UC Riverside
Recent Work

Title

2005-2006 Coachella Valley MSHCP Monitoring Framework Priorities: Impacts of Exotic Weed Species including Saharan Mustard (Brassica Tournefortiil)

Permalink

https://escholarship.org/uc/item/3gr6974t

Authors

Barrows, Cameron W.
Allen, Michael F.

Publication Date

2007

eScholarship.org Powered by the California Digital Library
University of California

UNIVERSITY OF CALIFORNIA, RIVERSIDE

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO | SANTA BARBARA • SANTA CRUZ

CENTER FOR CONSERVATION BIOLOGY
RIVERSIDE, CALIFORNIA 92521-0122
TEL: 951-827-5494; FAX: 951-827-2620

COLLEGE OF NATURAL AND AGRICULTURAL SCIENCES
CITRUS RESEARCH CENTER AND AGRICULTURAL EXPERIMENT STATION

2005-2006 COACHELLA VALLEY MSHCP MONITORING FRAMEWORK PRIORITIES:

IMPACTS OF EXOTIC WEED SPECIES INCLUDING SAHARAN MUSTARD (*BRASSICA TOURNEFORTII*)

Final Report

by

Cameron W. Barrows
Project Coordinator
Post Doctoral Researcher

Michael F. Allen
Director
Professor & Chair of Plant Pathology
Professor of Biology

January 2007

TABLE OF CONTENTS

TABLE OF FIGURES

SYNOPSIS OF CCB ACTIVITIES

In 2002, the Center for Conservation Biology (CCB) at University of California at Riverside's initiated a multi-year collaboration with the Coachella Valley Association of Governments to develop a monitoring framework for the Coachella Valley Multiple Species Habitat Conservation Plan (CV MSHCP) (see Allen et al 2005). This final report reflects the findings for the 2005-2006 project period (September 1, 2005 – December 31, 2006), undertaken by the CCB's Desert Studies Initiative, to initiate an analysis of the impacts of the exotic weed, Saharan mustard (*Brassica tournefortii*) with regard to the conservation goals of the CV MSHCP. 2005 marked the most severe outbreak of Saharan mustard in more than a decade. Concern over the impacts of this weed not only with regard to the CV MSHCP, but in the entire southwestern desert region was the impetus for initiating this research. In particular, the questions addressed were the following, and are answered in the next section:

- What variables best predict the occurrence and density of this weed species?
- Does anthropogenic nitrogen deposition influence its distribution and density?
- Is the extent of the weed infestations expanding, or is it an oscillation in response to the pattern and amount of precipitation?
- What are the impacts of the exotic plants on the aeolian sand community? Are the impacts different in the different habitat divisions of the aeolian community?
- Does weed density impact CV fringe-toed lizard or flat-tailed horned lizard populations? Are impacts similar for these two species?
- Does weed density impact CV milkvetch populations? Does it impact plant distribution and/or reproduction?

Time and Effort

Task	2005-2006 (estimated hrs)
Project Development and Management	
Faculty Oversight/Review	2160
Task Management	150
Administrative Support	980
Fieldwork	
Sand Treader Cricket Surveys	100
Vegetation Analysis	300
CV Milkvetch Surveys	30
Arthropod surveys	350
Sand Compaction data collection	60
Summer sand transects - vertebrate surveys	600
Fall sand transects - vertebrate surveys	300
Mammal live trapping	140
Le Conte's Thrasher surveys	200

Burrowing Owl surveys	75
Brassica weeding	40
Data Entry/Management	
Sand Treader Cricket Surveys	25
Vegetation Analysis	125
CV Milkvetch Surveys	30
Arthropod surveys	95
Sand Compaction data collection	30
Summer sand transects - vertebrate surveys	120
Fall sand transects - vertebrate surveys	100
Mammal live trapping	30
Le Conte's Thrasher surveys	200
GIS	265
Niche Modeling	160
Data Analyses & Reports Preparation	1370
Scientific meetings/symposia	440
PROJECT TOTAL	**8475**

Outreach Activities

Listed below are the presentations of CCB research at the Annual CVAG - Coachella Valley Research Symposium. Held at UC Riverside Palm Desert Campus, November 16, 2006. *On file in the CCB data library.*

Allen, E.B., L.E. Rao, R.J. Steers, A. Bytnerowicz and M.E. Fenn. *Impacts of Anthropogenic Nitrogen Deposition in Joshua Tree National Park and Vicinity*. Center for Conservation Biology and the U.S. Forest Service Fire Laboratory.

Barrows, C.W. *Short-term and long-term impacts of Saharan mustard on aeolian sand communities*. Center for Conservation Biology – Desert Studies Initiative.

