source (Golley 1961; Reichman 1975; Simberloff and Dayan 1991). The size of a seed often determines its caloric content and can be a factor in influencing rodent seed preferences (Chen and Valone 2017; Davidson et al. 1984; Radtke 2011; Willson 1971). While studies have shown that some rodents prefer larger and more energy-dense seeds over smaller seeds (Chen and Valone 2017; Maron et al. 2012; Soholt 1973), nutrient and water content, as well as chemical and physical defenses, can also influence these preferences (Blate et al. 1998; Frank 1988; Soriano et al. 2015). In addition, seed coat characteristics and their influence on handling time can affect which seeds consumers choose for consumption (Taraborelli et al. 2003; Willson and Harmeson 1973). While there has been significant research on general rodent seed preferences (Blate et al. 1998; Frank 1988; Murray and Dickman 1994), less is known about how rodent seed preferences vary between native and non-native plant species.

The emergence of invasive grass fire cycles has significantly altered fire regimes in desert ecosystems in North America (D'Antonio and Vitousek 1992). Fire can shift the composition and abundance of rodent communities, altering their top-down effects on plant community assembly (Horn et al. 2012; Levine et al. 2004). *Neotoma* rodent species that dwell above ground have flammable dens that are particularly susceptible to the direct effects of wildfire (Simons 1991). Subterranean rodent species are less vulnerable to the direct impacts of wildfire but demonstrate sensitivity to losses of plant cover and food sources in post-fire environments (Leahy et al. 2016; Simons 1991). Rodent species demonstrate variable responses to post-fire environments; quadrupedal rodent species tend to have a higher affinity for unburned plant communities with abundant plant cover (Sharp Bowman et al. 2017a), whereas bipedal rodent species are more likely to be found in open spaces typical of post-fire environments (Simons 1991; Vamstad and Rotenberry 2010). Combined, these factors can result in dramatic changes in post-fire rodent community structure and their top-down effects on the post-fire plant communities (Sharp Bowman et al. 2017b; St.Clair et al. 2016).

The Mojave Desert is an ideal location for studying the influences of rodent communities on plant community assembly in post-fire environments. Rodent communities in the Mojave are abundant and diverse (Bishop et al. 2020; Sharp Bowman et al. 2017b). In addition to a rich native plant community, the Mojave Desert is colonized by several non-native plant species, including red brome (*Bromus rubens* L.), Arabian schismus (*Schismus arabicus* Nees.), cheatgrass (*Bromus tectorum* L.), and red stem stork's bill (*Erodium cicutarium* L.). These non-native species directly compete with native plant species for soil resources (Brooks 2000; DeFalco et al. 2003) and have contributed to the emergence of an invasive-grass fire cycle in the Mojave Desert, making fires larger and more frequent over time (Brooks et al. 2004; Horn and St.Clair 2017). These changing fire regimes are known to influence rodent communities (Horn et al. 2012, Sharp Bowman et al. 2017b), but we know less about how they may affect rodent seed preferences.

Previous studies have explored how fire and rodents herbivory of seedlings influence native plant community establishment (Sharp Bowman et al. 2017a, Sharp Bowman et al. 2017c, Stanton et al. 2025), but the impact of rodent granivory on ecosystem invasibility in the context of fire is less studied (Brown

and Heske 1990; Clements and Harmon 2017). This study explores how rodent granivory influences seed persistence in post-fire environments. We hypothesized that rodent preference would be greater for native species than invasives because of their shared co-evolutionary history, creating greater familiarity and adaptations for optimizing their use. We predicted that rodents would prefer plant species that produce larger seeds with higher water and nitrogen content. Finally, we hypothesized that burn treatments would indirectly affect seed fate by altering the composition and abundance of the rodent community.

