EXOTIC ANNUAL PLANT INVASIONS AND THEIR RELATIONSHIPS TO ROADS AND NATIVE PERENNIAL SPECIES IN THE MOJAVE DESERT, SOUTHWESTERN USA

Donovan Craig[1], Jill Pacovsky Craig[1], and Scott Abella[2]. [1]Public Lands Institute, University of Nevada Las Vegas, 4505 S. Maryland Parkway, Las Vegas, NV 89154-2040. donovan.craig@unlv.edu, jill.craig@unlv.edu, [2]Public Lands Institute and Department of Environmental Studies, University of Nevada Las Vegas. scott.abella@unlv.edu.

The study

We hypothesized that exotic species cover would:

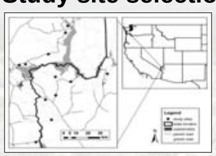
- **Decrease as distance from roadside increases,**
- **Increase below perennial shrub canopy, and**
- **Decrease in perennial shrub interspace.**

For the last five years, roadside monitoring for exotic invasive species has been a common practice for documenting distributions in Clark County, Nevada (Abella et al., *in press*). Yet, studies have shown that weed relationships to road corridors differ depending upon the natural system (Hansen and Clevenger, 2005). In the Mojave Desert, it is unknown whether exotic species are limited to or even predominant along roadsides.

Compounding this uncertainty, fertile islands under shrubs are known to enhance conditions for many annuals (Thompson et al., 2005). Thus, a site's shrub composition could influence exotic invasive plant distributions.

Sampling methods

Study site selection



- Stratified random throughout Lake Mead NRA
- Along gravel and paved roadways

Transect set-up

- Five, 100-m transects
- 2 m wide
- 5, 15, 25, 35, 45 m from road

Along each transect

- 2 of each microsite
- Center a 0.25-m^2 quadrat
- Record species and % cover

Data analysis

This design was a split-split plot design, consisting of two levels of the whole plot factor road type (gravel or paved), five levels of the subplot factor distance from roadside (5, 15, 25, 35, 45 m), and three levels of the sub-subplot factor microsite type (below *Larrea tridentata*, below *Ambrosia dumosa*, and interspace). The partially nested design was analyzed using PROC MIXED in the statistical software SAS V9.1 (2003 SAS Institute Inc., Cary, NC). Exotic cover was arcsine square-root transformed prior to analysis.

Results and Discussion

Table 1. Analysis of variance results for relationships of exotic species distributions to road type, distance from roadside, and perennial shrub microsite.

Effect	NumDF	DenDF	F	P-value
Roadtype	1	10	0.14	0.7201
Distance	4	40	3.54	**0.0145**
Roadtype*Distance	4	40	0.52	0.7247
Microsite	2	97	9.10	**0.0002**
Roadtype*Microsite	2	97	0.01	0.9875
Microsite*Distance	8	97	0.75	0.6447
Roadtype*Microsite*Distance	8	97	0.37	0.9350

A significant distance effect was found (Table 1); however, exotic cover did not vary in a systematic way with distance. The effect we found only revealed a general trend for higher exotic cover in plots closer to the road.

Microsite effects were much stronger with shrub microsites having higher exotic cover than interspace microsites. No significant interactions were detected.

Schismus spp. and *Erodium cicutarium* accounted for much of the exotic cover among all microsites (Figure 1). Exotics such as *Brassica tournefortii* and *Bromus rubens* appear to prefer shrub microsites to interspaces (Figure 1).

Most of the exotic species encountered in this study are very common and widespread in the Southwest. We cannot yet generalize these data to predict where incipient exotic populations will establish.

Further research might examine beyond 45 meters from roads to determine if and where exotic populations clearly diminish.