Barrows, C.W. *Fringe-toed lizard population persistence and extinction on aeolian sand islands* Center for Conservation Biology – Desert Studies Initiative.

Barrows, C.W. *Assessing risk in dynamic populations: using science to identify thresholds for adaptive management*. Center for Conservation Biology – Desert Studies Initiative.

Barrows, C.W. *Modeling current and past distributions of flat-tailed horned lizards and Coachella Valley fringe-toed lizards*. Center for Conservation Biology – Desert Studies Initiative

Fisher, M. *Aeolian sand dynamics on the Whitewater Floodplain Preserve*. Boyd Deep Canyon Reserve, UC Natural Reserve.

Fleming, K.D. *Comparing track counts to mark-recapture results for assessing small mammal communities: preliminary results*. Center for Conservation Biology – Desert Studies Initiative.

Gong, P. and Z. Yongchao. *Preliminary assessment of Landsat TM data for invasive grass mapping in southern California*. Center for Conservation, UCR and Ecosystems Division, UC Berkeley.

Hutchinson, D. *Monitoring Low Density Populations of LeConte's Thrasher by Comparing Playback vs. Passive Surveys.* Center for Conservation Biology – Desert Studies Initiative.

Additional Presentations, 2005-2006

Barrows, C.W. 2006. Range Contractions and Current Distribution of the Flat-tailed Horned Lizard in the Coachella Valley. Presented at the Wildlife Society Meetings in Sacramento, February 3, 2006.

Barrows, C.W. 2006. Non-equilibrium Population Dynamics in the Coachella Valley Fringe-toed Lizard: Implications for the development of a monitoring framework. Presented at the Wildlife Society Meetings in Sacramento, February 3, 2006.

Barrows, C.W. and M.F. Allen. 2006. A Framework for Monitoring Multiple Species Conservation Programs - an Example from the Coachella Valley's Desert Sand Dunes. Presented at the Sixth Conference on Research and Resource Management in Southwestern Deserts, Tucson Arizona, May 2-5, 2006.

Barrows, C.W. and E.B. Allen. 2006. Population, Community and Ecosystem Consequences of an Invasive Plant in a Desert Sand Dune Ecosystem. Presented at the Sixth Conference on Research and Resource Management in Southwestern Deserts, Tucson Arizona, May 2-5, 2006.

Barrows, C.W. 2006. Invited workshop participant "Ecosystem Health Assessment for Southern Nevada - Research Needs for Management in the 21st Century", Las Vegas Nevada, August 14-15, 2006.

Barrows, C.W. and E.B. Allen. 2006. Temporal and Spatial Impacts of Saharan Mustard, *Brassica tournefortii*, on Southwestern Desert Habitats: Developing Effective Control Strategies. Poster. Exotic Pest and Weed Symposium, UC Riverside, October 3, 2006.

Resultant Publications

Barrows, C. W. 2006. Population dynamics of a threatened dune lizard. Southwestern Naturalist 51:514-523.

Barrows, C. W. and M. F. Allen. Conservation implications of fragmentation in desert ecosystems. In R. H. Webb (ed.) The Mohave Desert Science Symposium. (in press).

Barrows, C. W. and M. F. Allen. Community complexity: stratifying monitoring schemes within a desert sand dune landscape. Journal of Arid Environments (in press)

Barrows, C. W. and M. F. Allen. Biological monitoring and bridging the gap between land management and science. Natural Areas Journal. (in press)

Barrows, C. W., M. F. Allen and J. T. Rotenberry. 2006. Boundary processes between a desert sand dune community and an encroaching suburban landscape. Biological Conservation 131:486-494.

Chen, X., C. W. Barrows and B. Li. 2006. Is the Coachella Valley Fringe-toed Lizard (*Uma inornata*) on the Edge of Extinction at Thousand Palms Preserve? Southwestern Naturalist 51: 28-34.

Chen, X., C. W. Barrows and B. Li. 2006. Phase coupling and spatial synchrony of subpopulations of an endangered dune lizard. Landscape Ecology 21:1185-1193

FINDINGS

What variables best predict the occurrence and density of this weed species?

Variables that best predict the dominance of Saharan mustard depend on the scale of analysis. At a regional scale this mustard occurred with the greatest dominance on aeolian sands, but can also be present in desert wash and rocky hillside habitats. The Coachella Valley floor landscape can be divided into at least four distinct aeolian sand communities, each distinguished by sand transport rates, sand depth and biotic associations (Barrows and Allen, *in press*). Saharan mustard's dominance in each of these communities varied between years (Fig.1). That variance was in part explained by the stochastic rainfall patterns. When precipitation exceeded average levels (2005) the mustard dominated the stabilized sand fields. At moderate, slightly below average rainfall levels (2004 and 2006) mustard dominance shifted between ephemeral sand fields in the west and active sand dunes in the east. This shift may be again explained by rainfall patterns. In 2004 rainfall fell primarily in the winter-spring and was 30% higher in the west. In 2006 rainfall fell primarily in the fall (of 2005) and was heavier in the east.