Materials and methods

Study system

Our study site is in the Beaver Dam Wash region of the Mojave Desert, near Lytle Ranch Research Preserve, approximately 40 kilometers West of St George, Utah (37°8'53.46" N, 114°0'49.59" W, elevation 915 m). The average temperature is 17.3°C, with the average January temperature being 7.2°C and the average July temperature being 29.4°C (Lytle Ranch GHCN: COOP, Utah Climate Center). An average of 206 mm of precipitation falls annually, with a large portion falling in the winter months between October and April. The soil is classified as young alluvium with a gravelly, sandy-loam texture. Common rodent species are Merriam's kangaroo rat (*Dipodomys merriami* Mearns), the long-tailed pocket mouse (*Chaetodipus formosus* Merriam), and the desert woodrat (*Neotoma lepida* Thomas). The most common native plants in the area include Joshua trees (*Yucca brevifolia* Engelm.), white bursage (*Ambrosia dumosa* (A. Gray) Payne), and the creosote bush (*Larrea tridentata* (DC.) Coville). Non-native plant species in the study area include red brome (*Bromus rubens*), Arabian schismus (*Schismus arabicus* Nees), cheatgrass (*Bromus tectorum*), and redstem storksbill (*Erodium circutarium* L.). Wire fences surrounding the study site have prevented grazing from cattle for at least the last 30 years, and there is no evidence of recent wildfires.

Experimental design

A full factorial block design, replicated five times, was constructed to assess the influence of rodent exclusion and fire on seed persistence in the study plots. Each block consisted of four 30 m x 30 m plots randomly assigned one of four treatment combinations: burned with rodent exclusion, burned with rodent access, unburned with rodent exclusion, and unburned with rodent access. Burn treatments were carried out on 18th June 2011. Local fire marshals used drip torches to ignite the fires, and red brome, which had already invaded the system, provided enough fine fuel within the intershrub spaces to carry the fire across the plots. Fire severity was high, with approximately 90% vegetation cover loss within the burn treatment plots (Sharp Bowman et al. 2017c). Rodent fences were constructed of 1 cm welded wire mesh. The fencing extended 35 cm below the ground and 65 cm above the ground. Rodent access plots had 10 cm x 12 cm openings in the mesh fencing every 4 m at ground level to facilitate rodent entry.

Exclusion plots had 20 cm metal flashing along the top of the outward-facing side to prevent rodents from climbing into the plots.

Species selection

This study aimed to assess the top-down influences of rodent granivory and fire legacy on dominant plant species found in our study area, so we selected ten common plant species from the study area for this experiment (three invasive species and seven native species) (Table 1). Invasive seeds and Joshua tree seeds for the experiment were gathered by hand adjacent to the study site, and the remaining native seeds were obtained from Granite Seed and Erosion Control (Lehi, Utah, USA), a company specializing in native seed collections.

Table 1
Descriptions of all the seed species used in this study.

Species	Code	Common name	Status
Bromus rubens L.	BRRU	Red brome	Invasive
Bromus tectorum L.	BRTE	Cheatgrass	Invasive
Erodium circutarium L.	ERCI	Redstem stork's bill	Invasive
Ambrosia dumosa (A. Gray) Payne	AMDU	White bursage	Native
Baileya multiradiata Harv. & A. Gray ex A. Gray	BAMU	Desert marigold	Native
Coleogyne ramosissima Torr.	CORA	Blackbrush	Native
Larrea tridentata (DC.) Coville	LATR	Creosote	Native
Sphaeralcea ambigua A. Gray	SPAM	Globemallow	Native
Krascheninnikovia lanata (Pursh) A. Meeuse & Smit	KRLA	Winterfat	Native
Yucca brevifolia Engelm.	YUBR	Joshua tree	Native

Rodent trapping

The rodent populations were surveyed by live trapping within each plot during the new moon prior to the seed experiment, 9th -12th July 2018. For each consecutive day in the 3-day trapping period, eight Sherman live traps were set in the center of each plot just before sunset at 8:30 p.m. and baited with commercially available bird seed. We emptied the traps just after sunrise the following morning, between 6–8 a.m. Captured rodents were given an individually numbered ear tag to identify them as recaptures following subsequent trapping nights. After tagging, the rodents were released at the point of capture unless caught within an exclusion plot. In such cases, we released the rodents outside the plots. Abundance was measured as the number of live rodents captured in each plot.

Seed experiment

On 5th June 2018, we placed four 100 mm Petri dishes of each plant species in each experimental plot. The petri dishes were spaced 2 m apart in a randomized order. Each dish contained one hundred seeds mixed with sieved soil collected from the study site. Mixing the seeds with soil prevented loss from the wind and ensured that the only seed predators assessed in this experiment were rodents (Vander Wall et al. 2003). Since seed presence is minimal below a depth of 10 cm in the Mojave Desert (Guo et al. 1998), we collected the soil below 10 cm depth and sieved it to remove any remaining seed bank.

