# Proceedings

## California Invasive Plant Council Symposium
## 2010

Cal-IPC

*"Weeds and Wildlife: Impacts and Interactions"*

# Proceedings

## California Invasive Plant Council Symposium
## Volume 14: 2010

*"Weeds and Wildlife: Impacts and Interactions"*

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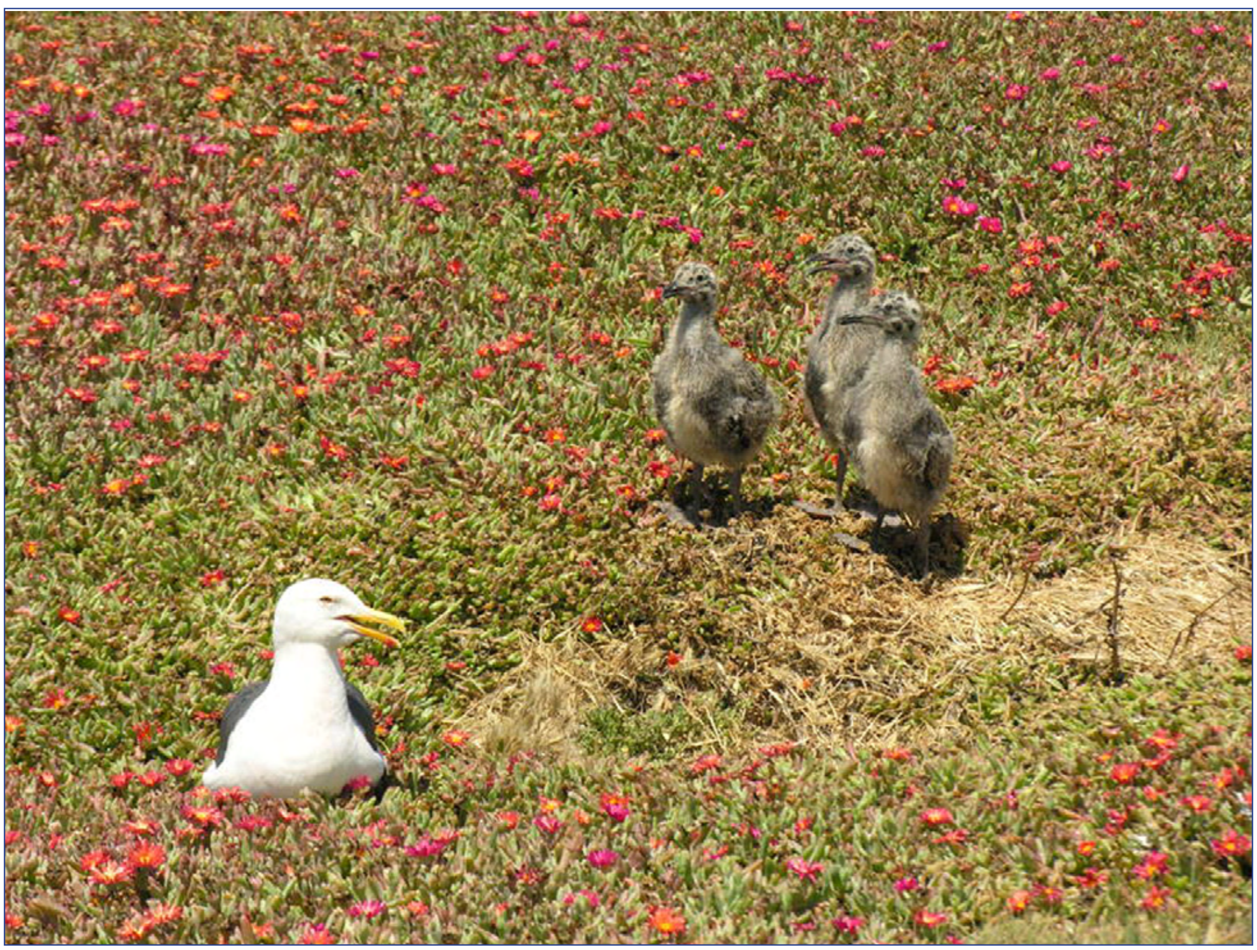

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California Invasive Plant Council

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On the cover: Karen Flagg of Growing Solutions describes a project to restore native plants at the Foothill Open Space preserve on the Santa Barbara field trip. Photo: John Ekoff

On the title page: Coppery iceplant doesn't make the best nesting habitat on Anacapa Island. Photo: John Knapp, The Nature Conservancy

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* Indicates presenting author in multi-author papers

On the boat to the Santa Cruz Island field trip. Photo: Arpita Sinha

# Foreword

We chose the 2010 Symposium theme: "Weeds and Wildlife: Impacts and Interactions" to highlight the need to take a broad view when conducting restoration projects. After all, invasive plant removal is rarely an end unto itself; usually this work aims to protect native habitats or improve conditions for wildlife species. At the same time, conflicts can arise when an invasive plant project may cause harm to wildlife or when wildlife species rely on the same invasive plants that need to be removed to protect native plants. We worked with the Western Section of The Wildlife Society to identify speakers who could address these complicated questions and provide some examples of how many priorities can be balanced. These sessions followed upon our 2007 joint meeting with TWS on the same topic. The contributed papers, contributed posters and discussion groups filled out the program with presentations on invasive plant biology and management.

Biologists need to be creative when removing *Arundo donax* from islands in the Prado Wetlands, Corona. Photo: David McMichael, Orange County Water District, Santa Ana Watershed Association

# Keynote Speaker

## Weeds and Wildlife, Impacts and Interactions: A Case Study from Santa Cruz Island, California

*Scott A. Morrison, Ph.D., Director of Science, The Nature Conservancy, 201 Mission Street, 4th Floor, San Francisco, CA 94105, smorrison@tnc.org*

Interactions between wildlife and invasive plants can be complex and can complicate management and the attainment of conservation goals. Examples abound across California of ways in which pest plants, and their management, directly and or indirectly affect the conservation management of native (and nonnative) wildlife – and of the ways in which wildlife can affect the management of weeds. I illustrate such relationships by providing an overview of three decades of conservation management of Santa Cruz Island, California. Management programs on the island have ranged from the eradication of feral vertebrates and invertebrates to the control of pest plant infestations; from the recovery of imperiled endemic species to the design and implementation of biosecurity measures to prevent future threats. Recognizing that on islands some of the challenges of and opportunities for managing invasive species are unique, I discuss how lessons from the conservation management experience on Santa Cruz Island may find application to mainland California issues and systems. Especially in an era of intense global change, natural resource protection in California requires goals be clear and priorities shared across scales relevant to the problem; strategies be explicitly focused on seizing management efficiencies and economies of scale; and support of the necessarily adaptive implementation of those strategies be enduring and programmatic.

# Trends in Early Detection Mapping

## There's an App for That: Tracking Weeds with Mobile Technology

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Here we report on a new tool to map invasive species using a mobile phone application and web-interface to record and visualize invasive plant populations. The application, called *What's Invasive!*, allows managers to upload photographs and other information about target invasive plants that is then used to generate a mobile phone application for use by the public. The application is available in a variety of formats including a general format and a specific application for the iPhone. These applications are downloaded by a prospective user (e.g., hiker) from our internet site (www.whatsinvasive.com). Using the phone application, when a person finds one of the target species, they can compare it to the images and text, take a digital picture of the plant or population while the GPS location is automatically recorded by the phone and label the photograph with a plant name via a drop-down menu. The application uploads the photographs, GPS points and data labels to the Web site where this information is translated into a map. We tested this application in the Santa Monica Mountains of Southern California with eight National Park Service staff over two weeks. Participants carried the phones during their regular work and recorded target species when they encountered them. Over the test period we collected over a thousand data points and field checked a subset of the data. In addition to this test-run, over 20 members of the public have downloaded the application and used it to map invasive plants within the Santa Monica Mountains. Eleven other parks have created their own What's Invasive applications. Our results suggest that this tool is a way to rapidly map invasive plants while engaging and educating the public.

## BAEDN, LAEDN, MAEDN, SAEDN, California EDN? Can We Build a Coordinated Network of Early Detection Networks to Protect California from New Invasions?

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### Introduction

Each of us has noticed a small outbreak of some harmful weed and thought "someone should do something about that before it expands." Fortunately, there are tools that can save some of our remaining wild places. Early detection and rapid response (EDRR) is the most cost-effective approach for coping with biological invasions and is consistently identified as "the single most important element" in coping with biological invasions. However, an effective EDRR program is a rare thing; it requires large-scale coordination of multiple actors, it requires systems for prioritizing targets and managing multi-year treatment and it means that some large and compelling invasions go without treatment so that we can address small but important outbreaks.

### Methods

The Bay Area Early Detection Network (BAEDN) builds an EDRR system to serve the entire nine county San Francisco Bay Area. BAEDN was formed in 2006 by partners from the nine counties in contact with the San Francisco Estuary: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Solano, Santa Clara and Sonoma counties.

The BAEDN project was initiated in December 2006 with a full-day workshop at which partners presented updates on current Early Detection efforts and needs, shared information regarding networks elsewhere and discussed research and technical innovations available to support such efforts. Following a presentation of the BAEDN vision participants refined the vision through focused discussions, identified additional partners, defined the project scope and agreed upon strategies for building a robust and efficient Early Detection Network.

Key principles were that an effective Early Detection Network must:

1) Be coordinated by paid staff. Volunteer resources and existing professional capacity are not sufficient to operate an effective EDN.
2) Include several counties and sufficient resources to reliably and consistently support at least one full time paid staff person
3) Be maximally inclusive and include all major stakeholders from the service region. Stakeholders must be provided the opportunity to help structure the network.
4) Apply science-based techniques in a rigorous and transparent manner, adapting existing tools rather than "reinventing the wheel." Systems should be shared so that we realize the benefits of pooled resources

and avoid the "Tower of Babel" created by multiple competing systems.

### Results and Discussion

Following the initial scoping meeting, BAEDN began developing financial support for the network. Project proposals were funded by the California Department of Food and Agriculture (CDFA), the National Fish and Wildlife Foundation (NFWF), the US Fish and Wildlife Service's Coastal Program, and ARRA funding from the US Forest Service's State and Private Forestry Program. With this generous support we were able to recruit two very talented biologists to serve as Early Detection Coordinator (Aviva Rossi) and Rapid Response Coordinator (Mike Perlmutter).

We publicly launched the BAEDN during California's Invasive Weed Awareness Week, July 2009. The launch included a "narrow-cast" outreach campaign, led by Jennifer Stern, that placed informative articles in numerous agency and organization newsletters. This campaign sought to inform and involve all key stakeholders in early formation of the network, so it would benefit from their insight and expertise and so they would know the network is something that they helped to create. Broad involvement has been critical to success of the initiative; stakeholders have built a great network, are actively seeking important detections and participating in response actions and are assisting in identifying funding to support ongoing action.

Calflora developed the BAEDN Occurrence Reporting Database in 2009 (available at http://BAEDN.org). The BAEDN database is an extension of Calflora's extensive database and is a central repository for new and existing plant occurrence data collected by agencies and the public. In addition to the database, Calflora has worked with BAEDN to develop additional tools for data entry and extraction: an upload tool for geotagged photos, a smart phone application for effective and easy field mapping, a My Observations portal to allow users to edit and manage their occurrence reports and Web applications for uploading and downloading larger datasets in a variety of formats. With these tools, BAEDN and Cal-IPC have begun consolidating thousands of orphan mapping data into a single shared "cloud" database. This Integrated Plant Mapping Platform is streamlining data collection and management and planned improvements hold the promise of radically simplifying how field workers map and plan invasive plant management.

### BAEDN's First Field Season

BAEDN is now completing its first season. In this season BAEDN staff downloaded thousands of unique georeferenced invasive plant occurrence reports from the Calflora database and used these data to evaluate the distribution of potential target species in the Bay Area. A weed risk assessment identified those species that are known to have high impacts and rates of spread but are not yet widespread in the nine county Bay Area. This 2010 Target Species List includes 73 species, some with very familiar names and others with names that are not yet familiar and cursed throughout California.

Occurrences were prioritized for treatment using the WHIPPET occurrence prioritization model, developed for CDFA by UC Davis graduate student Gina Darin. The model prioritizes infestations for elimination based on their size, accessibility, feasibility of treatment and geography. BAEDN staff are currently working through a prioritized list of nearly 500 infestations, contacting land managers to verify status of each occurrence: does it still exist, is it under treatment, if not will you please treat it, do you know of other occurrences of that species? The result of this careful work is that all 50 of the top 50 priority occurrences were under treatment as of mid-September. BAEDN staff continue to work through the list of occurrences; those that remain untreated at the end of this field season will be included in permitting and environmental compliance work over the winter so that BAEDN and partners can fund treatment of these infestations during the 2011 field season.

## Next Steps

We are heartened at the early success of this ambitious initiative. BAEDN would not be possible without the tremendous in-kind expertise, equipment and capacity donated by partners. This support has demonstrated that there is a strong belief in the value of this approach. In addition, it has become clear that there is interest across California: nascent Early Detection Networks are forming in northern California and in the Los Angeles area.

A core goal of the BAEDN initiative has been to work with partners in other regions of California to advance the development of other systematic and transparent EDRR networks. BAEDN's intent is to provide scalable templates for adoption by other regional Early Detection Networks and to encourage establishment of coordinated networks serving every region of California. The tools and systems developed by BAEDN are now available for easy adoption by other multi-county regional early detection networks. Core infrastructure, such as the occurrence reporting database and integrated plant mapping platform, can be shared by partners across California.

Can we build a network of networks protecting California from harmful new invasions? Can we have a dozen networks, well-funded and using a common system, that protect our wildlands in a cost-effective manner? If so, then such a shared success could transform the way we deal with biological invasions; it could begin producing measurable and important achievements that convince funders and decision makers; it could give us hope and revitalize our commitment to protecting wild California; it could be the beginning of an effectiveness revolution in natural lands management with far-reaching benefits.

However, building an effective network of networks will take more than effective tools, good strategies, and committed professionals – we have had these elements for a long time. An effective network of networks will require a level of coordination that California weed work has lacked since CDFA and Agricultural Commissioner budgets were eviscerated decades ago. To succeed we must work together to build a truly integrated network of networks such that each are larger than watersheds, weed management areas, or any one person's geographic interests. Most importantly we must build a system that provides new capacity and resources, rather than parsing an already too small pie.

Building an effective network of networks will require a California EDN. We need a California EDN that:

- Promotes the formation of regional Early Detection Networks (EDNs) by bringing potential partners together and assisting in obtaining start-up funding and building organizational structure;
- Provides essential infrastructure and services to support EDNs, including innovative technical infrastructure, organizational and strategic templates and assisting with environmental compliance;
- Facilitates sharing of tools and wisdom among EDNs, including disseminating methodological advances, providing protocols and trainings, and developing and sharing communication approaches
- Helps make EDNs successful, including legislative efforts to provide funding, efforts to create regulatory frameworks that support strategic invasive plant management and growing public outreach and involvement.
- Most of all, we need a California EDN that we all build together, that serves our needs specifically and generally and that we believe is finally doing what we know is right.

Invasive weeds are important, not because they are out of place but because the worst of them diminish the biodiversity of lands we love. Humans have introduced these species and humans have disrupted ecosystems so that weeds can thrive. We have the moral obligation to right what we have wronged and we have the responsibility to use our heads so that our actions are strategic and effective. The last two decades have seen a tremendous burst of innovation as invasive plant management has become a focus of essentially all land management entities and as thousands of practitioners have generated new tools, methods, systems and technologies. With hard work and a lot of luck, the next two decades will see us organize, strategize and apply these powerful innovations to begin making things better.

# Map the Spread! Cal-IPC's Statewide Weed Mapping for Early Detection and Strategic Management

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## Abstract

Mapping weed occurrences make effective management and early detection/rapid response programs possible. In collaboration with the state's Weed Management Areas (WMAs) over the last three years, Cal-IPC has created statewide distribution maps for over thirty weeds. Now, thanks to federal stimulus funding through ARRA, Cal-IPC is mapping more species, increasing the resolution of our mapping and developing an online portal to share the information. This information will support strategic planning at all levels: by individual landowners, WMAs, regional early detection networks, state agencies such as the California Department of Food and Agriculture, the Invasive Species Council of California, and developing national early detection networks.

## Introduction

From 2006-2008, Cal-IPC mapped the existing distribution of all 200 species on the Cal-IPC Inventory by Jepson floristic region and county (available at www.cal-ipc.org/ip/mapping/statewide_maps). Then, for 35 species, we overlaid that information with projections of suitable habitat derived from downscaled climate models. This enabled us to identify areas where a species does not currently occur but, given no management intervention, is likely to spread. This project provided baseline data to launch us into our current American Recovery and Reinvestment Act-funded effort for 2010-2012. Our current effort will provide an interactive online tool to examine landscape-level risk maps and help land managers plan, prioritize and win funding for their restoration projects.

To improve the resolution of the 2006-2008 maps, we are collecting existing datasets from land management entities, attending WMA meetings and interviewing experts in each county to create statewide maps with presence and absence data at the scale of USGS quadrangles. This project will add critical distribution data needed for implementing CDFA's strategic prioritization model to determine the most effective populations to target for treatment. Through our online portal, data can be entered and viewed by the state's natural resource managers. We are coordinating with the Bay Area Detection Network (www.baedn.org) and Calflora (www.calflora.org) to explore the most effective way to develop an online system that will be useful and user-friendly. Local land managers play a key role in building this data system and we need your help for this effort! Cal-IPC members represent a wealth of knowledge about invasive plant distribution and can collectively build a system that will make us all more effective in terms of prioritizing treatment.

This program has three components. First, we are meeting with local experts to map invasive plants while collecting existing GIS datasets. Using these data, we are modeling the potential suitable habitat for these species under climate change conditions. Third, we aggregate the data and potential habitat in an online statewide database that will serve as a centralized site for submitting and viewing invasive plant data.

The specific objectives of Cal-IPC's current (2010-2012) mapping effort are to:

1. Map Current Distribution: Work with local land managers to collect "expert knowledge" data to map plant distribution by USGS Quadrangle ("quads"). Show this distribution atlas online.
2. Model Projected Suitable Habitat: Combine distribution data with precipitation and temperature layers using Maxent to create models of the projected future suitable habitat of invasive plants with and without climate change . Show this information online.

3. Aggregate Data: Encourage users to contribute their data to Calflora. Collaborate with partners to contribute to an online system where land managers can participate in a statewide mapping system by contributing to, viewing and downloading three types of weed data:
    a. Field observations through an online mapping tool
    b. GIS datasets
    c. Field data collected by smart phone

Mapping and modeling together show which areas are most vulnerable to spread. This will help land managers prioritize detection and containment activities and win funding. Data aggregation can identify rapid response targets, will provide information to support suitable habitat modeling and, over time, aggregated data will provide more detailed distribution data for each species.

## Methods

Here we describe the first of these efforts: how we're mapping distribution by USGS quadrangle using "expert knowledge". Starting in June 2010, we have worked hard to refine our methods in order to capture this knowledge quickly and effectively. We seek a small group of experts with knowledge of invasive plant distribution and botanical skills to identify the weeds present in their region. We then gather this group for a meeting (we buy lunch!) and map approximately 50 species on the Cal-IPC Inventory, noting the abundance, spread rate and treatment status for each species within each quad. In order to complete all species on the Inventory, our mapping crew will need to make several trips to each area.

As of November 2010, we have mapped the first set of species in approximately half of California's 58 counties, with more meetings continuing to be scheduled (Figure 1). The meetings are informative and collaborative, with palpable excitement about the final mapping products.

## Results and Discussion

As we gather data in adjacent counties, spatial patterns emerge. For example, Fred Rinder of Fresno County sounded a warning bell to Tulare County to be on the watch for early detections:

"We have been surveying and treating rush skeletonweed (*Chondrilla juncea*) in the southeast corner of the county. This species was confined to the downtown and west Fresno quads but we lost funding for two years and now populations are found east of Fresno and are continuing to spread." Since the predominant winds are out of the W/NW, he asks Tulare to be vigilant in looking for it and controlling it since he is finding occurrences just upwind of them.

This expert knowledge mapping can also demonstrate leading edges. We have not mapped in Kern County yet, but in an update to the US Forest Service, Eddy Greynolds of Kern County wrote that they have been treating Scotch thistle (*Onopordum acanthium*) in areas adjacent to the national forest boundaries. To date they have prevented it from spreading to forested lands, but are concerned about the potential for this spread. Because quad mapping combines abundance and treatment information per quad, our distribution


Figure 1

Cal-IPC expert opinion data gathering meetings mapping would emphasize to the USFS that the species is present and under treatment on land that is adjacent to theirs. This information would help the USFS prioritize surveys for that species and encourage eradication efforts if Scotch thistle is found on their land.

Absence data is another important piece of what we're collecting. A California Native Plant Society botanist, a weed watcher volunteer, or a land manager could submit a point occurrence online (or via a smart phone) to Calflora. According to the quads mapped in that area, that species is absent. This occurrence could then be confirmed as an early detection and prioritized for rapid response.

Simply getting experts in a room together to put information that exists in their head onto a map has been quite rewarding; if nothing else, experts sharing information about what weeds they're watching where and what species they are treating is helpful to everyone attending the meeting. These mapping exercises are a great opportunity to share knowledge that has, in many instances, accumulated over an entire career, and to teach the younger workforce what they know.

In 2011, we will bring the mapping and modeling aspects of the program together into an online tool that will allow users to view and query data, expanding the accessibility of spatial data to invasive plants in California. Eventually, our online tool will integrate with existing databases such as Calflora. By the project's end in early 2012, California weed workers will have new tools to help guide their long-term efforts more effectively.

## Acknowledgements

Funding for this projected is provided by the USDA Forest Service State and Private Forestry Program, California Department of Food and Agriculture (through the American Recovery and Reinvestment Act), National Fish and Wildlife Foundation, Resources Legacy Fund, and the Richard and Rhoda Goldman Fund. Cal-IPC is an equal-opportunity employer.

# DPR Laws and Regulations

## Risk Management and Liability Insurance in Habitat Restoration and Weed Control

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Anyone who advertises, solicits or operates as a pest control business must obtain a Pest Control Business License (There are some exemptions.). Each pest control business must have a qualified applicator licensee, or a certificate holder for a maintenance gardener, responsible for the pest control operations of the business.

In addition, you must provide proof of financial responsibility for potential damages resulting from your pest control work, by submitting evidence of either liability insurance; a surety bond; or a certificate of deposit in the DPR Director's name. For instance, the minimum coverage for an agricultural pest control business making applications by ground is $100,000 bodily injury per person; $300,000 bodily injury per occurrence and $50,000 for property damage or a surety bond of $75,000.

How do you manage risk, especially if you're in a public agency or you are a private applicator and not covered by liability insurance? Of course, follow the regulations and apply herbicides in good faith. Attend this presentation to discuss the options.

## Wildlife Protection During Habitat Restoration and Weed Control

*Lohmus, Natasha, California Department of Fish and Game, (805) 684-6281*

The Department of Fish and Game (DFG) is responsible for conserving, protecting and managing California's fish, wildlife and native plant resources. To meet this responsibility, the Fish and Game Code (Section 1602) requires an entity to notify DFG of any proposed activity that may substantially modify a river, stream or lake. Notification is required by any person, business, state or local government agency or public utility that proposes an activity that will: substantially divert or obstruct the natural flow of any river, stream or lake; substantially change or use any material from the bed, channel or bank of, any river, stream or lake; or deposit or dispose of debris, waste or other material containing crumbled, flaked or ground pavement where it may pass into any river, stream or lake.

The notification requirement applies to any work undertaken in or near a river, stream or lake that flows at least intermittently through a bed or channel. This includes ephemeral streams, desert washes and watercourses with a subsurface flow. It may also apply to work undertaken within the flood plain of a body of water.

If you are planning an activity that requires DFG notification, you will need to provide your regional DFG office with a completed notification form and the corresponding fee.

If DFG determines that the activity may substantially adversely affect fish and wildlife resources, a Lake or Streambed Alteration Agreement will be prepared. The Agreement includes reasonable conditions necessary to protect those resources and must comply with the California Environmental Quality Act (CEQA). The entity may proceed with the activity in accordance with the final Agreement.

## The Inspection Process: What Does the Agricultural Commissioner Look For?

*Martel, Rudy Ventura County Agricultural Commissioner's Office, rudy.martel@ventura.org*

The Agricultural Commissioner's Office plays a key role in regulating pesticides in California. The size and diversity of California agriculture and the State's increasing urbanization, require a more complex partnership between state and local pesticide regulatory authorities than anywhere else in the nation.

The Department of Pesticides Regulation works closely with the County Agricultural Commissioner's Office, the primary local enforcement agents for pesticide laws and regulations. The Agricultural Commissioner's Office regulates pesticide use to prevent misapplications or drift and possible contamination of people or the environment. A main component of the Agricultural Commissioner's Office enforcement is through pesticide application and pesticide mix/load inspections.

The Agricultural Commissioner's inspection focuses on the safety of the pesticide user. We verify compliance of the employer with the pesticide label, personal protective equipment, pesticide handler training and the safe use of the pesticides by the handlers.

## Rules to Follow for the Use of Aquatic Herbicides in California

*Blankinship, Michael, Blankinship and Associates, mike@h2osci.com*

Do you apply herbicides to aquatic weeds? Recent court activity has clarified (or confounded) the requirement that herbicide applications to waters of the United States must be permitted. This presentation will define various components of the permit process, including what constitutes waters of the US; the statewide general National Pollutant Discharge Elimination System (NPDES) permit for the Discharge of Aquatic Pesticides for Aquatic Weed Control in Waters of the US; and the ten herbicides approved for aquatic use. A permit can protect you from citizen lawsuits, the method of enforcement of the Clean Water Act. The USEPA just published a draft of their nationwide permit intended for use in states without an existing permit. However, California will not likely adopt the EPA permit, because California has an existing permit that is more stringent than the proposed EPA permit. Learn whether you will need coverage by this permit.

# Student Paper Contest

## Herbicide Treatment of an Invaded Grassland Following a Prescribed Fire

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### Abstract

Over the past 200 years, California grasslands have become increasingly invaded by a suite of Mediterranean annual grasses and forbs. The invasion has reduced the richness of the native annual plant community and converted a perennial bunchgrass community into an invasive annual grassland. Prescribed fires are used by land managers on these converted landscapes as a method to control the density of invasive species. These prescribed fires target invasive grasses in order to reduce their dominance and facilitate re-establishment of native species, but invasive forbs such as *Erodium brachycarpum* often emerge as the dominant species following the burn. In this study, three herbicide treatments (Rodeo, Fusilade and control) were applied to a native grassland in the winter following a prescribed burn and were followed with one of two seeding treatments (seeded and control). The Fusilade treatment increased the cover of the invasive grass *Vulpia myuros* to levels comparable to *Avena fatua* in control plots and did not alter native richness. The Rodeo treatment reduced invasive cover and increased native forb richness. The seeding treatments increased native forb richness and cover in the Rodeo treatment and had no effect in control and Fusilade plots. Our results suggest that cover and richness of invasive species can be reduced in grasslands through a combination of fire and chemical removal techniques.

### Introduction

Invasive species are a global problem and have the ability to out-compete native species and alter ecosystem processes (Simberloff 1996, Vitousek et al. 1996, Mack et al. 2000). In the native grasslands at the Santa Rosa Plateau in Southern California, a suite of exotic invasive annual forbs and grasses are replacing native species. The dominant invasive annual grasses are *Bromus*, *Avena* and *Vulpia* species and the dominant invasive annual forbs are *Erodium*, *Centaurea* and *Brassica* species.

The combination of prescribed fire and herbicide application can have synergistic effects for invasive removal (Tyser et al. 1998). Prescribed burning is a restoration technique commonly used by land managers to control invasive species (Meyer and Schiffman 1999) and restore ecosystem structure and function to North American ecosystems, many of which are adapted to natural fire regimes (Kozlowski and Ahlgren 1974). However, recent observations have demonstrated that although prescribed burns can effectively remove invasive annual grasses, they may cause an unintentional competitive release of invasive annuals forbs, whose abundance can increase following invasive grass removal (Dickens unpublished data).

Herbicide application can range from species-specific to broad-spectrum, depending on the goals of the land manager. In this study, we tested two herbicides. The grass specific herbicide Fusilade II® is an effective control method for invasive annual grasses (Cione et al. 2002, Steers 2008). It has also been shown to control *Erodium* species (Christopher and Holtum 1998, 2000) and specifically *E. cicutarium* in Southern California (Steers 2008). Rodeo® is a non-selective herbicide that controls invasive grasses and forbs with little damage to natives when applied before natives emerge (Mike Kelly , personal communication).

Highly invaded communities often require post exotic removal treatments to reconstruct the native community. Since soil seed banks are susceptible to degradation by invasive species (Vila and Gimeno 2007, Cox and Allen 2008), land managers often use seeding or transplanting techniques to enhance revegetation efforts (Tyser et al. 1998, Holmes 2001). This study sought to evaluate the efficacy of herbicide and seeding treatments in an invaded grassland previously treated with prescribed fire. We hypothesized that seeding treatments would be most effective in plots where Rodeo was applied, although there would likely be non-target effects. We also hypothesized that seeding would have little to no effect in control plots, which would likely continue to be overwhelmed by invasive species.

## Methods

This study took place on the Santa Rosa Plateau Ecological Reserve, located at the southern end of the Santa Ana Mountains in southwestern Riverside County. The plots were located in a parcel that had been burned by a prescribed fire the previous spring. Three herbicide treatments (Rodeo, Fusilade and control) were applied to the site and were followed with one of two seeding treatments (seeded and control). Four 5 x 5 m plots per treatment were arranged in a randomized block design. Herbicide was applied in early winter after *Erodium* species had germinated. Fusilade plots were sprayed with 0.5% Fusilade II with the surfactant R-11 at 0.5% and Rodeo plots were sprayed with 1% Rodeo with the surfactant R-11 at 0.5%. Seeded plots were hand seeded with a mixture of annual forbs native to the Santa Rosa Plateau, as well as the perennial bunch grass *Nassella pulchra*.

Pre-treatment plant species percent cover was taken from 1.0 x 0.5 m plots at two locations per plot giving a total of 48 plots. Following herbicide application, the plots were surveyed again to determine percent-kill. A final vegetation survey was completed at peak biomass to measure diversity and richness in each plot.

## Results and Discussion

Our results show that the fire alone did not effectively control invasive plant growth and there is a significant difference between the effectiveness of Fusilade and Rodeo on the post fire emergent community. Rodeo killed 98% of early germinating plant material in the plots, while Fusilade killed 45% of the plot cover. Fusilade appeared to damage *Erodium* seedlings, but did not kill them directly.

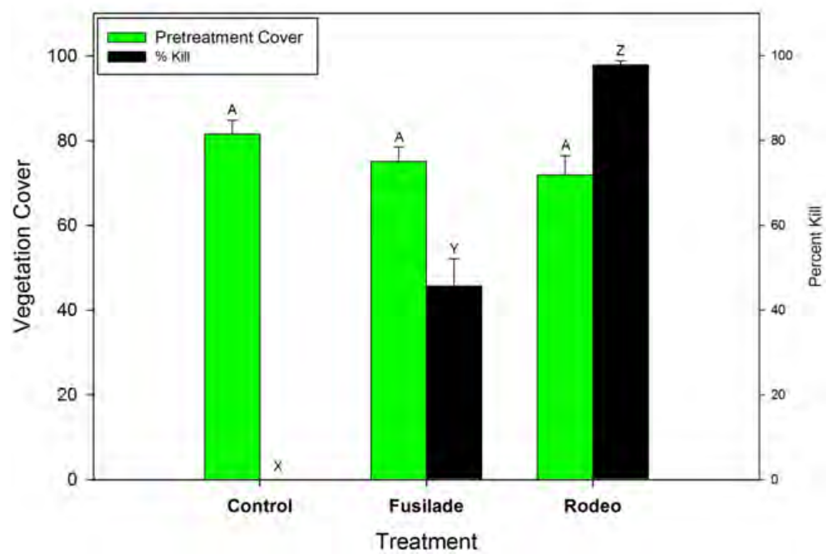


Figure 1

Average cover of vegetation prior to treatment and % of vegetation killed by herbicide treatment. Error bars represent standard error of the mean.

At peak biomass, there was not a significant difference between total cover of invasive species within the control and Fusilade plots. Both of these plots maintained exotic plant cover over 100%. Seeding treatment also had no effect on exotic plant cover nor did it increase the cover of native plants within these plots. The main difference between control and Fusilade plots was the composition of the exotic plant species present. Control plots were dominated by a mix of *Avena* spp. and *Erodium brachycarpum*, while Fusilade plots were dominated by *Vulpia myuros* and *Erodium brachycarpum*. *Vulpia myuros* was not affected by Fusilade and therefore was able to grow in the open space vacated by *Avena* spp.

Plots treated with Rodeo had a reduction of invasive plant cover to 56.4% in unseeded plots and to 20.3% in seeded plots. Native cover in the Rodeo plots was from the same as the other two treatments when seeding was not applied. The seeding treatment in the Rodeo plots increased native plant cover to 62.3%.

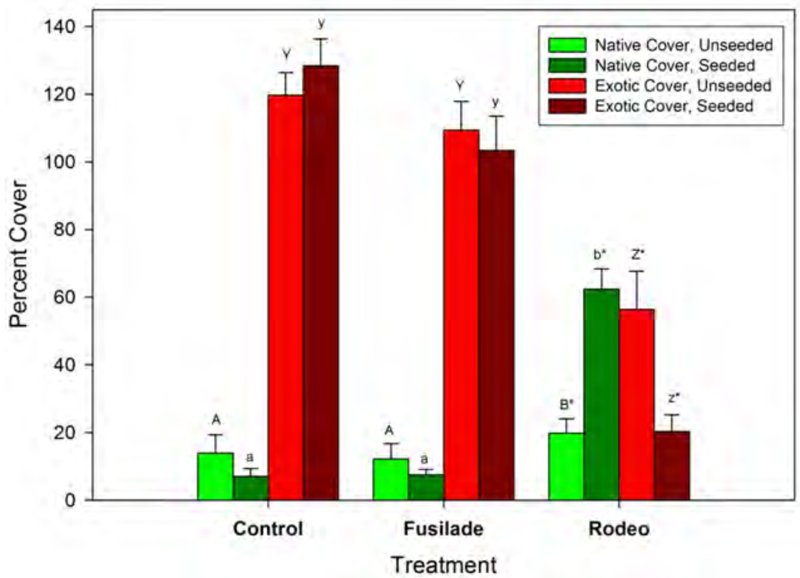


Figure 2

Native and exotic cover at peak biomass separated by treatments. Error bars represent standard error of the mean. (*) represent significant difference (p<0.001) between seeding treatments.

The results of our seeding efforts are consistent with prior research in which seeding treatments only worked on plots sprayed with herbicide (Cione et al. 2002). With exotic plant cover already at 100% before most native seeds began to germinate, there was very little space and few resources available for native plants to establish. The results from the Rodeo plots suggest that the native seed bank has been degraded due to long-term invasion. Artificially altering seed bank composition gives the native plants more opportunity to grow in areas where invasives have been removed. While seeding proved effective on this site, success can be variable depending on soil quality following invasion and subsequent removal efforts (Holmes 2001).

These results will be useful for land managers using prescribed fire as a restoration tool in invaded areas because they suggest that multiple steps need to be taken in order to restore an invaded grassland. Herbicides can be effective in reducing the cover of returning invasive grass species, but without providing additional seed to the system, recovery by natives may be slow.