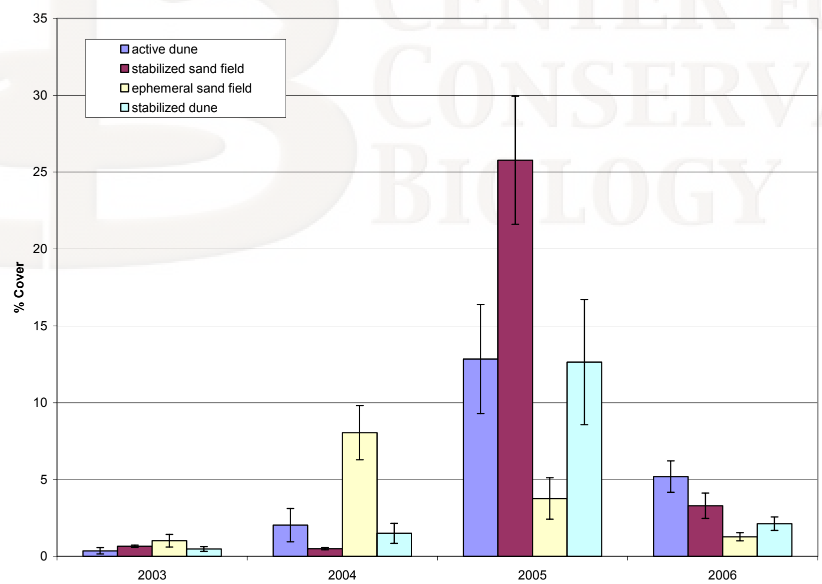

Figure 1. Dominance patterns of Saharan mustard (as measured by percent cover) across the Coachella Valley floor, partitioned by year and community type. Error bars indicate one standard error.

Perhaps surprisingly, this mustard does not appear especially well adapted to desert conditions. When drought conditions prevail, the mustard either does not germinate or withers and dies before setting seed. In October 2005 heavy rains resulted in a second wave of germination for that year. We measured densities approaching 300-1000 seedlings/m² on the inter-dune, stabilized sand field communities. That was the last rain event for the 2006 rain year. We recorded 98% mustard mortality prior to setting seed by March 2006, entirely due to the drought conditions. However on the active dunes which have a greater ability to hold on to moisture due to unique inter-grain pore size, the mustard completed its life cycle and produced seed. High sand moisture and low wind velocities appeared to allow the mustard to become established on the active dunes in higher densities 2006 than were measured in the spring of 2005. This finding may be a cause for concern, since many of the CV MSHCP target species are found in their greatest abundance on the active dunes.

At a finer, community level scale, predicting within community dominance of Saharan mustard proved to be more difficult. In 2006, when the mustard was most dominant in the active dunes, there was a positive significant correlation between sand compaction and percent cover of the mustard ($R^2 = 0.325$, $p = 0.004$) in that community. What wasn't clear was whether this correlation was due to a response or an effect. In 2005 there was no correlation between sand compaction and mustard dominance in the stabilized sand field community where the mustard was most abundant ($R^2 = 0.003$, $p = 0.808$). In 2004 there was a weak correlation between sand compaction and mustard dominance in the ephemeral sand field community where the mustard was most abundant ($R^2 = 0.097$, $p = 0.065$).
To address the question of whether higher sand compaction facilitated mustard establishment or higher compaction levels resulted from mustard occurrence, we measured compaction on mustard removal plots (Fig. 2). Mustard plants were removed by hand from plots in the winter of 2005 with measurable impacts extending into the fall of 2005. Our results indicate a mustard effect on compaction; removing mustard reduced compaction relative to adjacent control plots. Besides sand compaction, no other independent variables provided any explanation for the within community variances in mustard dominance.