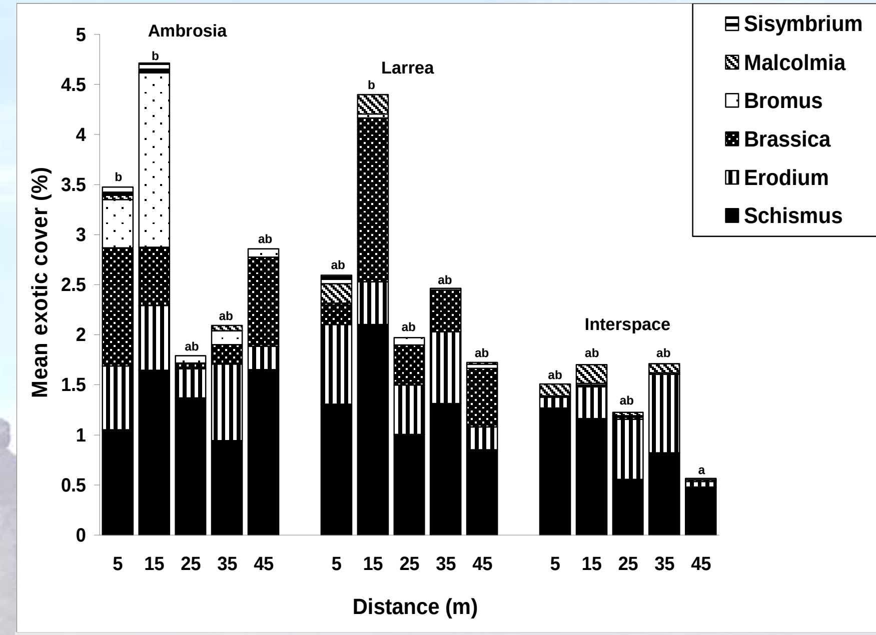


Figure 1. Mean percent exotic species cover for each microsite (*Ambrosia dumosa*, *Larrea tridentata*, and Interspace) across distances from roadside (m). Patterns within bars represent the relative contribution of each exotic species to the total. Exotic species are *Schismus* spp., *Erodium cicutarium*, *Brassica tournefortii*, *Bromus rubens*, *Malcolmia africana*, and *Sisymbrium irio*. Bars with different letters are significantly different ($p < 0.05$).

Conclusions

Roadways have been considered a vector for exotic plants. However, once exotic plants have been established in an area for some time, roads may not be the most reliable indicator of exotic plant distributions. Several species found in this study have clearly dispersed beyond roadsides. Microsite composition plays a significant role in determining the overall exotic cover of a site. Disturbances coupled with microsite influence could be more influential to exotic species distributions than road corridors. Future surveying should incorporate landscape features beyond roadsides to detect exotic species distributions. Additional research examining a greater variety of shrub microsites is needed to determine if some shrubs facilitate or inhibit exotic species.

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References

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IMPLICATIONS FOR MANAGEMENT PRIORITIZATION OF EXOTIC ANNUAL WEED MONITORING NEAR ROADSIDES IN THE EASTERN MOJAVE DESERT, USA

Donovan J. Craig[1], Jill E. Craig[1], and Scott R. Abella[2]. [1]Public Lands Institute, University of Nevada Las Vegas, 4505 S. Maryland Parkway, Las Vegas, NV 89154-2040. donovan.craig@unlv.edu, jill.craig@unlv.edu, [2]Public Lands Institute and Department of Environmental Studies, University of Nevada Las Vegas. scott.abella@unlv.edu.

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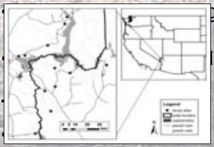

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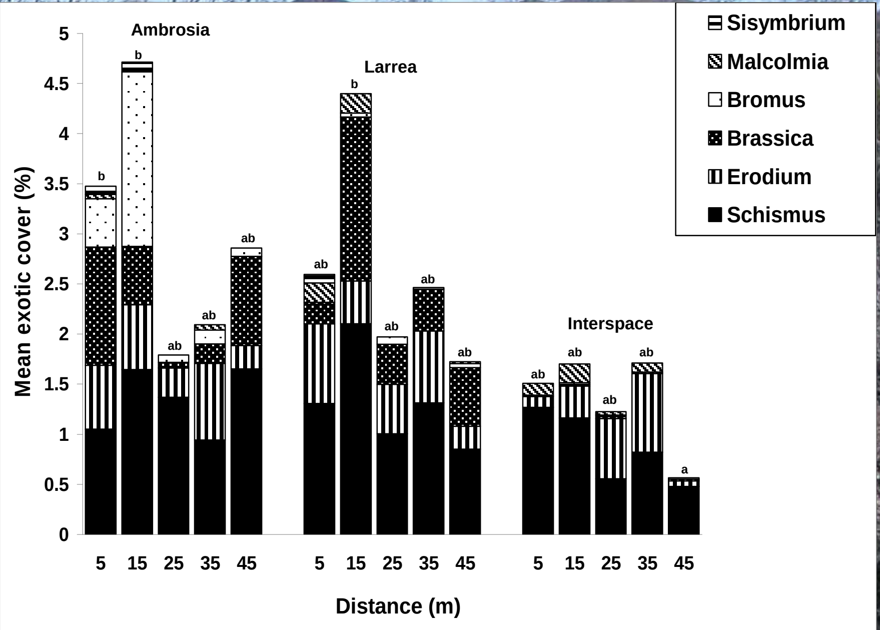
Most of the exotic species encountered in this study are very common and widespread in the Southwest. Likewise, these exotics are some of the most destructive by increasing fire frequency and severity in the Mojave.