We removed one dish of each species from each plot on collection days one, three, seven, and fourteen after placement in the field and brought them back to the lab. We used a series of different-sized sieves to separate and count the seeds that remained in the dishes.

Seed analysis

We measured the seeds for size, moisture content, and C: N ratio. We weighed a random selection of 50 surplus seeds for each species using a mass balance (Denver Instrument, Bohemia, New York, USA) to calculate the average seed mass for each species. Seeds were then placed in a drying oven for 24 hours at 60°C to calculate percent seed moisture. To measure C: N ratios, seeds were milled, and samples were analyzed using a TruSpec, CN Determinator (LECO Cooperation, St. Joseph, MI) using the combustion method (Campbell 1991).

Statistical analysis

Following the methods described by Zuur et al. (2010), we conducted data visualization analysis to check if the data met the model assumptions of normality and equal variances required for parametric analysis. Since the assumptions for equal variances were not met, we used a non-parametric rank-based ANOVA model from the Rfit package in R (Kloke and McKean 2012; R Core Team 2018) to test how the proportion of seeds left in the dishes varied with the rodent and fire treatments and how the seeds left in the dishes varied with the collection day. The effects of the collection day on the proportion of seeds remaining plateaued after seven days, so we used only the data from day seven to analyze the effects of fire and rodents on individual seed species. The fire effect was insignificant, so we averaged the species comparisons across burned and unburned treatments for Fig. 2, showing the comparative effects of rodents on the different species. We used a Mann-Whitney U test to test if rodents differentially influenced native and invasive seed fate. We included the proportion of seeds remaining on day seven as the response variable and averaged the comparison across burned and unburned treatments. We then used Pearson's correlation to test how the proportion of seeds remaining in the dishes varied by seed mass, moisture content, nitrogen content, and C: N. We again used a Mann-Whitney U test to test the effects of fire and the exclusion fences on rodent abundance.

Results

Rodent effects

When averaged across species, the percentage of seeds remaining in rodent exclusion plots after seven days was 80% (SE = 1.33), compared to 33% (SE = 1.60) in rodent access plots ($F_{1,1167}$ = 796, p < 0.01; Table 2; Fig. 1). Seed removal changed over the study period, as indicated by the significant time effect ($F_{3,1167}$ = 98, p < 0.01). Seed persistence in the rodent access plots was 54% (SE = 2.4) after day one and dropped to 20% (SE = 1.90) by day fourteen. There was a significant rodent-by-time interaction in which the rodent effect was greater in the beginning and decreased over time ($F_{3,1167}$ = 35, p < 0.01; Table 2; Fig. 1).

Table 2
The main and interactive effects of rodents, fire, and time in the field on the percentage of remaining seeds in dishes during our seed fate experiment in the summer of 2018 averaged across species. For a graphical representation of data, see Fig. 2.

Treatment	df	*F*	*p*
Rodents	1, 1167	796	< 0.0001
Fire	1, 1167	0.97	0.32
Time in field	3, 1167	98	< 0.0001
R x T	3, 1167	35	< 0.0001
R x F	1, 1167	0.29	0.59
F x T	3, 1167	0.93	0.42
R x F x T	3, 1167	0.45	0.72

After seven days, the presence of rodents significantly reduced the persistence of all ten seed species (p < 0.05; Table 3; Fig. 2). Blackbrush (*Coleogyne ramosissima* Torr.) and Joshua tree (*Yucca brevifolia* Engelm.) seeds were the most affected by rodent presence. Both species had an average of less than 1% of their seed remaining in rodent allowed plots after seven days (Fig. 2). White bursage (*Ambrosia dumosa* (A. Gray) Payne) was least affected by the rodents, having approximately 62% (SE = 8.41) of its seed remaining in the rodent allowed plots after seven days (Fig. 2). Seed persistence did not vary significantly between native (27% seeds remaining on day seven, SE = 3.33) and invasive species (16% seeds remaining on day seven, SE = 4.52) in rodent access plots (W = 1969, p = 0.21; Fig. 3).

Table 3
The main and interactive effects of rodent exclusion and burn on the percentage of remaining seeds in the dishes, after being left seven days in the field, of individual seed species used in our experiment in the summer of 2018.