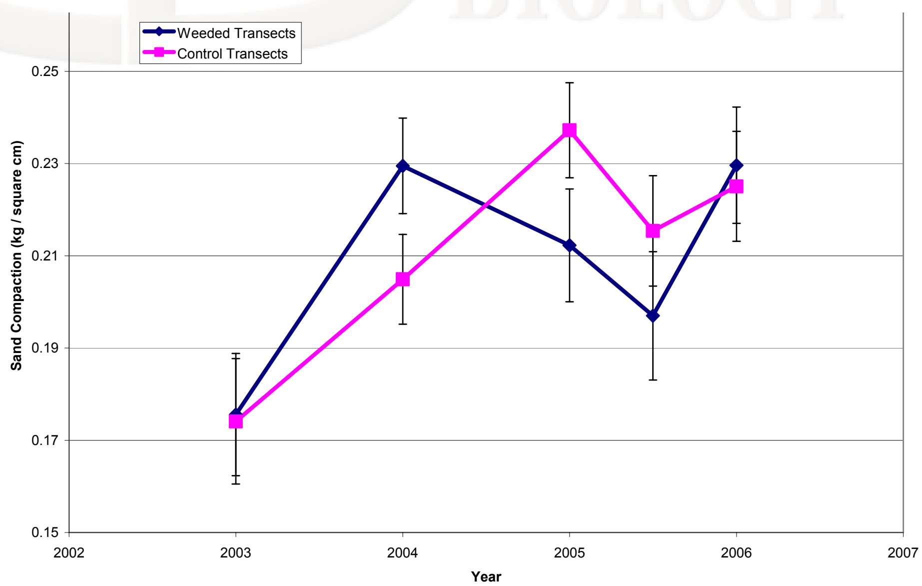

Figure 2. Results from experimental removal of mustard on sand compaction levels. Actual removal occurred in winter of 2005. Error bars indicate one standard error.

Does anthropogenic nitrogen deposition influence its distribution and density?

The nitrogen-mustard abundance hypothesis was evaluated in the fall of 2005. We collected soil samples from throughout the Coachella Valley at the same locations where we had collected mustard abundance data. The samples were sent to U. C. Davis where they were analyzed for nitrogen and Phosphorous content. The patterns of measured soil nutrients by natural community are shown in Fig. 3.

The high nitrite abundance measured in the stabilized dunes may be related to the occurrence of nitrogen fixing shrubs (honey mesquite, *Prosopis glandulosa*) in this community. No significant correlation was detected for a nitrogen or phosphorous/mustard abundance association (p = 0.159 – 0.922).

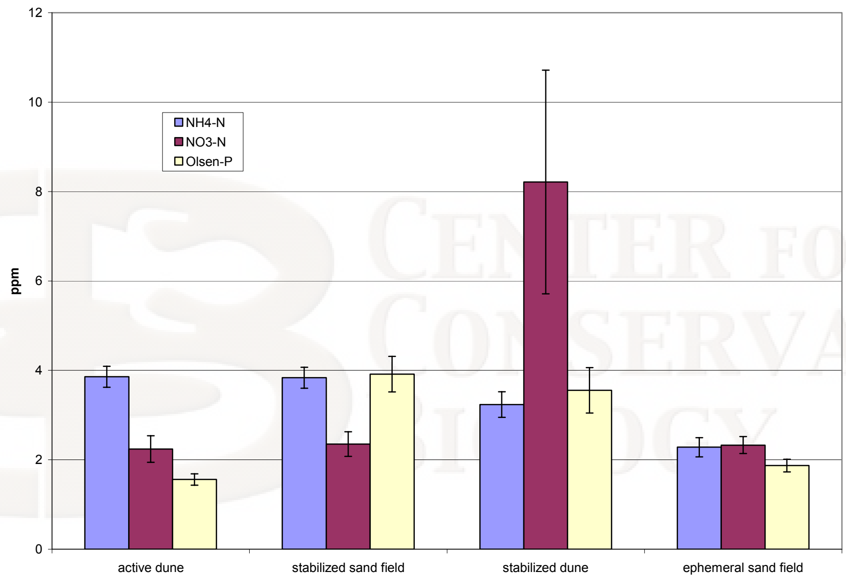

Figure 3. Soil Nutrients compared between aeolian community types. Error bars indicate one standard error.

Is the extent of the weed infestations expanding, or is it an oscillation in response to the pattern and amount of precipitation?

Saharan Mustard has been present in the Coachella Valley since at least 1927, possibly introduced in soil attached to the roots of date palms brought to the Coachella Valley from north Africa for agricultural purposes. Since that introduction, major "outbreaks" of Saharan have occurred in 1977-1983, 1994-1995, and in 2005, coinciding with high rainfall (Sanders and Minnich 2000). Precipitation clearly plays an important role in the mustard infestation levels. The previous heavy mustard infestation years were in 1994 and 1995, years with similar rainfall levels to those in 2005, however in the intervening years Saharan mustard was a minor component of the valley's flora.

We purchased LandStat satellite imagery for a time series including from 1993, 1995, 1998, 2002, and 2005. Using these data we hope to determine whether the ebb and flow of mustard abundance is resulting in trend toward an expanding distribution in each subsequent wet year, or not. These satellite images are currently being analyzed by a team lead by Dr. Peng Gong at UC Berkeley under a separate grant and so at no cost to this project. We expect results sometime in 2007.