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Seed removal by granivores in burned Mojave Desert habitat: implications for revegetation

Alexis A. Suazo[1], Donovan J. Craig[1] and Scott R. Abella[1, 2]
Public Lands Institute, University of Nevada Las Vegas, e-mail: alex.suazo@unlv.edu
Department of Environmental Studies, University of Nevada Las Vegas
4505 S. Maryland Parkway, Las Vegas, NV 89154

Introduction

The extent and frequency of wildfires in North American deserts has increased during the last 30 years. In the Mojave Desert high amounts of biomass of exotic invasive grasses serve as fuel for wildfires. In most cases wildfires destroy nearly all above ground vegetation, and re-vegetating burned areas is a top priority for land managers. As a result, direct seeding techniques have been implemented to re-establish plant species important to Mojave Desert function. However, fire is a relatively new disturbance in desert systems and as a result little is known about its effects on endemic desert species. Granivorous ants and rodents play an important role in the establishment and distribution of plant species through their seed eating behavior and selectivity (Brown et al. 1979, Valone and Schutzenhofer 2006), and can potentially consume a disproportionate amount of the seed used in restoration efforts. To discern granivory patterns by ants and rodents after wildfire, we manipulated access to seeds and compared seed removal patterns in unburned and burned habitats.

Study Area

The study site was located north of Goodsprings, NV. In 2005, the site was burned by a wildfire. Burned areas lack an above ground vegetation component (Fig. 1A). Unburned areas are typified by creosote (*Larrea tridentata*) scrub vegetation (Fig. 1B).

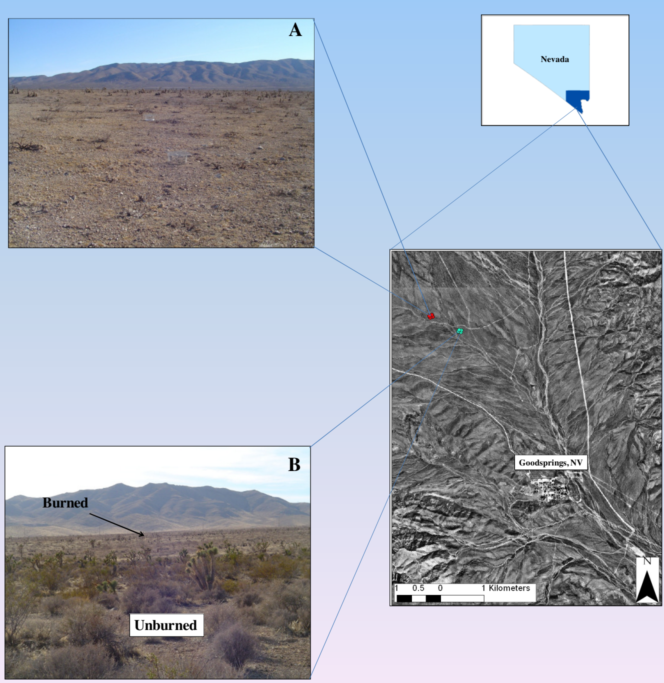

Fig. 1. A) Fire destroyed above ground vegetation and created a homogeneous landscape, and B) creosote desert scrub characterizes unburned habitats

Results

Table 1. List of species used to investigate seed removal patterns by granivorous ants and rodents in unburned and burned desert scrub habitats near Goodspring, NV

Species	Seed weight (mg) (mean ± 1SE)	Seed size (mm) (mean ± 1SE)
Ambrosia dumosa	4.765 ± 0.712	4.510 ± 0.138
Baileya multiradiata	0.505 ± 0.057	3.074 ± 0.549
Coleogyne ramosissima	15.860 ± 0.610	5.021 ± 0.925
Encelia farinosa	1.00 ± 0.107	4.853 ± 0.122
Eriogonum fasciculatum	1.00 ± 0.107	2.938 ± 0.062
Hymenoclea salsola	3.930 ± 0.389	4.953 ± 0.158
Larrea tridentata	4.700 ± 0.369	5.262± 0.195
Penstemon bicolor	0.545 ± 0.111	1.653± 0.098
Sphaeralcea ambigua	1.090 ± 0.084	1.597 ± 0.055

Seed Removal

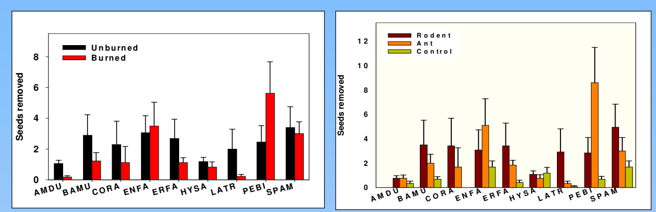

Fig. 3. Mean (±1SE) number of seeds removed in A) unburned and burned habitats and B) mean number removed by granivores. The 4 letter code pertains to a species' name and follow the order in table 1.