Species		RODENTS		BURN		RODENTS x BURN	
	Status	*F*	*p*	*F*	*p*	*F*	*p*
BRRU	Invasive	68	< 0.001	1.52	0.23	1.91	0.17
BRTE	Invasive	286	< 0.001	0.72	0.5	0.53	0.6
ERCI	Invasive	59	< 0.001	1.99	0.16	0.6	0.56
AMDU	Native	6.11	0.02	0.65	0.53	1.03	0.37
BAMU	Native	31	< 0.001	1.13	0.34	0.68	0.51
CORA	Native	12	0.002	1.34	0.28	1.39	0.27
LATR	Native	100	< 0.001	0.12	0.89	0.41	0.67
SPAM	Native	3.72	0.07	0.79	0.47	1.02	0.38
KRLA	Native	55	< 0.001	0.38	0.69	2.29	0.12
YUBR	Native	9.21	0.006	0.97	0.4	0.97	0.4

Seed preference of rodents was not significantly correlated with variation in the size (r^2 = 0.21, p = 0.19), moisture content (r^2 = 0.003, p = 0.88), nitrogen content (r^2 = 0.02, p = 0.69), or C: N ratio (r^2 = 0.10, p = 0.35) of the ten species.

Fire

The main effect of fire did not significantly impact seed persistence when averaged across species ($F_{1,1167}$ = 0.97, p = 0.32; Table 2; Fig. 1). The fire by rodent interaction ($F_{1,1167}$ = 0.29, p = 0.59), the fire by time interaction ($F_{3,1167}$ = 0.93, p = 0.42; Table 2) and the fire by rodent by time interaction $F_{3,1167}$ = 0.45, p = 0.72; Table 2; Fig. 1) were not statistically significant. Fire did not have a significant effect on the seed persistence of any of the individual species studied (p > 0.1; Table 3) or a significant rodent by burn interaction (p > 0.1; Table 3).

Rodent abundance

In the summer of 2018, we captured 34 individual rodents among six species in our experimental plots during the sampling period. Merriam's kangaroo rats represented 68% of the captures. The difference in average rodent abundance in the burned vs. the unburned plots was not statistically significant (W = 56, p = 0.70). Rodent abundance was reduced in exclusion plots by 79%, from an average of 2.8 (SE = 0.48) individuals in rodent access plots to 0.60 (SE = 0.21) in rodent exclusion plots (W = 11, p < 0.01).

Discussion

When averaged across species, rodents significantly reduced seed persistence in the experiment, while fire had no significant impact (Fig. 1). The results did not support our first hypothesis that rodent preference would be higher for native seeds. Rodents showed variable seed preferences between the ten species (Fig. 2). Our data also did not support our prediction that rodents would show preferences for species that produce larger seeds or have greater moisture or nutrient content. We rejected our final hypothesis that burn treatments would indirectly affect seed fate by altering the composition and abundance of the rodent community, as our burn treatments did not significantly affect seed persistence (Fig. 1). Previous studies have shown that rodents can suppress the establishment and spread of red brome and cheatgrass (St. Clair et al. 2016, Bishop et al. 2020). Results from this experiment suggest that a key mechanism of rodent control of red brome and cheatgrass is seed predation (Fig. 2).

Rodent preference: native vs. non-native species

Rodents can reduce invasive plant abundance (Allington et al. 2013; St.Clair et al. 2016), but we know less about the mechanisms that drive consumer regulation of invaders. Data related to our ten study species suggest that rodents dramatically reduced seed persistence. However, there was little evidence for differential preferences between native and non-native seeds (Fig. 3). This supports the idea that rodent suppression of many common plant species, including invasive annual grasses (St. Clair et al. 2016), may partially occur through granivory. This contrasts with works by Lucero and Callaway (2018) and Pearson et al. (2011), who suggest rodents have a lesser impact on invasive grass suppression. These studies took place in cooler northern territories (Idaho and Montana, respectively), whereas the Mojave system is a hyper-arid desert where seeds are a critical rodent food source for energy, water, and nutrients (Brown et al. 1979). Rodents are known to select certain seeds proportional to their availability, so rodents may be less selective in more resource-limiting environments where seeds are less available (Ivan and Swihart 2000). Even though our results suggest that rodents may consume invasive seeds at high rates, the number of invasive seeds produced during a plant invasion can saturate the consuming capacity of rodent communities, particularly during periods in which rodent populations crash (St. Clair and Bishop 2019).