What are the impacts of the exotic plants on the aeolian sand community? Are the impacts different in the different habitat divisions of the aeolian community?

Barrows and Allen (*in press*) have identified four distinct communities within the Coachella Valley sand dune system. Those four include active dunes, stabilized (mesquite) dunes, stabilized sand fields and ephemeral sand fields. Of these, the stabilized sand field community had the highest mustard densities in 2005 (Fig. 1). On a series of transects located within the stabilized sand community we conducted a series of mustard removal experiments that revealed significant negative impacts to native annual plant density, percent cover, flower production and seed production (Table 1). Subsequent sampling on those same plots after the October 2005 rains revealed that for every native annual species measured there was a significant increase in seedling density on the weeded plots the year following weeding (ANOVA, $p < 0.05 - 0.0009$) (Fig. 4).

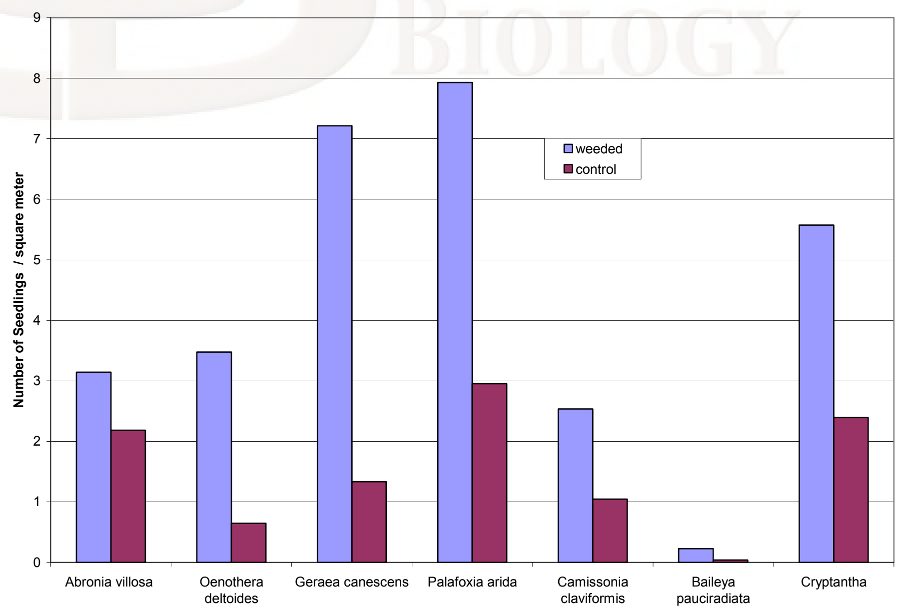

Figure 4. Native annual plant seedling density on weeded and control (un-weeded) experimental plots.

While annual plant species richness was not statistically significantly impacted by the explosion of Saharan mustard in 2005, native annual plant density, percent cover and especially reproductive success were negatively impacted. Annual plant reproductive success was determined by counting flowers on selected plant species in the weeded and control experimental plots (Fig. 5). The differences in germination rates shown in Fig. 4 indicate that Saharan mustard could have long-term impacts on native annual plant abundance.

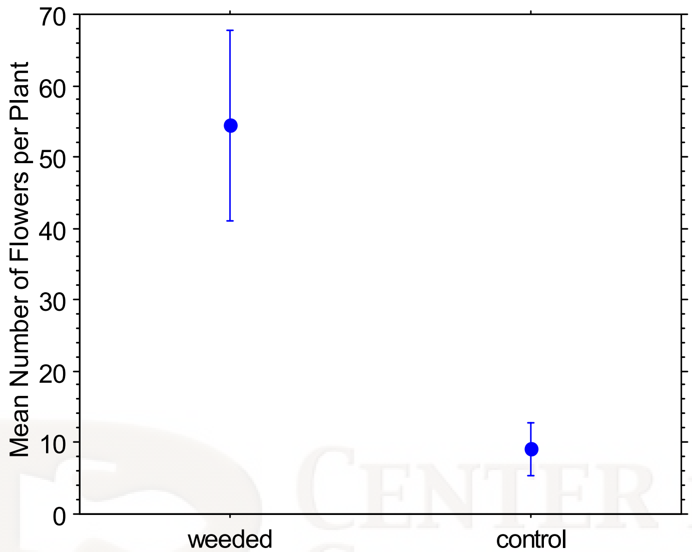

Figure 5. Mean number of flowers/plant for dune primrose, *Oenothera deltoides* on weeded and control plots. Error bars indicate one standard error.

The weeding experiments also had a measurable impact on non-native annual plants. On weeded plots there was a significant reduction of Saharan mustard germinating the following season, as well as an increase in *Shismus barbatus*, a non-native annual grass (Fig. 6).