Treatment Effect

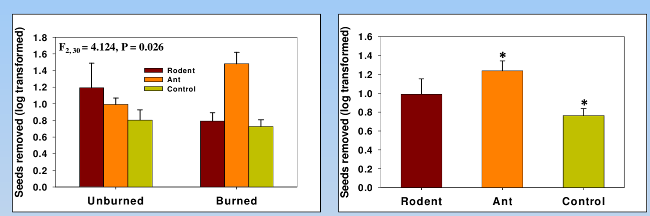

Fig. 4. Mean (±1SE) number of seeds removed by A) desert granivores in unburned and burned habitats, and B) Tukey HSD for multiple comparisons found mean number of seeds removed by ants significantly different from control cages (P = 0.022).

Methods

We used a total of 36 cages in a randomized complete block design to quantify seed removal in unburned and burned habitats. Cages were set up in six blocks per habitat type and granivory treatments were randomly assigned within blocks. We used 1.27cm- mesh hardware cloth to construct cages. Each cage was cylindrical approximately 30cm high and 45cm in diameter, and buried to a depth of approximately 10cm (Fig. 2A). Control cages excluded all seed predators (Fig. 2B). Ant cages excluded rodents, and rodent cages had a piece of vinyl flashing around it coated with Fluon to prevent ant access to seeds (Fig. 2C). We used seed of 9 plant species (Table 1) native to the Mojave Desert for seed removal trials. We offered 20 seeds of each species in a Petri dish and assessed seed removal by quantifying the number of seeds removed after 4 nights. We used a two factor ANOVA to examine patterns of seed removal in unburned and burned habitats, and log-transformed the seed removal data to improve variance and normality.

Fig. 2. A) Experimental cages were buried to a depth of at least 10 cm, B) ant and rodent exclusion cage, and C) rodent access cage

Discussion

The effects of desert granivores on plant community composition and establishment in North American deserts have been well documented (Davidson et al. 1985, Samson et al. 1992). However, few studies have assessed the impact and dynamics of seed harvesting ants and rodents in desert habitats after wildfire. We found that ants removed more seeds in burned habitats than rodents which are believed to be the dominant seed harvester in American deserts (Kerley and Whitford 1994).

Seed removal by rodents in burned habitat was low suggesting that rodent activity at our study site is low or that rodents are having a difficult time finding experimental seeds. It appears that changes in vegetation structure caused by fire may benefit ants. In a Chihuahuan desert grassland under different grazing pressures, ants removed more seeds than rodents (Kerley and Whitford 2000).

In unburned habitat, the roles of the two granivores changed; it appears that rodents are removing more seeds than ants. This finding suggest that rodents will be important seed consumers in burned areas as a function of vegetation recovery.

Conclusion

- Seed eating ants removed more seeds in burned than unburned habitats
- Ant foraging activity may have increased in burned habitats
- Three years after fire, it appears that ants are the main seed eating taxon in burned habitats
- Seed removal by rodents in burned habitats was low suggesting that their foraging activity or abundance may have decreased due to changes in vegetation structure

Acknowledgements

We thank Toshi Yoshida for his help setting up granivory cages and counting seeds. Josh Hoines provided us with CORA seed, and we acknowledged his contribution. This study was partially supported by a grant from the Joint Fire Science Program (07-1-3-24) and a cooperative agreement between Lake Mead National Recreation Area and the University of Nevada Las Vegas. We thank Alice Newton and Christina Lund for serving as federal cooperators and the Bureau of Land Management (Las Vegas Field Office) for facilitating this study.

Literature Cited

Brown, J. H., D. W. Davidson and O. J. Reichman. 1979. An experimental study of competition between seed-eating desert rodents and ants. American Zoologist 19:1129-1143.
Davidson, D. W., D. A., Samson and R. S. Inouye. 1985. Granivory in the Chihuahuan Desert: interactions within and between trophic levels. Ecology 66:486-502.
Kerley, G. I. H., and W. G. Whitford. 1994. Desert-dwelling small mammals as granivores: intercontinental variations. Australian Journal of Zoology 42:543-555.
Kerley, G. I. H., and W. G. Whitford. 2000. Impact of grazing and desertification in the Chihuahuan Desert: plant communities, granivores and granivory. American Midland Naturalist 144:78-91.
Samson, D. A., T. E. Philippi and D. W. Davidson. 1992. Granivory and competition as determinants of annual plant diversity in the Chihuahuan Desert. Oikos 65:61-80.
Valone, T. J., and M. R. Schutzenhofer. 2006. Reduced rodent biodiversity destabilizes plant populations. Ecology 88:26-31.