Previous research in our lab (Stanton et al. 2025) showed that rodents prefer native seedlings over invasive ones. In contrast, our current findings show no such preference at the seed stage, rodents consumed native and invasive seeds equally. These results suggest that rodents suppress invasive annual grasses through non-selective seed predation (St Clair et al. 2016) and points to granivory as a key mechanism in limiting invasive grass dominance.

Rodent preference: seed traits

Studies have shown that seed consumers can be highly selective of different seed types, thus controlling which plants persist and germinate into seedlings (Marone et al. 2008). Our data demonstrate that while the rodents significantly reduced seed persistence of all ten species, the effect size varied dramatically

(Fig. 2), implying that rodents show preferences for some species over others. We hypothesized that this variation in granivory preference would be due to seed size or variation in seed resource content (Chen and Valone 2017, Soriano et al. 2015, Frank 1988). However, seed size, water, and nutrient content did not significantly correlate with seed persistence in our study. Rodents of similar sizes will often seek similar-sized seeds (Ivan and Swihart 2000). The rodent community in the Mojave Desert is diverse, spanning different rodent size classes, which could partially explain why seed size did not correlate with seed preference in our study system.

Studies also indicate that chemical and physical defenses (Blate et al. 1998), seed coat characteristics (Taraborelli et al. 2003), or seed scent (Vander Wall 2003), which we did not measure in this study, can contribute to differential seed preference of rodents. Anecdotally, the most persistent seed in our study was *Ambrosia dumosa* (61% remaining in rodent-allowed areas; Fig. 2). This seed is relatively average in size compared to the other seeds in the study but has obvious physical defenses in the form of spikes that may make it a less desirable food source. Blate et al. (1998) also identify that the physical defense provided by the hardness of a seed's coat may be a key indicator of granivore preference. In their system, nutrient rewards within harder seed coats were more challenging to access. Auger et al. (2016) compared rodent seed preferences of five common native species to the human palatability ranking of the same seed species in a cafeteria study on seed preferences, ultimately finding that the rankings were very similar. Seeds that study participants ranked lower on the palatability scale were reported to have a more bitter taste, indicative of secondary chemical compounds that act as a defense against predation.

Fire effects on seed persistence

Post-fire environments can strongly influence rodent community abundance and diversity, potentially changing the top-down impacts that rodents have on the re-establishing plant community (Horn et al. 2012; Zwolak et al. 2010). Our data, however, suggest that fire did not have a significant effect on seed fate in this study (Fig. 1). Rodent surveys in the study plots confirm that the dominant rodent at this site was Merriam's kangaroo rat, a bipedal kangaroo rat that demonstrates less sensitivity to post-fire burn conditions (Horn et al. 2012; Simons 1991; Vamstad and Rotenberry 2010). We caught thirty-four individual rodents during the trapping period, seventeen in burned plots and seventeen in unburned plots. Of the rodents in the burned plots, 82% were Merriam's kangaroo rats. However, in the unburned plots, only 53% were Merriam's kangaroo rats, and the other 47% were quadrupedal long-tailed pocket mice and desert woodrats. These trends are consistent with other studies conducted in our study system, which show that fire lowers rodent diversity but not the abundance; rodent communities in burned areas consist primarily of bipedal species, such as kangaroo rats, which prefer spaces common in post-fire environments (Horn et al. 2012).

Conclusions and implications

Overall, our study highlights the critical role that rodents play in plant community assembly through top-down effects on seed persistence. Knutson et al. (2014) suggest that seedling recruitment failure following seeding efforts is primarily due to climatic factors. However, our data indicate that rodents

also play a significant role. Our data suggest that understanding not only the herbivory of established plants, but also the rodent seed preferences for native and non-native species is essential when developing and implementing management strategies for post-fire land restoration. Furthermore, understanding the composition of the local rodent community seems crucial when deciding when to seed an area and when tailoring the seed mixes to better compensate for seeds lost to rodent granivory. Recent research suggests that seed coating technology may work to protect native seeds from granivory, thereby increasing rodent consumption of non-native seeds (Taylor et al. 2020). Future studies are needed to assess additional seed traits to better understand rodent seed preferences and to better identify not just seed persistence but also seed fate.