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# Resident Community Species Diversity Decreases the Fitness of an Invasive Annual Grass

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## Abstract

At a local scale, increasing the species diversity of a native plant community has been shown to increase the resistance of the community to invasion. It has also been shown that increasing the genetic diversity of a plant population can increase population performance. The objective of our study was to examine the importance of these two types of biodiversity (species diversity and genetic diversity) to the survival and fitness of invasive species populations. We directly manipulated the species diversity of native California grassland communities and the genetic diversity of populations of an annual invasive grass (*Avena barbata*) to test the following hypotheses: 1) Increasing species diversity of a resident plant community will increase the resistance of that community to species invasion and 2) Increasing the genetic diversity of the invasive species population will increase invasion success. We established communities that ranged in diversity from 1-16 native California grassland species. We invaded these communities with populations of *Avena*, which varied in genetic diversity from 1-8 distinct genotypes. We measured invasion success by measuring the percent of *Avena* individuals that survived to reproductive adulthood and the fitness of *Avena* populations. We found no effect of either community species diversity or *Avena* genetic diversity on *Avena* survival. *Avena* survival was on average 80% across all treatments, indicating that these two forms of biodiversity have little impact on the establishment of *Avena* in a single generation. Species diversity decreased *Avena* fitness significantly, while genetic diversity had no impact on population fitness. Our results suggest that conserving native species diversity is a good natural barrier to invasion.

## Introduction

California supports some world's most diverse endemic plant communities (Myers et al. 2000). Yet, threats to endemic species such as habitat loss, agriculture and fire continue to increase (Wilcove et al. 1998, Sugihara 2006). Theory predicts that species-diverse communities are more resistant to exotic species invasions, especially at local scales (Levine and D'Antonio 1999, Kennedy et al. 2002). Thus, understanding how species loss affects invasion resistance in species-rich communities is important for predicting which systems may be most susceptible to invasion. Increasing the species diversity of resident plant communities can inhibit the success of invasive species via two mechanisms. First, increased species diversity may increase the number of niches filled by plant species and limit available resources such as light. Second, increased species diversity may increase the chance the communities contain specific plant species that are particularly good competitors against invasive species.

Although often overlooked, genetic diversity may be a form of biodiversity that is as important as species diversity for plant invasions. Recent research has shown that increasing the genetic diversity of plant populations can increase their productivity, fitness and colonization success as greatly as species diversity effects (Crutsinger et al. 2006, Crawford and Whitney 2010, Genung et al. 2010). However, very is little is known about how invasive population genetic diversity will influence invader success (Vellend et al. 2010). Increasing the genetic diversity of invasive plant populations can increase invasion success via two mechanisms. First, increased genetic diversity may increase resource partitioning or facilitation between individuals with different traits. Second, increased genetic diversity increases the chance that invading populations will contain a particularly high performing individual.

Our study aimed to test two hypotheses regarding the importance of biodiversity to invasion: 1) Increasing the species diversity of a resident plant community will increase invasion resistance and 2) Increasing the genetic diversity of an invasive plant population will increase invasion success.

## Methods

In order to examine the effects of both resident community species diversity and invasive species genetic diversity we manipulated both factors in a common garden experiment conducted in the spring of 2010. We directly manipulated the native species diversity of California grassland communities to include 1 to 16 species (Table 1). Communities were assembled from random draws from the species pool (without replacement). Species diversity treatments were replicated four times and grown in a randomized block design. Communities were established using a seeding density of $10 g/m^2$ and were planted in $0.25 m^2$ plots at South Coast Research and Extension Center in Orange County, California. The two perennial grass species were planted as small plugs. In a fully factorial manner that which differed in genetic diversity (presence of 1, 2, 4, or 8 genotypes). Each community was invaded with eight *Avena* seeds.

Table 1

Native California grassland species pool. Assembled communities contained between 1 and 16 species randomly drawn from the pool.

| Species | CA Native | Growth Form | Life Cycle |
|---|---|---|---|
| *Amsinckia menziesii* | Yes | Forb | Annual |
| *Lasthenia californica* | Yes | Forb | Annual |
| *Lupinus succulentus* | Yes | Forb | Annual |
| *Lupinus bicolor* | Yes | Forb | Annual |
| *Calandrinia ciliata* | Yes | Forb | Annual |
| *Hemizonia fasciculata* | Yes | Forb | Annual |
| *Heterotheca grandiflora* | Yes | Forb | Annual |
| *Eremocarpus setigerus* | Yes | Forb | Annual |
| *Stephanomeria virgata* | Yes | Forb | Annual |
| *Lotus purshianus* | Yes | Forb | Annual |
| *Cryptanthia intermedia* | Yes | Forb | Annual |
| *Escholizia californica* | Yes | Forb | Annual |
| *Vulpia michrostachys* | Yes | Grass | Annual |
| *Bromus carinatus* | Yes | Grass | Annual |
| *Nassella pulchra* | Yes | Grass | Perennial |
| *Melica californica* | Yes | Grass | Perennial |

Invaded communities were allowed to establish under natural growing conditions (natural rainfall, no additional fertilizer). Communities were allowed to grow until *Avena* reached peak flowering. In May 2010, communities were harvested and performance was measured by counting the number of individuals of each species in each treatment. Because not all species established, we calculated the realized species richness of each treatment. To measure *Avena* invasion success we counted the number of *Avena* individuals that established in each community at the time of harvesting (survival success). *Avena* fitness was also measured by counting the number of spikelets produced by each *Avena* plant (that on average produce two viable seeds). To determine if light limitation could have influenced performance, at peak biomass light availability (photosynthetic photon flux in $\mu mol/m^2 \cdot s$) was recorded at the base of all plots.

### *Statistical Analysis*

In order to assess how biodiversity affected measures of community and *Avena* performance as well as light availability we used an ANCOVA analysis. We included realized species richness, *Avena* genetic diversity, the relative abundance of each native species and block as main fixed effects. Interactions between explanatory variables were not significant and were removed from the final model.

## Results

The number of individuals in the resident community increased with realized species richness ($F_{1,288} = 4.47$, $p < 0.05$), but was not influenced by *Avena* genetic diversity ($F_{1,288} = 0.18$, $p <$ ns). The increase in the number of individuals with diversity was primarily driven by the increased chance of the presence of *Lasthenia californica* ($F1,288 = 1030.49$, $p < 0.0001$), an early season forb. When present, *Lasthenia* composed on average 23% of the individuals in a community.

The percent of *Avena* individuals that survived to reproductive age was not influenced by realized species richness ($F1,287 = 0.37$, $p <$ ns) or by *Avena* genetic diversity ($F1,287 = 0.67$, $p <$ ns). Instead, *Avena* survival decreased with the presence of *Calindrinia ciliata* ($F1,287 = 4.27$, $p <0 .05$), an early season forb and increased with the presence of *Bromus carinatus* ($F1,287 = 3.70$, $p =0 .05$), a mid season biennial grass. *Avena* population spikelet production decreased with species diversity ($F1,159 = 8.65$, $p <0 .01$), but was not influenced by *Avena* genetic diversity ($F1,159 = 3.18$, $p >0 .05$). The decrease in *Avena* fitness with diversity was primarily driven by the increased chance of the presence of *Eschscholzia californica* ($F1,159 = 5.02$, $p <0 .05$), a mid season forb. The presence of *Eschscholzia californica* was also the main factor decreasing light availability at peak biomass ($F1,288 = 44.52$, $p < 0.0001$).

## Discussion

Our results support our hypothesis that the species diversity of a native grassland community can increase community performance and decrease the fitness of an invasive annual grass, *Avena barbata* (Figure 1). These affects occurred primarily by increasing the chance that the community contained a highly productive species or a species that was a good competitor against *Avena*. For example, increasing diversity increased the chance the community contained the most productive species *Lasthenia*. While species diversity had no impact, the increased abundance of *Calindrinia* decreased *Avena* survival. Because *Calindrinia* is a fast growing early season forb, it likely grew to densities that shaded out smaller *Avena* individuals early in the growing season and decreased their survival. In contrast, the abundance of *Bromus* increased *Avena* survival. *Bromus* had the similar phenology, growth rate and morphology as *Avena* and likely did not increase shading early in *Avena* establishment and therefore promoted survival. The relative abundance of *Eschscholzia* had the most negative impact on *Avena* fitness and this was likely due to the formation of dense stands that significantly decreased light availability to the plot. These results suggest that conservation of native species diversity can be one of the best natural barriers to invasion. This is due to the chance that multiple species are present and each may offer different competitive traits that can decrease the success of different types of invasive species.

Our results do not support our hypothesis that the genetic diversity of an invasive species population can increase invasion success. Instead, species diversity had a much greater influence on the fitness of *Avena* populations. However, *Avena* genotypes did differ in fitness with one particular genotype producing on average 200 more seeds per individual than the next most productive genotypes. This indicates that while genetic diversity did not increase *Avena* fitness in a single generation, over time selection could act to increase the abundance of highly productive genotypes and increase invasion success. Our results are similar to that of the only other published study that manipulated genetic diversity in invasive populations (Vellend et al. 2010). Vellend et al. (2010) found that genotype identity, not genetic diversity, influenced the success

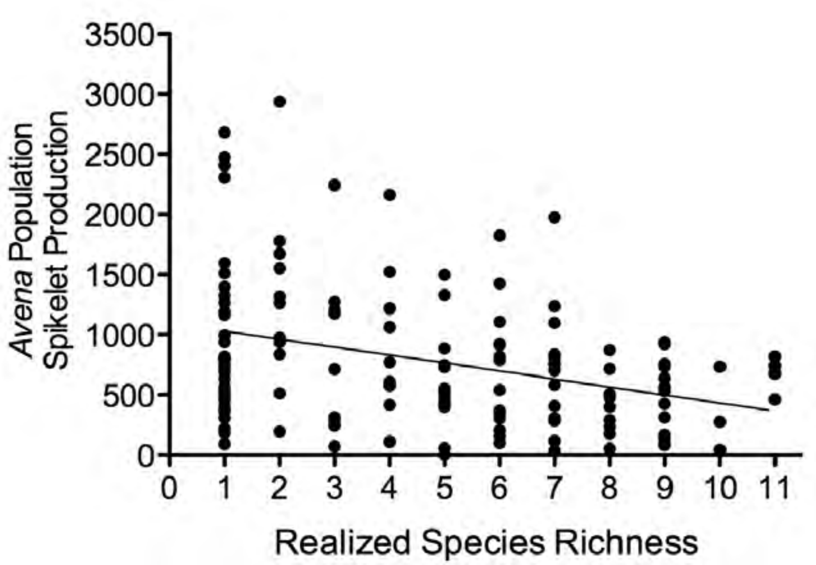


Figure 1

*Avina barbata* fitness significantly decreased with native species richness of invasive populations. Together, these results suggest that it is important to monitor the fitness of individuals in invasive populations and target eradication efforts to the most productive individuals. This will help to slow spread and curtail the evolution of highly productive populations.

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## The Effects of Climate Change on the Growth of Barbed Goatgrass (*Aegilops Triuncialis*) in Serpentine Grasslands


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### Abstract

The invasion of California grasslands by European annual grasses has resulted in widespread changes in the productivity and composition of native plant communities. The few remaining intact grasslands are often found on harsh, unproductive soils, such as serpentine. Although historically dominated by native forbs and relatively resistant to invasion, climate change could potentially alter this resistance by influencing the success of non-native species. The goal of this study was to determine how changes in spring precipitation and the native community would influence the growth of an aggressive invader in serpentine soils (barbed goatgrass, *Aegilops triuncialis*). We grew *A. triuncialis* plants in a nested design under three levels of spring precipitation (50% above ambient, ambient and 50% below ambient) and two levels of competition (native community present or absent). *A. triuncialis* growth was monitored over the course of the growing season. June growth rates were significantly affected by an interaction between spring precipitation and competition. The presence of the native community significantly increased growth rates in the low spring rain treatment, but decreased growth rates in the high spring rain treatment. This study suggests the effects of climate change on invasive grasses may depend on the native community and that, if climate becomes wetter, maintaining an intact community may slow the invasion process.


### Introduction

Invasive species have caused incalculable ecological and economic damage to native communities (Thomsen 2007). Climate change may potentially alter the current trajectories of many invasive plants in the near future (Thomsen 2007), but the magnitude and extent of these effects remain unclear. Recent work suggest that a number of changing climatic variables, such as temperature and precipitation, may influence the dynamics between invasive and native plants, resulting in increased or decreased community resistance to invasion (Thomsen 2007). Understanding these interactions and identifying at-risk communities is essential for the development and prioritization of management strategies.

Many of California's grasslands have undergone nearly wholesale transformations due to invasions by European annual grasses (Huenneke et al. 1990, Harrison 1999). The few remaining intact grasslands provide important refugia for native species and are often found on unproductive soils, such as serpentine (Harrison et al. 1999). Serpentine grasslands are often surrounded by heavily invaded non-serpentine grasslands, yet they remain dominated by native annual forbs. Previous studies have shown that both low resource availability and competition from the native community contribute to community resistance to invasion in these grasslands (Going et al. 2008). However, if climate change alters the competitive balance between native and invasive species, community resistance could be weakened, leaving these important communities vulnerable to new invasions.

Native serpentine communities are currently at risk of invasion by a relatively new invader, barbed goatgrass (*Aegliops triuncialis*). This winter annual has been invading California grasslands since the early 1900s, but has recently begun to encroach on serpentine communities. It is unclear if the current trajectory of this species will continue under a new climate regime. The aim of this study was to determine the effects of changes in spring precipitation on the growth of *A. triuncialis* and to determine if this response depended on the native community.

## Methods

This experiment was conducted at the Donald and Sylvia McLaughlin Natural Reserve (38°52'N, 122°24'W), managed by the University of California, Davis. This site is characterized by a Mediterranean climate with cool, wet winters and hot, dry summers. During the year that our study was conducted, the reserve received approximately 35.585 cm of spring precipitation. In November 2009, 24 1.2 m x 0.8 m plots were established in a serpentine grassland. Each plot was randomly assigned to one of three spring rain treatments, high (50% above ambient), control (ambient) and low (50% below ambient) and was replicated eight times. The low spring rain treatment was created using rain-out shelters and the high treatment was created using a small irrigation system. Spring rain is defined as rain that occurs February 1 through May 31. Within each spring rain plot we placed two 30 $cm^2$ subplots; each subplot was surrounded by a 25 cm buffer. One subplot was designated the "without competition" treatment (hereafter "cleared" treatment) and all aboveground biomass was removed by monthly clipping from November 2009 to June 2010. The remaining subplot was designated as the "with competition" (hereafter "uncleared treatment") subplot and all background biomass was left intact. Each subplot was seeded with 20 *A. triuncialis* seeds in November 2009. All plots received water from ambient rain events until February 2010, when rainout shelters were erected over the low spring rain plots. In April 2010, *A. triuncialis* seedlings were randomly thinned to three individuals per subplot to reduce intraspecific competition. Individual heights were measured in April, May, and June 2010 and relative growth rates were calculated from these height measurements, using the following formula

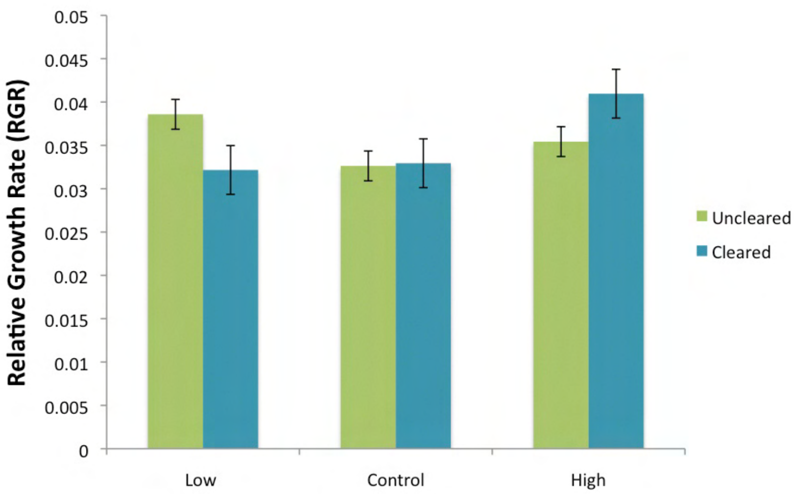
Relative growth rate (RGR) = [ln(hgt2) – ln(hgt1)]/(t2-t1), where hgt1 and hgt2 are heights at time point 1 and 2, respectively.

May and June RGRs were analyzed with a split-plot ANOVA, with precipitation and competition as the independent, nested variables.

## Results and Discussion

May RGR was unaffected by spring rain treatments, while June RGR showed a significant interaction between spring rain treatments and competition. In the high spring rain treatment, RGR was 14% greater in the cleared plots than the uncleared plots. However, in the low spring rain treatment, RGR was 17% greater in the uncleared plots than in the cleared plots.

Recent climate models vary widely in their forecasts for precipitation patterns in California, ranging anywhere from a 44% increase to a nearly 70% decrease in annual precipitation (Cayan et al. 2008). Our spring precipitation treatments were within this range and interacted with competition to significantly influence the growth rates of barbed goatgrass (*Aegilops triuncialis*).




We found that the native community had a facultative effect on *A. triuncialis* in the low spring rain treatment, but had a competitive effect when spring rain was supplemented. Thus, success of invasive species in the future may depend on the direction of climate change.

Variation in precipitation has been observed to have strong effects on the success of non-native grasses on serpentine. Hobbes and Mooney (1991) observed that high rainfall years led to an increase in the abundance of an exotic annual grass, *Bromus hordeaceus*, but drought years nearly eliminated the same species from the grassland. Consistent with Hobbs and Mooney's observations, *A. triuncialis* also responded positively to an increase in spring precipitation, suggesting the invasion of serpentine grasslands may be limited by water availability. In contrast, the growth of *A. triuncialis* in the low spring rain treatment was faster when the native community was present, suggesting that the native community may actually facilitate some invaders during drought years. *A. triuncialis* may have been shaded by the background community and could have grown faster due to etiolation. However, *A. triuncialis* may have experienced etiolation as an artifact of our experimental design, since the rainout shelters may have shaded the low precipitation plots. We intend to examine this possibility by analyzing background biomass samples that were collected at the end of the experiment.

The results of our study partially support the hypothesis that competition from an intact native community can provide resistance to invasion by non-native species. Competition from the native community slowed the growth rates of *A. triuncialis* in the high spring rain treatment, but not the low spring rain treatment. Similarly, Going et al. (2008) found that invasive grasses were negatively affected by competition with a resident serpentine community. This suggests that the strength of community resistance in the form of competition from the native serpentine community depends on the availability of water in the latter half of the growing season.

The results of this study have several management implications. Based on our data, increases in spring precipitation may improve the success of *A. triuncialis* on serpentine soil. However, our results also show that the native serpentine community can compete with *A. triuncialis*, suggesting that perhaps the most effective way to minimize the spread of *A. triuncialis* in the face of climate change is to maintain an intact native community on serpentine soils.

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## Ecological Correlates of Fountain Grass (*Pennisetum setaceum*) in California Coastal Sage Scrub

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### Abstract

African fountain grass (*Pennisetum setaceum*) is invasive outside its native range and is now spreading in wildlands in Hawaii, Arizona and California. While fountain grass is increasing in California, its potential range and impacts on local communities have not been determined. The use of a climate-matching model to predict potential for spread of fountain grass showed that many areas of southern California are suitable for invasion by fountain grass, including areas that support coastal sage scrub (CSS) communities. Invaded CSS sites in southern California were analyzed for cover of native and exotic species, using replicated transects and plots containing four cover classes of fountain grass. All six sites were located on steep, rocky slopes that faced southwest. Sites in the Santa Monica National Recreation Area (SAMO) showed a significant decline in native species richness and cover with increasing fountain grass cover, based on regression analysis. Sites in San Diego County showed significant but smaller declines in native cover as fountain grass cover increased and no significant differences in native species richness. Principal Components Analysis (PCA) of abiotic variables associated with sites showed a significant separation by region: SAMO sites were characterized by less surface area covered by rock, but rockier and drier soil, which may explain differences in the relationship between natives and fountain grass by region. Analysis of second year-data as well as soil texture, nutrients, PAR and temperature may help determine whether these factors cause differences in recruitment of native species under increased fountain grass cover.

### Introduction

African fountain grass (*Pennisetum setaceum* (Forssk) Chiov.) is a perennial C4 grass that is invasive outside its native range and is now damaging native ecosystems in Hawaii. Fountain grass is an invasive plant of growing importance in the southwestern US where it was introduced as a drought-tolerant ornamental (Williams et al. 1995). While it is increasing in California (Poulin et al. 2005), its ability to spread and potential impacts on local communities have not been determined. Fountain grass invades dry landscapes and has been shown in Hawaii to alter fire cycles and microhabitats and can facilitate a conversion from dry forest to grassland (Blackmore and Vitousek 2000). The goal of this research is to quantify community factors involved in fountain grass invasion using vegetation analysis of invaded communities.

Results of climate-matching modeling (Sutherst and Maywald 1985) show that areas that support CSS have a climate that is potentially suitable for establishment of fountain grass (Sweet and Holt, unpublished data). This research aims to expand on modeling results by investigating the community, environmental and disturbance factors most correlated with fountain grass occurrence and, in addition, to determine whether native species richness is reduced post-invasion. Different functional and dispersal strategies compared to native species, as well as disturbance, may be allowing fountain grass to invade this community in southern California. Experimental results will indicate what factors may allow fountain grass to invade intact coastal sage scrub (CSS), the most widespread southern California community.

Additionally, the large biomass and extensive root system of fountain grass will decrease resource availability for native genera in similar microhabitats. This may result in a decrease in native diversity in invaded areas. Results will be used to develop recommendations for management organizations that are based on the risk and consequences of fountain grass invasion in southern California plant communities, including endangered CSS.

## Methods

Field sites within two regions of southern California containing significant fountain grass populations were sampled in April 2009. Population locations were selected that were greater than 10m in diameter and not located within cleared/scraped or highly-disturbed land or cut-slopes immediately adjacent to roads. Populations were sampled in northwest Los Angeles County (Point Mugu State Park, Santa Monica National Recreation Area (SAMO)) and eastern San Diego County (San Diego National Wildlife Refuge and Crestridge Ecological Reserve).

At each site, aspect and slope were measured as well as the shortest distance from the invaded area to a trail or road. A small amount of soil was collected (if permitted) to confirm that soil matched soil maps and to compare soil texture and nutrients in high- and low- fountain grass density areas.

Three transects were established at each site in San Diego and SAMO sites, each perpendicular to the aspect of the hillside. Obvious areas of difference (such as washes or variations in aspect/direction) were excluded from transect sampling. Along each transect, which was run from at least 2m beyond the visible invasion boundary, line-intercept data was taken for fountain grass only, allowing a baseline of cover to be established over the entire transect. Point-intercept data was also taken at 2 m intervals for all species along the entire transect.

In order to document cover and richness of native and exotic species with fountain grass cover, eight one half-by-one meter plots were established on each transect. Plots were located using a stratified random sampling method along the transect in order to ensure that a full range of cover of fountain grass was represented. The four cover classes of fountain grass were 0, 1-33%, 33-66% and 66-100%. Plots were located either above or below the transect line, arranged with the half-meter side touching the transect tape. Cover for all plant species was recorded in each plot, as well as bare ground, rock and litter.

## Results and Discussion

Fountain grass occurs with a wide variety of native and non-species and is capable of persisting at high densities, covering up to one meter square per plant, and producing large amounts of litter. Site analysis data clearly suggests that fountain grass tends to occur on southwest-facing slopes, regardless of region, and on rocky outcrops in particular in Riverside County. Fountain grass also occurs on especially steep slopes and is capable of establishing and persisting with no apparent requirement of disturbance.

Sites in the SAMO showed a significant decline in native species richness and cover with increasing fountain grass cover, based on regression analysis of all sites (grouped), and lower species richness in high, as opposed to low, cover classes, based on ANOVA results. Analysis of sites in San Diego County as a group showed significant but smaller declines in native cover as fountain grass cover increased and no significant differences in native species richness. Further analysis of functional group characteristics and differences among cover levels may help indicate which community types are capable of invasion.

Principal Components Analysis (PCA) of abiotic variables associated with sites showed a significant separation by region: SAMO sites were characterized by less surface area covered by rock, but rockier and drier soil, which may explain differences in the relationship between natives and fountain grass by region.

This research, like many studies, employed a correlative approach to investigate current and potential impacts of invasive species on native communities. However, results cannot be used to examine causes of exotic species spread or mechanisms of impacts on native species. Brewer (2008) employed a longer-term approach measuring both vegetation and changes in abiotic factors over several years. This method allows the documentation of the invasion process as it occurs and therefore reveals a more direct suggestion about the interaction between species than in a correlative study. A second year of vegetation analysis in CSS fountain grass invasions has been conducted in order to further explore the relationship of fountain grass and native species occurrence.

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## Origins of Invasive French Broom

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### Abstract

Evidence of hybridization among ornamental cultivars and species and naturalized populations is important because it can increase invasiveness and make management, particularly biological control, difficult. French broom, believed to be *Genista monspessulana*, was introduced into California by the horticultural industry and has caused serious environmental damage throughout the state. It is no longer available commercially, but its close relative, sweet broom, is a popular ornamental and may be contributing to invasive populations. The goals of this research are to: 1) identify the cultivated sources of invasive broom populations in California and 2) determine whether hybridization between ornamental plants and naturalized populations has occurred. To address these objectives, we collected samples from invasive French broom populations throughout California, landscape plantings, horticultural outlets and botanical gardens and arboreta from its native range. These samples were used to reconstruct a phylogeny of brooms using two chloroplast and two nuclear DNA regions. We also cloned nuclear internal transcribed spacer (ITS) sequences to confirm parentage and assess hybrid origin. ITS sequences are non-coding DNA regions that occur several hundred times throughout the genome. The copies are usually homogenized so that only a single sequence is found within an individual. However, this homogenization process may not be complete in recent hybrids. Thus, analyzing multiple copies of ITS from suspected hybrids can give information about parentage and hybrid origin.

Phylogenetic analyses revealed a well-supported group containing *G. monspessulana* samples from its native range and the majority of invasive French broom samples from California. ITS phylogenetic analysis with the additional sequences from cloning experiments revealed an ornamental sweet broom group containing sequences from a small number of invasive French broom individuals. Our results suggest that the majority of invasive French broom in California originated from *G. monspessulana* but that ornamental sweet

broom can contribute to invasive populations via hybridization.

## Introduction

Despite considerable research effort, no general mechanism or suite of factors underlying invasive success has been found. A growing body of research suggests, however, that all invasions pass through four spatio-temporal stages (transport, colonization, establishment and spread) and that key filters common to all invasions control success at these stages (Theoharides and Dukes 2007). Adaptation to a novel environment may be necessary for colonization, establishment and spread and typically requires genetic diversity. Ornamental plantings have the potential to increase the genetic diversity of related invasive species via intra- and inter- specific hybridization or multiple introductions (Schierenbeck and Ellstrand 2009).

Phylogenetic studies offer important background information and a useful starting point for investigating whether adaptation to a novel environment occurs during an invasion by providing taxonomic clarification, the source of invasive individuals and the genetic makeup and variability of invasives and natives. In addition, phylogenetic analyses using the nuclear ribosomal ITS region has proven useful for identifying hybridization (e.g. Rauscher et al. 2004). The ITS regions are highly repeated throughout the genome and concerted evolution homogenizes these copies so that a single sequence is found for an individual (Liao 1999). However, recurring or recent hybridization may increase ITS variation and following hybridization it is possible that both parental copies of ITS are retained and can be used to identify the parent species of hybrids. Including phylogenetic analyses of chloroplast DNA regions can provide additional information about hybridization and differences in seed and pollen dispersal because the chloroplast is maternally inherited in most angiosperms.

We used phylogenetic analyses of ITS and two chloroplast DNA regions to investigate genetic and taxonomic factors that may be important across the spatial-temporal stages of broom invasion in California. We focused on French broom, a woody exotic legume that was introduced into California in the mid-1800s for landscape planting. French broom is thought to be either *Genista monspessulana* or a hybrid, potentially between *G. stenopetala* and *G. canariensis* (McClintock 1993). It is also possible that some invasive populations are comprised of the ornamental plant sweet broom or are the result of hybridization between French broom and sweet broom. Although French broom is no longer available commercially, sweet broom is sold under a variety of scientific names and the two are very similar morphologically. Thus, the specific objectives of this project were to: 1) determine the taxonomic identity of invasive French broom and ornamental sweet broom and 2) ascertain if sweet broom contributes to invasive French broom populations directly or via hybridization.

## Methods

Our sampling included 1) French broom from populations throughout its invasive range in California; 2) sweet broom from growers, nurseries and garden centers, and landscape plantings throughout California and 3) closely related individuals of known species identity from the native range. DNA was extracted from silica-dried leaf material using the CTAB procedure. The nuclear ITS region and chloroplast trnL-F and trnL(UAA) intron regions were PCR-amplified and sequenced using the primers and conditions described in Chandler et al. (2001) and Taberlet et al. (1991). Amplicons (pieces of DNA; used here to indicate multiple copies of the same region from throughout the genome) of the ITS region were cloned using the TOPO TA Cloning Kit (Invitrogen) and 8-10 amplicons per invasive and ornamental individual were sequenced.

Sequences were aligned using Clustal W2 and phylogenetic analyses were performed in PAUP* 4.0 for Maximum Parsimony (MP) analyses and in MrBayes 3.1.2 for Bayesian analyses.

## Results and Discussion

Results of phylogenetic analyses of the chloroplast DNA and ITS regions in the French broom group are presented in figures 1 and 2, respectively. Both phylogenetic trees contain one strongly supported clade (a group consisting of a single common ancestor and all of its descendents) including the majority of the invasive French broom individuals and all samples of *G. monspessulana*. Thus, the majority of the French broom individuals included in this study can be considered to be *G. monspessulana*.

The ITS analysis, which includes multiple amplicons per individual, offers greater resolution than the chloroplast analysis and provides insight into the origin and amount of variation present in invasives and ornamentals. Although all the amplicons from most invasive French broom samples group together with *G. monspessulana*, they form subgroups that are not defined exclusively by individual, geographic distance, or habitat type. Variation within invasive French broom is common and widespread, which is not surprising considering that it reproduces sexually, produces extensive seed banks and was introduced as an ornamental plant. All sweet broom amplicons form a single group (Figure 2), but this group also contains sequences from a number of closely related *Genista* species, so it is not possible to determine with certainty the origin of ornamental sweet broom. Most of the sweet broom amplicons resolve into subgroups with *G. stenopetala* and *G. canariensis*, so it is probable that some sweet broom is *G. stenopetala* and some are hybrids between *G. stenopetala* and *G. canariensis*. All of the amplicons from an individual from an invasive broom population (FB La Canada) were found in the sweet broom group, meaning that sweet broom itself may have the potential to become invasive.

Our ITS results also offer information about hybridization within invasive French broom. Five French broom individuals have their amplicons split equally between the French broom and sweet broom clades (Figure 2), implying that they are hybrids between French broom and the sweet broom group. They do not all group together or with a particular French broom or sweet broom and are found throughout the invaded range. Interestingly, the hybrid plants

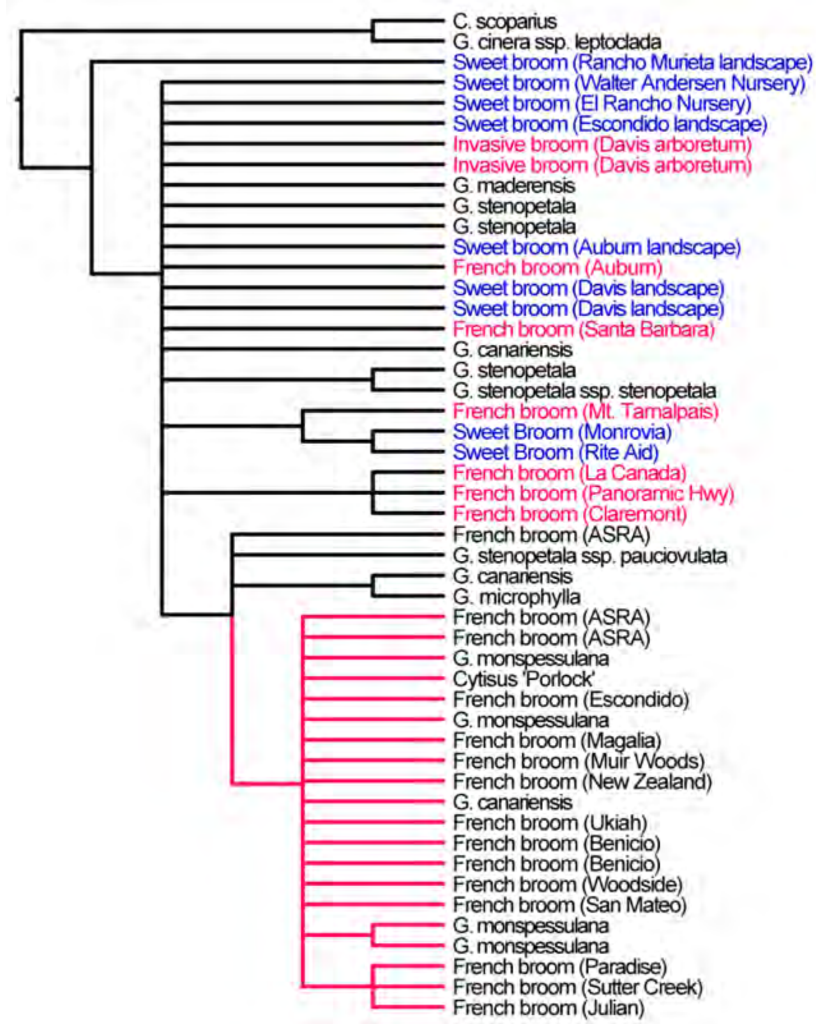


Figure 1

50% majority rule consensus tree from a Bayesian analysis of the French broom group based on the combined data set of chloroplast DNA sequences.

are all from hot and dry locales, although invasive French broom prefers coastal low-altitude climates.

The presence of variation within invasive French broom populations and hybridization with the sweet broom group has important implications for biological control of French broom in California and for preventing future invasions. We are currently using increased sampling in the native and invaded range and more quickly evolving molecular markers to investigate the region of origin of French broom in the native range and to distinguish between the contributions of

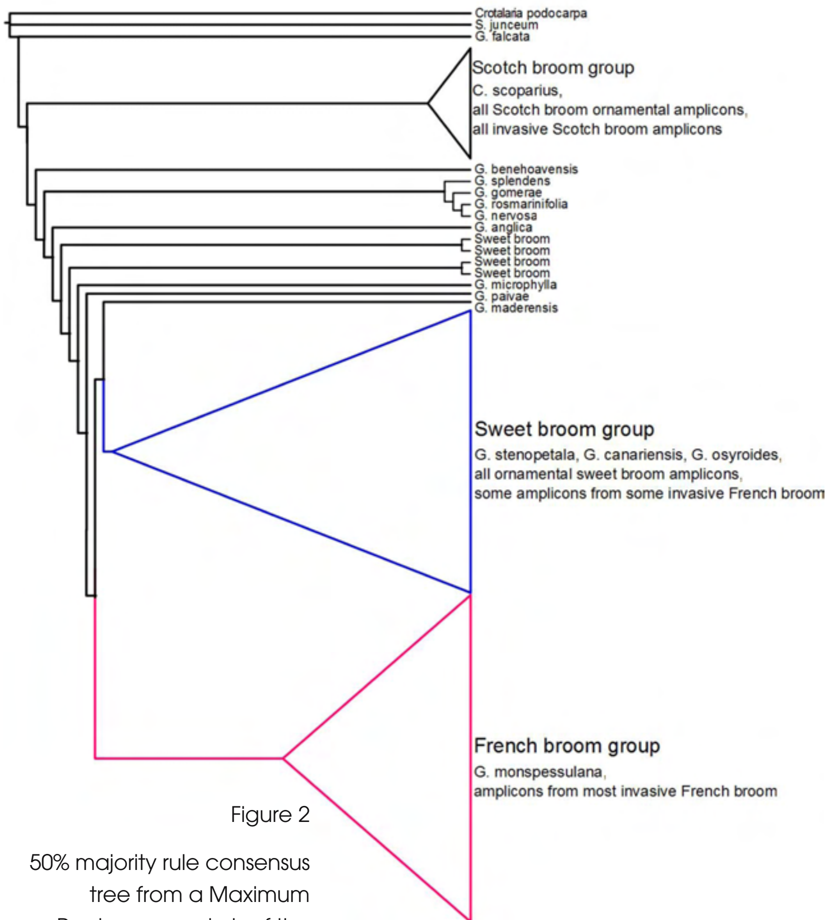


Figure 2

50% majority rule consensus tree from a Maximum Parsimony analysis of the French broom group based on nuclear ITS sequences. Triangles indicate that there are a very large number of closely related or identical sequences in a group.

different sweet broom plants. These results will have the potential to inform ongoing biocontrol programs and the horticultural industry and gardening public about the invasiveness, or lack of invasiveness, of ornamental sweet broom.