Road Corridor Surveys Alone May Not Reliably Detect Extent of Exotic Annual Plant Distributions

Donovan J. Craig[1], Jill E. Craig[1], and Scott R. Abella[2]. [1]Public Lands Institute, University of Nevada Las Vegas, 4505 S. Maryland Parkway, Las Vegas, NV 89154-2040.
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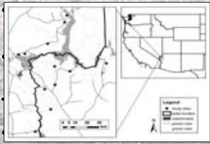

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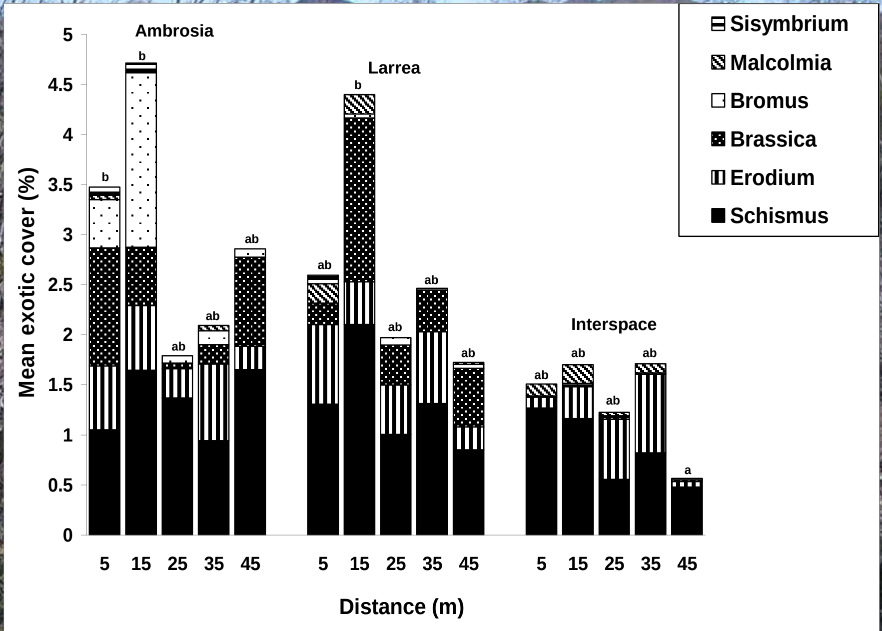

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Seed removal by granivorous ants and rodents in burned and unburned Mojave Desert habitat

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Study Area

The study site was located north of Goodsprings, NV USA. In 2005, the site was burned by a wildfire. Burned areas lacked an above ground vegetation component (Fig. 1A). Unburned areas are typified by creosote (*Larrea tridentata*) scrub vegetation (Fig. 1B).

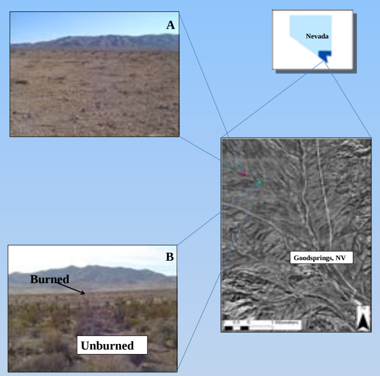

Fig. 1. A) Fire destroyed above ground vegetation and created a homogeneous landscape, and B) creosote desert scrub characterizes unburned habitats.

Methods

We used a total of 84 cages in a randomized complete block design to quantify seed removal and seedling emergence in burned and unburned habitats. Cages were set up in six blocks per habitat type and granivory treatment. We used 1.27cm- mesh hardware cloth to construct cages. Each cage was cylindrical approximately 30cm high and 45cm in diameter, and buried to a depth of approximately 10cm (Fig. 2A). Control cages excluded all seed predators (Fig. 2B). Ant cages excluded rodents, and rodent cages had a piece of vinyl flashing around it coated with Fluon to prevent ant access to seeds (Fig. 2C). We used seed of 9 plant species (Table 1) native to the Mojave Desert. We offered 20 seeds of each species in a Petri dish and assessed seed removal by quantifying the number of seeds removed after 4 nights. We assessed germination success by quantifying seedling emergence in the different granivory treatments. We used GLMs (Generalized linear models) to examine seed removal patterns and seedling emergence. Models were created in R (R development Core Team 2008).

Fig. 2. A) Experimental cages were buried to a depth of at least 10 cm, B) ant and rodent exclusion cage, and C) rodent access cage

Results

Table 1. List of species used to investigate seed removal patterns by granivorous ants and rodents in unburned and burned desert scrub Habitats in the Mojave Desert near Goodspring, NV, USA.

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Eriogonum fasciculatum	1.00 ± 0.107	2.938 ± 0.062
Hymenoclea salsola	3.930 ± 0.389	4.953 ± 0.158
Larrea tridentata	4.700 ± 0.369	5.262± 0.195
Penstemon bicolor	0.545 ± 0.111	1.653± 0.098
Sphaeralcea ambigua	1.090 ± 0.084	1.597 ± 0.055

Table 2. Negative Binomial Analysis of deviance table on seed removal in unburned and burned desert scrub habitats in the Mojave Desert near Goodspring, NV, USA.