Declarations

Competing interests

The authors have no relevant financial or non-financial interests to disclose

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Authors contributions:

SBS and RLS formulated the study and designed and developed the methodology. RLS, KLC, BCN, EB, RW, TBB, SBS conducted field work and prepared materials for the field. RLS and SBS wrote the manuscript and KLC, BCN, EB, and RW provided editorial feedback.

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Data availability statement:

data will be made available on reasonable request

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Figures

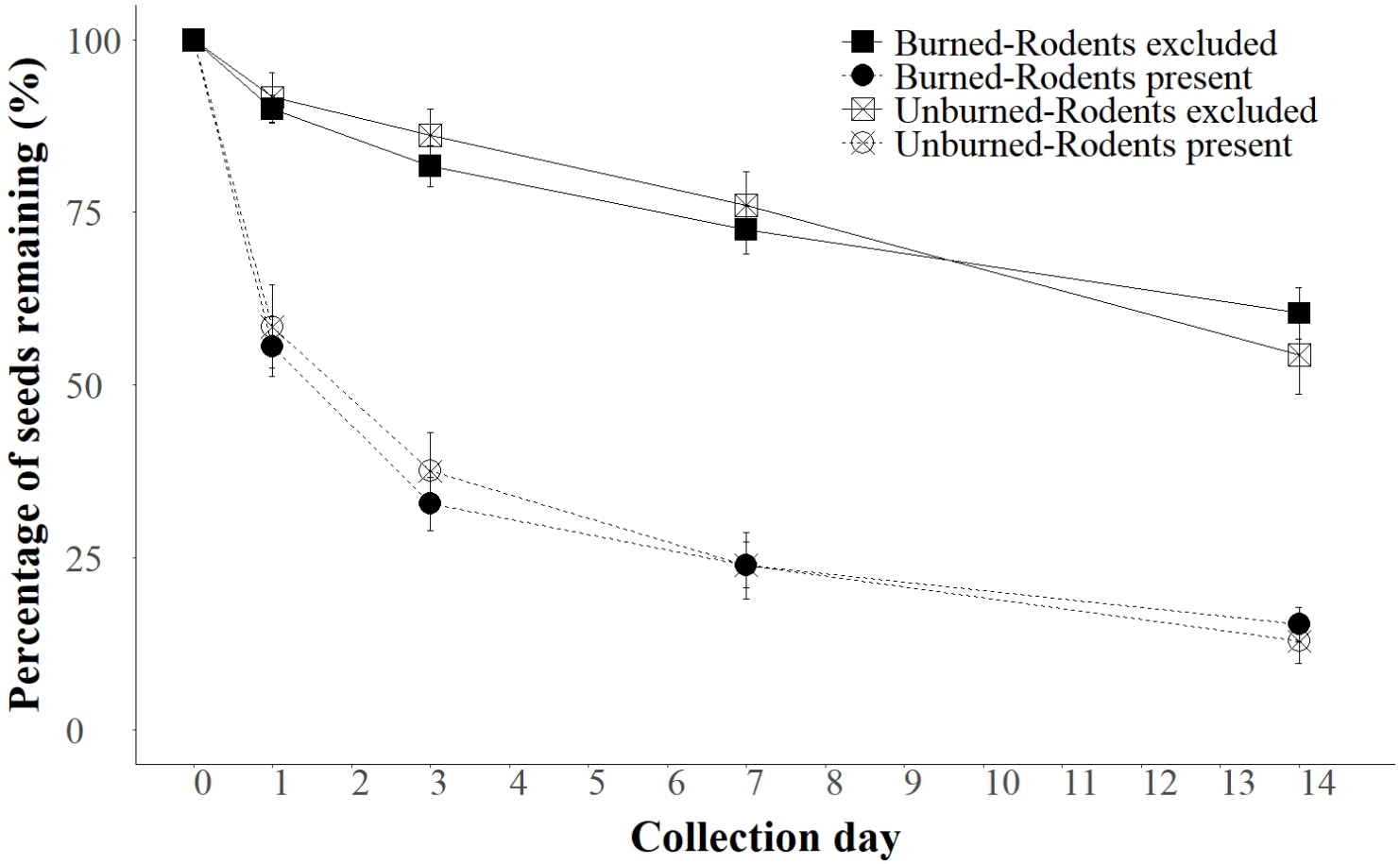

Figure 1

A time series showing the effects of fire and rodent exclusion on seed removal over 14 days in the summer of 2018. Filled symbols represent dishes we placed in plots burned in June 2011, and the open points represent dishes we placed in unburned plots. Points paired with a solid line represent dishes we placed in rodent exclusion plots, whereas those paired with dashed lines represent dishes placed in rodent access plots. Mean values are presented with error bars as ±1SE. For F statistics and significance values, see Table 2.