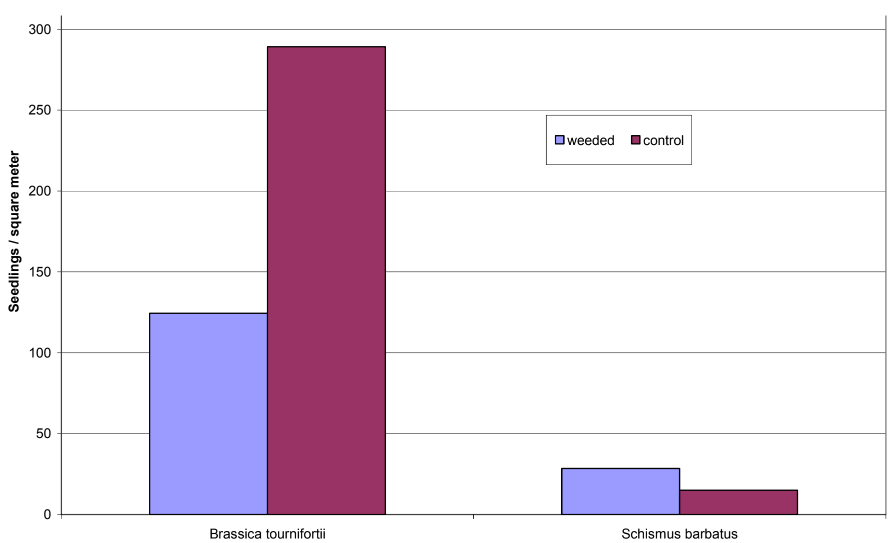

Figure 6. Germination response of non-native weeds following mustard removal experiments.

Table 1. Results of ANOVA analyses comparing weeded with un-weeded (control) experiments. Those species with statistically significant difference are highlighted in bold.

	Weeded		Control
Native Annual Plant Species Richness			
Mean (# of species)	9.4		8.4
Paired t-test results		p = 0.105	
Native Annual Plant Species Density			
Mean (plants / m²)	14.063		10.03
Paired t-test results		**p = 0.020**	
Native Annual Plant Percent Cover			
Mean	41.23%		23.34%
Paired t-test results		**p = 0.007**	
Coachella Valley Fringe-toed Lizard			
Mean (lizards / transect)	2.505		1.629
Paired t-test results		**p = 0.009**	
Flat-tailed Horned Lizard			
Mean (lizards / transect)	0.138		0.111
Paired t-test results		p = 0.736	
Round-tailed Ground Squirrel			
Mean (squirrels / transect)	0.915		1.004
Paired t-test results		p = 0.604	
Desert Kangaroo Rat			
Mean (krats / transect)	6.125		5.287
Paired t-test results		**p = 0.001**	
Merriam's Kangaroo Rat			
Mean (krats / transect)	3.287		3.695
Paired t-test results		p = 0.250	
Total Arthropod Abundance			
Mean (indiv. / pitfall)	33.537		36.067
Paired t-test results		p = 0.765	
Giant Sand-treader Crickets			
Mean (burrows / transect)	21		17.8
Paired t-test results		p = 0.339	
Harvester Ants			
Mean (indiv. / pitfall)	2.867		4.667
Paired t-test results		p = 0.110	

Does weed density impact CV fringe-toed lizard or flat-tailed horned lizard populations? Are impacts similar for these two species?

Coachella Valley fringe-toed lizard populations were significantly reduced on control plots (Table1). This impact was correlated with significantly increased sand stabilization on the control plots as well as less open ground for this lizard to utilize its escape behaviors (fast running and then diving into loose sand). These impacts appeared to have short duration; by the spring surveys of 2006 no negative impacts from the occurrence of mustard on the control plots could be detected (Fig. 7). In 2006 Saharan mustard was reduced on all plots, but was still fairly common on the active dunes in the eastern Coachella Valley. The mustard was hand removed from the "I" and portions of the AD2 plots in 2006 but was untouched on the "AD4" and "J" plots. This difference in treatments resulted in different population trajectories on these plots (Fig.8).