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# Exotic Plant Invasion Interrupts Chaparral Ecosystem Resistance, Resilience and Succession


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## Abstract


Fire, at an invasion front, offers a unique opportunity to study exotic plant effects on resistance, resilience and succession of chaparral above and below ground following wildfire. Above ground plant community resistance and resilience to exotic plant invasion is well studied; however, the ability of soils in the same systems to resist and recover from invasion are less understood. In chaparral ecosystems of southern California, exotic annual species invasion is limited in mature communities, but following fire, may dominate a site and alter natural post fire soil inputs. We examined chaparral system resistance and resilience to exotic plant invasion above and below ground in intact, mature chaparral and post fire chaparral succession process. Hypotheses were that 1) Presence of exotic plant species in the chaparral changes biological and chemical characteristics of soils by altering soil inputs, 2) Presence of exotic plants slows succession of chaparral above and below ground and 3) If exotics are controlled and native chaparral species restored, soil biological and chemical characteristics return to pre-invaded conditions because native soil

inputs are restored. Intact, mature chaparral, aboveground plant communities were resistant to invasion; however, the very low levels of invasion that did occur lead to alterations of the soil chemical and microbial characteristics of the soils. Post fire succession was slowed both above and below ground by the presence of exotic plant species indicating that post fire chaparral is not resistant to invasion or the impacts of invasion. Removal of exotic plants and seeding of natives post fire facilitated rates of succession similar to uninvaded chaparral.

# Managing Invasive Plants

## Strategic Planning for Control of *Arundo donax* and Restoration of Riparian Vegetation in Semi-Arid Landscapes: A Case Study from The Lower Santa Clara River, CA

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Conservation and restoration of California's semi-arid river corridors is a daunting challenge, particularly in light of increasing demands for water and land coupled with invasive species and global climate change. The lower Santa Clara River (Ventura County, California) has been significantly altered by levees, water diversions, agriculture and urbanization that have altered natural geomorphic and hydrologic processes, causing riparian habitat loss or degradation and facilitating invasion by *Arundo donax*. The California Coastal Conservancy's Santa Clara River Parkway project seeks to ameliorate these impacts and conserve existing riparian habitats by acquiring and restoring a 25 mile-long floodplain corridor. We coupled vegetation sampling and mapping with studies of the hydrogeomorphic processes that shape these systems, including large El Nino flood events, to improve our understanding of the key drivers affecting riparian vegetation dynamics. These findings, coupled with recent research by others on *Arundo* ecology and invasive grass-fire cycles, are being used to develop strategic plans and priorities for *Arundo* control and riparian restoration in the Santa Clara River watershed. Various strategic actions to control *Arundo* are being considered, such as focusing initially on higher terraces that are less likely to be reinvaded from upstream sources during the next big flood and that are adjacent to fire-prone shrub lands, areas in and adjacent to high quality riparian habitat, river reaches with lower levels of nutrient loading where native vegetation can better compete with *Arundo*, preparing contingency plans to remove new propagules immediately following major floods and to the extent feasible removing sources in an upstream to downstream direction.

## *Euphorbia terracina*: Why worry?

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### Abstract

Understanding the mechanisms that promote the invasiveness of newly introduced non-native species is imperative to control the spread of ecologically damaging plants. *Euphorbia terracina*, a new invader to California's Santa Monica Mountains, has dramatically increased its distribution over the last five years. With numerous scattered isolated populations now found throughout Ventura and Los Angeles counties, including large populations within the Santa Monica Mountains National Recreation Area it is proving to be a threat to our native communities. Careful monitoring of populations on National Park Service land has highlighted multiple characters that lend to its invasive potential. Tracking its life cycle, we have found that it is productive ten months out of the year and rapidly moves through life stages. It has a vegetative and flowering stage of one month and a fruiting stage of three weeks. Its indeterminate mode of reproduction allows it

to be a prolific seeder. Germinating early in the growing season enables it to readily exploit available niches where native plants are not found. We are examining the best treatment methods for this species by looking at the effect of pre-emergent (chlorsulfron) and post-emergent (glyphosate) herbicides and hand pulling. The pre-emergent herbicide was the most effective treatment (100 percent cover decrease) followed by pre-emergent coupled with hand pulling (92 percent cover decrease). Hand pulling and leaving Eubphobia terracina around natives was ineffective (3 percent cover increase).

## Introduction

Why worry about *Euphorbia terracina*? First, it is spreading dramatically. *Euphorbia terracina* was first discovered in southern California near the Los Angeles Airport and has spread north into Santa Barbara County and south past Palos Verdes. This area includes the Santa Monica Mountain National Recreation Area where it has proved to be difficult to remove. The method of long distance dispersal is not known but likely is human caused. Local dispersal is facilitated by the explosive release of seeds from fruits (up to several meters according to Randall and Brooks 2000), the harvesting of elaiosomes (fleshy structures containing lipids and proteins attached to the seed) by ants and by small rodents as evidenced by seed coats and droppings being left by plants and caches of germinating seedlings found throughout the park.

Second, its life cycle characteristics facilitate its invasiveness. Seedlings germinate early in the year soon after it rains and depending on rainfall patterns, can germinate multiple times per year. Early germination allows them to become established before and inhabit niches not used by native species to the extent of being able to form dense stands of monocultures. Additionally, plants remain reproductive throughout much of the year (early spring to late summer). Flowers go to fruit about a month after they are produced and seeds are dispersed as soon as three weeks after fruit production. New flowers/fruits are continually produced throughout the growing season. Seed production in the first year can be as great as 186 per individual for early cohorts (Cheam and Lee 1996). Reproductive output is even greater for older plants and for those that have had the top part removed because they can resprout multiple branches. Topped plants can produce up to 13 branches and 1755 seeds (Cheam and Lee 1996). This ability to resprout is of concern because in late summer small mammals such as gophers and ground squirrels will chew off the tops of *E. terracina* promoting the growth of many new branches thus increasing seed production (personal observation). In combination these characteristics allow this species to displace natives making controlling its spread imperative.

## Methods

We conducted our study in Solstice Canyon, a site within the Santa Monica Mountains National Recreation Area. A total of eight sites were chosen based on the mix of native species and *E. terracina*, thus simulating field conditions experienced when managing natural areas within this region. Sites were set up in 2008, treated yearly and monitored pre-treatment, at one month (2009 and 2010) and six months post-treatment.

### *Experimental set up*

Site preparation was done in May of 2008. Each site was divided into six fixed two $m^2$ plots with one meter borders on each side. These borders were installed to avoid cross contamination between each treatment and from outside the treatment site. In the center of the two $m^2$ plot a one $m^2$ area was permanently set up to be used for data collection. These plots were randomly assigned to one of six treatments: glyphosate + no pull, glyphosate + pull, chlorsulfuron + no pull, chlorsulfuron + pull, pull + no pull and pull + pull. The assignment of treatment determined whether the plot would be sprayed with a 2% solution of glyphosate (a post-emergent herbicide), sprayed with chlosulfuron (a pre-/ post- emergent herbicide) at 15g/hectare, or by hand pulling. Pull specified that all target weeds were to be pulled within a 10 cm proximity to natives. No pull indicated that no such pulling would occur. This was consistent for all assigned treatments except for pull + pull and the pull + no pull treatments. In the pull + pull treatment every target weed was pulled regardless of proximity to natives. Contrastingly, in the pull + no pull treatments every target weed was pulled except those within 10 cm of natives. Weeds and the ground (to test the pre-emergent effect on seed germination) were sprayed. Care was taken not to spray any natives in the treatment areas.

### Data collection

In June of 2008 the first yearly treatment application was conducted. Prior to performing each assigned treatment the 1 $m^2$ data collection area was assessed for percent cover (estimation of the total area occupied) of *E. terracina*, native vegetation, non-native vegetation and bare ground. The same data was collected in post-assessments. To examine the effectiveness of treatment, percent cover of dead weeds and resprouts were also collected at this time. Photographs were taken at the time of data collection pre- and post- treatment to visually monitor treatment effect. To evaluate natural yearly fluctuations in *E. terracina* cover assessment data was collected from an adjacent property where control measures have not been attempted.

### Data Analysis

Paired two-tailed t-tests and percent reduction and/or increase were calculated comparing pre-treatment 2008 and pre-treatment 2010 percent cover of *E. terracina* and natives to determine if there were changes within treatments.

## Results and Discussion

Pretreatment conditions were compared from the start of the experiment in 2008 and in 2010 (after two years of treatment). Percent covers of *E. terracina* were significantly different in the glyphosate + no pull ($p = 0.0003$), chlorsulfuron + no pull ($p = 0.003$), and chlorsulfuron + pull ($p = 0.004$) treatments (Figure 1). Percent cover reduction by treatment was 100% for chlorsulfuron + no pull, 92% for chlorsulfuron + pull, 67% pull + pull, 56% glyphosate + no pull, 30% glyphosate + pull, and was increased by 3% for the pull + no pull treatment (Figure 1). Furthermore, *E. terracina* was found in none of the chlorsulfron + no pull plots, only one of the chlosulfron + pull plots, seven of the plots for glyphosate + pull and pull + no pull and in all of the plots for pull + pull and glyphosate + no pull treatments.

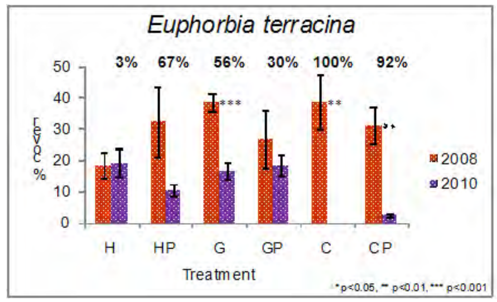


Figure 1

Graph showing percent cover differences in *E. terracina* from 2008 to 2010. Percentages over the bars are the percent change. Treatment abreviations:

H = pull + no pull
HP = pull + pull
G = glyphosate + no pull
GP = glyphosate + pull
C = chlorsulfuron + no pull
and CP = chlorsulfuron+ pull.
(Mean ± SE, n = 8)

Percent covers of natives increased in all treatments: 91% chlorsulfron + no pull, 69% pull + pull, 63% glyphosate + no pull, 60% chlorsulfron + pull, 58% pull + no pull, and 46% glyphosate + no pull (Figure 2). These differences were not statistically significant though the chlorsulfron + no pull ($p = 0.055$) and the pull + pull ($p = 0.058$) treatments were marginally so.

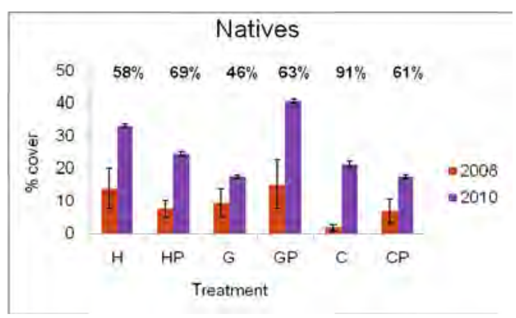


Figure 2

Graph showing percent cover differences in natives from 2008 to 2010. Percentages over the bars are the percent increase. Treatment abreviations:

H = pull + no pull
HP = pull + pull
G = glyphosate + no pull
GP = glyphosate + pull
C = chlorsulfuron + no pull
and CP = chlorsulfuron+ pull.
(Mean ± SE, n = 8)

The close proximity of *E. terracina* to native plants requires a combination of glyphosate spraying and hand pulling. Therefore, it is troubling to see that treatments with hand pulling are less effective than ones without pulling. The explanation for this has to do with the seed bank. *Euphorbia terracina* seeds can exist in the seed bank for three to five years (Randall and Brooks 2000) and only a fraction of seed produced each year germinate the next year (Cheam and Lee

1996). In addition, seeds mostly germinate at a depth of 1 cm (25%), a few at 5 cm (12%) and none at 10 cm (Cheam and Lee 1996). The disturbance caused by hand pulling brings seeds closer to the surface promoting their germination. Using chlorsulfron, a pre-emergent herbicide, appears to lessen this effect. We are excited to find chlorsulfron is so effective, especially in a short period of time, requiring only two annual applications. However, further study needs to be done to test the effects of chlorsulfron on native seed germination and recruitment and on native species planted at sites where chlorsulfron has been used.

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## Testing Efficacy of Control Methods for the Invasive Shrub *Cytisus scoparius* in Forest Habitats of the Pacific Northwest.


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### Abstract


The exotic shrub Scotch broom (*Cytisus scoparius*) has been implicated in failed reforestation efforts in the Pacific Northwest. We present the results of an ongoing experiment at Fort Lewis, Washington, testing the efficacy of broom control methods in the context of Douglas-fir (DF) reforestation. Following initial clearing of mature broom at five sites, we implemented two broom control methods in a replicated, controlled design: 1) soil scarification at different times of year and different intervals and 2) herbicide application at one time point. We measured resprouting rates of the initial cleared individuals, germination of broom from the seedbank and broom cover for three years following initial clearing. We found that resprouting of broom stumps did not depend on stump diameter or height. While germination rates declined dramatically across all treatments over three years, removal of competing vegetation with herbicide tended to increase broom germination compared to controls. However, soil scarification increased germination rates still further. Broom cover was lower in all treatments compared to control plots, with similar responses to scarification and herbicide. We observed high mortality rates of DF seedlings in our experiment which was likely due to lack of rainfall. However, our previous work suggests that broom may alter soils so as to inhibit growth of certain species in broom-invaded sites. A subsequent greenhouse bioassay confirmed that DF seedling growth was substantially impaired in long-invaded broom soils compared to non-invaded forest soils, which suggests a long-term legacy of broom on both managed and wild lands.


### Introduction

The pest plant Scotch broom (*Cytisus scoparius*, hereafter *Cytisus* or broom) is hindering effective reforestation at Fort Lewis, resulting in both a loss of land available for military training as well as a loss of native forest habitat for native plants and animals. In prairie areas of Fort Lewis and nearby public lands, *Cytisus* control has been a central feature of prairie restoration and management for decades and best management practices are well developed for that environment. However, the forestry context presents challenges as well as opportunities for *Cytisus* control. For example, there may be fewer control options available in reforestation compared to prairie restoration. On the other hand, a successful endpoint in reforestation is definable: at some point tree seedlings should overtop and shade out the *Cytisus* layer.

Our primary objectives are to examine the control strategies that are unique to reforestation. In particular, the use of fire is not a viable control option in reforestation, especially after tree seedlings have been planted in. Alternatives such as soil scarification and herbicides are more viable, yet it is currently unknown whether, or to what extent, repeated treatments are more efficient than single treatments. Our secondary objectives include understanding indirect effects of control strategies, such as broom mulch left on-site following biomass removal. The effects of broom mulch are currently not well-known: mulch has high nitrogen concentrations and may provide a fertilization effect for tree seedlings, but *Cytisus* also produces secondary defense compounds which may have inhibitory effects.

Here we present *Cytisus* response to management treatments three years following initial site clearing via brushcutting across five sites. Our specific questions were the following:

1. What is the rate of stump resprouting and does it vary with stump size?
2. Do multiple rounds of mechanical removal decrease broom germination and cover relative to a single treatment?
3. How do mechanical versus herbicide control methods affect broom germination and cover?

## Methods

Five sites were chosen by Fort Lewis for Scotch broom removal and experimental treatment. In fall of 2007, a large brushcutter removed all mature broom from the sites, leaving mulched material on-site. Within this removal area at each site, we established forty-eight 56 feet x 56 feet plots. Plots were arranged in blocks of six in a randomized block design. Within each block, we implemented both mechanical and chemical (herbicide) control treatments. Mechanical treatments were conducted by an operator using a brushcutter mounted on a small tractor. Brushcutting blades were positioned so that the topmost layer of mineral soil was disturbed, with the objective of both stimulating germination while removing all aboveground *Cytisus* (plus other vegetation). Herbicide treatments were applied by technicians using backpack sprayers containing 2% Garlon. Care was taken so that all *Cytisus* individuals in a plot were targeted, but non-target plants were inadvertently sprayed.

Over the three growing seasons reported here (2008-2010) we collected data on initial broom resprouting rates, germination and broom cover in all plots. Here we present data from the spring 2010 measurements. For stump resprouting, we marked five stumps in each plot then revisited all flagged stumps the following fall to measure their diameter and height. For germination, seedlings were counted in a 24.1 m-long, 10cm-wide belt transect at every plot resulting in a total of 2.4 square meters of sampled area per plot. For broom cover, we ran a line transect down the hypotenuse of each plot and counted all individuals that hit the line (for density); we additionally measured the length along the transect covered by each individual (for % cover). We collected resprouting data at one time point (in 2008) and germination and cover of broom at three time points (2008, 2009 and 2010) although only 2010 data are reported here.

We analyzed the effects of control methods using analysis of variance, with site as a random factor and control treatment (mechanical or chemical) as fixed main effects. We used logistic regression to analyze the effect of stump size (stem height and diameter) on resprouting rate.

## Results and Discussion

Overall, we found strong effects of mechanical and chemical control on broom cover and germination, with very minimal differences among these approaches.

### *Resprouting rate*

Resprouting rates were highly variable across sites, but four out of the five sites were more similar with around 10% of the remaining stumps resprouting. One site, however, resprout-ed at the rate of nearly 40%. We currently have no explanation as to why this site had such high rates of resprouting. We found that there was no relationship between stump height or diameter and resprouting rates. This result is contrary to the prevailing belief that larger or taller stumps resprout at a greater rate following cutting.

### Germination rate

Initially (2008) germination rates were variable across sites, with one site having virtually no germinants and others having up to 160 germinants/m$^2$. We measured almost 50% more germination in May of 2008 compared to March 2008, reflecting the fact that germination occurs throughout the spring and is best measured later in the spring as opposed to earlier. Germination rates did not appear to be related to initial broom density (as estimated by stumps remaining following the initial clearing of all sites).

After measurement in 2010, we found that all treatments caused greater rates of germination compared to control. Across sites, however, we found that the most consistent and strongest treatment effect was mechanical removal (scarification) that occurred two consecutive years (2008 and 2009). In these plots, there was up to ten times more germination compared to control plots. However, there was interesting site-to-site variation. For example, at one site there was no difference in seed germination between plots that had been scarified once (in 2008) and twice (both in 2008 and 2009). At another site, there was no difference in germination between plots that had been scarified twice and had herbicide applied once.

### Percent cover

In general, all treatments we tested resulted in lower percent cover of broom compared to controls. Plots that received two scarification treatments had lower percent cover compared to the other mechanical treatments. The response to mechanical versus herbicide, however, depended on the frequency of mechanical control. Those plots that received only one early scarification treatment (in 2008) had much greater percent cover of broom by 2010 compared to plots that were scarified once in 2009, scarified twice (2008 and 2009), or herbicided once (in 2009). The most obvious explanation is that those plots had one more year of growth compared to the other plots. When only those plots that were last treated in 2009 are compared, there appears to be virtually no difference between one or two mechanical treatments, or between both those treatments and herbicide.

## Summary of Treatment Effects

1. *What is the rate of stump resprouting and does it vary with stump size?*

   The rates vary from ~10% for most sites, with one outlier site resprouting at almost 40%. We currently have no explanation for why that site responded that way to initial clearing of adult broom.

2. *Do multiple rounds of mechanical removal decrease broom germination and cover relative to a single treatment?*

   It depends. The single most consistent and strongest treatment effect on germination rates was the twice scarified treatment (treated in 2008 and 2009). However, at some sites there was no difference between that treatment and plots that were scarified once (in 2008). On the other hand, the plots that were scarified once had the greatest broom percent cover compared to other treatments, and this was generally consistent across sites.

3. *How do mechanical versus herbicide control methods affect broom germination and cover?*

   While both these approaches stimulated more germination compared to controls, mechanical treatments had greater germination rates compared to herbicide. Similarly, all treatments generally resulted in lower percent cover of broom compared to control plots. Plots that were mechanically treated twice had lower percent cover compared to plots treated once. However, there appears to be no difference in percent cover among both mechanical treatments (once and twice) and herbicide application.

## Solar Tents Demonstrated to be Effective in Several California Climatic Areas for Inactivating Plant Propagative Material

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Throughout California, interest is high in removing invasive plants from riparian areas and other sensitive habitats. Many of these sites are accessible only by hiking through brush or into canyons. While hauling plants away for pickup and disposal, viable seeds and vegetative material can be left behind and/or scattered. Tent solarization, a safe, inexpensive, non-toxic and effective technique, can be used to inactivate viable weed materials onsite. It can generate high temperatures (>70ºC = >158ºF) on a routine basis during summer months in warmer areas and can eradicate hydrated pests over the course of a single days time. Previously, supportive results had been shown at Sierra Nevada foothill and Central Valley sites. In summer 2009, demonstrations were expanded to three inland and coastal Southern California locations, using local, invasive plants. In all cases, at Riverside (shortpod mustard), Del Mar (bristly oxtongue) and Lakeside (bristly oxtongue; curly dock) where nontreated seeds were germinable for comparison, the solar tents were 100% effective. The Lakeside location was set up as a field demonstration, with the help of local, volunteer "weed warriors". They were able to see the results – a mushy mass of "cooked" weedy plant material. Updated information on constructing solar tents, maximizing heat and efficacy will be discussed.

# Balancing Management for Invasive Plants and Wildlife

## How Will *Tamarisk* Biocontrol Affect Wildlife?

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The program to develop biological control of *Tamarix* spp. using the specialist saltcedar leaf beetle, *Diorhabda elongata sensu lato*, has produced some spectacular results (and more failures), but also some exceptional political conflicts, primarily over perceived threats to endangered southwestern willow flycatchers (SWFL) nesting in tamarisk. Numerous species of birds, reptiles and small mammals occupy tamarisk habitat in western riparian areas, although in general tamarisk provides somewhat poorer quality habitat than the native species it has replaced. The introduction of biocontrol will affect tamarisk habitat by changing the physical structure (temporary loss of canopy shading, gradual dieback of stems) and presenting a new food resource for insectivores. We focus here on two basic questions: 1) will biocontrol alter the relationship between tamarisk and wildlife negatively or positively? and 2) is restoration of native vegetation a feasible option following biocontrol? We are addressing these and other questions at the Virgin River, which flows through SW Utah, NW Arizona and southern Nevada to join the Colorado at Lake Mead. The Virgin watershed is the first ecosystem where *Diorhabda* and SWFL co-occur and in 2010 we anticipate that several thousand acres of tamarisk-dominated vegetation could be newly defoliated. We hypothesize that short-term structural change may reduce habitat quality in some locations during the breeding season (with real threats to some individual birds but not other vertebrates), while this new food resource will sustain or improve conditions for wildlife species in general. Subsequently, because sufficient propagules of native riparian plants are still present in the Virgin River, recovery should follow the gradual decline of *Tamarix* biomass and by the time of this presentation, we may even have some results to begin to answer these questions. The implications for T&E species and for other western rivers, will be addressed along with a novel strategy to facilitate riparian restoration on river segments lacking adequate native propagule sources.

The conflict between the Fish & Wildlife Service and the Department of Agriculture over potential threats to nesting SWFL is the basis for a lawsuit against USDA that has halted the *Tamarix* biocontrol program and could have significance beyond this system because it has led to further restrictions on the use of biocontrol as a tool for managing invasive species in wildland environments. In this political environment in which the opposing federal agencies are unwilling to support comprehensive monitoring of the ecosystem responses to biocontrol, we run the risk that long-term data will not be available that could provide resolution to these conflicts.

## Effects Of Sahara Mustard, *Brassica tournefortii*, on the Biodiversity of a Desert Landscape

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### Abstract

Given the abundance of non-native species invading wildland habitats, managers need to employ informed triage to focus control efforts on weeds with the greatest potential for negative impacts. Our objective here was to determine the threat Sahara mustard, *Brassica tournefortii*, represents to meeting regional goals for protecting biodiversity. Sahara mustard has spread throughout much of the Mojave and Sonoran Deserts. It has occurred in southern California's Coachella Valley for 80 years. In years when the mustard occurs at high densities it has clear negative impacts on the native flora. We identified reductions in native plant reproduction, shifting composition increasingly toward Sahara mustard while decreasing the fraction of native species. We also examined the impact of Sahara mustard on wildlife species, including the threatened Coachella Valley fringe-toed lizard, *Uma inornata*. The mustard invasion appears to result in complex responses to the lizards' prey and habitat quality. Without control measures the long-term impacts to desert biodiversity will be an increasing decline in native annual plants, arthropod species richness and dune stabilization with broad regional trophic impacts and reductions in potential habitat for a host of dune narrow-endemic species.

### Introduction

Our objectives were to determine the spatial and temporal patterns of occurrence of Sahara mustard, *Brassica tournefortii*, across the aeolian sand communities of the Coachella Valley, Riverside County, CA. In addition, we identified interactions with native biota and ecosystem processes over a four-plus year time span, examining mustard interactions within a community context and across trophic levels. Our aim was to provide land managers information that will allow them to view mustard infestations from a triage perspective, allowing them to prioritize their finite resources appropriately.

### Methods

In January 2005 we hand-removed Sahara mustard from 15 10 m x 100 m (0.1 ha) plots, randomly placed across a stabilized sand field landscape on the Coachella Valley National Wildlife Refuge. These 15 plots were coupled with 15 adjacent control plots where no mustard removal occurred. The size of the plot was dictated by habitat needs of the small mammals and reptiles that occur in the area and that could select for or against the treated plots. In March 2005 through March 2009 we surveyed annual plant species occurrence and densities in the treated and control plots. These surveys consisted of 12 $m^2$ sample squares placed along the midline of each plot. In April 2005 through April 2009 we surveyed ground arthropods using pitfall traps (3 per plot). All arthropods were identified to species. In May 2005 through 2009 we measured sand compaction at 25 points along the midline of each plot using a hand-held sand penetrometer. In May-July 2005 through 2009 vertebrates were surveyed on all plots. These surveys were conducted using unique track patterns characteristic of each species, including six species of rodents, seven lizard species and three species of snakes.

### Results and Discussion

Sahara mustard cover clearly tracked rainfall over the span of our study, but response rates were uneven across communities and the wind/precipitation gradients of the Coachella Valley. Stabilized sand fields in the eastern valley had by far the greatest level of mustard dominance whereas western communities were relatively less impacted. More stable aeolian sand communities had higher infestations than active habitats. Prior to the mustard removal, in 2003 and 2004, there was no difference in native annual plants between the paired removal and non removal plots. In 2005 when the mustard removal occurred the difference between treatment (removed) and control (non-removed) plots was dramatic. After the drought year in 2007 there continued to be an increased cover of native annual plants on the treatment plots compared to controls in 2008 (one-tailed paired t-test, $p < 0.005$), and a decreased difference in 2009 (one-tailed paired t-test, $p < 0.08$). Although the 2009 difference did not reach traditional levels of significance, we feel the difference is real as it is consistent with the previous years' patterns. These results indicate that there can be beneficial effects to biodiversity, measured by increased native annual plant cover, as many as three or four years following treatments.

We compared patterns of abundance for annual plants, arthropods, reptiles and mammals to patterns of mustard on non-treatment plots across the Coachella Valley's aeolian sand communities (Barrows et al. 2009). The stabilized sand fields in the eastern valley had the highest mustard cover, as well as the greatest reduction in native annual plants compared to conditions prior to the 2005 mustard outbreak. Coachella Valley giant sand-trader crickets also showed a significant decline on stabilized sand fields, especially as compared to the adjacent active dunes. Both of these observations, while only correlative, indicate a broad, incremental impact on biodiversity associated with very high levels of Sahara mustard abundance. The impact on Coachella Valley fringe-toed lizards was less apparent, although preliminary results from the summer surveys of 2009 also indicate a population decline only on the stabilized sand fields, whereas on active dunes the lizards' populations appears to be increasing.

To evaluate longer-term impacts to native plants we collected soil samples from the weeded and control plots in the fall of 2006 to analyze seed bank composition. Relatively few plants germinated from our soil samples, either due to small samples and/or high spatial variance or due to a depletion of the seed bank with no seed set following the October 2005 rain event. The mean number of native annuals germinating from three samples/plot for the weeded sites was 1.364, or roughly 34 plants /$m^2$; for the control plots just 0.364 plants germinated (nine plants / $m^2$) (Mann-Whitney U test, $p = 0.268$). The mean number of Sahara mustard plants germinating from three samples/plot for the weeded plots was 1.636 (41 plants / $m^2$); for the control plots it was 5.273 (132 plants / $m^2$) (Mann-Whitney U test, $p = 0.333$). Although these mean values indicate a potential treatment effect, the sampling effort appeared to be insufficient to statistically detect one.

Previous to 2005, Sahara mustard outbreaks appeared sporadic, uncommon events in response to higher than average fall-winter rainfall. Since then, in 2005, 2008 and 2009 there were repeated mustard outbreaks. This grant has provided us the rare opportunity to measure the response of native biodiversity over this sequence of repeated impacts to native species. The most dramatic impact is to native annual plants; mustard reduces the size and reproductive output (seeds) of these plants by competing with them for space, light and water. With reduced reproductive output there can be an incremental decline in the abundance of those natives. This impact appears to have consequences to trophic relationships; small rodents and harvester ants both eat seeds, but usually avoid competition by dividing seed resources by size. When Sahara mustard dominates, its seeds are essentially the only resources available to seed eaters. We have seen evidence that harvester ant-rodent competition results. This then has implications to populations of ant-eating specialists such as horned lizards. The flat-tailed horned lizard is a focus of conservation efforts in the Coachella Valley (Barrows and Allen 2010). Their numbers have declined concordant with the repeated mustard outbreaks.

Another concern is the infestation of the mustard into the active dunes resulting in increasing stabilization. Many dune endemics require active (not stabilized) dunes. Where the mustard has invaded the active dunes these species are in decline. Sahara mustard is of great concern to managers of the Coachella Valley Multiple Species Habitat Conservation Program, Anza Borrego State Park, Lake Mead National Scenic Area, Joshua Tree National Park and all low desert managers. This research provides these managers with a clearer knowledge of the mustard's impacts to the mission and objectives for each of these managers. With this knowledge choices can be made as to when to marshal the resources to fight this pest. We are passing along our results through regular meetings and sending managers copies of our research results.

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## Impacts of California's Invasive Plant Species on Invertebrate Fauna: A Review

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In order to effectively manage invasive plants in California, it is essential to understand each species' ecosystem-level impacts. An important component of those impacts is effects on higher trophic levels, including invertebrates. Acting as pollinators, decomposers, herbivores, predators and prey, invertebrates are critical to ecosystem function. In order to investigate the effects of California plant invaders on invertebrates, all available Cal-IPC Plant Assessment Forms were reviewed (197 species); this information was supplemented with additional published and unpublished studies when available. Only 25% of these California invasives had any invertebrate information available. Of those 49 species, observed impacts appear to be negative for 57%, positive for 18% and both negative and positive for 20%, while there was no apparent impact for 4%. The source of these assessments varied widely, however, from general observations that the species attracts pollinators or is toxic to most organisms, to more comparative or experimental studies. Fifty-four percent of these determinations were from "other published material," while 31% were from reviewed, scientific publications and 15% were from unpublished observations. When results are restricted to scientific publications, 13 of 15 species (87%) showed negative impacts, versus one positive and one no impact. Examples and recommendations will be given.

# Invasive Plant Impacts to Wildlife

## Effects of an Exotic Herbaceous Perennial, *Cynara cardunculus*, on Small Mammals and Songbirds

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### Abstract

Artichoke thistle, *Cynara cardunculus*, has invaded 283 ha at 1583 ha Starr Ranch. Experiments indicated a non-chemical control method that reduces thistle cover by 95% after one season. To understand how thistle control and subsequent coastal sage scrub (CSS) restoration affect wildlife populations, we monitor small mammals and songbirds throughout the process. In 2004 we selected an artichoke thistle-dominated site and a matched pristine CSS site (for size, elevation, aspect and slope). During the wet and dry season annually since 2004 and ongoing, we trap small mammals over three consecutive nights and do songbird point counts in each site. We also spot-mapped songbirds in 2006 over a restoration chronosequence from baseline artichoke thistle-dominated through the sixth season of restoration. In 2010, we trapped small mammals in four sites of increasing restoration age. Results indicate that artichoke thistle-dominated sites are relatively poor habitats for wildlife. In point count results, the pristine CSS site had 55% higher songbird species richness than the matched thistle-dominated site. Spot mapping data indicated an increasing trend in songbird species richness over the chronosequence from baseline through year six of restoration. Small mammal species richness was 83% lower in the artichoke-thistle dominated site compared to the matched pristine CSS site. In small mammal chronosequence sampling, artichoke thistle-dominated sites had the lowest richness (two species) and numbers of captures (one) compared to four sites of increasing restoration stage (2 – 3 species; 3 – 19 captures). Our results support implementation of restoration soon after exotic control for native wildlife recovery.

### Introduction

Coastal sage scrub, a vegetation type found only in southern Alta and northern Baja California, is an imperiled habitat in semiarid southern California. Coastal sage scrub (CSS) restoration at Starr Ranch begins with non-chemical control of the exotic herbaceous perennial, artichoke thistle (*Cynara cardunculus*), which has invaded approximately 283 ha of native and degraded grassland stands at Starr Ranch. Native shrubs also colonize grasslands. A series of experiments led to a successful non-chemical method of artichoke thistle control (DeSimone 2006) through regular and repeated cutting away of all photosynthetic surfaces (every three weeks during the growing season the first year of treatment, then widened treatment intervals in subsequent years depending on rainfall) and, after one season, thistle is reduced by 95% per site (i.e. stand). During the second year of thistle control, we begin the scrub restoration process. Five of six sites monitored since 2001 reached 60% total native cover by the end of the third year of restoration. To approach an ecosystem level understanding of effects of artichoke thistle control and subsequent CSS restoration, we initiated long term studies to examine effects of our work on songbirds and small mammals.

### Methods

The study site is Starr Ranch, a National Audubon Society sanctuary located in the foothills of the Santa Ana Mountains in southeastern Orange County, California (33° 37', 117° 33'). The climate is mediterranean with 360 mm mean annual rainfall, most of which falls from December to March. Vegetation is distributed in mosaics of oak and riparian woodlands, chaparral, grassland and CSS typical of lower elevations (< 500 m) in southern California. Coastal sage scrub occurs most often on steeper slopes adjacent to grassland or on less northerly aspects adjacent to chaparral. Cattle grazing at Starr Ranch ended in 1963. In late October 1993 fire burned about 10% of the study site; two earlier fires, in 1958 and 1980, each burned >90% of the Ranch.