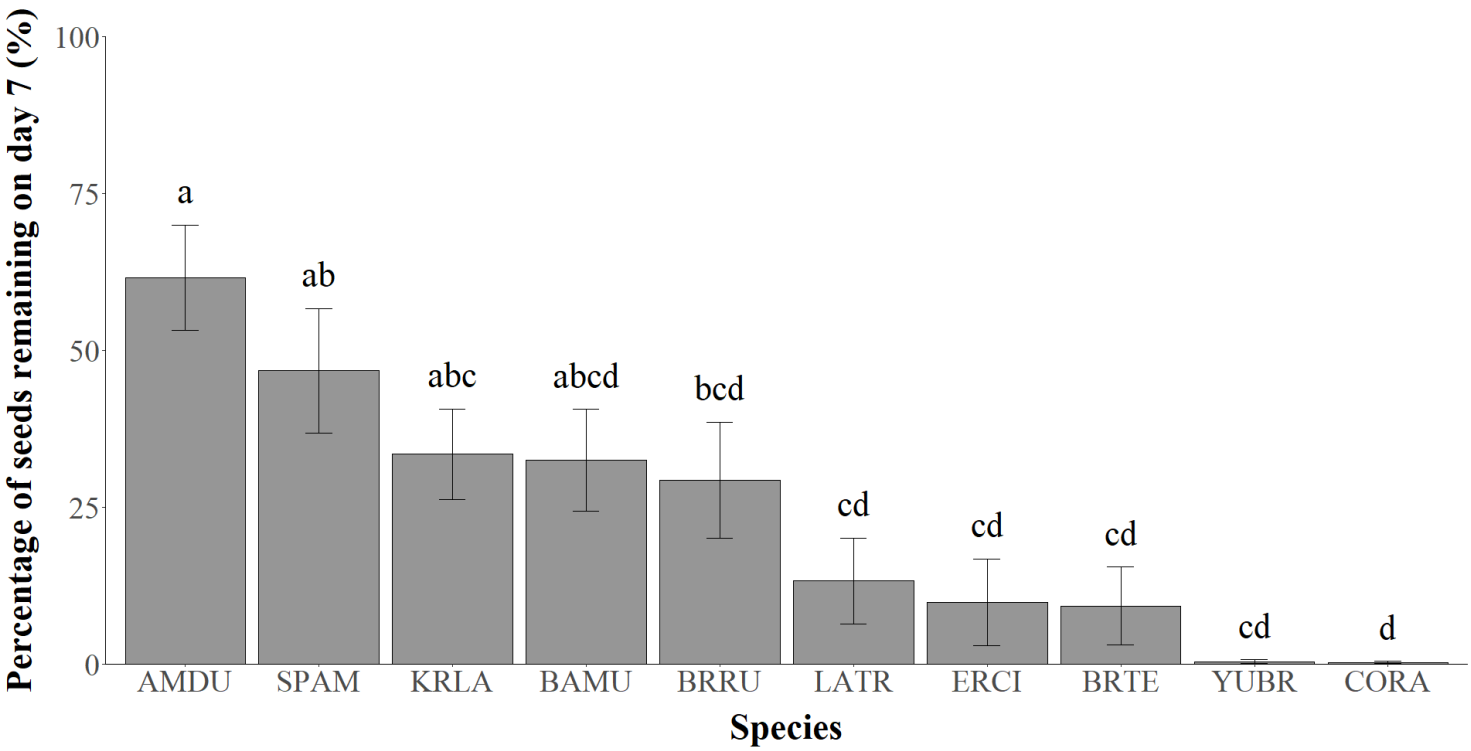

Figure 2

A comparison of the seed persistence in rodent access plots after seven days during our experiment in the Summer of 2018. Mean values are presented with error bars as ±1SE. We tested comparisons using pairwise Wilcoxon rank sum tests, with correction for multiple testing. Significant differences at the $p < 0.05$ level are denoted by different letters.