Source	DF	Deviance	Residual df	Residual deviance	P (>|Chi|)
Null			287	633.37	
Treatment	2	64.38	285	568.99	< 0.001
Habitat	1	0.87	284	568.12	0.35
Month	7	122.17	277	445.95	< 0.001
T x H	2	25.29	275	420.66	< 0.001
T x M	14	66.71	261	353.95	< 0.001
H x M	7	12.86	254	341.09	0.08
T x H x M	14	35.48	240	305.61	< 0.001

Seed Removal

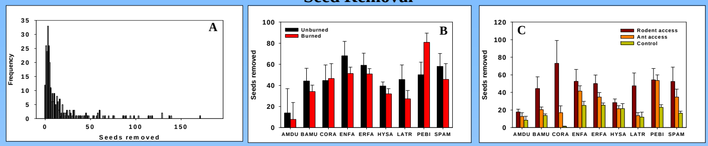

Fig. 3. A) frequency of seeds removed, B) mean (±SE) number of seed species removed by ants and rodents in unburned and burned habitats, and C) seed removal patterns in experimental cages. The 4 letter code pertains to a species' name and follows the order in table 1.

Treatment Effect

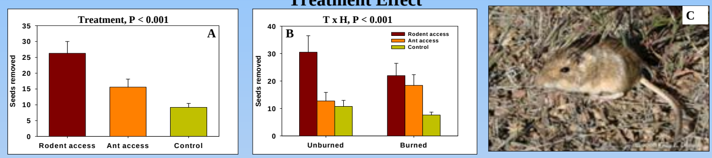

Fig. 4. Mean (±SE) number of seeds removed by A) granivores, B) seeds removed in unburned and burned habitats, and C) pocket mouse (Perognathus sp.) a common seed eating rodent in North American deserts. See table 2 for deviance explained by factors.

Temporal patterns

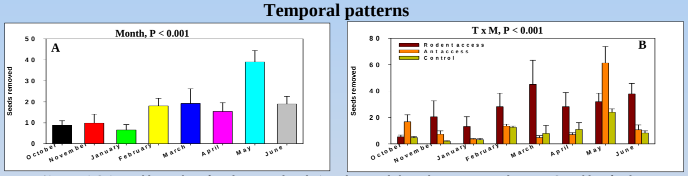

Fig. 4. A) mean (±SE) monthly number of seeds removed, and B) seed removal showed strong temporal pattern. See table 2 for deviance explained by factors.

Seedling emergence

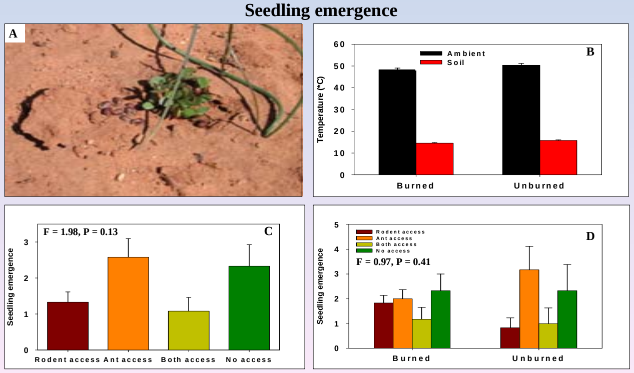

Fig. 5. A) Blackbrush (*Coleogyne ramosissima*) seedlings, B) temperature at the study sites, C) mean (±SE) seedling emergence in different granivory treatments and D) in burned and unburned habitats.

Discussion

The effects of granivorous ants and rodents on plant community composition and establishment in North American deserts have been well documented (Davidson et al. 1985, Samson et al. 1992). However, few studies have assessed the impact and dynamics of seed eating ants and rodents in desert habitats after wildfire. We found that rodents removed a significant number of seeds in unburned habitat. However, the observed seed removal was driven by temporal patters rather than habitat condition. Monthly seed removal results indicate that during October, November, and January seed removal was low suggesting that during this time period the activity of granivores is low, and it may be a good management strategy to conduct reseeding efforts during this time. Black brush seedling emergence was not influence by granivory treatments or habitat condition suggesting that other factors such as precipitation, soil and ambient temperatures may play a stronger role on seedlings. However, rodents showed a strong preference for black brush seed, therefore, their long term impact on the establishment of black brush remains to be documented.