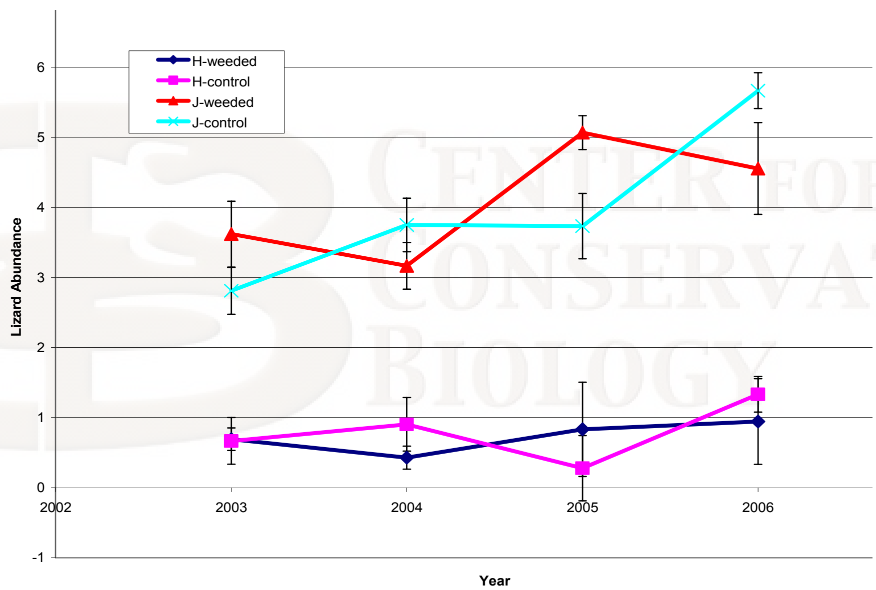

Figure 7. Temporal abundance of Coachella Valley fringe-toed lizards on two (H and J) experimental plots. Mustard was hand removed from weeded plots in 2005. Error bars represent one standard error.

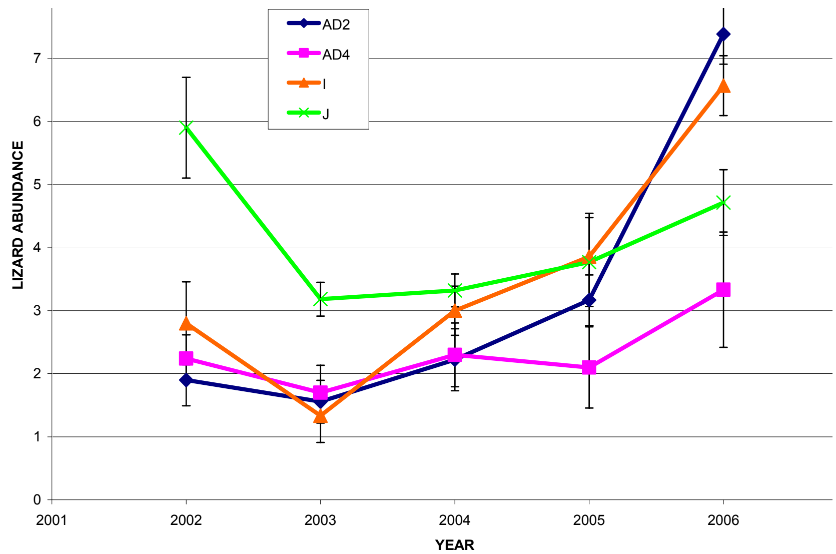

Figure 8. Coachella Valley fringe-toed lizard abundance on a series of active dune plots between 2002 and 2006. Error bar represent one standard error.

The reduced rate of population growth on the AD4 and J plots as compared to plots AD2 and I was correlated in part with the abundance of mustard on those plots (linear regression, $R^2 = 0.275$, $p = 0.006$).

Flat-tailed horned lizards are not as closely tied to loose, active sand compared to fringe-toed lizards, and do not depend on running for escape. Their numbers appeared unaffected by mustard densities (Table 1). The horned lizard population had been in decline for the past 3-4 years, however in 2006 their population rebounded, as did fringe-toed lizard and harvester ant populations occurring in the same stabilized sand field community (Fig.9). Although not specifically tested, it is possible that the changes in population trajectories were mediated by food resources provided by the Saharan mustard "explosion" of 2005.

Does weed density impact CV milkvetch populations? Does it impact plant distribution and/or reproduction?

There was a significant negative impact on Coachella Valley milkvetch flower and seed pod production on those sites where the milkvetch and mustard co-occurred (Fig 10). The milkvetch appeared to expend their energy trying to reach above the mustard canopy and had little reserves left for reproduction. However, for the most part their two distributions did not overlap.

Figure 9. Harvester ants, Coachella Valley fringe-toed lizard and flat-tailed horned lizard population levels between 2002 and 2006.