Songbirds were monitored using two techniques. In spring 2006 we did spot mapping over a "chronosequence" (substitutes space for time in studying temporal dynamics when long term studies aren't possible or efficient) from baseline thistle-dominated through increasing age since initiation of thistle control and restoration. During spot mapping, we observed songbird presence and behavior in fifteen sites: five restoration sites from baseline through sixth year restoration; each matched for size, aspect and slope with one thistle-dominated (>50% thistle cover) and one pristine CSS site. For long term studies, we chose pairs of sites matched for size, elevation, slope and aspect – one restoration site matched with a pristine CSS site. Songbird point counts have been done in these sites since 2004 in fall, winter, spring and summer, and are ongoing. Here we present data from one set of matched paired sites.

Small mammal trapping is ongoing and long-term in the aforementioned matched pair sites and also, in late winter 2010, over a restoration chronosequence of thistle-dominated through sixth year of CSS restoration. We set out trapping grids with 4 m spacing between traps (n = 33). Traps were placed 5 – 10 m from adjacent habitat edges. We placed traps unopened the day before trapping began then opened the next evening and trapped for three consecutive nights. In the long term study we sampled once in dry season and once in rainy season. We don't trap within three days of a full moon since previous southern California research indicates strongly that small mammal activity patterns change.

## Results and Discussion

There were many challenges in the course of this study. Though thistle control reduces cover by 95% per site in one season, restoration success is highly variable and parallels the unpredictable timing and amount of annual rainfall. Additionally, vegetation mosaics contribute to small habitat patch sizes and CSS is a very fragile habitat.

Songbirds are useful indicators of weed control and restoration success since they are easily detected and readily distinguished to species level. Songbirds provide useful information about ecosystem function since they have fairly specific habitat requirements, expend high levels of energy and are high on the food chain. Data on songbirds are widely comparable due to standardized field methods; however, songbirds respond to the environment at multiple spatial and temporal scales and, thus, may be strongly influenced by factors outside any one study area (Golet et al.2008). Over the chronosequence from thistle-dominated through sixth year CSS restoration, spot mapping indicated a trend of increasing species richness (Figure 1). In data from long term point counts in matched restoration and pristine sites over time we observed species from first year restoration not present in thistle-dominated sites: coastal cactus wren, California towhee, golden-crowned sparrow and California thrasher. In later (4th and 5th seasons) restoration stages only the rufous-crowned sparrow and lazuli bunting, both birds of pristine CSS, were recorded.

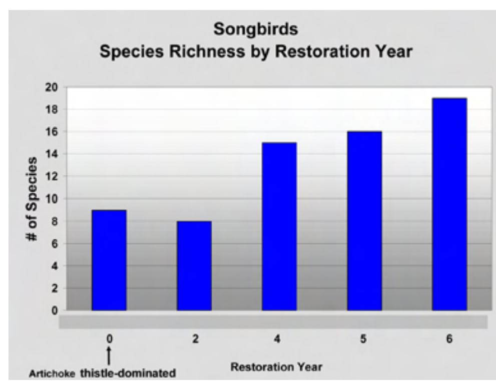


Figure 1

Songbird species richness from spot mapping observations during breeding season 2006. Observations were made over a chronosequence consisting of one site per "restoration year," from baseline artichoke-thistle dominated through sixth season of restoration.

Small mammals can exert strong influence on vegetation patterns in southern California (DeSimone and Zedler 1999). However, small mammal abundances are highly variable (Anderson et al. 2000). In the matched sites, we used surface tilling in the restoration site to control artichoke thistle the first year of treatment so that earliest trapping there yielded no captures (Figure 2). We detected a trend of increasing small mammal species richness as the restoration site progressed (Figure 2). Data on numbers of captures in the pristine site showed the extreme cyclical nature of small mammal populations since there was variability within one season and between years; however, in the matched restoration site there was a trend of increasing numbers of captures as CSS restoration progressed. In later restoration sites composition shifted. A species of open habitats, the California vole, was the only species captured in the artichoke thistle-dominated site during drier years in grassy areas between thistles (six individuals). By the third restoration season, we captured species typical of CSS: brush mice, which are semiarboreal and need high vegetation cover, California pocket mice and California mice. Cactus mice and desert and dusky-footed woodrats were very common in the pristine site; our goal, as shrubs grow and expand in the restoration site, is to bring in these species.

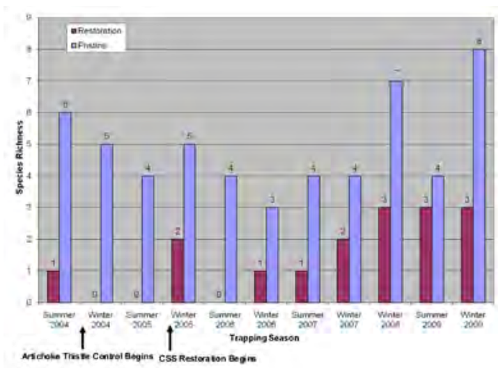


Figure 2

Species richness results of small trapping in two matched paired sites, one pristine coastal sage scrub and one restoration site monitored over time. The restoration site was monitored from baseline artichoke-thistle dominated through fifth season of restoration. Sites were matched for size, elevation, slope, and aspect.

Results from chronosequence sampling showed small mammal abundance and richness were higher for all restoration sites compared to thistle-dominated site levels but lower than pristine sites. Our oldest restoration site (sixth year), was only trapped for one night due to gray fox trap depredation, so results from this effort are incomplete. Nevertheless, we identified at least two species not detected in "younger" restoration sites and which are common in pristine sites (California mouse and two woodrat individuals not identifiable to species). Our results suggest that small mammal populations respond positively to CSS restoration efforts and that sites at later restoration stages may harbor a similar small mammal community that matches pristine sites. Our results generally support implementation of restoration soon after exotic control for native wildlife recovery.

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## Controlling the Invasive Offspring of Historic Olive Trees on Santa Cruz Island, Channel Islands National Park

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Santa Cruz Island, the largest of the islands in Channel Islands National Park, is home to many endemic and rare plants and animals. However, the vegetation has been highly altered during the past 150 years by introductions of non-native species. For example, European olive (*Olea europea*) was planted during the late 1800's as part of an island-wide ranching operation. The olive orchard is now a contributing element to the cultural landscape. In the past 100 years, olive seeds have dispersed throughout the island. Native plant communities, recovering from years of overgrazing by feral sheep and pigs (which were removed during the past two decades), are now threatened by the spread of aggressive olive trees. Data will be presented on the time and cost required to control olives in recovering native plant communities. A range of options for managing the spread of historic olive trees also will be discussed.

## The Bay Area Early Detection Network (BAEDN)

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Control and eradication of invasive plants is a high priority for land and water management agencies across the San Francisco Bay Area. Paired with prevention, early detection and rapid response (EDRR) to invasive plant outbreaks represents the highest level of environmental protection against the threats of new invasive plants and the impacts of controlling them. Early-stage detection and treatment of invasive plant infestations – when they are small and prior to long term establishment – greatly increases treatment efficacy and return-on-investment (yielding a cost-to-benefit of $17-$34 for every $1 invested [Cusak 2009]) and greatly reduces ecosystem damage, treatment impacts (physical, biological and chemical), and financial costs.

In recognition of the value of early detection and rapid response to invasive plant outbreaks, numerous land management agencies across the San Francisco Bay Area have independently adopted early detection and rapid response resolutions. Invasive plant introductions and dispersal stretch across jurisdictional boundaries, preventing any single land-management agency from effectively tackling the problem alone. Given the interconnectedness of landscapes, corridors and disturbance and invasive plant dispersal vectors, coordination at a regional scale is needed to best manage early detection and rapid response programs.

The Bay Area Early Detection Network (BAEDN) was formed in 2006 to meet the regional need for coordinated regional early detection and rapid response across the nine-county San Francisco Bay Area. The BAEDN provides critical early detection coordination, expertise, equipment and funding to a burgeoning partnership. By contributing to and receiving information at the regional level, partners gain a clearer understanding of species distributions and can act more strategically. In sharing resources, partners also receive economies of scale with resources, training and technical support.

### Bay Area Early Detection Network's Scope:

- Identify the invasive plant species that most threaten the San Francisco Bay Area and promote a list of these detection targets
- Provide a user-friendly online database that standardizes reporting and tracking of priority invasive plant species
- Develop detection protocols and reporting guidelines; promote recruitment and training of citizens and in the use of these tools
- Prioritize occurrences for eradication; provide eradication recommendations to responsible land managers; and provide assistance to ensure eradication of prioritized occurrences
- Provide scalable templates for adoption by other regional Early Detection Networks and encourage the establishment of coordinated networks serving every region of California

### Support the Bay Area Early Detection Network!

1. Report non-native plant occurrences and/or upload entire datasets to the Calflora database
2. Join or start a "Weed Watcher" volunteer invasive plant detection program
3. Subscribe to the BAEDN partners listserve for BAEDN announcements
4. Register your organization as a BAEDN partner
5. Contribute your expertise for weed evaluations, training, fundraising, etc.

For more information and contacts visit www.BAEDN.org

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## Simulating Avian Weed Spread and Control Strategies: A Simulation Model of *Rhamnus alaternus* on Rangitoto Island, New Zealand.


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### Abstract

Large complex invasions are often both difficult to understand and quantify. Surveying such invasions, if possible, can be costly and may not necessarily provide the information required to successfully and efficiently manage them. Variables that affect both invasive spread and management when viewed or analyzed across landscape structure can greatly improve the understanding and management of such invasions.

A simple, individual-based, bottom-up, mechanistic, simulation model based on discrete time and space was built using cellular automata theory. It was used to characterize the avian spread of the invasive plant *Rhamnus alaternus* and evaluate the effectiveness and efficiency of different control scenarios across the contextually rich, ecologically important Rangitoto Island in the Hauraki Gulf, Auckland, New Zealand.

The model has captured the variable environmental patterns that influence both the spread and management of this invasion and has led to the adoption of the best strategy for implementation of the program. The model is an example of the assessment and application of modeling and invasive spread research, to practical management and implementation of a complex invasive issue, within a complex natural environment.


### Introduction

Weed invasions are often large, complex and evident across a range of landscapes and habitats. Simple interactions between plants, animals, climate, landscape, time and space produce complex patterns that are difficult to fully understand, particularly over vast areas that are too large to implement traditional weed surveillance techniques.

*R. alaternus*, also known as evergreen buckthorn or Italian buckthorn, is an evergreen, dioecious tree, imported into New Zealand as an ornamental plant. It invades both older and younger forests on Rangitoto Island and competes with native vegetation forming dense stands. The unique succession of species that clothes bare lava with thick dark Metrosideros excelsa is compromised. The invasion encompasses approximately 400 hectares.

A simple, individual-based simulation model based on discrete time and space was built to recreate the invasion of *R. alaternus* on Rangitoto Island. The model was then used to determine the extent of different invasion zones and the control effort required for each landscape patch. Control scenarios were then incorporated into the model and implemented through time to determine the most effective strategy to reach the control threshold with the least control effort expenditure.

## Methods

A model was built on a cellular automata platform using a satellite image to capture and classify spatial landscape structure. The spatial resolution used was 400 m²/pixel. Each patch or pixel within the landscape was given variables for forest-density, *R. alaternus* reproductive rate, growth rate and patch-capacity. Variables were based on landscape classifications, field data and previous literature.

Plants were placed within the model at locations where the highest known densities on the island are found, the assumed origin of the invasion. Each time step (one year) plants grew. Once individual plants matured (dependant on their age and habitat) and were close enough to another mature plant to breed, "isolates" were dispersed according to their dispersal kernel, which was based on habitat type, in a random direction.

If the establishment site is a habitable patch the "isolate" germinates. The plant remains an "isolate" until another plant establishes within 200 meters and pollination takes place when both plants reach maturity.

To determine the best control strategy the study area was computationally classified at the end of each time step into three subsets (invasion front, stratified and long distance dispersal areas) following each annual dispersal event. This allowed specific parts of the invasion to be targeted to test for control efficiency. The patch variables and invasion subset parameters were used to compute control effort required for each cell.

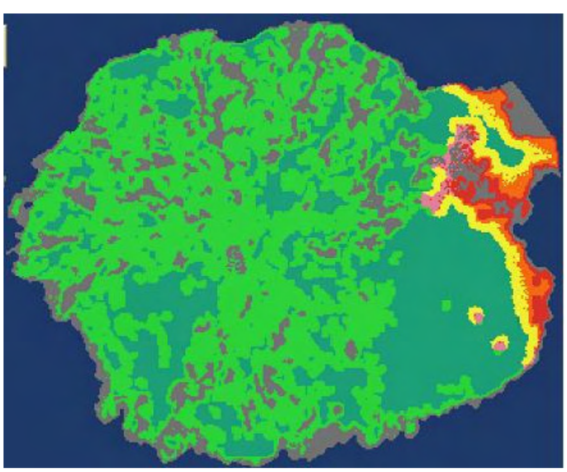

Figure 2

Invasion subsets are computationally divided into the front (red and orange), stratified (yellow and pink) and long distance (greens) zones.

Nine strategies were run through the model. Each selection compiles a list beginning with the top priority grid cell and finishing with the lowest priority grid cell of each control strategy. The patches within the list were systematically cleared of *R. alaternus* until the specified control effort budget was reached. The model runs until no viable populations remain. By comparing the different strategies over time and reducing the control effort used each model run, the most effective strategy was defined by the shortest time to control the infestation to the threshold level of no viable populations while utilizing the lowest control effort.

## Results and Discussion

The simulation model appeared to provide a realistic representation of the observed invasion. Experimentation with different dispersal kernels and other variables in consideration of the current literature and known locations proved to be the best means to judge the success of the model.

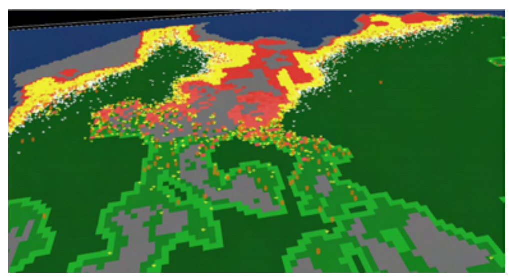

Figure 1

The *R. alaternus* spread is strongly affected by habitat and landscape structure.

The most obvious factor determining the pattern of spread was habitat structure formed by different aged forests. The shorter maturation rate, faster growth rate and higher dispersal distances in open, younger forest types, on older forest edges and vegetation islands isolated by lava favors conditions for faster spread, a higher total population and establishment of "isolates" further from the parent plant.

The mosaic vegetative landscape structure also had a large influence on invasion velocity. Spread was rapid where vegetation islands and forest edges comprised the majority of the landscape. Again this was largely attributable to the factors already mentioned but also confirms fragmentation plays an important role in invasive spread.

Due to the dioecious nature of *R. alaternus*, the density dependence factor of requiring two mature plants to be within 200 meters of each other before pollination was likely imposed a limiting factor on the invasion. This restriction resulted in many isolated plants within the long distance dispersal zone never getting the chance to reproduce.

A fundamental condition for weed control to be successful is that the rate of weed removal is greater than the rate at which the population is increasing (Panetta and Timmins 2004). When the control effort was set to 5000 labor units within the model, five of the eight strategies failed to meet this basic requirement. The control effort was further lowered until the best strategy had been isolated.

The third best strategy focused control on the younger outlying infestations (stratified zone) through to the older higher initial populations (front) regardless of forest type. This strategy best resembles that proposed by Moody and Mack (1988) and was deemed to be unsuccessful after further lowering the control effort because it restricted the invasion but failed to make positive progress. The second best strategy represented the opposite of that proposed by Moody and Mack (1988) targeting the older initial

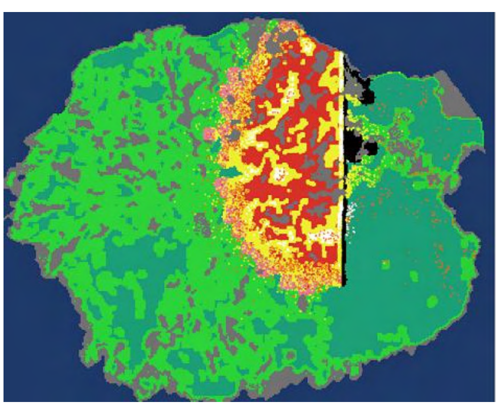

Figure 3

Control effort is expended (black) in this strategy from what was the front of the invasion towards the stratified zone. This strategy failed to halt expansion of the invasion into new areas at this level of control effort.

populations (front) through to younger outlying infestations (stratified zone). When the control effort was lowered further the invasion expanded rapidly from the stratified zone as predicted by Moody and Mack (1988). The most successful strategy at controlling the invasion and the one that has been adopted for this project, targets the stratified then frontal zones of the invasion within younger forest, edges and vegetation islands followed by the targeting of the frontal then stratified zones within the older forests.

This suggests that when landscape or habitat structure has a high influence on invasive spread or control effort or when resources are limited as is often the case, a different approach to managing invasive plants is required than has been suggested in the literature. Aspects of a weed's demography and habitat need to be analyzed to determine weaknesses and strengths of the species so that they may be used for efficient control.

Weeds exist in all shapes and forms, utilize different dispersal mechanisms, differ in demography and occupy a huge range of environments with different landscape and habitat structure. Universal models of weed spread that do not take these factors into consideration will have limited use because they will not be context specific and will therefore fail to address the important relationships that exist and determine the nature of the spread.

This model supports Higgins and Richardson (1996) who promote the use of individual-based cellular automata simulation models utilizing discrete space and time and allowing the incorporation of stochasticity and spatial heterogeneity, which are essential to simulate flexible environmental patterns. It also supports Kean at al. (2003), who suggest that interactions between habitat suitability, population demography, dispersal and disturbance (including management) are important. All these factors were incorporated into the model and had a large influence on the observed pattern of spread.

The effects of spatial pattern and landscape were suggested to be important to invasive spread by With (2002). This model supports this view where the landscape pattern affected the characteristics of the invasion through its effect on dispersal, growth, and reproductive success.

The strengths of the model are:

- it is context specific
- it is discrete in space and time

- the dispersal kernel is based on vector behavior
- it includes plant demography and habitat relationships
- it includes landscape structure and
- it is able to include management scenarios

These factors are essential if a simulation model is to account for environmental flexibility and be of use in real world situations.

The structure of the model could be modified to model other plants with different demography, dispersal vectors and in different environments. The key to achieving this will be in the representation of capturing the real world and the key relationships that occur between the participating organisms that determine the very nature of invasive spread.

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# Grazing, Weeds and Wildlife

## Targeted Grazing for Weed Control and Wildlife Management

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### Abstract

Livestock grazing can provide many services beyond the production of food and fiber when grazing is managed to achieve specific vegetation or ecological objectives. Targeted grazing is a term used to describe highly managed grazing regimes that are strategically applied to produce specific impacts on vegetation and consequently other ecosystem components. Such grazing regimes are used to manage weed populations, fire fuels, plant community composition, water quality and wildlife habitat. Desired grazing impacts are accomplished by manipulating several grazing parameters that describe and define the type of grazing system applied. These grazing parameters are generally well understood by targeted grazing practitioners, but it is important for people making rangeland management decisions to understand these parameters in order to plan effectively and communicate grazing management decisions to others.

The primary grazing parameters that are manipulated to achieve desired results are livestock density, grazing duration, timing of grazing and the type of animal. Livestock density, expressed as the number of animal units (AU) per acre, can be changed to influence grazing selectivity. The duration of grazing will vary according the livestock density, the amount of vegetation and the desired amount of vegetation utilization. Timing of grazing may be planned for specific seasonal conditions or for a plant's phenological stage. The type of livestock is chosen based on the type of vegetation that needs to be manipulated or, as is often the case, what is available. These grazing parameters are used in conjunction with ecological parameters to determine appropriate and targeted grazing applications.

### Grazing Versus No Grazing

Livestock grazing can be a contentious and volatile issue for people with very strong beliefs about the positive and negative impacts grazing can have on an ecosystem. Ironically, it seems people at each end of the grazing debate are ultimately seeking the same outcome from their management philosophy, which is a healthy ecosystem that sustains ecosystem functions and services. Given this common goal, there should be some middle ground to work through the issues and rhetoric. Unfortunately we have endured several years of cantankerous accusations and poor management decisions from both extremes resulting in over and under-grazing situations with negative ecological consequences. Despite the vitriol, there have been moves to the middle and acknowledgements of the errors to each argument. Moderating attitudes have both resulted from and precipitated interesting research addressing appropriate grazing practices that achieve ecological benefits.

In 2006 the Society for Range Management, California-Pacific chapter hosted a symposium titled Grazing for Biological Conservation. Several research projects were presented describing how specific types of grazing regimes on California grasslands were found to produce biological benefits, including increases in native plant diversity and abundance (Hayes and Holl 2006), vernal pool function (Marty 2005), protection of federally listed small vertebrates in the San Joaquin Valley (Germano 2006), increased lizard abundance (Bell and Riensche 2006), improved habitat for tiger salamanders and California red-legged frogs (DiDonato 2006) and increased use by native songbirds (Gennet et al. 2006). These projects and others are demonstrating compatible and ecologically beneficial uses of well managed livestock grazing.

## Defining Grazing

An essential element to any effort aimed at identifying appropriate grazing practices is a precise and universal definition of grazing. Different grazing applications can produce wildly different results making precise definitions of grazing necessary to communicate and reproduce successful practices and avoid damaging practices. A universally accepted way to define grazing is through the use of animal units (AU), which is a measure of forage consumption. One animal unit is equal to the amount of forage consumed by one cow weighing 1,000 pounds. Cattle and other species of livestock of different sizes are expressed as animal unit equivalents, for example one sheep is often considered 0.2 AU, which makes five sheep equal to one AU. Forage supply and offtake are often expressed as animal unit days (AUD, 26 pound of dry matter), or animal unit months (AUM, 780 pounds of dry matter). If a 1,000-pound cow grazes an area for six months, the amount of forage offtake is 6 AUMs. Forage supply or carrying capacity can be expressed as the number of AUMs per acre per year and defines the amount of forage that is available in an annual cycle. Chapter 11 in Vallentine's book *Grazing Management* (2001) provides a very clear description of animal units and the animal unit equivalents for many species and sizes of livestock.

Vegetation management objectives will largely determine the grazing management regimes that are applied. Grazing regimes and their impacts can vary greatly depending on several grazing factors that are manipulated to achieve specific results. Livestock density (AU per acre) and the duration of grazing are the primary grazing variables that can be manipulated to generate desired impacts on vegetation. Generally, a low stock density is associated with a long duration of grazing and a high stock density with a short duration of grazing. A high stock density will result in a more uniform impact on the vegetation by reducing livestock selectivity and by evenly distributing forage consumption and hoof impact. Longer periods of grazing that result from low stock densities will result in selective grazing and an uneven or patchy impact. Stock density and the duration of grazing are combined to describe the stocking rate or the amount of grazing on a specific area over a period of time. Stock density alone only provides a snapshot of information at any one time and doesn't convey much more information without a reference to an amount of time. For this reason, AUD and AUM are commonly used along with a time period to describe the stocking rate. A stocking rate of one AUM per acre per year indicates that one acre of land supports one animal unit for one month or thirty animal unit days during a one-year period. There are many ways to accomplish a stocking rate of 1 AUM per acre per year:

- Grazing 1 AU for 30 days on 1 acre during the year
- Grazing 1 AU for 60 days on 2 acres during the year
- Grazing 100 AU's for 180 days on 600 acres during the year
- Grazing 30 AU's for 1 day on 1 acre during the year

Each grazing regime results in the same stocking rate, but with very different stock densities and durations of grazing and most likely with very different impacts on the vegetation. The timing of the grazing event(s) will also affect the impact since animal preferences for specific plants and parts of plants change as plant quality changes throughout the year.

Grazing for specific vegetation management purposes is usually accomplished with cattle, sheep or goats. The type of animal used depends on the type of vegetation that must be managed and vegetation that should not be disturbed. Cattle and sheep are classified as grazers, meaning they are less selective in their dietary preferences as compared to goats, which are classified as browsers (Van Soest 1982). This classification only generally describes how some herbivores interact within their nutritional environment. Generally, grazers are better at consuming a poorer quality diet of more mature grasses and forbs while browsers are often better at selecting only the best and most nutritious parts of grasses, forbs and woody plants. As an herbivore's environment changes temporally and spatially, so too will its behavior in an effort to meet its nutritional needs, causing dietary overlap between browsers and grazers.

The grazing variables (stock density, duration of grazing, timing of grazing and type of animal) are planned and manipulated to achieve specific vegetation management objectives. It is critical to also consider vegetation conditions, water availability and livestock production objectives that will interact with on-going grazing management decisions. These are real and pressing factors that livestock producers use in an adaptive management style to base their daily management decisions. While established grazing guidelines provide a framework to achieve desired impacts, the ultimate success of a grazing event is largely attributed the art of grazing management that only comes from an experienced person.

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## Species Composition Changes, Habitat Effects and the Role of Livestock Grazing in Improving Recovery Potential for Ohlone Tiger Beetle in Santa Cruz County, California


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### Abstract


Invasive plants contribute to habitat quality decline for wildlife species (DiTomaso 2000). In spite of this, few studies focus on management regimes applicable at large scale that can ameliorate invasive species impacts on specific wildlife species. The federally endangered *Cicindela ohlone* (Ohlone tiger beetle, "OTB") is threatened by vegetation encroachment, especially introduced grasses and forbs, within the narrow range of its distribution, within California coastal prairie (US Fish and Wildlife Service 2001). Whereas many despair about controlling invasive grasses and forbs in grasslands, managers responsible for this and other sensitive grassland species are adapting practices to address these species (Coastal Training Program 2005).

In these cases, it may be more possible to moderate impacts of invasive species rather than eradicate or reduce their frequency/abundance (Hayes and Holl 2003, Goerrissen 2005). Unfortunately, due to its cryptic nature, low population numbers and limited distribution, little is known

about the OTB. However, livestock may be useful for maintaining habitat necessary for restoring the OTB where prescribed fire, chemicals and mechanical treatments are not possible. Properly managed livestock grazing can modify OTB habitat by reducing exotic grass and forb cover, establishing and maintaining the bare ground that is necessary for the species and maintaining other desirable habitat structure traits.

The livestock impacts necessary for creating OTB habitat likely require frequent and intense grazing during the growing season (D'Antonio et al. 2004). Such management regimes are often avoided by conservation lands managers concerned with other objectives. However, these regimes may be necessary to effectively reduce impacts of exotic invasive species on this and other grassland species.

## Introduction

As recently as ten years ago, the topic of discussion here, grazing to control exotic invasive plants, would stir up dogmatic responses from even the well educated (Painter 1995). Fortunately, today, there are publications documenting the effectiveness of "targeted-grazing" and professional curricula on how to make less desirable plants more palatable to livestock (e.g., Pywell et al. 2010). What we describe here is not that topic. What we propose is to look at annual exotic plant modification of Ohlone tiger beetle habitat and effective tools to address this issue. The premise that livestock be part of a weed warrior's toolbox is more an issue of economics and effectiveness than a presumably easy solution to a complex challenge.

## Our Argument

The challenge for land managers is not in creating the habitat conditions suitable for wildlife with very specific habitat needs, but rather maintaining habitat conditions using limited budgets applied in continually changing environments. We understand that the war against early arrivals, such as wild oat, Italian ryegrass and many others, cannot be won if the goal is total eradication. This can be said for the state of California in general, but it would disingenuous, irrational and fatalistic to propose that no areas exist in the state where this goal might be achieved. The fiction of universal vegetation restoration breaks down very rapidly when examined on site-specific basis. When working at the scale of individual properties, we not only have biological considerations in mind, but we must also remain rational within the context of available tools and funds.

Habitat improvement for the Ohlone tiger beetle provides a good example. Every successful plan has a clear goal and specific objectives (Slocombe 1998, Cipollini et al. 2005). For the recovery of the OTB, the overall goal is to maintain habitat quality so that the species can complete its lifecycle and maintain populations through time (Knisley and Arnold 2004). The specific objectives needed to meet the first part of the goal seem fairly reasonable: clean and smooth bare ground of at least 0.2 square feet in association with relatively tall native perennial grass species.

The parameters of the habitat described here are not all encompassing or even well understood. As in most cases, the continual trickle of science-based information places managers in positions of needing to translate information into action as allowed by the specific planning environment. Consequently, our concept here of suitable bare ground for OTB habitat may be substantially different four years from now; this implies that the manager be both flexible and nimble, because time is running out for the OTB.

This beetle seems to be very particular about which soils are suitable for laying its eggs, which is, of course, where we want to create suitable bare ground. It seems that OTB is only associated with a few specific soil series. This fact immediately reduces the toolbox to extremely site specific parameters.

The tools available to help create the habitat conditions we want aren't much different than the tools we would apply to achieve any grassland management goals: fire, manual treatment, mechanical treatment and biological treatment.

Chemicals are usually part of the toolbox for addressing invasive plants, but, in this case, it isn't merely the presence and preponderance of undesirable species present but also the biomass these species produce that must be addressed.

Fire seems like a suitable approach. In fact, one of the sites with the highest OTB concentrations had repeated prescribed burns in conjunction with firefighter training. But, the training program was discontinued and OTB numbers rapidly declined. Still more unfortunate, across the range of the OTB, between site constraints, weather factors and air quality considerations, actual implementation of even occasional burns is unpredictable, making fire an important but largely inaccessible tool for consistent biomass reduction (Riebau and Fox 2001).

Manual and mechanical treatments allow for a high level of control of invasive species. At least it seems that way until the timing is off or until the money runs out. Even so, limited scale applications of mowing, weed-whacking and/or clipping show promise in reduction of standing material. Naturally, these methods must also incorporate measures to reduce the amount of loose litter which ultimately degrade the habitat – clipping material into small pieces during the growing season to facilitate decomposition seems to hold promise (Hayes, unpublished data). Needless to say, mechanical and manual treatments from a long-term perspective are comparatively an expensive proposition.

Biological treatments are often referred to as biological control. In this case, we are considering biological control of site conditions. For the purpose of OTB habitat improvement, our tool of choice is the common Bos taurus for several reasons. Active OTB sites are frequently located where cattle are grazing, creating suitable bare ground. Other species of grazers may also have similar effects, but, as of yet, there is no indication of similar overlap between active OTB sites and grazing by livestock other than cattle; this is likely due to the limited diversity of livestock within the range of OTB.

Where active OTB sites occur in conjunction with cattle grazing, the most obvious effect is that of trailing. Most trails are not continuous either spatially or temporally, but the effect of cattle grazing in open grassland during the early growing season tends to establish smooth compacted areas which oftentimes are predictable in their locations.

As we can see from numerous examples, the toolbox may be larger than we may initially assume. Grazing is but one tool we emphasize here, but as we all know there is never is a one-size-fits-all tool. We need to size up the problem, consider what we are willing to accept in terms of success and effort exerted and apply the tool that fits the need. But we need to be careful about our assumptions.

Rancher Chet Vogt is fond of advising: "Grazing is not grazing is not grazing. A cow or a sheep is like a gun or a hammer, it is a tool to an end, but it can't be used for every job and it certainly can create problems if used the wrong way." Chet proposes that it is not grazing, but the kind of grazing that dictates the results. A flexible grazing strategy based on achievable goals and rational objectives is critical to the success of any scenario where we consider using livestock as a tool. Otherwise, the unintended consequences may be all that is left of what may have been initially a "great idea." Controlling the timing, the class of animal, animal distribution and applying an appropriate stocking rate are all critical elements to address the goals and objectives of an effective plan (Sotoyome Resource Conservation District 2008).

## Conclusions

Too many of us are abandoning the notion of manipulating habitat structure in annual grasslands and a host of other ecological sites heavily modified by invasive plants. As society gains better understanding of ecosystem dynamics and develops rational goals for management, we can find ways to maximize native biological diversity within invaded landscapes. The answers may not be readily apparent and the problems not obvious, but it is the persistence of collaborative efforts that leads to new discoveries about limitations and flexibility at the site-specific level. The future looks a little brighter for the OTB and many other species; this is because we refuse to surrender to presumably impossible circumstances and erroneous blanket assumptions.

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# Variable Responses of a California Grassland to the Reintroduction of Tule Elk

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Although large mammalian herbivores are known to have had large effects on the ecology and evolution of terrestrial plant communities, many of these populations have been dramatically reduced or extirpated from their pre-historic ranges due to hunting and other human-caused alterations to the landscape. Over the last century, there have been many successful reintroductions of mammalian herbivores throughout the world. However, these herbivores are often returned to sites that are no longer pristine, having been grazed by cattle and invaded by exotic plants. One such herbivore is tule elk (*Cervus elaphus nannodes*), which was on the brink of extinction 150 years ago, but now has several stable populations throughout California due to successful conservation and reintroduction efforts. Here, we summarize results from a five-year exclosure experiment that explores the effects of reintroduced tule elk populations on a northern California coastal grassland community. Our results indicate that the reintroduction of elk increased plant species richness and abundance, with these effects due primarily to the responses of both native and exotic annual species, rather than perennials. Elk did not significantly alter shrub cover, although this may have been due to the slow response time of woody species and the duration of this experiment. However, we found that elk promoted the successful establishment of *Lupinus arboreus* seedlings, a native shrub that is known to have large effects on soil nitrogen availability and community composition. We also found that the exotic grass, *Holcus lanatus*, experienced reduced levels of elk herbivory when associated with the native shrub, *Baccharis pilularis*. In summary, our work shows that while tule elk have positive effects on the native species composition, this comes at the cost of increasing the richness and abundance of the exotic taxa in the community.

# Habitat Restoration

## Patch-Level Treatment Monitoring: An Invasive Spartina Project End-Game Strategy

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Regional control coordinated by the San Francisco Estuary Invasive Spartina Project (ISP) has reduced the cover of invasive *Spartina* populations in the Bay Area by 85% since the height of the infestation in 2005. As control progresses and native plants revegetate, locating and identifying the last remaining patches of invasive *Spartina* becomes much more difficult, even for treatment crews and monitoring staff with years of experience. Beginning last summer, ISP field biologists began working with treatment crews in the field, using GPS units to relocate and record the treatment of each individual remaining *Spartina* patch in a few select sites. This trial was so successful that the ISP doubled its field staff in 2010 so as to scale-up patch-level treatment monitoring to many more sites. In this presentation I will review how we achieved an 85% reduction in invasive *Spartina* cover in four years and how we are using patch-level treatment surveys to help us reach our goal of invasive *Spartina* eradication.

## Pacific Gas and Electric Company's Use of Safe Harbor Agreements to Enhance Habitat for Endangered Species in the San Francisco Bay Area

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### Abstract

Since 2008, Pacific Gas & Electric Company (PG&E) has implemented two Safe Harbor Agreements (SHA) with the US Fish and Wildlife Service (Service). SHAs contribute to species protection and habitat enhancement while balancing certain land use activities, such as ranching, mining, timber harvesting or in PG&E's case operations at critical utility facilities. Typically a SHA is between the landowner and the Service assuring the landowner that no added restrictions will be imposed as a result of carrying out activities expected to provide a net benefit to protected species. In Contra Costa County, PG&E is partnering with the Antioch Dunes National Wildlife Refuge (Refuge) to protect and enhance the quality of critical habitat for three endangered species: Lange's metalmark butterfly, Antioch Dunes evening primrose and Contra Costa wallflower. The approved SHA allows PG&E to use herbicides and equipment to reduce invasive plants near listed species. PG&E is also partnering with the Service and the Silicon Valley Land Conservancy (SVLC) to protect and enhance habitat for the threatened bay checkerspot butterfly on Tulare Hill in Santa Clara County where PG&E maintains transmission lines. This SHA incorporates cattle grazing as a management strategy to reduce invasive grasses and enhance endemic serpentine plants that provide nectar for the butterfly.

### Introduction

PG&E's large service area supports a very diverse and sometimes legally protected flora and fauna that can be affected by the maintenance of utility facilities. The Federal Endangered Species Act provides several methods for authorizing incidental take of listed species resulting from otherwise lawful activities. On private lands the Habitat Conservation Plan is the more often used method. A lesser known method, the SHA, provides legal protection to organizations that may impact protected species and habitat, while contributing to the conservation and net benefit to the protected species.