Conclusion

- Seed eating rodents removed more seeds in unburned than burned habitats
- There was a seed removal pattern by ants in burned habitat
- Seed removal was influenced by time
- Abiotic factors may be better predictors for seedling emergence
- Reseeding should be conducted in late fall when rodent and ant activity is low, and abiotic conditions are favorable for seedling emergence

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Literature Cited

Brown, J. H., D. W. Davidson and O. J. Reichman. 1979. An experimental study of competition between seed-eating desert rodents and ants. American Zoologist 19:1129-1143.
Davidson, D. W., D. A., Samson and R. S. Inouye. 1985. Granivory in the Chihuahuan Desert: interactions within and between trophic levels. Ecology 66:486-502.
Samson, D. A., T. E. Philippi and D. W. Davidson. 1992. Granivory and competition as determinants of annual plant diversity in the Chihuahuan Desert. Oikos 65:61-80.
Valone, T. J., and M. R. Schutzenhofer. 2006. Reduced rodent biodiversity destabilizes plant populations. Ecology 88:26-31.

Identifying Candidate Native Species for Revegetating Desert Wildfires

Scott R. Abella[1] and Donovan J. Craig[2]

[1]Public Lands Institute and School of Environmental and Public Affairs, University of Nevada Las Vegas, Las Vegas, NV 89154-2040, scott.abella@unlv.edu. [2]School of Environmental and Public Affairs, University of Nevada Las Vegas, Las Vegas, NV 89154-2040.

School of Environmental and Public Affairs

UNLV

UNIVERSITY OF NEVADA LAS VEGAS

SUMMARY

Species selection can have a major influence on the success of burn revegetation projects. Candidate native species for revegetating wildfires in arid lands, such as the Mojave Desert, must meet at least two criteria: (i) have the ability to reliably become established through seeding or planting in burned environments, and (ii) be competitive with exotic annual grasses that often infest post-burn habitats. With funding from the Joint Fire Science Program, we are assessing species selection using a set of complementary studies that are testing the abilities of five native community types and 12 native species to resist invasion by exotic grasses (*Bromus rubens* and *Schismus* spp.), the relative performances of these species in seeding and outplanting on a burn in the eastern Mojave Desert, correlations of these species with exotic grass abundance in unburned desert communities, and a value-added literature synthesis of natural post-fire establishment patterns of desert species. One year after outplanting on the burn, we found that species typically considered as early successional generally have higher survival percentages. For example, *Sphaeralcea ambigua* has exhibited the highest overall survival at 65%, and also the highest survival (60%) among plants not given supplemental water or any treatment. However, some late-successional species, such as *Larrea tridentata*, have exhibited > 50% survival if provided supplemental water and protected from herbivory. In the correlational field study, early successional natives (e.g., *Encelia* spp.) that tend not to formal fertile islands have exhibited lower abundance of exotic grasses below their canopies. Results of the synthesis of natural post-fire establishment support these conclusions.

PROJECT GOALS

The objective of this in-progress research is to identify native species that can reliably establish on desert burns and compete with exotic annual grasses. Native species that meet these criteria could be considered as candidate species for revegetation projects and could represent the types of species in which to invest long-term effort in propagating quantities of plant material.

The work reported here has four components: (1) an invasibility field experiment, (2) seeding and planting experiment of species performance, (3) non-manipulative study of exotic grass fuel loads below different native perennial species, and (4) a literature synthesis of natural post-fire establishment patterns of native perennial species.

References

Abella, S.R. 2009. Post-fire plant recovery in the Mojave and Sonoran Deserts of western North America. Journal of Arid Environments 73:699-707.

Craig, D.J., J.E. Craig, S.R. Abella, and C.H. Vanier. 2010. Factors affecting exotic annual plant cover and richness along roadsides in the eastern Mojave Desert, USA. Journal of Arid Environments (in press).

Fig. 1. View of an experimental community plot (left), and individual species plots (right), established at the Lake Mead National Recreation plant nursery. Exotic grasses have been sown in the plots for two years and we are measuring which native species combinations best resist invasion.

Scientific name	Common name	Functional Group
Larrea tridentata	Creosote bush	Late-succession shrub
Ambrosia dumosa	White bursage	Late-succession shrub
Eriogonum fasciculatum	California buckwheat	Late-succession shrub
Encelia farinosa	Brittlebush	Early succession shrub
Bebbia juncea	Sweetbush	Early succession shrub
Hymenoclea salsola	Cheesebush	Early succession shrub
Sphaeralcea ambigua	Desert globemallow	Forb
Baileya multiradiata	Desert marigold	Forb
Penstemon bicolor	Two-toned beardtongue	Forb
Achnatherum hymenoides	Indian ricegrass	Grass
Aristida purpurea	Purple threeawn	Grass
Sporobolus airoides	Alkali sacaton	Grass

Table 1. Summary of the 12 project species we are assessing for their abilities to resist invasion by exotic annual grasses and amenability to active revegetation.