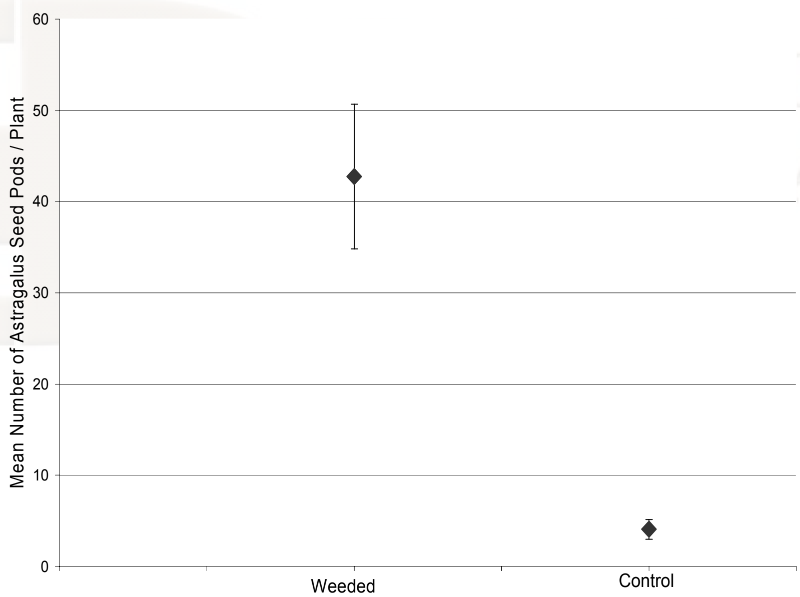

Figure 10. Impact of Saharan mustard on Coachella Valley milkvetch reproduction from a single paired mustard removal-control plot. Error bars represent one standard error.

Summary and Management Recommendations

Saharan mustard's impacts to the natural communities of the Coachella Valley aeolian sand landscape vary depending on mustard density and the species of comparison. The variability in mustard density is related to rainfall patterns as well as soil characteristics. Negative impacts to fringe-toed lizards appear to be of short duration. However, negative impacts to native annual plants may have much longer effects. During 'wet" years native annual plants usually have large population densities and subsequent successful reproduction. It may be that in those wet years that the largest contribution to seed banks, and so future germination, occurs. As Saharan mustard limits native annual plant reproduction and reduces their contributions to future seed bank reserves, those impacts may have long-term consequences. Despite the lack of a short-term measured negative impact on most animal species, losses in annual plant abundance and species richness over time could have a long-term negative cascade effect on biodiversity in general.

Our results indicate that modest mustard removal efforts can have measurable positive impacts. Although the scope of the mustard's invasion may cause managers to forgo management efforts due to a sense of hopelessness, we recommend that managers identify locations where species or communities that are particularly sensitive to the mustard are to be protected. In those wet years when the mustard population explodes, managers could call on their available resources to lessen the negative impacts and create "islands" or "refugia" for maintaining natural biodiversity intact.

LITERATURE CITED

Allen, M.F., J. T. Rotenberry, C. W. Barrows, V. M. Rorive, R. D. Cox, L. Hargrove, D. Hutchinson, and K. Fleming. 2005. Coachella Valley Multiple Species Habitat Conservation Plan Monitoring Program: 2002-2005 Progress Report. http://repositories.cdlib.org/ccb/CCB2005b.

Barrows, C. W. and M. F. Allen. Community complexity: stratifying monitoring schemes within a desert sand dune landscape. *Journal of Arid Environments* (in press)

Sanders, A. and R. Minnich. 2000. Brassica tournefortii. In Bossard, C. C., J. M. Randall and M. M. Hochovsky. *Invasive plants of California's wildlands.* University of California Press, Berkeley, CA.

PROJECT TEAM AND CONTRIBUTORS
2005-2006

About a dozen CCB staff members were involved as team members in this project, participating in implementation or assessment activities or offering their expertise as advisers. This team met regularly over the course of the project period.

Project Leads

Michael F. Allen, Director, Center for Conservation Biology, Professor of Biology & Professor and Chair of Plant Pathology

Cameron W. Barrows, Project Coordinator & Post Doctoral Associate, Center for Conservation Biology

Advisors

Edith B. Allen, Professor & Extension Specialist, Botany & Plant Sciences

Kristine L. Preston, Assistant Researcher, Center for Conservation Biology

Richard Redak, Professor & Vice Chair, Entomology

John Rotenberry, Associate Director, Center for Conservation Biology, Professor of Biology & Director of UCR Natural Reserves

Thomas Scott, Associate Director, Center for Conservation Biology & Natural Resources Specialist

Research Staff & Associates

Kathleen D. Fleming, Field Assistant

Christopher Glover, Webpage & Database Junior Specialist

Charlotte Gonzalez-Abraham, GIS Junior Specialist

Darrell Hutchinson, Field Assistant

Robert Johnson, GIS Junior Specialist

Glenn Jones, Volunteer

Cecelia Morentin, Administrative Assistant

Veronique Rorive, Academic Coordinator

Donna Thomas, Volunteer