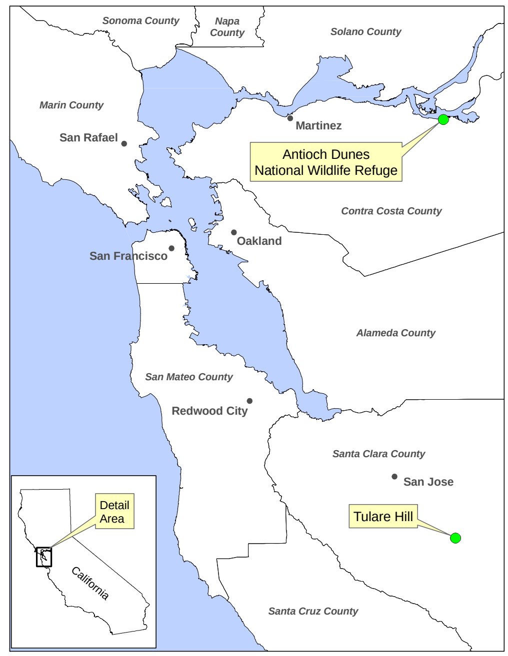
This paper describes how PG&E uses SHAs to manage its facilities in two sensitive habitat locations in the greater San Francisco Bay Area that support several rare and endemic species. In both locations, the control of invasive plants plays a key role in the implementation of these Agreements. In Santa Clara County, PG&E maintains five electric transmission lines on a 45-acre parcel on Tulare Hill. Tulare Hill supports the protected bay checkerspot butterfly (*Euphydryas editha bayensis*), Santa Clara Valley Dudleya (*Dudleya setchellii*) and the Metcalf Canyon jewelflower (*Streptanthus albidus* ssp. *albidus*). In Contra Costa County PG&E maintains two electric transmission towers that are adjacent to the Refuge. The Antioch Dunes properties support three protected species – the Lange's metalmark butterfly (*Apodemia mormo langei*), Antioch Dunes evening primrose (*Oenothera deltoides* subsp. *howellii*) and the Contra Costa wallflower (*Erysimum capitatum* var. *angustatum*).

Maintenance of the transmission towers at both locations includes vegetation pruning and removal and possible ground disturbance. These activities can potentially impact protected species. However, at both locations there are opportunities for performing conservation measures to enhance habitat quality.

## Study Sites

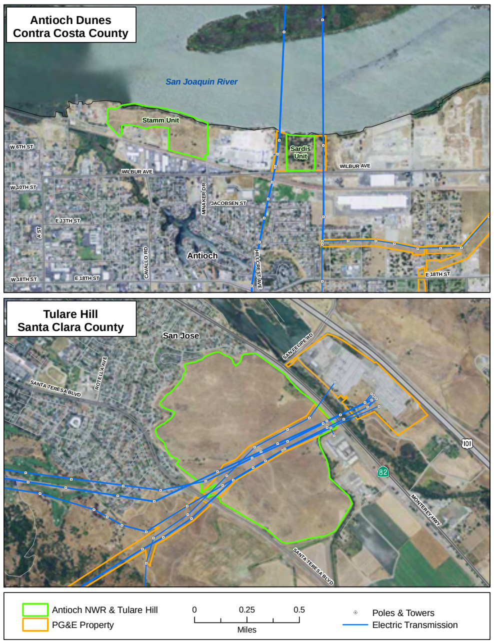
### Tulare Hill

The habitat on Tulare Hill is serpentine grassland and supports endemics including California plantain (*Plantago erecta*) and owl's clover (*Castilleja exserta*), the food plants for Bay checkerspot butterfly larvae. Santa Clara Valley *Dudleya* and Metcalf Canyon jewelflower are also found here. In addition to these endemic species, non-native grasses have also invaded Tulare Hill and displaced the butterfly's host plants (figures 1 and 2). Cattle grazing historically controlled non-native grasses allowing host plants to persist. In 2001, a third-party installed fence stopped the grazing on PG&E's property and on an adjacent parcel managed by the SVLC. This led to the expansion of non-native grass populations which reduced bay checkerspot host and nectar plants.




### Antioch Dunes

The 54-acre Antioch Dunes National Wildlife Refuge consists of two parcels of land known as the Sardis and the Stamm units. Flanking the Sardis unit are two smaller parcels, each approximately six acres and owned by PG&E to support electric transmission towers (figures 1 and 2). The endemic and rare species supported by the unique dune habitat are at some risk from facility maintenance activities and by invasive plants. In particular, tree-of-heaven (*Ailanthus altissima*), yellow starthistle (*Centaurea solstitialis*), Russian thistle (*Salsola tragus*), vetch (*Vicia* spp.) and ripgut brome (*Bromus diandrus*) pose a threat to the protected plants and the host plant for Lange's metalmark butterfly, naked stem buckwheat (*Eriogonum nudum* ssp. *auriculatum*).




## Methods

### *Safe Harbor Agreement*

The federal Endangered Species Act allows the Service to enter into SHAs with property owners to implement conservation measures for covered species. This is accomplished through a permit that authorizes implementation of conservation measures as well as incidental take of covered species. Baseline conditions are established for each of the covered species and following execution of the Agreement, periodic monitoring determines if the implemented conservation measures are working.

**Implementation at Tulare Hill**

At Tulare Hill, PG&E partnered with the Service and the SLVC to reinstitute grazing under a SHA in 2008 (USFWS 2008). The SHA allows PG&E to improve butterfly habitat through cattle grazing, while receiving regulatory protection against incidental take of protected species.

Baselines were established for each of the covered species. The bay checkerspot butterfly baseline was established with two measures. One measure is whether the property is grazed or not grazed. The other measure is based upon the vegetative cover for plant species that relate specifically to the life history of the bay checkerspot butterfly.

For the Metcalf Canyon jewelflower, because no individuals were detected during baseline surveys, the baseline was established at zero plants. For the Santa Clara Valley dudleya, surveys determined the baseline to be 1,000 plants.

Required annual monitoring includes plot photographs, bay checkerspot butterfly larval counts, adult counts, Santa Clara Valley dudleya counts with comparisons between grazed and ungrazed plots and Metcalf Canyon jewelflowers observed. The Agreement also requires cattle grazing to resume on the property to control non-native grasses.

**Implementation at Antioch Dunes**

The SHA for Antioch Dunes was implemented in March 2010 (USFWS 2010). SHAs allow for flexibility in the way a baseline is established. Because habitat conditions are directly affected by invasive plants, the baseline level for this Agreement was established in terms of the amount of invasive plants. Baseline cover values were established for all invasive plant species recorded during surveys in April 2008. The total cover value for invasive plant species was 81.8% and this value was adopted as the baseline for the Agreement that must not be exceeded. To reduce weed cover, PG&E is required to fund the eradication of tree-of-heaven plants and must hand pull weeds two times per year. Using volunteer groups from PG&E and from the local Weed Management Area, the hand-pulling effort focuses on removing winter vetch, yellow starthistle and ripgut brome. Monitoring will be performed in April of even-numbered years.

## Results and Discussion

Grazing was reinitiated on PG&E's Tulare Hill parcel and adjoining properties in June 2008, approximately two months following the approval of the SHA. Post-Agreement monitoring still shows much variation in survey plots of cover values for measured grasses and sensitive plants and does not yet show a clear trend.

At Antioch Dunes, the baseline established for the SHA was based upon invasive plant cover that was measured at 81.8% in 2008. Following the implementation of the Agreement in 2010 and subsequent weed eradication measures, the re-surveyed cover for invasive plants was 68.8%, a 13% decline. This decline was in response to targeting tree-of-heaven for removal and hand pulling of other invasive plants.

PG&E has received praise for enhancing wildlife habitat from regulatory and conservation organizations by implementing SHAs at Tulare Hill and Antioch Dunes. In general, much of the nation's current and potential habitat for listed, proposed and candidate species exists on non-Federal property. Conservation and collaborative stewardship efforts on non-Federal lands are critical for the protection of listed species and are important in preventing more species from becoming listed. Under a SHA, property owners voluntarily undertake management activities on their property to enhance, restore or maintain habitat benefiting federally listed species. SHAs encourage private property owners to implement conservation efforts for listed species by assuring that they will not be subject to increased restrictions if their efforts attract listed species or increase the numbers or distribution of listed species already present on their properties. PG&E finds the SHA to be a useful tool for ensuring compliance with species protection regulations, for enhancing habitat and for furthering partnerships with regulators and community stakeholders.

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## Preventing the Inadvertant Introduction of Invasive Argentine Ants During Native Plant Restoration Projects


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### Introduction

The Argentine ant, *Linepithema humile*, which has invaded most continents, is known to impact ecosystems by displacing native ant species and reducing the diversities of other invertebrates. In California, Argentine ants tend to be evenly distributed throughout urban and suburban settings, but are much more rare and patchily-distributed in open-space settings. This patchiness is probably due to Argentine ant dispersal biology: Because queens of the invasive form of Argentine ants do not fly, the main dispersal modes are budding (where they crawl to new sites) and jump dispersal (where they are transferred to sites via human-transported commerce).

Nursery stock has been named as one such commerce. Realizing that native plant restoration projects often involve the transfer of nursery stock to restoration sites, I asked the following questions: 1) What is the extent of Argentine ant infestations in native plant nurseries? and 2) What steps can nursery managers and restoration project managers follow to avoid inadvertently transferring Argentine ants from native plant nurseries during native plant restoration projects?

### Methods

#### *Argentine ants in native plant nurseries*

To study the extent of Argentine ant infestations in native plant nurseries, I searched for Argentine ants in ten native plant nurseries along the California coastline. If there were homopteran infestations on the potted plants, the Argentine ants were often visible as they foraged on honeydew secreted by the homopterans. At some nurseries, the ants had formed trails along dark crevices and underneath the nursery benches, spanning from the potted plants to homopteran infestations on landscaping plants surrounding the nurseries.

In most nurseries, I attempted to find nesting ants by removing the potted plants from their pots. However, this method proved unsuccessful unless I exposed the center of the root balls to air. One successful alternative method, which did not destroy the root-balls, was to submerge the potted plants in water. As the water rose through the soil of each potted plant, the ants escaped the water by flushing up and out of the soil. For each native plant nursery that I visited, I recorded whether I found Argentine ants and the time of year during which I conducted my search.

#### *Preventing transfers from nurseries*

To develop recommendations for nursery and project managers to follow in order to avoid inadvertently transferring Argentine ants from nurseries to native plant restoration sites, I developed draft recommendations based on what I knew about Argentine ant biology. I then iteratively refined, tested and monitored those recommendations through several efforts to implement the recommendations at restoration sites throughout California.

To estimate costs the costs associated with the recommendations, I tracked the number of the labor-hours and the cost of supplies required to implement the recommendations at one site (MidPeninsula Regional Open Space District 2010). To evaluate the effectiveness of the recommendations, I estimated the rate of ant infestation in the potted plants before and after implementation. This estimation was determined by submerging randomly-chosen potted plants in water until Argentine ants became visible or until the soil of the plants became completely drenched. Fifty plants were sampled before the recommendations were implemented and 64 plants were sampled afterwards.

### Results and Discussion

#### *Argentine ants in nurseries*

I found Argentine ants in nine of the ten native plant nurseries I searched. There was no season of the year during which Argentine ants were not found. The one nursery where I did not see Argentine ants had been undergoing intense treatment in order to control fire ants. The fact that nearly all native plant nurseries were infested was not surprising. Some nurseries occured near urban or suburban settings, where Argentine ants are known to be common. In addition, many of the nurseries were surrounded with landscaping plants--potential vectors for Argentine ant invasion. Also, most of the nurseries were characterized by moderate and consistent temperatures and consistent moisture, which Argentine ants are known to require. Finally, the potted plants were often characterized by soft, moist and well-drained soils, which are optimal for Argentine ant nesting.

#### *Preventing transfers from nurseries*

For most restoration projects, a quarantine/bait system (QBS) was necessary. However, because QBSs were sometimes cumbersome and not always necessary for all sites, it was important to determine whether a QBS is necessary by considering the following:

1) Are Argentine ants already at the restoration site? A quick method was to search for them along the trunks of oak trees and coyote brush throughout the site.
2) Are Argentine ants likely to get to the restoration site on their own? The closer the restoration site is to another site with Argentine ants, the more likely the ants can disperse to the restoration site on their own. However, even if a restoration site is close to a location that contains Argentine ants, they may not be able to disperse to the restoration site on their own if inhospitable habitat acts as a dispersal barrier. Because little is known as to what exactly constitutes “inhospitable” habitat, if it was ever unclear whether Argentine ants can disperse to the restoration site on their own, it is best to prevent Argentine ants from getting introduced to the site via the restoration project.
3) Do Argentine ants occur at the nursery or storage site? It was important to check each nursery site, as well as any storage/staging sites.
4) Are a few plants going to be transferred? If so, the cheapest method was to avoid using a QBS and instead use the submersion method described above to

determine which potted plants have been infested and to simply avoid transferring any of those specific individuals.

5) Are many plants going to be transferred? If so, it was extremely laborious to monitor all the plants that were to be transferred, so a quarantine/bait system was necessary.

Quarantine/bait systems were much more successful than quarantine-only or bait-only systems. With bait-only systems, the Argentine ants avoided the baits if alternate nutrition was available. In addition, the baits often attracted Argentine ants that were not nesting in the restoration material. With quarantine-only systems, the ants were able to survive for a long time without ingesting anything.

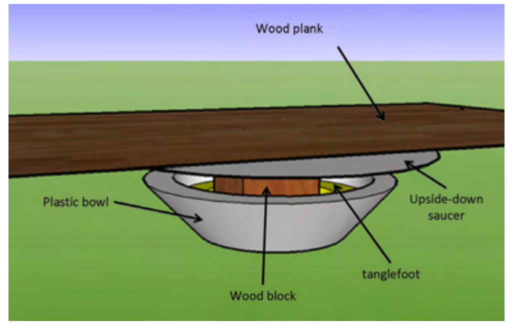
In implementing QBSs, it was necessary to consider the following:

a) Where should the QBS be assembled? The supplies were inexpensive, but it was somewhat laborious to place the plants on the quarantine/bait stations. One way to save labor-expense was to set-up each QBS where the plants would have been stored otherwise.

b) What type of quarantine material should be used? Placing nursery bench legs in water was not successful; I found that ants can swim in plain water. A soap/water mixture worked better, but it was very difficult to keep wildlife (such as frogs) from immersing themselves or ingesting the mixture. The best material was tanglefoot, a sticky goo ants cannot cross. Applying tanglefoot to bench legs was not successful either because water and debris ran down the bench legs; the water diluted the tanglefoot and the debris created bridges for the ants. The tangelfoot also rubbed off on people hands and clothes and was difficult to remove. Thus, I found it necessary to consider ways to block contact between humans/wildlife/debris and the tanglefoot (consideration c).

c) What is the best way to avoid contact between humans/wildlife/debris and the quarantine material? The following system worked well (Figure 1):

- Set-out enough wood planks to hold all the plants
- For each plank, assemble four "legs". For each leg, wrap the inside of one plastic bowl with tanglefoot. Inside the center of the bowl, place one vertical post that is taller than the bowl. On top of the post, place one saucer (that is wider than the bowl) upside-down, so it blocks contact with humans/wildlife/debris




- Place the corners of the wood planks on top of the legs to create "beds" and place the plants and baits on top of each bed

d) What type of bait should be used? A mixture of boric acid, sugar and water worked well. It was necessary, however, to protect and weigh-down the baits, so that they were not disturbed and/or ingested by wildlife.

How should the QBS be evaluated? The monitoring system that involves submerging randomly-chosen plants in water, as described above, was an efficient way to evaluate QBSs.

### Overall results

The quarantine/bait system constructed at Mid-Peninsula Open Space District, which involved 500 plants (Figure 2) cost three extra person-hours, $400 in re-usable supplies and $50 in non-reusable supplies. The system's benefit was clear: Before implementation of the quarantine/bait system, the infestation rate was 6% (n=50); afterwards, the rate was 0% (n=64).

## Post-Fire Recovery Plan for Solstice Canyon in Malibu, CA

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### Abstract

Post-fire establishment of native plant species is essential to the health of Southern California plant communities. To accomplish this, inhibiting the rapid spread of ecologically damaging invasive plant species post-fire is imperative. Following the 2007 Corral Fire in the Santa Monica Mountains National Recreation Area we drafted a work plan with the goal to monitor and restore 200 acres of burned area in Solstice Canyon (Malibu, California). This plan involved the rapid detection, control and monitoring of twelve ecologically damaging non-native invasive plant species. The restoration strategy was as follows: 1) GPS mapping of invasive plants targeted for removal, 2) assessing infested areas for native and targeted plant percent cover, 3) prioritizing the timing of treatment of these areas based on plant species composition, 4) treating of these mapped infested areas, 5) surveying the areas post-treatment to determine the need for further treatment and 6) post assessing all infested areas at the end of the treatment season to ascertain treatment effectiveness. A three year implementation of this plan resulted in an overall increase of native plant species cover by 22%, an overall reduction in non-native plant species cover by 86% and an overall reduction in the cover of Geraldton carnation spurge (*Euphorbia terracina*) by 78%.

### Introduction

Solstice Canyon, 550-acres of parkland within the Santa Monica Mountains National Recreation Area, was burned in the Corral Canyon Fire on November 24, 2007. Containing a perennial stream this canyon supports one of the most floristically diverse native plant communities in the Santa Monica Mountains (147 native species) and a number of locally uncommon vegetation associations (e.g., white alder-sycamore woodland and walnut woodland). Unfortunately, one result of the Corral Canyon fire was that it created an open environment that promoted the colonization of twelve non-native invasive plant species, one being the aggressive Euphorbia terracina. Because of this canyon's floristic importance, post-fire recovery focused on the control of these twelve ecologically damaging non-native invasive species within Solstice Canyon. Rapid suppression however required a post-fire recovery plan that was multi-faceted. First, it was imperative to remove non-native invasive plants from the burned areas where they had the potential to change native plant composition. Secondly, this suppression of invasives needed to be maintained to allow native species to recover naturally. Lastly, seasonal tracking of treatment success over three consecutive years was essential to determine if and when our goals were obtained.

### Methods

Two hundred sprawling acres of parkland encompassed the 37 acres of total work area that was recognized as needing invasive species removal. The three-year post-fire recovery plan was as follows: 1) park surveys, 2) defining of treatment areas, 3) pre-treatment assessments, 4) treatment prioritization, 5) treatment and 6) post-treatment assessment.

#### *Park surveys*

Primary work under the post-fire recovery plan consisted of surveying 200 acres of parkland in Solstice Canyon (Malibu, California) to determine areas in need of active weed control. The goal was to locate large populations of twelve invasive target species (*Euphorbia terracina, Carduus pycnocephalus, Ricinus communis, Nicotiana glauca, Cirsium vulgare, Silybum marianum, Conium maculatum, Vinca major, Foeniculum vulgare, Bidens pilosa, Cyperus involucratus*, and *Tropaeolum majus*) and note the locations where weed presence was dominant and appeared to be hampering native plant species establishment. Information gathered from surveys was location within the park, approximate size of infestation and identification of the dominant target weed species. Following these surveys it was determined that 37 acres of parkland were in need of successful native plant re-establishment post-fire via invasive species removal and/or native species plantings.

| Criteria | Points |
|---|---|
| Intermixed native vegetation, potential for recovery if weeds are removed | 5 |
| Species ID<br>• EUTE<br>• SIMA<br>• CAPY | <br>3<br>2<br>2 |
| Stage of weed<br>• Fruit<br>• Flower<br>• Vegetative | <br>3<br>2<br>1 |
| Potential to spread into important habitat type<br>• Heavy foot traffic & ~ 2 m from creek<br>• Moderate foot traffic<br>• Low foot traffic | <br>3<br>2<br>1 |

Table 1

Criteria used during assessments. Totals for each aspect of criteria were multiplied by the factors denoted from tables 2 & 3 and added together to determine priority level assigned to each polygon.

### Defining of treatment areas

From the park survey findings, areas in need of treatment were defined as treatment polygons using GPS. The total area of the treatment polygons was recorded and used when determining treatment prioritization and effectiveness. These defined polygons were assessed to determine pre-treatment conditions at the start of each year.

### Pre-treatment assessments

Data collected in these assessments were the percent cover of natives, non-natives, target weed species, bare ground and litter. This information was used to determine the methods by which treatment polygons would be treated, and to prioritize treatment.

### Treatment prioritization

Using the pre-assessment information we set up a scoring system to prioritize the order in which the defined polygons would be treated. The categories of criteria used in scoring to define treatment priority were as follows: 1) proportion of percent cover of native plants to that of non-native plants (50-80% cover natives received highest score), 2) stage of maturity of target (in fruit received highest score), 3) proximity of the infested site to creek and/or foot traffic (≤ 2 m to creek or heavy foot traffic received highest score) and 4) presence of target species with the presence of *Euphorbia terracina*, *Silybum marianum* and *Carduus pycnocephalus* receiving highest scores because of high densities in the treatment years (Table 1). Using this scoring method we assigned defined polygons to a high, medium and low priority in terms of the sequence in which they would be treated. High would be treated first, medium second and low last.

### Treatment

Data gathered from pre-treatment assessments determined what treatment type, mechanical or a mix of chemical and mechanical would be used. Treatment type was based on the proximity of the target species to surrounding native plant populations so that natives were not damaged by herbicide spray. All targeted weed species were removed using approved IPM methods.

### Post-treatment assessment

Defined treatment areas (GPS polygons) were post-assessed to ensure control methods were meeting management objectives. Data collected in these assessments were the same as collected during pre-treatment assessments.

## Results and Discussion

Suppression of *Euphorbia terracina* and the other ecologically damaging non-native invasive species and the re-establishment of native species in a burned area can be attained in three years using persistent and aggressive eradication methods. Comparing pre-treatment conditions 2008 to post-treatment conditions 2010 we found that our post-fire recovery plan proved to be successful. Overall, there was an 86% reduction in the cover of non-native plant species (43 to 6% cover), a 78 % reduction in the cover of Geraldton carnation spurge (*Euphorbia terracina*) (17 to 4% cover) and a 79% reduction in all other invasive target species (6 to 1%). This plan also proved to promote the re-establishment of native plant species, with an overall 22% increase in the cover of native plants (22 to 28% cover).

Results showed that comparing pre-treatment assessment and post-treatment assessment data permitted successful tracking of treatment progress and confirmation of native species recovery. In addition, we have found that this systematic approach of defining an infested area, determining its level of importance and monitoring for continued infestation and/or improvement simplified management decision-making and focused efforts in a post-fire landscape. It was found that our three year post-fire recovery plan was effective at controlling the spread of the twelve target invasive species. Ultimately, we were able to reduce the treatment areas that continue to have a high percent cover of these ecologically damaging species by 85% (37 to 5.6 acres).

### Future work needed

Complete elimination of these twelve ecologically damaging species will not be accomplished without future monitoring and treating of areas that still contain these species. These areas will need to be monitored and treated as necessary until the native plant canopy completely closes. Without this continued work, the gains made during this post-fire recovery project will be lost because non-native invasive plants have multi-year seed banks that require preventative measures to control mass germination events.

## The Matilija Dam Ecosystem Restoration Project

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### Introduction

Matilija Dam is located on Matilija Creek, approximately 16 miles north of the Pacific Ocean. The creek flows downstream from the dam for approximately 0.6 miles before joining the North Fork Matilija Creek and becoming the main stem of the Ventura River. Construction for the dam was completed in 1948 for the County of Ventura. The original intent of the dam was to provide water storage for local agricultural use and for limited flood control, but even before construction was completed, the dam was cursed. Over the years, large volumes of sediment were deposited behind the dam, thus causing a number of serious issues including the reduction in the amount of water that can be stored, degradation of the native habitat;, the obstruction of wildlife migration and significant oceanic beach erosion. A report was issued when the dam construction was completed in 1948 that predicted the dam would be rendered ineffective by trapped sediment in 39 years. The dam did not make it to 1987 before it was condemned. During construction in 1947, Harold E. Burket, the architect, warned the County Supervisors that the aggregate used in the concrete mix contained sulfides which would slowly deteriorate the overall strength of the concrete. In 1964, Bechtel Corp completed a safety study and condemned the dam and recommended its removal due to the weakened concrete. In an effort to save the dam, the County of Ventura cut a thirty foot deep notch out of the dam which reduced the capacity to sixty five percent in order to reduce the load on the dam. The dam was notched again in 1978. The last section of the dam to be removed occurred in 2000 during a project to determine the best method for removing the dam entirely (See the Matilija Coalition website and the Matilija Dam Ecosystem Restoration Project websites for references).

Since 1999, several active groups have pursued the permanent removal of the dam. Support has grown during the course the last eleven years and now includes the Matilija Coalition (including Patagonia's dam busting Yvon Chouinard, who gained notoriety for the American Express advertising commercials), the Ventura County Watershed Protection District (current owners) and numerous government agencies, including the Army Corps of Engineers that originally argued against the dam construction. At an original height of 198 feet, now at 160 feet due to sectional removals in 1965 and 1978, this is the largest dam to ever be considered for removal. The removal of the concrete structure is a straight forward procedure, but the devastation the dam has wrought since 1948 is posing an incredible challenge. This includes the proliferation of thousands of acres of invasive species, a stockpile of six million cubic yards of sediment and the threat to the safety of the local community. In addition, this dam removal is the testing ground for how hundreds of other aging dams will be dismantled.

Although the issues surrounding the sediment removal and the safety of the community are important, our focus in the dam removal process is the elimination of the prevalence of the invasive species in order to allow the ecosystem to heal. One element of the destruction caused by the dam was the creation of a warm water climate that led to an environment dominated with invasive species including *Arundo donax, Tamarix aphylla, Ricinus communis* and *Spartium junceum*.

Our work on the elimination of these species began in 2007. This large scale project had far more challenges than just the straight forward removal of the invasive species.

## Methods

In 2007, our primary focus was the removal of approximately 1,200 acres of *A. donax* as one of the first steps in revitalizing this ecosystem. *A. donax* by far had dominated the habitat areas above and just below the dam (The Google Earth satellite photograph from 2005 shows how much of the area behind the dam was dominated with *A. donax*). Removal of the vast amounts of unwanted vegetation required us to use specialized heavy equipment and an adequate quantity of a safe herbicide to eliminate the weeds. As was anticipated, the local community was very concerned about the herbicides utilized on the project. With these concerns in mind, we worked very closely with the Ventura County Watershed Protection District to develop a restoration plan that would allow for the removal of the invasive plant species without contaminating the precious life-sustaining groundwater resources which are vital to local residences and the revitalization of the ecosystem.

In Augutst of 2007, we commenced with the first stage of *A. donax* removal. Initially, the *A. donax* and other invasive species were given a fo-

Project site in 2005

liar treatment of Monsanto's AquaMaster. Once the reed-like plants were dead, dry, and moved to a location away from the watershed, they were ground into fine mulch. We brought in specialized equipment that is designed to grind up large quantities of durable plants such as *A. donax*. *A. donax* regenerates through rhizomes, which makes it very difficult to eliminate. The shredding process significantly reduces the volume of the biomass, destroys the nodes of the plant to prevent them from sprouting, immediately eliminates the risk of a life threatening wildfire and reduces the amount of herbicide to be used on resprouts. As anyone who has fought this plant can tell you, mechanical methods alone are not successful in the elimination of A. donax from our watersheds. A critical part of process in the elimination of *A. donax* is the use of herbicide strong enough to kill the roots of the plant.

The second and most sensitive stage of the project involved spraying the resprouts emerging from the cut stalks of *A. donax* with additional treatments of AquaMaster herbicide. Because *A. donax* is so resilient, the plants must be cut down or shredded and then the newly formed shoots must be treated for up to 10 years. This is the most successful method for the herbicides to reach the deep roots of the reedy plants which is critical for its elimination. As with any project requiring the application of chemicals, we utilized only those herbicides deemed safe for use around all wildlife and approved by the EPA for application in or near watersheds. In addition, Natures Image used the safest application methods possible to prevent contamination of local water supplies, drift onto non-targeted species, and protection of the little remaining native habitat.

To allay fears of water contamination, the Ventura County Watershed Protection District conducted a long series of surface and groundwater tests at six different locations within and downstream of the project before and throughout the duration of the project. Natures Image was never informed of when or where testing would occur. The water underwent extensive analysis and the samples were monitored for temperature, pH, turbidity, dissolved oxygen, conductivity, glyphosate (AquaMaster) and non-ionic surfactants. The results of these tests showed no contamination from the herbicides used on the *A. donax* and the results were communicated on a regular basis to the community and its leaders. (See the Matilija Dam Ecosystem Restoration Project websites for references).

## Results and Discussion

The successful removal of vast areas of *A. donax* requires skill, patience and perseverance. It


Project site in 2009

has been three years since the initial removal commenced and we have eliminated almost all of the targeted invasive species. Because of our success, the Matilija Dam site is now posed to move into the next phase in the removal of the structure. Subsequent water testing has revealed no groundwater or surface water contamination with the herbicides and the native habitat in the area has greatly improved. By clearing the more than 1,200 acres of the targeted species and completing six of the retreatments, the Ventura County Watershed Protection District has noticed an increase in the amount of groundwater present and has greatly reduced the risk of life threatening wildfires in the area (The Google Earth satellite photograph from 2009 shows how much of the area behind the dam has been cleared of *A. donax*).

Matilija Dam is just one of many antiquated dams across the United States that has been targeted for removal to help restore rivers and recover precious ecosystems. The invasive species removal work we have completed was just the first step in the process to recapture and protect some of California's most precious natural wildlife and resources.

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# Managing Weeds and Wildlife on the Channel Islands

## The Anacapa Challenge – 'Iceplant Free by 2016!'

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Islands are particularly vulnerable to the harmful effects of invasive species. Anacapa Island is home to many endemic plants and animals and provides critical nesting habitat for rare seabirds. Approximately 60% of East Anacapa Island's 112 acres is infested with red-flowered iceplant (*Malephora crocea*), which has expanded very rapidly, displacing native plants and animals, since its introduction in the 1950s. In 2008, the Park's Superintendent challenged staff to eliminate iceplant from Anacapa by 2016, the NPS Centennial. Anacapa's combination of terraces and cliffs, huge biomass of iceplant, presence of sensitive species and limited availability of restoration resources necessitates a multi-faceted approach to iceplant eradication. Vegetation recovery will be assisted by planting of native plants grown in an on-island nursery, focusing on areas where long domination by iceplant has reduced native plant diversity. This project will rely on assistance from cooperating organizations, community and business-sponsored volunteers and school and youth groups to accomplish results that NPS resources alone cannot achieve. Key project elements include establishment of a scientific monitoring program to track project results, dissemination of project information to all island visitors and a comprehensive bi-lingual education program to create public awareness in coastal communities and throughout southern California about impacts of invasives in both island and mainland habitats. This presentation will detail project components and report on initial results. Project staff have already recorded vigorous growth of natives where iceplant has been removed, improved habitat for rare island wildlife and significant community support in terms of funding and volunteer participation.

## Herbicide Treatment of Invasive *Vinca major* Growing with Endangered *Galium buxifolium*, An Island Endemic

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### Introduction

*Galium buxifolium* E. Greene [Rubiaceae] (sea-cliff bedstraw) is a small shrub restricted to San Miguel and Santa Cruz Islands, in the California Channel Islands. Almost all of the 26 known populations grow on vertical north-facing sea cliffs in native scrub, sandwiched between the sea below and non-native annual grasslands on the terraces above. A notable exception is a population at Pelican Bay on Santa Cruz Island, growing on the cliff and on thin terrace soils above the cliff in a stand of coastal bluff scrub that is recovering from more than a century of sheep grazing (Figure 1). Ironically, this stand is near the location of the historic Eaton Resort, a charismatic inn frequented by Hollywood glitterati in the early 1900s. Several landscape ornamentals planted there persist today in the area of the *Galium* population. Italian stone pine (*Pinus pinaea*) and eucalyptus (*Eucalyptus* spp.) tower over the site while the invasive groundcover *Vinca major L*. [Apocynaceae] (greater periwinkle) forms dense mats at the cliff edge that are spreading into the developing native plant stand.


Figure 1

*Galium buxifolium E. Greene* (Rubiaceae) (sea-cliff bedstraw) population at Pelican Bay, Santa Cruz Island, California.

Wherever the *Galium* is found it is intermixed with other native scrub plants in dense communities on moist ocean bluffs. Historic notes and herbarium collections indicate that it may have been more widespread on nearshore terraces adjacent to sea-cliff populations before conversion to grassland. Since Pelican Bay is the only site that we know of where *Galium* is spreading onto the nearby terrace, we wanted to know whether the *Vinca* posed a roadblock to upslope population expansion. In 2005 we mapped *Vinca* and *Galium* at the site. We also measured *Galium* individuals to see where the smaller, younger plants were to better understand where the population is expanding. We observed that 1) both the *Galium* and the *Vinca* appear to be spreading from the cliff face upslope onto a series of rock outcrops, stone walls and benches, 2) the native scrub community is recovering at the site and 3) the *Vinca* appears to be moving into the native scrub where it overtops small plants, including those *Galium* in the smallest size classes. This observed pattern of *Vinca* displacement of native vegetation has been noted in other places, where it is treated as an invasive weed.

We concluded that *Vinca* may pose a threat to the expansion of both the native scrub and the *Galium* population that it supports. Therefore, we worked with the US Fish and Wildlife Service and others to develop a research project investigating 1) best techniques for killing *Vinca* within the boundaries of an endangered plant population and 2) demographic response of *Galium* to the treatment. Our intent is to push *Vinca* back to the vertical cliff face to give the natives a chance to establish a vigorous stand. Our conservation goal is to encourage natural establishment of new *Galium* plants on the terrace along with expansion of the native coastal bluff scrub and Galium population. Our immediate treatment objective is to reduce live *Vinca* cover by 90 % on the accessible upslope portions of the habitat. Our recovery objective is no net loss of *Galium* plants 2006-2016.

## Methods

We are implementing *Vinca* treatment in two stages, each accompanied by *Vinca*, *Galium* and plant community monitoring:

Stage 1 – Heavy treatment to reduce *Vinca* on the terrace by 90% (2009-2010)

Stage 2 – Maintenance treatment to keep *Vinca* cover less than 10% (2011-2015)

## Monitoring

Our monitoring objectives are to 1) document rates of *Vinca* reduction and 2) follow individual *Galium* plants before, during and after treatment to document effects on population growth. In spring 2006 we established a 15 x 50 meter plot encompassing and expanding beyond all of the *Galium* and *Vinca* above the cliff face. We mapped and tagged each *Galium* plant in the plot. We recorded plants as seedlings when they had seed-leaves (cotyledons) indicating that they had just germinated that season, otherwise they were recorded as older established plants. We repeated these measurements in spring 2008 and 2010 and will continue through 2016. In 2006 we also recorded pre-treatment plant community composition and mapped *Vinca* cover in the plot. Finally, as insurance against loss, we collected and banked *Galium* seed in each monitoring year.

## Vinca treatment

We began site preparation in December 2008 with the development of a rigging system for climbing ropes to be used whenever working near the cliff edge in a way that would not damage the vegetation. We flagged the *Galium* plants in the plot. Then, we pruned the lower branches of some shrubs, hand-cut bunch grasses and removed dead branches for better *Vinca* access. We were careful not to cut *Vinca* vines so that herbicide would travel effectively throughout the plant when treated.