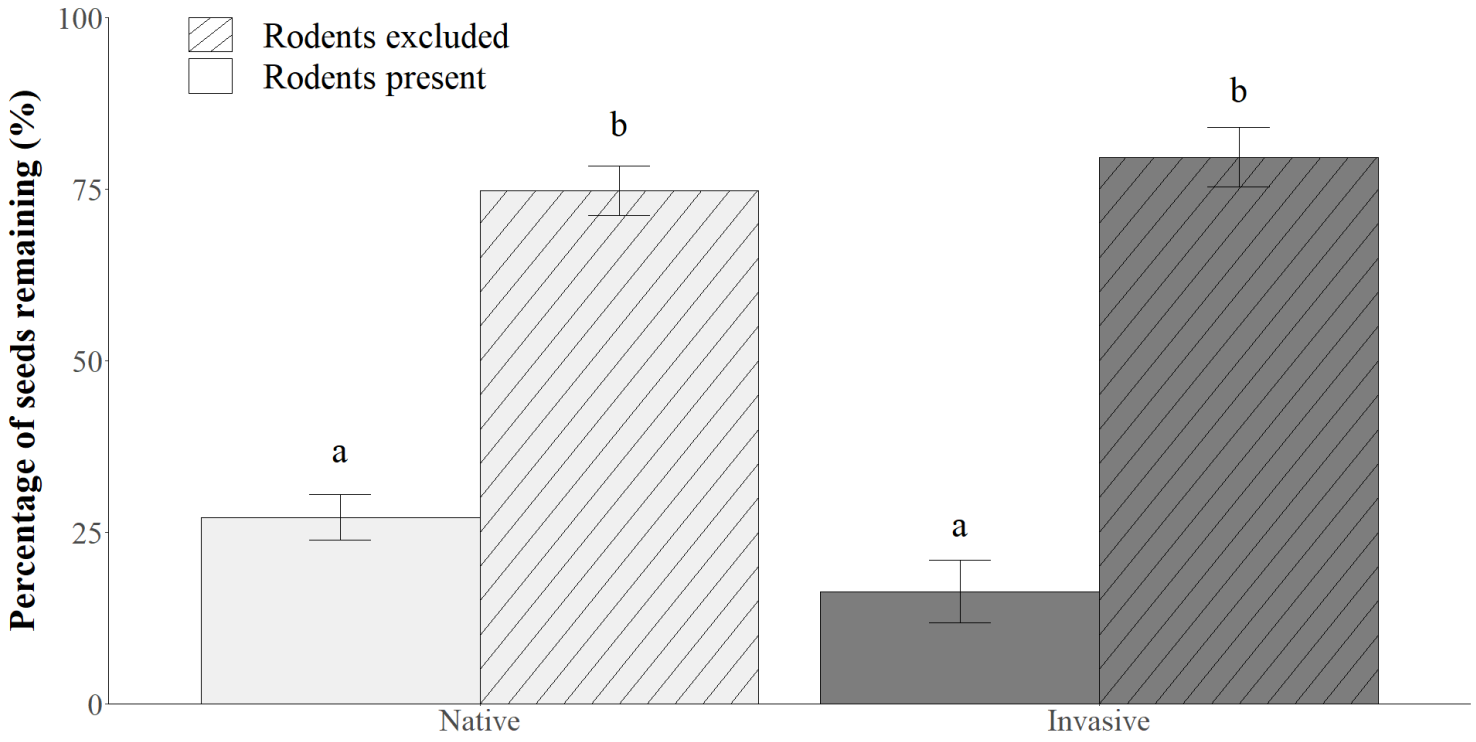

Figure 3

The main and interactive effects of rodent exclusion on the seed fate of native and invasive species after seven days in the field in the summer of 2018. Crosshatched bars represent rodent exclusion plots, while open bars represent rodent access plots. Light grey bars represent data from native seeds, and dark grey bars represent data from invasive seeds. Mean values are presented with error bars as ±1SE. We tested pairwise comparisons using pairwise Wilcoxon rank sum tests, with correction for multiple testing. Significant differences at the $p < 0.05$ level are denoted by different letters.