Fig. 2. Testing the effects of different irrigation and protection methods for establishing different species through planting on the Goodsprings Fire (2005) in southern Nevada (left photo). The same species also were compared for their performance in seeding with and without exclosures to protect from granivory and with or without water additions (right photo).

PRELIMINARY FINDINGS

(1) Invasibility field experiment: the purpose of this experiment is to identify whether different native plant communities and individual species differentially resist invasion by the exotic grasses *Bromus rubens* and *Schismus* spp., with and without augmented soil nitrogen **(Fig. 1).** Five native community types have been established in experimental plots: early successional forb, early successional shrub, perennial grass, late-successional shrub, and unvegetated control. Except for the control, each of the community types consists of three species **(Table 1).** Each of the 12 species then also are being grown individually to test species-specific effects.

(2) Species performance in planting and seeding: this component of our research integrates with the first component, because we must identify species that can compete with exotic grasses but that also are feasible to actually establish for revegetating wildfires. The purpose of this study is to compare performances of the project species in planting versus seeding revegetation treatments **(Fig. 2).** The early results suggest that the early successional globemallow has become established the best among species in planting **(Fig. 3)**. The performance of late-successional species such as creosote seems to be enhanced by shelter and water additions.

(3) Patterns of exotic grass invasion below native perennial species: we are conducting a non-manipulative field study of fuel loads below different native species to complement the experimental results of the first component of our research. To date, we have assessed fuel loads below approximately 20 native species and are continuing to work to increase the number of site replicates. It is not easy to find sites that have large numbers of our project native species to directly compare results within the same sites, but we hope to have at least 10 directly comparable sites. Results comparing bursage and creosote and including distance from road effects have been published (Craig et al. 2010) and are summarized in **Fig. 4.**

(4) Literature synthesis of natural post-fire establishment patterns: in this value-added component to our Joint Fire Science funded project, we have completed a literature synthesis of post-fire recovery patterns in the Mojave and Sonoran Deserts (Abella 2009). One of the relevant findings of this review for species selection was identifying the native species that have been reported as the strongest post-fire colonizers **(Table 2).** First, the findings of the review supported our selection of early successional species in the first component of the research. Second, species that have been reported as strong natural post-fire colonizers, such as globemallow, also have performed well in our revegetation planting treatments in the second component of the research.

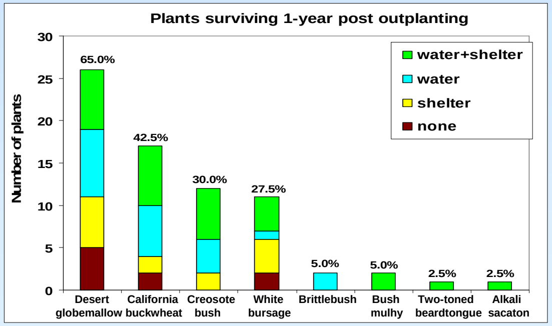

Fig. 3. Performance through planting of different species across shelter and watering treatments. Survival % is given at the top of bars.

Species	Burned	Unburned	Ratio[b]
	Mean (no. studies)[a]		
Sphaeralcea ambigua	5.2 (6)	0.2 (2)	21.0
Gutierrezia microcephala	1.2 (1)	0.1 (1)	16.3
Achnatherum speciosum	4.4 (4)	0.6 (5)	7.7
Gutierrezia sarothrae	5.3 (3)	0.8 (3)	6.6
Senna covesii	1.2 (1)	0.2 (1)	5.6
Encelia virginensis	3.9 (4)	0.7 (4)	5.6
Thamnosma montana	2.2 (4)	0.4 (4)	5.0
Hymenoclea salsola	7.1 (5)	2.2 (5)	3.2
Chamaesyce polycarpa	5.3 (1)	1.7 (1)	3.1
Baileya multiradiata	3.1 (3)	1.0 (2)	3.1

Table 2. The 10 most dominant post-fire colonizers, based on their ratio of burned:unburned relative abundance, reported among 13 studies in the Mojave and Sonoran Deserts. Values are mean relative abundance and the ratio of burned:unburned abundance. Higher ratios indicate greater fidelity to burned areas.

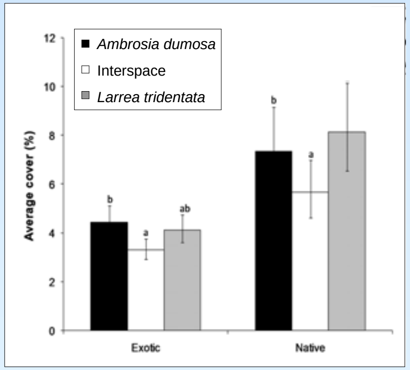

Fig. 4. Comparison of the average cover of exotic annual and native species below bursage and creosote in relation to interspaces. Further sampling of this type is required to evaluate a wider range of native species, which is in progress.

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