We began herbicide application when the *Vinca* came out of dormancy in early February, 2009. We worked on very small sections at a time (approximately 0.5 x 0.5 meters). Within each section we covered the *Galium* plants with plastic trash bags and then prepared the *Vinca* by wounding the leaves with a wire brush to break the waxy leaf cuticle (Figure 2). This was followed immediately by application of a 3% solution of Aquamaster and 3% solution of Agridex surfactant. We used painting sponges to wipe on the herbicide. These allow for more precise application of the herbicide than a wick applicator. The technique seems like a very safe but slow way to treat *Vinca*; it took between 4 and12 hours to treat several 3x3 meter patches where Vinca is growing in close proximity to the *Galium*. Rain, wind and high seas precluded further work in 2009 and delayed our 2010 start until mid-April. We treated about 25% of the site in 2009, focusing the bulk of our work in *Vinca* areas outside of and encroaching into edges of the Galium population. In April 2009, site inspection showed that about 95% of the treated *Vinca* was dead while the *Galium* looked healthy. Therefore, we treated the remainder of the accessible *Vinca* at the site using the same techniques in April and May, 2010. In several spots re-sprouting and seedling *Vinca* emerged from the tangle of dead vines; we treated these spots as well.

Figure 2

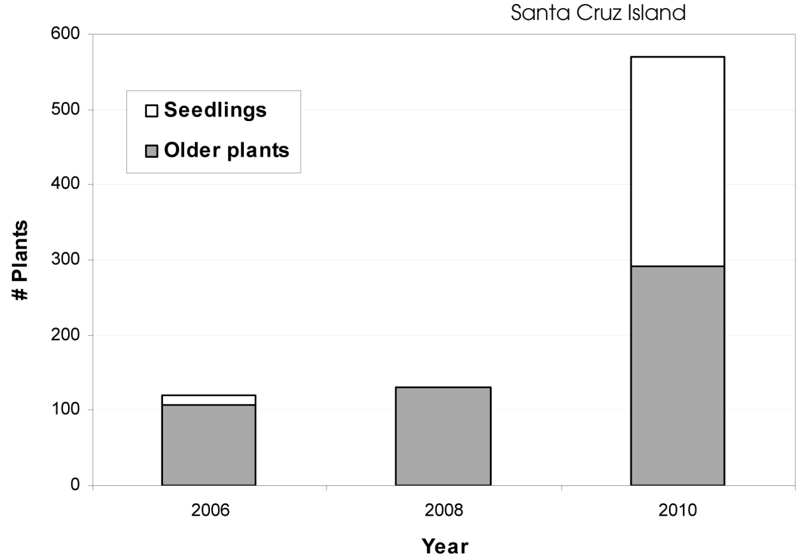
*Vinca major* leaf wounded with a wire brush to improve herbicide uptake before painting with herbicide.

## Results

There has been little change in species composition at the site 2006-2010. Inspection in April, 2009 and May, 2010 indicated almost total kill of the treated *Vinca* across the plot; more than 95% of the *Vinca* vine and leaf tissue was dead. In 2006 we found 107 non-seedling *Galium* plants in the plot and that number increased to 131 in 2008 (Table 1). In 2010 there was a huge increase to 292 established plants; about 75% of those appeared to have germinated in 2009 across both treated and non-treated areas. We counted 12 seedlings in 2006, none in 2008 and 277 new seedlings in 2010. Altogether, there were totals of 119, 131 and 569 *Galium* plants and seedlings in the plot in 2006, 2008 and 2010, respectively. We have lost 23 tagged plants

Table 1

Number of *Galium buxifolium* seedlings and older plants 2006-2010, Pelican Bay plot, Santa Cruz Island



2006-2010; mostly small plants and seedlings of the previous year, evenly distributed within and outside of the treatment zone. Since 2006, not counting seedlings, there has been a net gain of 185 plants in the plot for a near doubling of pre-treatment plant numbers.

## Conclusions

This has been a logistically difficult project to implement. It is about a six-mile round-trip hike over steep terrain to the site from the pier. Weather often precluded work at the best time of the growing season. Working near a sea cliff edge required extra safety equipment beyond the routine protective gear. Our biggest treatment challenge was devising a way to kill *Vinca* with an herbicide without harming the endangered *Galium*. We worked to make herbicide treatment very efficient to minimize the number of times we needed to be in the habitat. This was done by careful pruning for best access to *Vinca*, and by wounding the *Vinca* leaves immediately before applying herbicide. We minimized the possibility of herbicide contact with *Galium* by covering it before application and by hand-painting herbicide directly onto the *Vinca*.

Despite the logistical and technical challenges, we have met our project goals so far: we have killed more than 90% of the *Vinca* with no net loss of *Galium*. At this point we see no need to adjust our approach. We do not know whether the high rate of seedling recruitment from 2009 and new seedling establishment in 2010 are the direct result of *Vinca* reduction. It could be that these would have been “good” seedling years for *Galium* anyway. It is encouraging that we did have this increase in the face of such potentially harmful site work. Results of such treatments are often striking in the short-term. However, we want to encourage population growth over the long term. Our monitoring through at least 2016 should show whether our careful work in 2008-2010 makes a difference in the long run.

Use of trade names does not imply endorsement by the U.S. Geological Survey.

# Bringing It All Together

## Desire, Disappointment, Surprises, and Food Webs: Melding Conservation and Ecological Perspectives to Better Understand Animal-Invasive Plant Interactions

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Because plants and animals often exert strong mutual influences on each other, fundamental plant-animal interactions such as pollination, herbivory, granivory and seed dispersal are likely to have different effects on each group in different phases of the invasion process. Within a given phase of invasion, these effects will be determined primarily by 1) the direction and strength of interactions between animal and invasive plant species and 2) stochastic or deterministic environmental events that alter interaction strengths. A number of examples from island and mainland systems provide evidence of the complex relationships between animals and invasive plants, especially when plants are released from long periods of intense herbivory. Unanticipated outcomes have resulted from these interactions, some of which have not been desirable from a conservation perspective. From an ecological perspective though, these outcomes are not particularly surprising.

These points are illustrated with data from a series of studies conducted on Santa Cruz Island, California, from 1991 to 1998. The goal of these studies was to evaluate the effects of the spread of a highly invasive perennial forb, fennel (*Foeniculum vulgare*), following removal of grazing mammals (cattle and feral sheep) in the 1980's. Although fennel was introduced to Santa Cruz in the 19th century it occurred in only a few localized populations throughout most of the 20th century. Following removal of the cattle and, to a lesser extent, the feral sheep in the 1980's, the distribution of fennel increased 50% and mean cover 11% to 51%. Although fennel had largely negative effects on native plants, this was not necessarily so for animals. Conversion of grasslands to fennel stands resulted in a change in bird species composition; however, diversity was as high or higher in fennel stands as in other vegetation types. Similarly, density of small mammals, including an endemic deer mouse (*Peromyscus maniculatus santacruzae*), was two to seven times higher in fennel stands as in other vegetation types, primarily because of greater rates of survival. Effects on birds and rodents were not simply an outcome of altered vegetation structure; seed removal trials showed that fennel seeds were consumed by rodents and granivorous birds.

In essence, two highly undesirable grazing mammals had, for over a century, limited the spread of what became a highly undesirable and surprising plant invasion. In ecological terms, the removal of the grazers resulted in a change in interaction strengths, allowing fennel to rapidly spread and establish an alternative vegetation state. Native plant species tended to have negative relationships with fennel, but native animals tended to have positive ones. The case study from Santa Cruz demonstrates that evaluating outcomes of plant invasions and setting realistic management goals will, in many cases, be best done in the context of food webs and multi-trophic interactions. Moreover, it will be essential to acknowledge that management of invasive plant species can send systems on unpredictable trajectories leading to various states and transitions, sometimes with contrasting patterns between plant and animal communities.

## Understanding Research on Herbicide Impacts: Toxicology Resources for Today's Habitat Restoration Worker

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Weed management with herbicides has the potential to impact wildlife and humans; however, different locations frequently have different at-risk populations because of geography, species distributions or proximity of water or sensitive sites to treatment areas. This presentation will highlight the Pesticide Risk Mitigation Engine (PRiME), a new Web-based tool that provides an estimate of site-specific pesticide risks for birds, small mammals, earthworms, pollinators, aquatic invertebrates and fish. For humans, inhalation and dermal risk indices have been developed. All indices are based on field data and provide the probability of an undesirable impact occurring as a result of a pesticide application. Mitigation measures (such as a buffer strip to reduce runoff into waterways) that reduce exposure potential are incorporated into the tool and serve to highlight measures applicators can take to reduce risk. PRiME provides a means to compare different pesticide products, weigh impacts of application methods, account for site-specific conditions, access information on mitigation options for specific product/application selections and evaluate an index "score" and ranking for each application and specific endpoints of concern. The tool includes a novel user interface, including GIS mapping of treatment area boundaries and sensitive sites, as well as automated retrieval of Natural Resource Conservation Service soils data.

## Hey, What Are They Doing Over There? What We Can Learn from Animal and Pathogen Prevention and Control Projects

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California has been the site of some of the most innovative and successful invasive plant prevention and control efforts. But from the start we have recognized that there is much to learn from outside the state and beyond the United States. Cal-IPC's creation in 1992 was itself inspired by the Florida Exotic Pest Plant Council which had been launched eight years earlier. We can also borrow and learn from the successes and failures of projects to prevent and control invasions by animals and pathogens. For example, earlier failures to control or eradicate invasive lampreys and other freshwater fish have led to more recent efforts to suppress reproduction or manage population structure and thereby limit their abundance and impacts. On the other hand, some recent successes in controlling and eradicating small invasive ant populations in Australia and the Pacific hinged on use of a strategic hierarchy: detect and delimit all target ant populations/colonies in the area; contain target ant populations, reduce target ant numbers and distribution; eradicate target ants. Approaches used in combating plant and animal pathogens have featured a strong focus on prevention and on taking steps to boost resistance of the hosts and host communities and thereby slowing or halting spread. Fresh looks at these approaches and at applying them to invasive plant problems are warranted.

# Student Poster Contest

## Contrasting Effects of *Carpobrotus edulis* on Arthropods in a Coastal Dune Ecosystem

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### Abstract

Highway iceplant (*Carpobrotus edulis*) has been shown to have numerous impacts on the habitats that it invades, including reducing native plant species cover and diversity, stabilizing dunes and increasing litter biomass. Yet little is known about its effects on the arthropod fauna, which is a critical component of biodiversity and ecosystem function. This study revealed contrasting effects of *Carpobrotus edulis* on soil and aerial arthropods. While soil arthropods were both less abundant and less diverse in *Carpobrotus*-dominated dunes than native-dominated dunes in February and May, the opposite was true for aerial arthropods in February and no difference was found for aerial arthropods in May. An investigation of aerial community composition and function revealed that *Carpobrotus* supports primarily detritivores dominated by members of the Order Diptera (flies), while the native dunes supported more herbivores and pollinators, in the Orders Heteroptera (true bugs) and Hymenoptera (bees and wasps). In addition, the depauperate soil fauna under *Carpobrotus* was significantly lacking in larval forms, suggesting that the invaded dunes may be functioning as a sink for insects which undergo complete metamorphosis, while two native ant species in the native dunes were replaced by the invasive Argentine ant in the invaded dunes. The results presented here illustrate the importance of evaluating composition and function when undertaking to determine the impact of an invasive plant on an invertebrate assemblage.

### Introduction

Highway iceplant (*Carpobrotus edulis*) is a significant threat to the few remaining coastal dune ecosystems in southern California. It suppresses the growth of native plant species in coastal dune areas by forming dense, mat-like monocultures (D'Antonio 1993, Molinari et al. 2007), causes a build-up in organic matter and limits the natural movement of dunes (Alpert 2000). These characteristics are widely suspected to alter the native assemblage of insects and other arthropods and lower their biodiversity, however this important impact has not yet been investigated.

Arthropods are an essential component of the food web, as a prey base for many of the birds, reptiles and mammals that inhabit the dunes. They are also the major pollinators and decomposers, herbivores and predators which are vital to proper ecosystem functioning. Because of this importance, terrestrial arthropods are excellent indicators of ecosystem health. Here, I explore the question how do the diversity, abundance and composition of arthropods differ between *Carpobrotus*-dominated and native-dominated dunes at Coal Oil Point?

### Methods

This study was conducted within two adjacent areas of backdune habitat at Coal Oil Point Reserve, Santa Barbara County, one of which is dominated by *Carpobrotus edulis* (5.1 hectares) and one of which is dominated by native dune species (7.8 hectares). Eight 7 x 7 meter plots were established randomly in both *Carpobrotus*-dominated and native-dominated dunes. Arthropod sampling was conducted in February and May of 2010 using both sand sifting and yellow pan trapping techniques, described below.

Sand sifting was conducted in one randomly-chosen 2 x 2 meter plot within the larger 7 x 7 meter plot. Five 1-liter soil cores were sifted through a 1 mm mesh sieve. A container was placed below the sieve to capture fine materials and very small arthropods. Arthropods were aspirated from both within the sieve and the container until two minutes had passed beyond the last arthropod captured (minimum of five minutes). For yellow pan trapping, a yellow bowl filled with water and a small amount of dish detergent was placed in the center of each 7 x 7 meter plot, secured with two wood skewers, and left in place for 48 hours. This was conducted in two two-day intervals (four samples per treatment each).

## Results

### Soil arthropod abundance and diversity

Native dunes had a significantly higher abundance of soil arthropods (6.6 ± 1.4 standard error) than *Carpobrotus* dunes (1.8 ± 0.5) (Behren's Fisher t-test, p= 0.01) in February. Ants and termites were excluded from this abundance analysis due to their extremely high variability. As shown in Figure 1, family-level richness was also

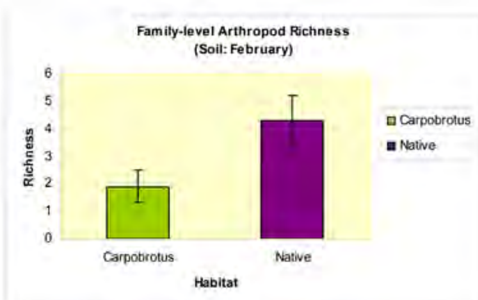


Figure 1

Native dunes had a significantly higher family-level arthropod richness (4.3 ± 0.9) than Carpobrotus dunes (1.9 ± 0.6) in February (Student's t-test, p=0.04, df=14, t = 2.22).

significantly higher in native dunes (4.3 ± 0.9) than *Carpobrotus* dunes (1.9 ± 0.6) in February (Student's t-test, p=0.04, df=14, t = 2.22). Family-level diversity, estimated for the whole collection of individuals in each area by the Brillouin index (Krebs 1999), was also higher in the native plots (0.83 vs. 0.75 for *Carpobrotus*).

Native dunes had a significantly higher abundance of soil arthropods (42.4 ± 9.3) than *Carpobrotus*-dominated dunes (17 ± 4.9) in May (Student's t-test, log transformed, p= 0.02, df = 14, t = -2.6). Order-level richness between native dunes (5.8 ± 0.8) and *Carpobrotus* dunes (5.4 ± 0.6) did not differ significantly (Student's t-test, p=0.72, df=14, test statistic = -0.36). Family- level analyses are being conducted and will be presented elsewhere.

### Aerial arthropod abundance and diversity

*Carpobrotus*–dominated dunes had a higher aerial arthropod abundance (12.9 ± 2.3) than native dunes (6.6 ± 2.5) in February; this difference is nearly statistically significant (Wilcoxon signed-rank test, Chi-square = 3.61, p = 0.06). Carpobrotus dunes also had a significantly higher family-level arthropod richness (6.4 ± 0.9) than native dunes (3.5 ± 0.8) in February (Student's t-test; p=0.03, df=14, t = -2.4), as shown in Figure 2. In addition, family-level diversity, as

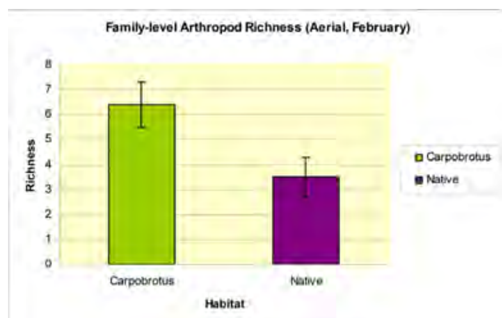


Figure 2

*Carpobrotus*-dominated dunes had a significantly higher family-level arthropod richness (6.4 ± 0.9) than native dunes (3.5 ± 0.8) in February (Student's t-test; p=0.03, df=14, t = -2.4).

measured for the whole collection of individuals in each area by the Brillouin index (Krebs 1999), was higher for *Carpobrotus* dunes (0.97) than for native-dominated dunes (0.85).

There was no significant difference in abundance of aerial arthropods between native (28.0 ± 5.8) and *Carpobrotus*–dominated (31.5 ± 3.7) dunes in May (Student's t-test, t=-0.51, p=0.62). The difference in order-level richness between native (5.8 ± 0.6) and *Carpobrotus* (5.1 ± 0.4) dunes was also not significant (Wilcoxon signed-rank test, Chi-square= 1.0, p=0.32).

### Soil arthropod composition

The *Carpobrotus*-dominated dunes were found to support invasive Argentine ants (*Hymenoptera: Formicidae: Linepithema humile*), while two different native species (*Monomorium* sp., *Solenopsis* sp.) were found in the native dune cores. This pattern was found in both the February and May sampling periods. Insect larvae were nearly five times more abundant on average in native dunes

(1.1 ± 0.4) than in *Carpobrotus* dunes (0.3 ± 0.2) in February, a difference that was nearly significant (Wilcoxon signed-rank test, Chi-square = 3.07, df = 1, p = 0.08).

### Aerial arthropod composition and function

Ordination using Non-metric Multidimensional Scaling (NMDS) revealed that the family-level aerial arthropod composition for the *Carpobrotus*-dominated dunes was significantly different from the native dunes (stress value was 10.4; 75 iterations, Monte Carlo significance p=0.04). Particularly more abundant in *Carpobrotus* plots were mites (order Acari); springtails (*Collembola: Isotomidae* and *Latritidae*); flies (Diptera: *Anthomyiidae, Scathophagidae, Chironomidae*) and thrips (*Thysanoptera: Phlaeothripidae, Thripidae*). More abundant in native dune plots were bees and wasps (*Hymenoptera: Colletidae, Halictidae, Pompylidae*, and *Apidae*) and true bugs (*Heteroptera: Aphididae, Cicadellidae*).

The *Carpobrotus*-dominated plots contained a higher proportion of all detritivores (0.11 ±0.03) than the native dunes (0.01 ± 0.01; proportions arcsine-root transformed; Wilcoxon signed-rank test, Chi-square = 6.98; p < 0.01). Native plots contained a higher proportion of herbivores and pollinators (0.29 ± 0.08) than *Carpobrotus* plots (0.05 ± 0.02), however this difference was not statistically significant (proportions arcsine-root transformed; Wilcoxon signed-rank test, Chi-square = 1.35, p = 0.24).

## Discussion

Soil arthropods were depauperate in both abundance and diversity in *Carpobrotus*-dominated dunes; this result was consistent to both sampling periods. The high amounts of plant litter are likely responsible for this result; litter was nearly four times as deep on average under *Carpobrotus* (6.6 vs 1.7 cm) than under native plants and weighed 6.5 times as much (average 123 vs 19 grams per core). This appears to form a barrier to arthropod movement and use. The depauperate soil fauna under *Carpobrotus* was significantly lacking in larval forms, suggesting that the invaded dunes may be functioning as a sink for insects which undergo complete metamorphosis. In addition, two native ant species in the native dunes were replaced by the invasive Argentine ant in the invaded dunes.

In contrast to soil arthropods, their aerial counterparts were both more abundant and more diverse in *Carpobrotus*-dominated plots in February, while no difference was found for aerial arthropods in May. The composition of the assemblage in *Carpobrotus* dunes was significantly different from that of the native dunes, however. It was dominated by detritivores, primarily of the Order Diptera (flies), while the native dunes supported more herbivores and pollinators, in the Orders Heteroptera (true bugs) and Hymenoptera (bees and wasps). The high litter volume produced by *Carpobrotus* is again likely the cause of the high arthropod abundance and shift in community composition.

The results presented here illustrate the complexity of invasive plant impacts and the importance of evaluating composition and function when undertaking to determine the impact of an invasive plant on an arthropod assemblage.

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## Using Native Shrubs to Control Re-Establishment of Giant Reed (*Arundo donax*)

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### Abstract

Giant reed (*Arundo donax*) is a hydrophytic invasive grass found widely in southern California riparian ecosystems. Research is underway to test cultural control methods for *A. donax* as a component of active restoration. Our objective is to test competitive control by native shrub species as a means of inhibiting the re-establishment of *A. donax*. Sandbar willow (*Salix exigua*) and mulefat (*Baccharis salicifolia*) were planted during spring and fall 2009 from whip cuttings at various densities and allowed to establish for 0 or 90 days prior to the introduction of *A. donax* within two irrigated fields at the University of California, Riverside. It was found that *B. salicifolia* significantly reduced the relative growth rate (RGR) of *A. donax* at all planting densities within both the spring and fall 2009 harvests, whereas *S. exigua* displayed limited competitive effects even under high planting densities (9/$m^2$). These results demonstrate the differences between the competitive effects of native species, potentially influencing land managers' decisions on restoration designs.

### Introduction

Useful as a light building material, horticultural specimen and source for instrumental reeds (Bell 1998, Perdue 1958, Hoshovsky 1989), giant reed (*A. donax L.*) has followed human migration around the world. This invasive, hydrophytic, perennial C3 clonal grass has aboveground stems (shoots) with hollow internodes and solid nodes and solid below ground stems (rhizomes). Reproduction is strictly vegetative in southern California (stem or rhizome fragmentation) as no viable seeds have been observed in the United States (Else 1996, Bell 1998).

Rapidly establishing ruderal species quickly form a closed canopy, minimizing the transmittance of light to the soil surface. The ability to form a closed canopy has been described as a mechanism whereby riparian communities resist invasion (Galatowitsch and Richardson 2004, Pywell et al. 2003). Sandbar willow (*Salix exigua* Nutt.) and mulefat (*Baccharis salicifolia* (Ruiz & Pav.) Pers.) are native riparian shrubs which form closed canopies and have been indicated as being good competitors with *A. donax* (Rauterkus 2004, Coffman 2007). Quinn (2006) found that *B. salicifolia* negatively affected *A. donax* success within a common garden competition experiment and suggested that restoration designs (cultural control) should focus on species identity when considering reinvasion. Once established, *A. donax* becomes an invasive transformer species (Richardson et al. 2000); therefore, the critical period to control this invasive plant is during establishment.

Research was completed testing the effect of cultural control methods for *A. donax* as a component of active restoration. Our objective was to test competitive control by native shrub species as a means of inhibiting the re-establishment of *A. donax*. I hypothesized that shading from native woody riparian shrubs would negatively effect *A. donax* establishment in common garden experiments, increasing with native plant density.

### Methods

The experimental design was additive with replicate treatments (r = 5) blocked by irrigation direction in order to test native planting density effects on *A. donax* establishment within a common garden experiment at the University of California, Riverside (UCR) Agricultural Operations. *S. exigua* and *B. salicifolia* were planted during spring 2009 from whip cuttings at various densities (0, 3, 6, 9, 12/$m^2$) in 1 $m^2$ plots with 0.5 $m^2$ native buffer perimeter plantings and allowed to establish for 0 days (concurrent) or 90 days (delayed) prior to the introduction of

*A. donax* ($3/m^2$). The various planting densities represented the different experimental treatments, where one block was comprised of one control and four of each of the varying densities of the native shrub species. A second replicate field was planted in fall 2009 adjacent to the first field in order to test seasonal differences in *A. donax* establishment. A total of 180 plots were created: 90 plots in March 2009 (spring field) and 90 plots in October 2009 (fall field). *A. donax* rhizome fragments were collected and standardized by weight (250 ± 10g) prior to planting. Both fields were irrigated regularly and fertilized with a slow-release fertilizer. *A. donax* biomass was destructively harvested once it was observed that *A. donax* had surpassed the native shrubs in height, then dried and analyzed for RGR. *A. donax* growth parameters were measured during the experiment and prior to harvest including emergence time, height, shoot count, and native canopy leaf area index (LAI).

## Results and Discussion

It was found that *B. salicifolia* significantly reduced the relative growth rate of *A. donax* at all planting densities within the spring and fall 2009 harvests, whereas *S. exigua* displayed limited competitive effects even under high planting densities ($9/m^2$). The plots where the native shrubs were allowed to establish for 90 days (delayed) prior to *A. donax* planting showed a significant tendency to inhibit *A. donax* growth, which increased with native planting density and was most significant in the fall season. Concurrent plantings also had significant results in the fall for all *B. salicifolia* plots. LAI measures showed that the canopy of *B. salicifolia* was better able to shade the soil surface than *S. exigua* over all planting densities.

The premise of the experiment was to utilize cultural control to test the ability of *A. donax* to establish under limited light resources. The results demonstrate the differences between the competitive effects of two native shrub species to inhibit the establishment of *A. donax* within a common garden experiment. When providing active restoration within an *A. donax* control site, species selection may be an important factor in long-term invasive control. *B. salicifolia* was shown to provide dense shade which negatively effected the growth and ability for *A. donax* to establish, while *S. exigua* only provided moderate control under the most dense planting treatments. Fall restoration plantings may lead to better control as seasonal dormancy in *A. donax* enables native shrubs time to establish a robust canopy.

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## Effects of Exotic Mustard on Native Insect Communities in California Grassland

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Invasive plants are known to affect native plants, but little is known about how exotics affect higher trophic levels. In particular, the effect of exotic plants on insect communities is poorly understood. Most work connecting invasive plants to insect communities considers these interactions from the perspective of biological control (e.g. the Biotic Resistance Hypothesis or the Enemy Release Hypothesis). Because insects represent the majority of animals found in an ecosystem, it's crucial that we understand these interactions. In Southern California, Black Mustard (*Brassica nigra*) has invaded Grassland and Coastal Sage Scrub communities. Few plants can grow with Black Mustard without high fitness costs. In a one-season common garden experiment, we sought to understand how Black Mustard affects the insect communities found on the co-occurring native species, *Deinandra fasciculata*. Native *D. fasciculata* individuals were grown with and without Black Mustard. Insects were surveyed on *D. fasciculata* at peak flower, using visual counts. Growth and fitness were measured for both *D. fasciculata* and Black Mustard. Because Black Mustard tends to lower plant fitness and may lower plant allocation to defense against herbivores, we expect to find a greater abundance of insects on the plants grown with mustard. However, we expect there to be a higher diversity of insects on the plants grown without mustard because these plants will allocate more resources towards defensive chemicals, attracting a more diverse specialist insect community. In summary, we expect that Black Mustard may increase herbivore abundance on natives, but at a cost to insect diversity.

# Contributed Posters

## Control of Barbed Goatgrass in Serpentine Grasslands

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Serpentine grasslands are known for being relatively free of the invasive species that typify other California grasslands. Recently the special status of serpentine grasslands as strongholds of native plant diversity has been threatened by the spread of barbed goatgrass (*Aegilops triuncialis*), a Eurasian annual that is unique in its tolerance of serpentine soils. We evaluated nine treatments for their effectiveness controlling barbed goatgrass and for restoring native species cover and diversity: two grass-specific herbicides (fluazifop and clethodim) applied before goatgrass flowering (early-season), at flower initiation (mid-season) and at early seed development (late-season), a broad-spectrum herbicide (glyphosate) applied late-season and mowing and hand pulling. Treatments were applied to 4m² experimental plots in inner Coast Range serpentine grassland with high cover of barbed goatgrass but few other non-native species. After two years of treatment, all treatments except glyphosate and early-season clethodim reduced goatgrass cover. Hand pulling and mid-season fluazifop were most effective at controlling goatgrass, reducing cover by 60% (compared to a 30% increase on control plots). All treatments except late-season fluazifop increased native forb cover. Late-season clethodim and mid-season fluazifop also increased native bunchgrass cover. No treatment decreased the cover of any particular native species, including grasses, except for glyphosate, which tended to reduce or eliminate species that were actively growing at the time of application. The grass-specific herbicides show great potential to surgically control barbed goatgrass and other non-native annual grasses in grasslands that are otherwise dominated by native grasses and forbs.

## Predicting the Spread of Invasive Plants with Climate Change

*Elizabeth Brusati, Doug Johnson, Cynthia Powell*, cpowell@cal-ipc.org, and Falk Schuetzenmeister, California Invasive Plant Council (Cal-IPC), Berkeley, CA Presenter's email:*

### Introduction

The Sierra Nevada is likely to be heavily impacted by climate change. Invasive plants are predicted to spread into the region and to higher elevations. Land managers need to know where to focus their work to produce the most effective ecosystem restoration. Predictive models can help early detection by showing where invasive plants may spread and predicting the effects of changing conditions under global climate change. Such predictions are especially important in light of research showing that 66% of California's native plants could lose 80% of their range due to climate change (Loarie et al. 2008). Land managers can also use these data to justify projects to funding agencies.

In 2006-08, we examined 36 invasive plants statewide. We are currently studying 30 additional plants of concern in the Sierra region and improving the resolution of the results using new methods. This project will be completed in 2011.

### Goals

- Collect data on current distribution and population trends for a set of plant species of high priority for early detection

- Use predictive models to determine which areas of the Sierra are most suitable under current and future climate conditions
- Integrate data on current distribution and suitable habitat into risk maps using Geographic Information Systems (GIS)
- Generate watch lists based on these maps to distribute to Weed Management Areas in the Sierra Nevada

## Methods

### Data Collection

**Occurrence**

We trained the models with presence data from Calflora (www.calflora.org) and vouchered specimens from the Consortium of California Herbaria. We are adding additional data by contacting governmental agencies, organizations and individuals to better represent the plant habitat ranges. If you have data you are willing to share, please contact us!

**Environment**

We are using environmental layers from a free data product called BIOCLIM. This dataset contains parameters that are especially useful to describe the climatic conditions a plant needs to thrive. The variables are calculated from monthly maximum and minimum temperature, rainfall, solar radiation and pan evaporation from 1970-2000 within a 30 arc-second grid. For details see: http://fennerschool.anu.edu.au/publications/software/anuclim/doc/bioclim.html

**Future Climate Change Conditions**

BIOCLIM variables for future conditions are calculated from the outputs of major climate models, in our case Canadian Center for Climate Analysis and Modeling (CCCMA).

Maxent software (Stevens et al. 2006) is freely available and frequently used to assess suitable habitat for plants and animals given specific environmental variables. The principle of the algorithm assumes that the distribution of a species will be random or contain maximum entropy, unless conditions that encourage or discourage growth are in place.

Maxent requires only presence data in addition to environmental information. The software assumes pseudo-absence for areas with no presence. Environmental suitability is then mapped in the Maxent output in addition to the role, or percent contribution, each of the environmental variables played in the output. The resulting maps show the probability for that an occurrence in a raster cell is not random but an effect of the environmental conditions.

The results of this model fitting or training process can be used to estimate the future distribution under changing climate conditions.

However, habitat modeling does not work equally well for all species. Reliable results need a representative dataset (where all possible habitats are represented by data points), a state of relative equilibrium (the plant occurs in most of its possible habitats) and the adaptability of the species is restricted in a way that the environment variables provide actual limits for further spread.

Since these conditions are not necessarily met for all invasive species, we developed a model evaluation tool with the goal to inform potential users of our results about the limitations of modeled suitability. We are currently experimenting with strategies to model the potential habitat of new invaders in California. One way is to use natural range training since equilibrium can be assumed in the native range.

## Results

### Case Study #1 *Bromus japonicus* (Japanese brome)

*Bromus japonicus* (Japanese brome) is a cool season, annual grass common in Northern California. This grass out-competes native grasses in areas where grazing and fire have been reduced. Native to Europe, Japanese brome is now considered naturalized (in equilibrium) throughout the United States. It occurs on a wide variety of soils that include sand, silt and clay, but thrives on fine-textured soils. Waste areas, disturbed sites, roadsides, pastures, rangelands and wheat fields are areas where Japanese brome may establish. With climate change the available niche will increase further.

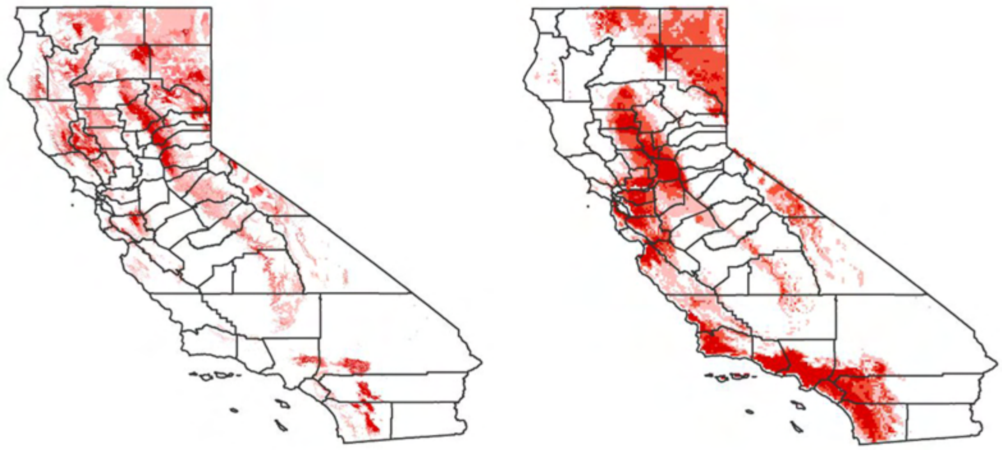

Figure 1

*Bromus japonicus* current potential habitat and 2080 potential habitat; darker red shows more suitable habitat

Annual precipitation, mean temperature of the wettest quarter and precipitation of the driest quarter each played a large role (> 15% each) in the Maxent results. These percentages were determined by an estimate of relative contributions of the environmental variables to the Maxent model. We had 151 presence points for this species. Our model shows that Japanese brome will spread with climate change, likely because of the more intense precipitation events.

### Case Study #2 Isatis tinctoria (Dyer's woad)

*Isatis tinctoria* (dyer's woad) is a winter biennial or short-lived annual herb/forb in the Brassicaceae family. Plants are highly competitive and often grow in dense colonies. Dyer's woad is native to central Asia and northern Russia. It was introduced to North America in the early 1900s as a contaminant in alfalfa seed. Plants occur in areas with poor, dry soils such as roadsides, rangelands and open forests.

Annual precipitation and precipitation of the driest quarter each played a large role (> 25% each) in the Maxent results. We had 210 presence points for this species.

We suspect that the reason dyer's woad habitat does not expand in the future climate change scenario is because it requires dry soils and extreme precipitation events are likely to increase with climate change. Dyer's woad thrives in dry, rocky or sandy soils and our model shows that, with climate change, its habitat will likely decrease due to increased precipitation events.

This project will lead to long-term improvement in the effectiveness of Sierra agencies and organizations to address invasive plant detection and control. Land managers will be able to identify species that are good targets for early detection/rapid response. Identifying the "leading edge" of new invasions will encourage regional cooperation, leading to more effective use of time and

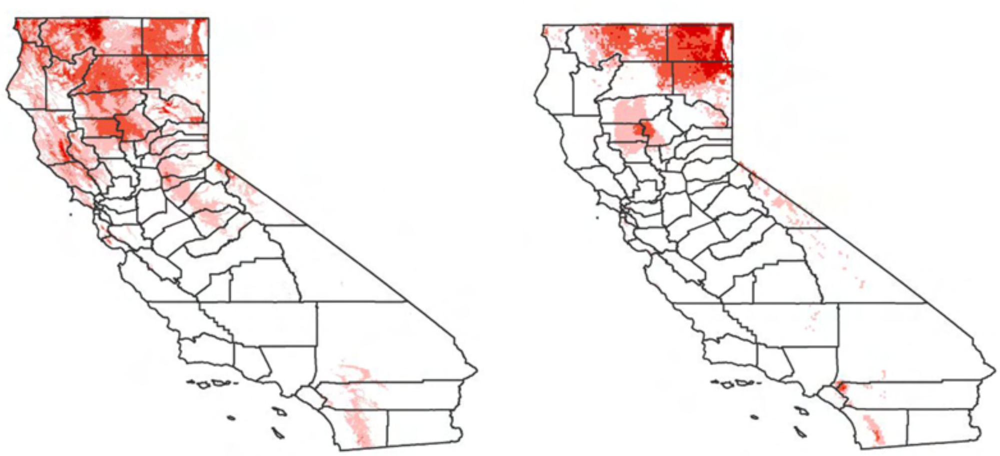

Figure 2

*Isatis tinctoria* current potential habitat and 2080 potential habitat; darker red shows more suitable habitat funding. Applying for funding to eradicate such species will be backed by finer scale maps to help verify the need for support. Effective prevention, detection and containment of invasive plant species in the region will decrease the stress that impedes range shifting of native species as our climate changes.

### Model Evaluation

In order to evaluate the accuracy and uncertainties of our Maxent models, we used the following criteria (scored from 1 to 3, poor to good for the model):

- Number of data points available
- Distribution of data points relative to known range
- Ease of accurate identification of species
- Adaptability of species to new environmental conditions
- Whether species is in equilibrium (i.e., no longer expanding, Stevens et al. 2006)
- Model statistics (Area Under the Curve (AUC) and significance) from Maxent
- Area where clamping is necessary in order to make a future prediction. Clamping recognizes that future climate might produce conditions that are not represented by the training data. In this case there are two options: One is to use the actual values as input for a prediction. Another option (clamping) replaces the actual value of an environmental variable with the closest value represented by the training data. If clamping in a big area is necessary, the future prediction will contain more uncertainties.
- Expert evaluation: We present our current suitability models to expert botanists and ask them how well our outputs represent their spatial and ecological knowledge about the plant. Please let us know if you want to be part of this process!

### Acknowledgements

Thank you to all the WMAs that provided data. Funding provided by California Department of Food & Agriculture, USFS State and Private Forestry Program, National Fish and Wildlife Foundation, Resources Legacy Fund Western Conservation Program. Data provided by Calflora, Participants of Consortium of California Herbaria, Cal-IPC is an equal-opportunity employer.

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## Effects of Invasive *Limonium ramosissimum* on Native Salt Marsh Communities in a Changing Environment

*Cleave, Autumn* and Katharyn E. Boyer, Romberg Tiburon Center for Environmental Studies and Department of Biology, San Francisco State University, 3152 Paradise Drive, Tiburon, CA 94920 Presenter's email: acleave@sfsu.edu*

*Limonium ramosissimum*, Algerian sea lavender, is an established invader in southern California marshes that is forming monotypic stands in the middle to high elevations of a number of marshes in the San Francisco Bay Estuary. *L. ramosissimum*'s high salinity tolerance, reproductive rate and dispersal suggest potential for spread in the Estuary and an understanding of its interactions with native species and effects on ecosystem function is needed. In this project, we are assessing how invasion by *L. ramosissimum* affects abundance and function of the native amphipod, *Traskorchestia traskiana*, and how anthropogenic changes may further affect these interactions. At two salt marshes in South San Francisco Bay we established plots of *L. ramosissimum*, and a native plant, *Jaumea carnosa*, at two elevations (levels of inundation) as a proxy for sea level rise. To simulate anthropogenic nutrient enrichment, we added nitrogen (N) fertilizer every two weeks during the growing season. Early results indicate that at both marshes, Coyote Point Marina and

Sanchez marsh, there was an increase in canopy height in correlation with nutrient addition, but *L. ramosissimum* canopies were still significantly shorter than *J. carnosa*. Field observations indicated that the native amphipod habitat preference is for *L. ramosissimum*. Additional study with stable isotope tracers, evaluation of native amphipod and other insect species use and decomposition rates will help to further establish ecosystem changes occurring as result of the invasion. This will also help us assess any further anthropogenic induced modifications on ecosystem changes.

## Developing Time*Temperature Inactivation Models for Thermal Death of Black Mustard (*Brassica nigra*) Seeds

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Many of California's native plants and wildflowers are being out-competed by invasive weed species. Solarization is a nonchemical method of that can provide an environmentally friendly alternative for inactivating weed propagules, as well as certain other pests. However, information is lacking on the duration of solarization treatment and temperatures required to control various weed species. We determined the time required for mortality of black mustard [*Brassica nigra (L.)* Koch] seeds at constant temperatures of 42, 46, 50 and 54 C. Seeds were placed in organdy bags and allowed to imbibe water at room temperature for two hours before heat treatment. Seed bags were placed in jars filled with sand wetted to field capacity, maintained at constant temperature in a water bath and removed at several time intervals for each constant temperature. After removal from the jars, seeds were incubated in a growth chamber and germination percentages were determined after 14 days. At sampling times with 0% germination, seeds with intact seed coats were confirmed as nonviable using a tetrazolium test. Seed samples reached 100% mortality by three hours at 54 C, nine hours at 50 C, 240 hours at 42 C and 97% mortality at 57 hours at 46 C. Nonlinear models were developed to estimate seed mortality as a function of heat treatment duration and temperature. These models have potential applications for predicting mortality of black mustard seeds during solarization, and other heat-based treatments, in the field.

## *Eriogonum* Hybrid Eradication Program on Santa Cruz Island, California: Eliminating One Island Endemic to Protect Another

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Santa Cruz Island buckwheat (*Eriogonum arborescens*) is a northern Channel Islands endemic shrub common in coastal scrub habitat on Santa Rosa, Anacapa and Santa Cruz islands. However, it is genetically threatened on Santa Cruz Island (SCI) by the introduction of *Eriogonum giganteum* var. *giganteum* which is endemic to Catalina Island. *E. giganteum* was introduced from Catalina to Santa Cruz in the late 1960s for landscaping around ranch buildings in the central portion of the island. Evidence of hybridization between the two species (*E. xblissianum*) was observed by 1972. The Nature Conservancy owns the portion of SCI where the Catalina buckwheat was introduced and has opportunistically controlled non-native *Eriogonum* since the early 1980s. Following an island-wide weed survey in 2007, all mapped non-native *Eriogonum* populations, both the species and hybrids, were targeted for eradication and treated. Funding was secured in 2010 to systematically resurvey known infestations and the surrounding areas on-foot and from low-level helicopter flights. Approximately ten new populations were found and all individuals were treated with 100% Garlon 4 Ultra as a cut-stump method or were hand pulled. One hundred percent of the populations were detected from the air, while only 20% of those populations were detected from the ground, suggesting that aerial surveys are more accurate at detecting incipient populations than ground surveys. Additional surveys and treatment will occur in 2011. These actions are designed to protect and preserve the genetic integrity of this endemic island buckwheat species.

## Use of Non-Native Plants by Island Foxes: Conservation Implications

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Endangered island foxes (*Urocyon littoralis*) occur on the six largest Channel Islands off the coast of southern California. Anthropogenic activities on the islands have resulted in the introduction of a number of exotic plant species. We examined fox foraging patterns during 2009 in part to determine use of non-native plants. Non-native fruits consumed by foxes included ice plant (*Carpobrotus chilensis, C. edulis, Mesembryanthemum crystallinum* and *M. nodiflorum*), Australian saltbush (A*triplex semibaccata*) and myoporum (*Myoporum laetum*). Ice plant was a primary food item for foxes (>10% frequency of occurrence in scats) during two seasons on San Clemente, three seasons on San Miguel and all four seasons on San Nicolas. Saltbush was a primary food item during one season on San Clemente and Santa Rosa and during two seasons on San Nicolas. Myoporum was a primary item during one season on San Nicolas. For all four seasons combined (i.e., annual diet), ice plant was a primary item for foxes on Miguel and Nicolas (41.8% and 35.0% of scats, respectively) and saltbush was a primary item on Nicolas (21.1% of scats). Although these plants are providing a benefit to foxes by increasing the diversity of available food items, these plants also may be excluding native species. Reducing or eliminating these non-native plants probably could be conducted without adverse impacts to foxes, with the exception of San Nicolas. On this island, foxes may be at least partially dependent on these species and any reductions should be conducted gradually and preferably in conjunction with active restoration of native species to provide alternate foods for foxes.

## Linking Vegetation Dynamics with Physical Processes to Develop Invasive Plant Control and Riparian Restoration Strategies for a Semi-Arid River and Its Floodplain


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*Gretchen Coffman, University of California, Los Angeles and Santa Barbara, CA*

*William Sears, Stillwater Sciences, Berkeley, CA and San Francisco Public Utility Commission, San Francisco, CA*

*Peter Brand, California Coastal Conservancy, Oakland, CA*


The lower Santa Clara River (Ventura County, CA) has been significantly altered by levees, water diversions, agriculture, invasive plant species and urbanization that have altered natural physical and ecological processes, causing riparian habitat loss or degradation. The California Coastal Conservancy's Santa Clara River Parkway project seeks to ameliorate these impacts and conserve existing riparian habitats by acquiring and restoring a 25 mile-long floodplain corridor. Understanding the physical drivers for riparian vegetation distribution and composition is a crucial part of developing feasible restoration strategies for the Parkway project. We used a variety of analytical tools, including historical analysis, vegetation classification and mapping, and riparian dynamics analysis, to elucidate the conditions and processes that shape vegetation distribution and composition. We found that the extent of riparian vegetation has been dramatically reduced by levees and floodplain development, that large areas of native riparian vegetation have been replaced by invasive, non-native species and that longitudinal position, groundwater, time since last flood and relative elevation are the physical variables most strongly correlated with riparian plant species distribution. Our understanding of watershed conditions and vegetation response to physical variables allowed us to develop effective and feasible restoration strategies for the lower Santa Clara River Parkway, including: identification of priority areas for restoring floodplain connectivity, conserving native vegetation, as well as active (horticultural) and passive (process-based) revegetation, tools for developing site-appropriate planting palettes and development of a strategy for non-native invasive plant species control.

## Preventing Invasion Through Mineral Materials Inspections


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The prevention of new introductions is a critical component of a comprehensive invasive plant management program. The import of contaminated sand and gravel for road construction projects provides a rapid and common way to introduce major new infestations. Yosemite National Park no longer operates its own quarries and all mineral materials are now purchased from external sources. Many quarries in the outlaying areas are heavily infested from which the park must be protected. Yosemite National Park is developing a gravel pit inspection and certification program that will be in full compliance with the national standards for weed-free gravel as developed by the North American Weed Management Association. Additionally, the program conforms to the California state mandate to control all A-listed noxious weeds as defined by the California Department of Food and Agriculture. While ultimately this project is a preventative measure to keep invasive plants out of the park, the program is conducted as an outreach service to gravel pits. The aim is to work collaboratively with gravel pit operators, providing the botanical skills and access to resources necessary for efficient and effective weed control. Successful participation in this program by gravel pits allows the sale of mineral material to Yosemite National Park and provides a marketable certificate that can increase the value of mineral materials. Similar programs are in place in the Lake Tahoe basin, Glacier National Park, and the greater Yellowstone area.

## Trials of Aminopyralid and a Cut-and-Dab Method for Himalayan Blackberry (*Rubus armeniacus*) Control

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### Abstract

Himalayan blackberry (*Rubus armeniacus* Focke) has gained a stronghold in many riparian areas throughout the western United States and Canada. Herbicide has been shown as an efficient and effective tool for Himalayan blackberry removal yet land managers sometimes must consider other natural or cultural resource issues that restrict its use. Some of these issues, such as off-target harm of desirable native plants or contamination of water may be mitigated with a selective herbicide or a targeted application technique. Here, we report first-year results of two of these mitigation measures (the use of aminopyralid, a selective herbicide and application of glyphosate using the cut-and-dab method), as well as a foliar application of glyphosate for use in Yosemite National Park. Reduction of Himalayan blackberry density and cover occurred in all three treatments compared with the control. We observed that the aminopyralid treatment was highly effective at some sites and only marginally effective at others. These results suggest that there are unknown factors affecting the efficacy of aminopyralid such that we need further field experimentation before using on a wider scale. The cut-and-dab method was effective but was time-intensive compared with foliar application. The cut-and-dab method therefore offers a promising mitigation tool for sites that require special consideration. These are only first year results and we will continue this study for two more years to look at longer-term effects.

### Introduction

Herbicide has been shown to be an efficient, effective and safe tool for invasive plant treatment. However, land managers sometimes must consider other natural or cultural resource issues that restrict its use. For example, invasive species may invade areas that contain rare or special status plants (Huenneke and Thomson 1995) or plants that are gathered by American Indians (Pfeiffer and Voeks 2008). Invasions of special status plants both demand immediate treatment and require additional attention to prevent off-target plant damage. In other cases, contamination of sensitive water bodies is a concern such that even by an EPA-approved aquatic formulation is restricted. Off-target harm of desirable native plants or contamination of water may be mitigated with a selective herbicide or a targeted application technique.

Himalayan blackberry (*Rubus armeniacus* Focke) has invaded 100 acres forest understory, meadows and riparian zones in Yosemite National Park and was selected as a primary target for herbicide use because of its difficulty to control with mechanical and manual methods and because other land managers have successfully used herbicide to control it. However, issues of blackberry occurring with cultural-use plants, rare plants or adjacent to water have prevented managers from treating all populations. In order to eradicate the species from Yosemite, all populations must be treated. Here we test the efficacy of an alternative, more selective herbicide, aminopyralid (Tradename, Milestone®), and an application technique, cut-and-dab (with glyphosate). Results from this trial will inform adaptations of our treatment prescriptions.

## Methods

We conducted this study in Yosemite National Park at six sites in the montane region at approximately 1,200 m elevation. *Rubus armeniacus* infested these sites with 60-100% cover. Within each site, we established three plots (6 m x 6 m) with the criteria that *R. armeniacus* cover was >50% and that the plot corners were located fully within the patch. We randomly assigned one of three treatments to each plot: glyphosate (2%), aminopyralid (7 oz/ac) and control. After these plots were established, we saw the potential to use the cut-and-dab method. Therefore, an additional plot was established, non-randomly but with similar conditions as the other plots, at four of the six sites. The addition of this test was to provide us with anecdotal information on the efficacy of the cut-and-dab treatment using undiluted glyphosate.


Figure 2

Treatment with aminopyralid yielded variable results. In some cases, Himalayan blackberry was effectively controlled and native plants persisted (left). However, aminopyralid had little effect at other sites (right)

We recorded pre and post-treatment percent *R. armeniacus* cover by visual estimation and stem density in the central 2 m x 2 m quadrat. We calculated the percent change in stem density and percent cover for each plot (t2-t1)/ t1 * 100. Additionally, we recorded the presence of all other vascular plant species in plots but these species composition data was not analyzed for this first year.

## Results and Discussion

Our results show that all three methods are effective at controlling *R. armeniacus* (Figure 1); however, our observations showed that they were not all equal. Foliar glyphosate applications yielded the most consistent result with very high levels of control but also observed off-target harm. As a broad-spectrum herbicide, this was expected.

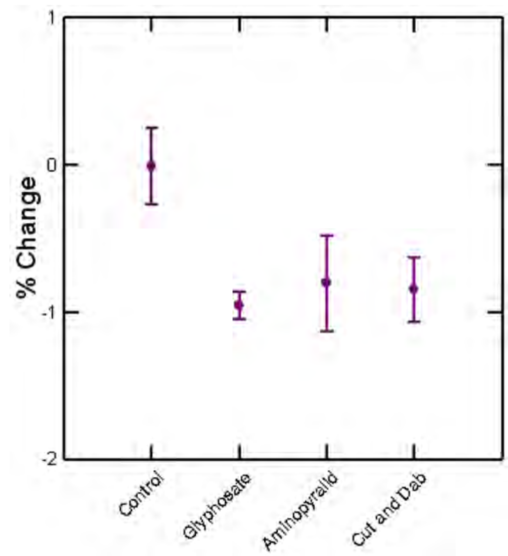


Figure 1

All three treatment types were quite effective at controlling Himalayan blackberry after only one year, compared with a control. Error bars indicate one standard deviation.

Aminopyralid-treated blackberry demonstrated highly variable responses (Figure 2). Not only was this phenomenon captured in the plot data, but, in treatments elsewhere in the park, field technicians observed a range from no change to nearly 100% control on infestations. Further testing of the conditions under which aminopyralid would be effective is necessary before committing to its use on Himalayan blackberry on a larger scale. Timing of application may be a factor; field technicians noted that the more successful applications occurred earlier (summer) and those that failed were later in the season (fall).

The cut-and-dab method was effective as well, but comes with a trade-off. This method is more time-consuming because it requires lopping, biomass removal and immediate application of herbicide. Also, this method exposes the applicators to more herbicide because they handle the concentrated solution. Therefore, we recommend its use only where highly selective application is required to protect other resources.

These data represent one year of treatment and its effects. With this, we have decided to abandon the use of aminopyralid because without better understanding of environmental factors playing into its efficacy, it is not an effective tool. Instead, we will continue to use glyphosate as a foliar application for most situations. We will also employ the cut-and-dab method when mitigation of off-target effects on co-occurring plants is necessary. This study will continue for two more years, after which we can revisit our conclusions and make a more definitive recommendation.

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## Herbicide Control of Velvet Grass in Yosemite National Park

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Wetland ecosystems are in constant flux, making them particularly susceptible to weed invasions. Once established, wetland weeds tend to spread quickly because of high habitat connectivity and animal usage. Common velvetgrass (*Holcus lanatus*), a perennial European grass noted as a prolific seed-producer, has invaded many highly-valued wet meadows in Yosemite National Park (YOSE). Three years of manual treatment of *H. lanatus* in YOSE did not lead to notable long-term improvements and were very time-intensive. Furthermore, manual methods cause soil disturbance that may activate the *H. lanatus* seed bank. Chemical treatment of velvet grass may provide better control because of the greater efficacy of herbicide and because the plants can be removed without soil disturbance. To evaluate the efficacy of herbicide and effects on the plant community we conducted a field study comparing glyphosate treatment with a control. Preliminary observations indicate that velvet grass plants may have had lower survival in the herbicide-treated plot than the control. However, velvet grass was still present in the treated plots and velvet grass cover was not significantly reduced. Plants in the treated plots appeared to be regenerating from both seed and rootstock. These results indicate that the seed bank was quite active and that some plants experienced "top-kill" in which the high concentration of herbicide worked only to kill the above-ground biomass. Based on these findings, our prescription recommendations are to 1) Treat velvet grass before seed-set and 2) Test lower herbicide concentrations such that the herbicide can translocate to the roots and affect the whole plant.

## Adaptive Integrated Vegetation Management of Invasive *Spartina densiflora* in the San Francisco Estuary

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*Spartina densiflora* (Chilean cordgrass) was introduced to Creekside Park along Corte Madera Creek, Marin County in the 1970's as part of a restoration effort. It had been misidentified as native *Spartina foliosa* (Pacific cordgrass) and was subsequently imported from Humboldt Bay where it infests more than 2000 acres after dry ballast was deposited there during the timber trade with South America in the 19th Century. By 2004, *S. densiflora* dominated the marsh at Creekside Park and had spread to twelve other marshes in Marin as well as Point Pinole and Mare Island across the North Bay. The Invasive Spartina Project (ISP) and Friends of Corte Madera Creek Watershed began treatment on these infestations in 2004-2006, relying predominantly on imazapyr application in the initial years to gain control of the problem, while also digging isolated plants and outliers with the Conservation Corps. Until receiving an amendment to the Biological Opinion in 2008, entry into many infested marshes was restricted until the end of endangered California clapper rail breeding season on September 1. Since *S. densiflora* sets seed by early July, that initial timing made it impossible to stay ahead of the infestation. In addition, imazapyr produced extremely variable results, especially on established meadow areas and on small plants with less leaf surface area. Mowing the persistent dead biomass remaining at meadows of previously-sprayed *S. densiflora* allowed for fresh green growth that could identify targets for retreatment with imazapyr or digging. Despite these considerable challenges, the annual imazapyr treatment significantly reduced the infestation, allowing the integrated vegetation management strategy to shift by 2010 to purely manual removal by ISP biologists at 93% of the sites.

## Santa Clara River Research Station: Developing a Preserve with a Watershed Focus

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The Santa Clara River is one of the few major river systems in the state that retains much of its natural hydrology and provides the ecosystem functions necessary to sustain more than 17 listed endangered species within its watershed boundaries. It is because of these environmental opportunities juxtaposed with anthropogenic threats that the California Coastal Conservancy and The Nature Conservancy have designated protection, habitat restoration and ecosystem management of the Santa Clara River as a conservation priority. Thus, there is increasing recognition of the need for a central facility and locally-based capacity to promote and coordinate research, restoration and monitoring activities within the watershed and to develop public education programs that convey environmental science information about the watershed to schools and the general public. In partnership with government and nongovernment organizations and private landowners throughout the region, we are working toward a multi-disciplinary, permanent research station and ecological reserve comprised of satellite locations throughout the watershed focused on research and education, invasive species management, riparian restoration and providing science-based resources to managers, policy-makers and the public.

## The Spread and Control of *Dittrichia graveolens*

*Meg Marriott, USFWS, San Francisco Bay National Wildlife Refuge Complex, Meg_Marriott@fws.gov*

*Dittrichia graveolen*s is a highly invasive, Cal-IPC designated Red Alert species in California, that is known to route its resources into seed production when stressed. We conducted an experiment to observe the effects of three control treatments on flowering *Dittrichia graveolens* and assessed the viability of seeds produced after plants were treated with herbicide. We pulled *D. graveolens* plants with roots intact, cut plants at their base without their roots and sprayed plants with Habitat® herbicide. We found that all treatment plants produced seeds after treatment, but that the seeds of the herbicide treated plants were not viable.

### Introduction

*Dittrichia graveolens* will route its resources into producing seeds when stressed. Once flowering, *D. graveolens* will go to seed under most control regimes, including herbicide application and hand pulling. We conducted an experiment to observe the effects of three control treatments on flowering *Dittrichia graveolens*. In addition, we assessed seed viability of flowering *D. graveolens* treated with herbicide.

### Methods

We conducted our experiment on the Mayhews Landing unit of the Don Edwards San Francisco Bay National Wildlife Refuge in Fremont, California. In November 2009, we hand-pulled seven *D. graveolens* plants with root intact and cut seven more plants at their base (not including roots). We secured plants on the ground (with rocks and wire) at treatment sites and flagged seven untreated *D. graveolens* plants within one meter of treatment plants, to use as a control group. We also sprayed an approximately 50 m2 infestation of *D. graveolens with* Habitat® (active ingredient: imazapyr).

### Results and Discussion

We returned one week after treatment and found that all plants in all three treatment groups had produced seeds. The cut plants and those sprayed with herbicide appeared to have produced seeds at approximately the same rate as the control plants. However, the plants pulled with their roots intact seeded to a much greater extent (not quantified) that the control plants.

We collected seeds from 14 *Dittrichia graveolens* plants that we had sprayed with Habitat (imazapyr) in the above experiment. We also collected seeds from 14 *D. graveolens* plants (control) that were not treated with herbicide, but allowed to seed out naturally. We planted seeds from the experimental and control groups in a controlled environment and watered twice per week. Within two weeks of planting, the untreated, control *D. graveolens* seeds began to germinate. The treated seeds did not germinate within two weeks and showed no signs of germinating three months after planting. We concluded that the herbicide treated plant seeds were not viable.

## Avian Response to *Arundo donax* Invasion on the Lower Santa Clara River

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*Arundo donax* is among the top invasive plant species degrading California's riparian ecosystems. While previous studies have examined the effects of other exotics, such as *Tamarix* spp., on riparian systems of the American Southwest, relatively little is known regarding the wildlife implications resulting from *A. donax* invasion, despite the scale of resulting habitat transformation. In 2009, I began an avian monitoring study to assess the habitat value of *A. donax* stands relative to native vegetation types (primarily *Salix* spp.). Habitat value was determined by abundance of individuals and diversity of species present. I conducted point count surveys at two sites on the Lower Santa Clara River, Ventura Co., once a month from May through August. Each site contained an equal distribution of points among *A. donax* (over 70% cover), mixed *A. donax* and natives and natives (over 70% cover). Preliminary results show diminished species diversity and fewer total individuals in *A. donax* relative to native stands, with intermediate diversity in mixed patches. I intend to continue this study and use results to inform river restoration efforts to maximize habitat value for vulnerable avian populations present in this system, including the least Bell's vireo, yellow-billed cuckoo and southwestern willow flycatcher.

## Prioritizing Invasive Plant Eradication in the San Francisco Bay Area

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*Andrea Williams, Marin Municipal Water District*

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### Abstract

The Bay Area Early Detection Network (BAEDN) coordinates Early Detection & Rapid Response to infestations of invasive plants throughout the nine county San Francisco Bay Area, proactively addressing with new outbreaks before they can grow into large and costly environmental threats. This strategy is applied to regional eradication of invasive species from the Bay Area, the feasibility of which will be higher the earlier eradication is conducted and the less established and widespread the target species are.

Limited-distribution invasive species in the Bay Area were identified by analyzing occurrence records within the Calflora database. These were then prioritized according to an abbreviated weed risk-assessment model and by expert opinion from throughout the region. This species assessment folded in state-wide eradication targets of the California Department of Food & Agriculture (CDFA) and included information on known invasiveness, impacts, reproductive biology and feasibility of treatment.

The results of this analysis comprise a priority early detection species list for the San Francisco Bay Area and are being applied to early detection efforts around the region. We then prioritized populations of high-priority species for eradication using a new tool: Weed Heuristics: the Invasive Population Prioritization for Eradication Tool (WHIPPET) that prioritizes eradication targets based on relative impact, invasiveness and feasibility of eradication.

### Introduction

The impact of biological invasions on resources and biological diversity are tremendous; impacts in the U.S. are estimated at $143 billion per year (Cusak 2009) and invasive species are second only to habitat destruction as a threat to wildland biodiversity and endangered species (Wilcove 1998). Invasive species reduce the size and genetic diversity of native wildlife and plant populations, reduce available habitat and compete for resources and reduce the resilience and resistance of ecosystems. Invasive species also carry negative impacts to agricultural resources.

Paired with prevention, early detection and rapid response (EDRR) to invasive plant outbreaks—when they are small and prior to long term establishment—is the most effective means of protecting against the harm caused by invasive plants. Early-stage detection and treatment of invasive plant infestations—when they are small and prior to long term establishment—greatly increases treatment efficacy and return-on-investment, yielding a cost-to-benefit of $17-$34 for every $1 invested (Cusak 2009). EDRR also carries secondary benefits of significantly less impacts, as these invasions can be treated within smaller areas and shorter timeframes and potentially with less physically, biologically and chemically disruptive methods. Further, EDRR also represents a significant opportunity to accomplish broader ecosystem management goals; intensive management resources required to adequately address larger and more entrenched invasive plant infestations can be shifted to other ecosystem needs.

Carried out at a regional scale, the benefits of EDRR at one site contribute both site-specific and regional benefits, as the threat of spread by new invasives to new sites is pre-empted. This represents a real incentive for coordination, information sharing and partnership across jurisdictional boundaries to maintain common goals.

## Methods

BAEDN used a data-driven process augmented by expert opinion to generate a list of priority early detection plant species for the San Francisco Bay Area. Listed species are known to be invasive and of limited San Francisco Bay Area distribution. Invasiveness was determined through an abbreviated weed risk assessment that evaluated species categorically as known or not known to be invasive through consultation with published literature and regional expert opinion.

Subsequent to determining priority EDRR species, BAEDN then prioritized reported populations of these species for eradication using WHIPPET, which prioritizes eradication targets based on relative impact, invasiveness and feasibility of eradication.

### *Species Prioritization*

The process of listing species combined quantitative analysis of distribution and invasiveness with supplemental expert opinion. California occurrence records for non-native plant species were downloaded from the Calflora database (www.calflora.org) on July 7, 2010. Point occurrence records were buffered by 100 meters and conspecific points with overlapping buffers were merged in an effort to reduce redundant reports (either from reports of the same population from various times, and/or by multiple observers). Each geographically distinct population was assigned a unique population code.

Populations corresponding to records from January 1, 2000 to July 7, 2010 for all non-native plant species were then evaluated for their level of documented invasiveness from a broad set of publications and rankings. Non-native species shown to be invasive and have limited Bay Area occurrence records were reviewed as candidate early detection species. Invasive plant experts from across the region then reviewed candidate species to verify distribution and invasiveness. Experts also reviewed species not documented as invasive by our consulted sources, so that invasive species not well studied or understood in the literature were not overlooked (Figure 1).

| **Experts ranked species on:** | **High species scores were assigned for:** |
| --- | --- |
| • impacts to wildlands, rangelands, and humans | • high impacts |
| • spread rate | • high spread rate |
| • reproductive ability | • low reproductive ability |
| • detectability | • high detectability |
| • control effectiveness | • high effectiveness of control |

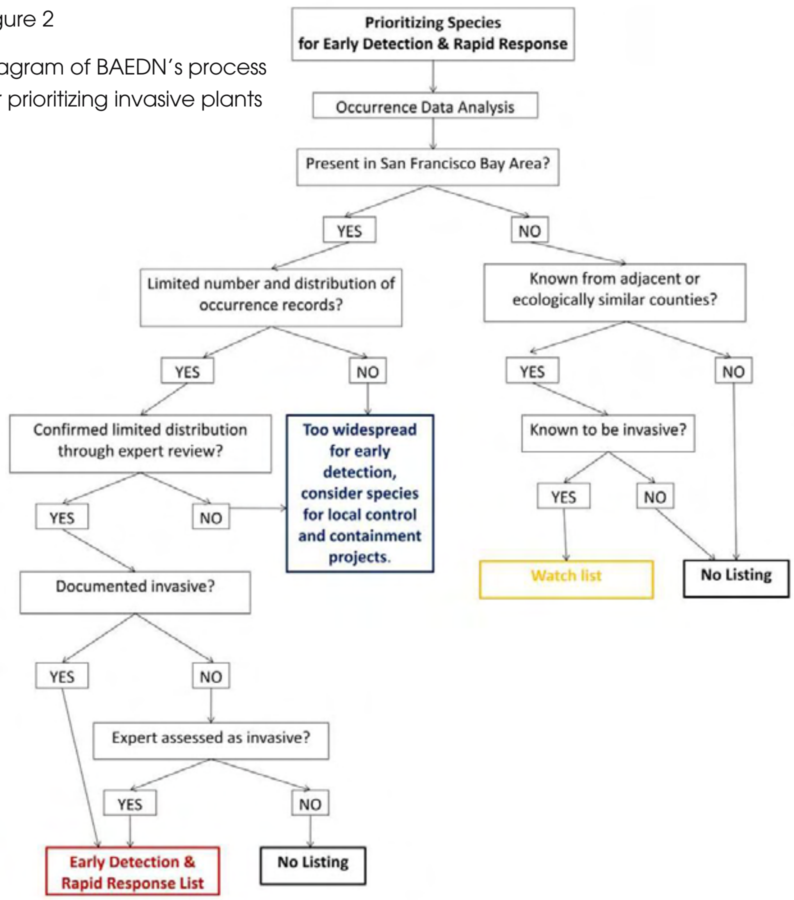
### *Population Prioritization*

Populations of target species were prioritized for eradication using WHIPPET, which scores each population based on a combination of proximity to high value assets and vectors of spread and species-specific criteria (Figure 2).

Proximity to high value assets and vectors of spread was measured for each occurrence using Geographic Information Systems software. Closer proximity garnered higher scores. Geoprocessing models were not available for one factor, propagule pressure. Rather than generating scores based on distance to nearest conspecific

Figure 2

Diagram of BAEDN's process for prioritizing invasive plants




population, we scored conspecific populations equally on this factor based on the number of populations in the region, with higher scores going to species with fewer populations.

Population and species-specific criteria scores were then multiplied by their relative model weight and then summed to the overall score as described in Skurka Darin et al. (2010).

## Results and Discussion

### *Species Prioritization*

From over 1400 species considered, 73 taxa remained as high priority early detection species. These invasive species of limited San Francisco Bay Area distribution represent a high threat if left unchecked but also offer a high feasibility of eradication success if acted upon promptly. Visit www.BAEDN.org to download a copy of the list.

A principle challenge of the species prioritization process is setting thresholds for what levels of establishment auger well for eradication, at what scale and what level of potential invasiveness should trigger listing, especially in the absence of much direct observation of the species in the target region.

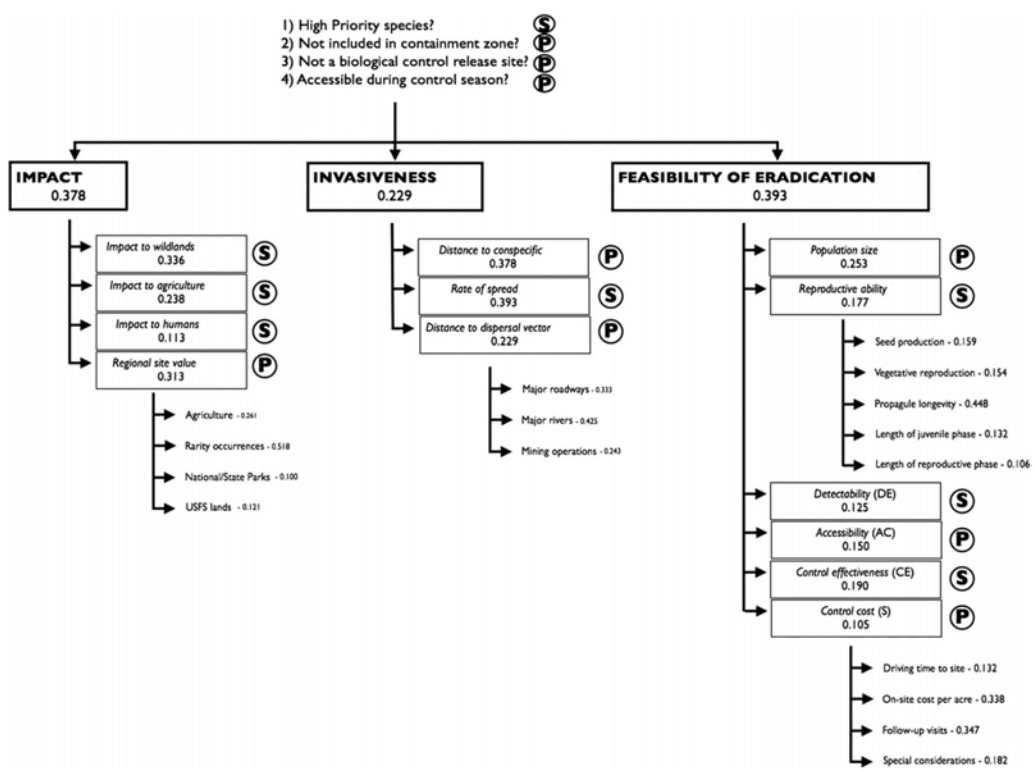



Figure 3

Weed Heuristics: the Invasive Population Prioritization for Eradication Tool (WHIPPET). Reproduced from Skurka Darin et al. 2010

Analysis of frequency and geospatial patterns of non-native plant occurrence from the Calflora database provided a first cut of species reported from only few locations throughout the region. Expert opinion was then used to account for underreporting of certain species and subregions and whittle the list down based on level of establishment for the entire nine county San Francisco Bay Area.

To estimate invasiveness, we leveraged previous research through an abbreviated weed risk assessment based on the single question "Is this species a weed elsewhere?" A complete formal weed risk assessment entails 49 questions for each species (Pheloung et. al 1999) and requires adapting the questions to the Bay Area. The abbreviated assessment saved time in the overall model design, as well as the evaluation for each species, which for complete weed risk assessments can average between 6 and 24 hours/species (Gordon et. al. 2008). Analysis of formal weed risk assessment performance in Florida has indicated that abridged weed risk assessments using the single question "Is the species a weed elsewhere?" resulted in the same or higher accuracy than that of the full 49 question weed risk assessment (Gordon 2008). Our first rankings using this method were later vetted by expert opinion from around the region.

This list will be revised periodically. Future updates will fold in additional date ranges and data sources, such as records from the California Consortium of Herbaria Pest Detection Records from the California Department of Food and Agriculture. Future updates will also address aquatic species, which are not yet included due to complicating factors of treatment. New species of highly invasive plants will be added as they are detected within the San Francisco Bay Area, species may also be removed from the list if they are found to be fully eradicated. Subregional lists may also be produced to target species too widespread for regional eradication, but still limited in distribution at smaller scales (such as the county) and relevant for containment and EDRR outside of current range.

### *Population Prioritization*

Two-hundred fifty San Francisco Bay Area populations of prioritized species with Calflora occurrence records from January 1, 2000 to July 7, 2010 were prioritized for eradication with WHIPPET. Population-level criteria allow the overall priority scores for conspecific populations to vary spatially corresponding to levels of impact, invasiveness and feasibility of control. Lack of certain attribute data (such as population size, driving time, access and cost of treatment) in our WHIPPET run prevented a full run of the model, probably skewing the output to weight species factors heavier than population factors. This is born out in the results, which show clustered scores for conspecific populations.

WHIPPET results are now being used to plan San Francisco Bay area rapid response work. Additional factors such as willingness of landowners to cooperate on management or eradication efforts or local socio-political concerns centered on particular control aspects (i.e. herbicide use) will also be considered. Targeting eradication for high-scoring populations thus directs effort to populations with the greatest potential to cause negative impacts, spread rapidly, and with the highest feasibility of eradication.

Future WHIPPET runs will be based on future listed species and will fold in the same additional date ranges and data sources associated with refinements to the species list. A new geoprocessing capability for propagule pressure will be also introduced with a new WHIPPET version for ArcGIS 10. Efforts will be made to incorporate more data attributes as information tracking and reporting improves in the region.

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## Successful Tactics for Controlling Invasive Fennel (*Foeniculum vulgare*) on Santa Cruz Island, Channel Islands National Park

*Power, Paula*, paula_power@nps.gov, James R, Roberts, Clark Cowan and Rocky Rudolph, Channel Islands National Park, Ventura, CA*

Santa Cruz Island, largest of the islands in Channel Islands National Park, is home to many endemic and rare plants and animals. Past management practices resulted in extensive disturbance of native plant communities and vast areas highly susceptible to invasion by non-native species. After the removal of sheep and cattle from the island during the 1980s and 1990s, the invasive fennel (*Foeniculum vulgare*) was the first species to colonize overgrazed areas. The park has undertaken an aggressive effort to control outlier populations of fennel on the east end of the island to provide a window of opportunity for the recovery of native vegetation. As part of the effort native seed was broadcast into randomly placed plots in areas where fennel treatment is on-going. Data collected from treatment plots provide a measure of the effectiveness of the fennel treatment, an indication of the extent of the seed bank and the value of seeding into treated areas. An effective treatment method for fennel, predicting future needs for fennel control, and native plant recovery efforts will be presented.

## An Evaluation of Flooding Risks Associated with Giant Reed (*Arundo donax*)

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*Arundo donax* may grow directly in a watercourse. Existing reports indicate that it constricts flows and alters hydrological regimes. However, there is little data with which to quantitatively gauge its direct impact on water movement within streams and channels. We determined the roughness coefficient for *Arundo donax*. This information was supplied to the HEC-RAS model in conjunction with data from three stream reaches. Two stream reaches were within Cache Creek (Yolo County, CA) and one was within Stony Creek (Glenn County, CA). Simulation results show that *Arundo donax* within a stream channel has a direct effect on flooded areas. Storm size and vegetation density directly increase the flooded area. However, it appears that *Arundo donax* growing within the low flow portion of the channels studied for this project does not dramatically increase the flooded area, no matter the density or flow. This study points toward the importance of understanding the effects of *Arundo donax* within the channel. Results could be used in conjunction with other studies or natural resource conditions, such as soil type, to help prioritize projects aimed at Arundo donax removal. The results from this study indicate

that large channels that are braided in nature, but have the majority of *Arundo donax* growing only within the low flow portion of the channel, might be ranked lower than other stream reaches that show significant changes in flood areas due to the presence of *Arundo donax*.

## Invasive Pine Tree Impacts on Coastal Scrub Vegetation in the Marin Headlands

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In southern Marin County, large expanses of coastal scrub vegetation have been colonized by Monterey pine (*Pinus radiata*) cultivars. To determine the impact of pine invasion on coastal scrub vegetation, floristic surveys were conducted in 20 blocks that consisted of invaded and uninvaded plots. An invaded plot contained two subplots located under the canopy of an isolated Monterey pine while a paired, uninvaded plot contained two subplots located in coastal scrub adjacent to each pine. Pine trees utilized ranged in size from 2.8 to 119 cm basal diameter. Our results showed that understory native cover and species richness decreased linearly as trees increased in size. Also, the cover and depth of litter found in the understory, which was mostly composed of pine needles, were positively correlated with tree size. Understory exotic plant cover and richness of species other than Monterey pine did not show any correlation with tree size. When comparing invaded (Monterey pine understory) versus uninvaded coastal scrub based on size classes of trees, only the understories of medium- (16 – 40 cm basal diameter) and large-sized trees (41 – 120 cm) exhibited lower native cover and species richness. Coastal scrub under small trees (2 – 16 cm) did not differ compared to paired, uninvaded scrub. Thus, removing Monterey pines before they reach a size of around 16 cm basal diameter will likely minimize negative effects from individual trees. However, removal of larger trees is also important for numerous reasons, one of which is to limit recruitment.

## Prescribed Burning Controls Barb Goatgrass (*Aegilops triuncialis L.*) in Central Valley Rangeland for up to Five Years

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Barb goatgrass (*Aegilops triuncialis L.*) is an invasive annual grass from the Mediterranean region that can strongly decrease both native plant biodiversity and the forage value of grasslands in California. The Cosumnes River Preserve has used fire as a grassland management tool to control invasive grasses like barb goatgrass and to enhance biodiversity. In June 2005, The Nature Conservancy and CAL FIRE conducted a 120-ha prescribed burn at the Howard Ranch, a cattle ranch near Ione, CA. We established four, paired study plots in burned and unburned areas to measure the response of the plant community to the fire. Additionally, we tested for percent germination of goatgrass seeds in burned and unburned plots. One year after the burn, goatgrass cover in burned plots was 3% compared to 21% in unburned plots. This reduction in goatgrass cover was still strong two years after the burn (burned = 6%; unburned = 27%) and weaker, but still significant, for another three years. The burn also reduced percent germination of goatgrass seed by 99%. The native plant community responded positively to the burn treatment in the first year following the burn with 33% native cover in burned plots versus 13% cover in unburned plots, but the effect was not detectable in subsequent years. Our study shows that a single springtime burn can result in a short-term boost in native species cover, reduced seed germination of barb goatgrass to near zero and reduced cover of barb goatgrass for up to five years after the burn.

## Effects of the Invasive Species *Arundo donax* on Bank Stability in the Santa Clara River, Ventura, CA

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*Tom Dudley, University of California, Santa Barbara, Marine Science Institute, Santa Barbara, CA, 530-902-5029*

The spread of *Arundo donax* in freshwater coastal systems in the western US poses a major threat to ecosystem and river stability. While the effects of *A. donax* on biotic systems has been well documented, there is no quantification of the physical effects. Based on observations in the field, it is hypothesized that *Arundo* may lead to massive cantilever type failures as the bank gets undercut due to the shallow root system of *Arundo*. This study found that, when compared to a common native riparian species, red willow (*Salix laevigata*), there is a significant different between the distribution and tensile strength of their roots systems. *Arundo donax* has more roots and occupies more area in the stream bank than red willow in the top 10cm. This relationship reverses below 10cm depth in the bank, where willow has more roots and occupies more area compared to *Arundo* (down to 100 cm depth). A linear regression of root diameter (mm) to tensile strength (MPa) shows that *Arundo* is stronger for root sizes between 0.1 and 3.0 mm. On average, for root sizes between 0.5 and 3.0mm, *Arundo* is 40% stronger than willow. A regression between diameter and tensile strength for *Arundo* and willow produced coefficients of determination (r2) of 0.24 and 0.20, respectively. Overall, this study shows that *Arundo donax* contributes more to bank cohesion when bank height (bh) is small (0<bh<20cm) than red willow. However, as bank height increases, *Arundo* provides little or no cohesion at lower depths in the bank compared to red willow and, therefore, may lead to greater destabilization of the bank through undercutting, and subsequent cantilever failure.

## Can Carbon Addition be used to Reverse the Effects of Atmospheric Nitrogen Deposition?

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### Abstract

Soil deposition of air-borne nitrogen originating from automobile exhaust has a detrimental effect on serpentine grassland because it stimulates the growth of non-native annual grasses, to the competitive disadvantage of native plants. The addition to the soil of a labile form of organic carbon, such as sucrose, has been shown to reduce plant-available nitrogen and inhibit the growth of these grasses more than that of native perennial bunchgrasses. I conducted an experiment to test the effect of carbon addition on the growth of annual grasses in test plots to which nitrogen fertilizer was applied to simulate atmospheric nitrogen deposition. The test was carried out in serpentine

grassland in the Peninsula Watershed of the San Francisco Public Utilities Commission. There were four treatments: control (no sucrose and no nitrogen), addition only of sucrose, addition only of nitrogen and addition of both sucrose and nitrogen. I found that addition of carbon to unfertilized test plots significantly reduced mean dry weight (at the 0.05 level), indicating the efficacy of applying labile carbon amendments. This effect was also found for test plots that were fertilized with nitrogen. However, because there was no significant difference in dry weight between the control treatment and the treatment of only adding nitrogen, it was not possible to demonstrate that carbon addition reversed a stimulatory effect of increased nitrogen. Though these results were inconclusive, this method should be further explored to evaluate its utility in the restoration of serpentine grassland habitat degraded by atmospheric nitrogen deposition.

## Introduction

Deposition of atmospheric nitrogen from automobile exhaust and other sources poses a threat to natural ecosystems comparable to those posed by habitat loss and non-native invasive species. Nitrogen deposition results in changes in ecosystem function and loss of biodiversity. For plant communities that are naturally very low in available soil nitrogen, such as serpentine grassland, this results in an increase in nitrophilic non-native annual grasses and a loss of native forbs and perennial grasses (Weiss 1999).

In this study I tested the effect of applying organic carbon, in the form of sucrose, to the soil of serpentine grassland. Application of labile carbon has been shown to temporarily immobilize nitrogen by stimulating the growth of soil microorganisms. Nitrogen fertilizer was also applied in this study to simulate the effect of atmospheric nitrogen deposition. The objective of the test was to determine whether carbon supplementation could be used to counter nitrogen deposition.

## Methods

This study involved the application of sucrose and nitrogen fertilizer to 2 ft. x 2 ft. treatment plots set up in serpentine grassland in the Edgewood Triangle area of the Peninsula Watershed of the San Francisco Public Utilities Commission. This area is known for its serpentine flora that includes a number of rare endemic serpentine plants. The study site was composed mostly of annual grasses, primarily *Lolium multiflorum* and *Avena* species.

Sucrose was applied at the rate of 7 oz. sucrose/4 ft$^2$. (480 g/m$^2$). Nitrogen, in the form of ammonium sulfate, was applied at the rate of 0.33 oz. fertilizer/4 ft$^2$. (4.5 g/m$^2$), equivalent to a fertilization rate of 1 lb. actual N/ 1000 ft$^2$. Each treatment was applied three times during the winter and spring of 2009, in February, March and April.

There were four treatments in this study: control (no sucrose and no nitrogen), addition only of sucrose, addition only of nitrogen and addition of both sucrose and nitrogen. There were ten replicates for each treatment, giving a total of 40 treatment plots. Treatments were randomly assigned to the treatment plots.

Fertilizer and sucrose were incorporated into the soil by natural rainfall occurring just after application in February and March. In April, because expected rain failed to occur, these treatment were manually watered in.

The annual grasses were harvested in the summer of 2009, air-dried and weighed. Soil tests were performed in 2008 and 2009 by a commercial soil laboratory to determine the background level of nitrogen and other soil nutrients.

## Results

The soil tests performed in 2008 and 2010 indicated that the baseline level soil nitrogen was low (8 ppm and 4 ppm respectively), as expected for serpentine soil. It was also found that the ratio of magnesium to calcium was high, as is typical for serpentine soil.

The mean values of dry weight for annual grasses were 138, 132, 56 and 69 g/m$^2$ for the control, nitrogen only, sucrose only and nitrogen plus sucrose treatments, respectively. The dry weight measurements for the ten replicates of the four treatments were subjected to two-way ANOVA. It was found that sugar addition resulted in a significant reduction in dry weight compared to the control and also when compared with the treatment of only applying nitrogen ($p=0.05$). However there was no significant difference between the control and the treatment of only applying nitrogen.

## Discussion

In this test the application of labile carbon significantly reduced the dry weight of non-native annual grasses. This demonstrated the efficacy of adding organic carbon to inhibit the growth of these invasive plants in restoration sites. The mechanism of this inhibition is assumed to be the immobilization of nitrogen by soil microbes metabolizing the carbon. This effect was observed for carbon addition both with and without added nitrogen.

However, there was the anomalous result that the application of nitrogen did not significantly increase dry weight compared to the control. A stimulatory response to fertilizer was expected because of the low background level of nitrogen. Therefore it was not demonstrated that the application of nitrogen fertilizer simulated the effect of atmospheric nitrogen in promoting the growth of annual grasses.

The absence of this response is difficult to explain. Perhaps it was because the nitrogen was applied in three small applications rather than one large one, allowing it to be leached from the soil before it could be absorbed by the plants. Alternatively, there may have been some other limiting factor besides nitrogen affecting plant growth. In a preliminary test conducted in 2008 of applying only sucrose to the soil, there was no significant effect of carbon addition. This apparently was because it was a drought year, and soil moisture limited growth more than nitrogen availability. However, this was not the case in 2009, when there was abundant winter rainfall.

Can carbon addition be used as a tool in restoration to reverse the effects of nitrogen deposition on serpentine grassland? Although in this test it was not clearly demonstrated that added carbon can be used to counter the effects of nitrogen deposition, several researchers have found that applying supplemental carbon can be useful for meeting restoration goals in habitats with high soil nitrogen. For example, carbon amendments were found to promote native plants and reduce exotic plants in tallgrass prairies (Averett et al. 2004), along road edges of the Irvine Ranch Land Reserve in Southern California (Cleland and Suding 2007), in coastal prairies in Northern California (Alpert and Maron 2000, Krupa 2006) and in woodland tussock grasslands in Australia (Prober et al. 2005). However, carbon addition did not result in an increase in re-seeded native grass species in mixed-grass prairie in Colorado (Morghan and Seastedt 1999).

It can be concluded that carbon addition has the potential to offset the added nitrogen contribution from atmospheric nitrogen deposition. This has implications for the restoration of nitrogen-poor habitats, such as serpentine grassland, altered by nitrogen deposition. However additional tests are needed to demonstrate this effect.

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## Mapping Flammable Invasive Weeds in the South Shore Area of Lake Tahoe

*Ian Turner, Tahoe Resource Conservation District, South Lake Tahoe, CA  iturner@tahoercd.org*

Deforestation and erosion due to wildfire are major concerns to land managers and stake holders in the Tahoe Basin. Lake Tahoe's famous clarity could be comprised if a wildfire were to contribute high amounts of sediment to this fragile ecosystem. Additionally, the threat of wildfire to private, public and commercial properties could be elevated if a vegetation component of flammable invasive weeds were to establish itself in the Basin. The objective of this study is to map three invasive weed species that pose a fire risk: medusahead (*Taeniatherum caput-medusae*), cheatgrass (*Bromus tectorum*) and broom (*Cytisus*) species. Both cheatgrass and broom species can be found in the Tahoe Basin; medusahead has yet to be documented in this area.

We intend to focus our surveys and mapping on "high priority" areas— areas within the Tahoe Basin that have been deemed "at risk" of invasion (i.e. meadows) and locations at the urban/wildland interface In 2010 this study may be limited to the South Shore region of the Tahoe Basin (South Lake, Stateline and Myers), with plans to expand Basin-wide in the future. Mapping in the area affected by the 2007 Angora Fire will also be of high priority to this study. Weed infestation in this disturbed area will undermine revegetation efforts and potentially set the stage for an elevated wildfire risk. Results of study forthcoming; mapping is in progress.

# Discussion Group Notes

## Mobile Technologies for Weed Management

**Moderators**: Christy Brigham, NPS (Christy_Brigham@nps.gov) and Dan Gluesenkamp, BAEDN (gluesenkamp@egret.org)

Also on hand were the developers of "*What's Invasive*", UCLA Students from the CENS Program.

Approximately 70 people attended this section

### Summary

This discussion session was centered on two new mobile technologies for mapping plants within California. The first is *What's Invasive*, an Android application created for the Santa Monica Mountains National Recreation Area to use as a citizen science tool to allow non-resource management employees to collect data on invasive plants that they see in the park. The second is *The Observer* which is a professional version of the Android application and allows for users to collect more detailed data about both native and exotic plants within California.

The main difference between the two programs is the amount of data that can be collected and accessed. The *What's Invasive* program is based around citizen science users. It is suppose to be fast and simple. *The Observer* is a professional tool. You can load longer species lists into it, it has more overall power, it links with CalFlora, and has links to Latin names instead of common names.

Currently both programs only run on the Android mobile platform, but an iPhone application is currently in the works. A question was raised on whether or not Blackberrys will ever be supported. There are currently no plans to, but with pressure from the outside and a donation of phones to work on from RIM, it could be a future possibility. If no one pushes for it, it won't happen.

This is one of the first "weed" applications in the marketplace. It was originally created with the Santa Monica Mountains NRA to have other employees in the park collect data. It was designed to be fast and easy, so that anyone could figure it out. There has been zero marketing so far, but people have found the application and are setting it up in their local areas. Now that the release is stable, they are going to start pushing it a little harder along with the upcoming release of "What's Blooming".

### The Data

The data collected from *What's Invasive* is currently available on www.whatsinvasive.com. It can be downloaded into spreadsheets with UTM coordinates and links to Flickr photos. If you feel that an observation is wrong, it is possible to annotate someone else's collection with proper information, but you cannot change it directly. If you think something is wrong, you can flag it as such. In other databases, such as CalPhotos, when contributors are told they have misidentified something, they will either change it, or remove it.

### Data Server

When you collect data in the field, it is either immediately uploaded to the main server or else stored on your phone until you return to an area where you have service.

Currently the data for *What's Invasive* is being stored on a server at UCLA. The data for *The Observer* is being stored at Calfora.org. Ideally as the networks expand, there will be one place to store everything.

Some people may have privacy concerns as they collect a lot of data. There can be options added to individual users that the data stays private as long as the counts of the species are recorded.

If your park is using *What's Invasive*, all you have to do in order to find out where the weeds are is to log onto the site and download the data. Then you can use your normal methods to plot the points on a map and kill them.

## Features

### Other people's points

The original application had an option that you could view other peoples points on the map while you were walking around, but it proved to be buggy and was removed from recent versions. They are working on a new way to view the data so that eventually you will be able to see it all again.

### User interface

In the future administrators will be able to have emails sent out to users who frequent certain areas to let them know when certain species are blooming or let them know where places are that no one has visited in a long time.

The plan is to create a social system within the *What's Invasive* Web site. Until then other social media platforms such as Twitter and Facebook will be utilized. There will be announcements released to the community about special updates such as someone's 1,000th observation or the first appearance of a weed in a new location.

Users could also be contacted by location to announce weed eradication events.

### Accuracy of GPS

The Android system will tell you your accuracy when you are taking a point. You can keep pulling data until you feel that it is accurate enough. An upcoming version of *What's Invasive* will have a +/- deviation to the GPS location. Accuracy is currently between 10 and 20m, but people who have used the program feel that it actually puts the point exactly where you are.

Technically speaking, the GPS uses differential processing and may be able to be updated through software in the future to increase accuracy.

### Timestamp

The program does record a timestamp on all data collected. Data stamp is based on the observation time even if a photo isn't uploaded until you return to civilization. The time is based on UTC, but is viewed online as local time from where you are viewing the data. Eventually the online program will change this function so that the time stamp will be from the time the point was collected within its original time zone.

### Tracks

The Android has other programs that can keep track of "tracks" to see where you've been searching. The main problem with them is that they are very battery intensive and will quickly drain your power. There is an option of buying a battery pack that can hold four times the charge of a normal phone battery. There is also a code available to load preprogrammed tracks into your Android, but it is not currently implemented in this applications.

### Recording Patch Size

The developers said that the easiest way to do patches is to force them in the data entry phase. Have a field for cover and number of plants. Another planned feature is that when two points are reported near one another, they will soon be clustered on the display map. The more points that are reported in a location, the larger the cluster becomes.

A question about determining patch size of a population was raised. A contractor stated that their group had gone away from using patch size measurements and instead split their research areas into a ¼ hectare grid (.6 acres) and measure presence/absence. It is more efficient when remapping year after year, as well as easier to incorporate into a larger grid. It is also easy to mark off what has been looked at already, and what has not. The developers said that this could be instituted in future versions but is something that would need to be directly desired.

### Herbarium Sheets

You have to option to create whatever fields you like in *The Observer*, which would allow you to create the proper fields for a label. Upon return to the office, it has an option to print Herbarium labels on the Web site.

### Rare Plants

In theory, you could populate the map with rare plant data, but the CNDDB is very sensitive with their plant locations. Currently they only report the data to quad level. Currently CNPS and CalFlora are rebuilding their rare plant inventory and it may be easier for managers to access the information.

### Animals

Animals are already included in the *What's Invasive* program. There is also another program called "Did you see it?" that tracks wild animal phenology.

### DFG BIOS

You can aggregate data collected with these applications and upload it into the BIOS program but it will not sync directly.

## The Future

### Life after CENS

The CENS program has limited funding to work with the application. After funding runs out, there needs to be a repository for data set up from an outside source. Since this program was designed for citizens, it will most likely be abused by citizens. There are plans to create a filter so that the program automatically deletes pictures of non plants. *The Observer* data currently is being transported to CalFlora and they are controlling it. As more people begin to use the program there will be a need to create membership fees to manage the data. This will keep the technology improving as well as will allow for more students to be hired to perform the data processing. Without any additional funding the program will continue to function as it does today but will never change. With increase funding, the application will continue to expand and include more species both invasive and native.

### What about the rest of the US?

Currently both programs can be used in any state. *What's Invasive* is more compatible, because you can create a small search area and upload your species lists to the site. There are currently sites across the US and overseas in Denmark.

*The Observer* is currently limited to California plant species, but can be expanded to include anything. Currently all data from the observer is funneled through Calflora. Other states may want to have control of their own data which could be troublesome but can be accomplished.

### How can we get involved?

As the program gets bigger and more advanced, people will start to want to see new things and have the application tailored to fit their needs. We hope that they will be willing to pay for these features, as that will allow the project to keep growing.

# A Management Decision Tool for Perennial Pepperweed

**Moderator**: Shea O'Keefe (USDAA NRCS)

**Topic Leaders**: Christine Whitcraft (California State University Long Beach- cwhitcra@csulb.edu) and Bill Winans (San Diego County Department of Agriculture)

**Notetaker**: Michelle Murphy- UC Riverside

## Discussion Notes

1. Christine Whitcraft introduced and explained a Draft Decision Key for the management of pepperweed. The key is divided into terrestrial and aquatic environments and lessons learned in those environments regarding treatments, treatment restrictions, etc. Christine requested feedback on the key (cwhitcra@csulb.edu).
2. Discussion of attendees' experiences with pepperweed and control methods ensued

a) Christine Whitcraft: created a weed management area after discovering pepperweed in San Diego Co. in 2000
   - 400 acres in a river park that is of major concern
   - 50 total sites, one large infestation
   - Using Telar herbicide but not getting good control in saturated area
   - Endangered species in the area helped get funding

b) Pepperweed is very resilient, hand pulling not a good option, because of very deep roots
   - Herbicide is considered the best treatment method
   - Mowing and disking are options
   - Grazing was used to get biomass out of the way and then herbicide was applied
   - $50,000/ 50 acres. Opinion was that the treatment method was expensive but yielded the best results
   - Difficult to apply herbicide to the stand without grazing pretreatment however grazing is limited to upland areas, too hard in wetland areas

c) Radio isotope analysis in mowed versus non-mowed pepperweed showed that herbicide moved into the roots more on a mowed plant that has regrown (dissertation research)

d) Dale Schmidt (LA Dept of Water, Bishop, CA)
   - 1600 acres of pepperweed scattered across 500,000 acres of land
   - Tillage = 200-300% inc. without herbicide
   - Hand pulling = 150% inc. without herbicide
   - After two years of Telar use applied more than once per year, it was apparent that there was resistance to the herbicide in pepperweed plants! Plants were increasing even though herbicide was applied three times per year
   - Imazapyr now being used

e) Habitat used on Pepperweed in an area that also had Tamarisk worked well on both species

f) Giselle Block and Renee Spenst are good references for control in brackish marsh habitat

g) Best time to spray appears to be between budding and flowering

h) Imazapyr good for use in tidal areas but not recommended in upland areas as it doesn't seem to wash out and no other plants will germinate afterwards

i) Appears pepperweed is not tolerant of salt on its leaves giving rise to the suggestion of aerial salt spray as a treatment method

j) Bill: Example of a fire in Fallbrook area in October/November. By April pepperweed was the only plant growing providing a great opportunity to treat the weed.

## Weed-Free Material Programs

**Moderators**: Peter Beesley (PG&E), PM87@pge.com, and Martin Hutten (NPS), Martin_Hutten@nps.gov

### Topics to discuss

1. Federal agency coordination and consistency
2. Stakeholder engagement/education
   a. Equestrians need to be included
3. Update the MOU
4. Leveraging existing programs and successes
5. Increasing demand to pressure companies to use BMP
6. Contract specifications
7. Monitoring project sites (erosion projects)
8. Corporation yards: vehicles transporting seed
9. Infrastructure building
10. Cal-IPC support
    a. BMP manual
    b. Web site, Cal weed talk
11. Protocols
    a. Preferred
    b. Minimum
12. Argentine ants and protected species in materials

13. Supporting and educating the industry
    a. Hay growers
    b. Aggregate materials
    c. How to approach the companies and foster relationships
    d. Regulations and zoning
14. Procurement recommendations and BMPs
15. BMPs – supply chain/full chain of custody
16. Go beyond North American Weed Management Association standards

## Discussion

### *Communication*

- Getting the word out: CalWeedTalk list-serv (Cal-IPC's list-serv) is a forum to get a message out to people about stores. There are national forums as well
- Have gotten encouraging feedback, support and interest from CA and nation-wide
- Weedy Stockpiles – Taking a picture of the problem and showing them to the target audience had a good impact. Visuals are convincing

### *Inspection Issues*

- What do you look for? Seeds? They are tiny.
- Project in 2004 with CDFA lab testing gravel coming out on the highway required stopping trucks and doing inspections. Didn't pull any seed. They had documentation of movement of diffuse knapweed but sampling didn't work.
- Even with low infestation rate per load, risk of eventually transporting weeds is high, for example, in weed-free forage. You can't do post-harvest inspection. You really need to see the source. CA allowed for post-harvest inspection. You are allowed to break open a small amount but it's like finding a needle in the haystack.
- Must inspect at the source; at the quarry and even that is difficult, but worth it
- Corporation yard vehicles transport seeds
- Infrastructure building (prior)

### *Best way to inspect or Best management practices (BMP) – Protocol Comments*

- Phenological time issues. The need for gravel doesn't always match the best time to inspect. Sometimes inspections come up at a phenologically wrong time. This is a common issue. There is a proper phonological time to do this. Contracting deadlines and fiscal year boundaries often interfere. The botanist is supposed to go out and inspect but to do this efficiently and safely is difficult. There is a need to get there at the opportune time. I feel good about being there at the right time. Next step is certification and relationship with operators. Pit A vs. B, which is OK?
- Certification of pits would allow us to investigate in advance to know which to go to in a rush
- Compliance agreements: Like growers who ship to other countries, the vendor signs an agreement in which they agree to maintain clean pits either by inspecting themselves or using contracted inspectors to do the regular inspections for them. This may work here, along with random inspections to keep them "honest."
- Consistent inspection: Pair self-policing with regular monitoring, especially when some are done during emergency basis projects. There is a need for constant monitoring, though, as new seeds can come in at any time. There needs to be a reporting of disturbance, infestations between CalTrans, DOT, contractors, CDFA, etc. to identify priorities on major corridors.
- When the fill was needed in an emergency situation and inspection may not have been at a good time to find plants, pair it with post project monitoring. Weeds found post-project monitoring may be due to multiple sources, such as pit, vehicles and recreational use.

**Example of Importance:** (For those who are not convinced) At a Modoc County drilling operation at 6000 ft., clay was brought in for clay-line sumps. After the operation, they found a listed vernal pool plant growing among sumps. The clay pit at the plateau down below was the source of the seeds. Client couldn't do much more with site since the site had a rare plant in it!

**Argentine ants** are spread via the soil like plants.

*What if you have materials that are supposed to be sterile, e.g. rock and sand. Do people apply pre-emergent herbicides?*

There is no specific chemical used to treat bulk soil. You would have to lace the whole load, which is not cost-effective. This may be inappropriate since you are moving the fill somewhere else, say near water, and you may have the wrong chemical in it. Basically, due to uncertainty as to where the gravel will end up, i.e. next to water, heat sterilization would be an alternative. Some of these are places that sit for years and then are suddenly dynamic and fill is moved out to projects. Businesses are designed to move product.

**Example:** At a project south of Yosemite a site/pit was inspected. Movement and within-pit operations were well-organized. However, the pit buffer was terrible, over-run with weeds. The pit operator asked if they could spray the gravel as it came up the belt. At least they were willing to consider some solution (This was not a good idea due to feasibility, reporting requirements, cost of using so much herbicide etc.).

### Why is there a problem?

*Why are some pits overrun with weeds?*

- It is a disturbed environment and they also have a lot of dust. They use glyphosate on weeds and it will be bound up almost immediately by dust in the pits.
- Gravel companies want to be good stewards so, if managers do outreach in a way to help them (deliver a service to them), they can be educated and will be willing to do the right thing. WMA's could be critical in this. Approach it as this is how I can help you do it at a lower cost and in a more effective way.
- What about a requirement that gravel orders cannot include the top few inches of soil?

### Communication with Operators

**Example**: WMA went on field trip to gravel pits sponsored by operators. They were excited to learn how to control their weeds; there was very positive feedback from recommendations. There is a role to play and a natural relationship that can be built on. Not as 'weed police' but as trained botanists and professionals who can deliver a service to them. This is how the interest should be communicated. Talk to the manager of the pit. Great progress can be made when appropriate recommendations are given.

- Make the contact as a service, e.g. "this will help your bottom line. Since compliance will be required for weed-free materials, here is some advice about how to do this economically."
- Show this will increase demand but also provide the means of doing it right (education + demand = better quality pits). Small groups need to work with a larger agency to create the demand level that will push the gravel company to make changes.
- Much of infrastructure and gear (e.g. rig for spraying) is already there; they often just need proper recommendations to address problems (right time with follow-up).

### Other Specific Issues

- Material is drawn from 10-15 sites sometimes. Contractors will bid on projects and the award will not necessarily go to the nearest pits. Material may come from a hundred miles away. Sometimes the pit has not been inspected, since there was no need before. Material is trucked around farther than you think.
- Outreach to DOT: They mentioned that they don't purchase erosion control materials directly. The contractor will go and get materials but there seems to be no specific requirements. District Biologist can put in restrictions, but it wasn't clear how frequent that is. Also there are standards for seeding and landscaping. But we need to be supporting ability of industry to do the right thing. PG&E, utilities, DOT's, Counties, if there is a demand, there will be more people available to provide that. Park service is small potatoes here.
- Get CalTrans on board and things may change. Need more demand. If it's only small outfits that want it, that's not enough to drive demand.

### Key Issues to advance (and how can Cal-IPC facilitate this effort?)

**Supporting and educating industry, being able to communicate value of stewardship and sustainability. Give them tools and recommendations to be able to advance this, in terms of people are interested in purchasing, how they can go about doing it.**

- Identify quarries in WMA, educate them about top three weeds. What about prioritizing certain weeds?
- This is too fine a point, since there are different weeds that are important in different areas and to different agencies. List will change based on where you are. NAWMA list as minimum compliance includes Avena, wild oats.
- How are weeds going to be prioritized? Gravel pit operators need direct, concrete recommendations (they are not going to investigate weed risk themselves).

**Cal-IPC can help bridge communication as a support to WMA's. WMA's have more enduring relationships with operators.**

- Maybe they can put together/help produce the materials to help communicate and even give the WMA's advice on how best to approach the organizations.
- County Ag Department and Weights and Measures? Not all counties are that engaged. But they do have the authority to act, with legal mandate; especially for Class A listed noxious weeds. Putting it in the County's hands to regulate will work very well in some places and not at all in others.
- Another tack is to use County Zoning laws. Sublet County in Wyoming used zoning laws in order to shut down pits if they were not compliant.

**Supply-chain management**

- Pit may look pristine but there is a supply chain involving trucks, equipment, etc. Distribution and transportation of materials is also important. Need to consider the supply chain, where is the gravel coming from, how clean is the transport and are proper stockpile methods being used at the storage site until used? It possible to order on an as-needed basis but this can get tricky.
- Often some are asked to inspect storage piles where chain-of-custody is not clear. Inspectors are hesitant where history is unclear. They will not certify this type of material for exposed applications (e.g. they might certify for use under layers of compacted material).

**Need for best-management practices advice (especially buffer area guidelines)**

- How do you properly stockpile?
- At most sand and gravel pits surface layers have been scraped, gravel is 20 feet underneath, so essentially it starts weed-free and just has to be maintained that way. Sometimes it is a matter of whether adjacent sites are infested and so the stockpile builds up weed seeds as it sits for a few years.
- Strategy: Go on an as-needed basis to the pits and look at the piles.
- This gets difficult with wind-dispersed species with known capability to spread several kilometers. Buffer areas are important; this may differ by region. NAWMA standards provide no guidance on how large the weed-free buffers need to be. For example, is having rush skeleton weed 200 yards from a pile good enough for Sequoia or Yosemite? That's going to be really hard to analyze when the time comes. There is need to go beyond NAWMA standards. Our current requirements for buffer areas are unclear and we need more concise standards that consider wind-dispersed seed.
- Best Management Practices have to look at whole supply chain and how that works.
- Similarly, hay growers should be reached out to in a similar fashion.
- Include hay growers in this effort to ensure weed seed free feed is used.

**Need for examples of what is working and what is not**

- Collect horror stories and stories about what is working. Do bring that camera, that day. Share in-group stories and photos.
- Are there stellar vendors? What's working (government agents cannot endorse any vendor)? Cal-IPC can showcase what sort of vendor is ideal.
- Nevada put into place inspections and they followed-through and Forest Service also got involved. It became a very successful program; they found that what was needed was education and outreach. The operators just didn't have the information to make good decisions. It was successful once they understood what they needed to do.
- Success stories often find that the pit managers just needed to be educated about better methods and they were willing to make changes. WMA field trips to vendors would be a good way to offer this type of outreach to gravel and hay vendors. Also, get pictures of examples of good vendor practice and the horror stories. These pictures can be used to motivate action.

**Next Steps**

Take the message to the Weed Management Areas. Informational materials from Cal-IPC would be helpful here. Send these materials to pits. WMA can be of service by conducting a field trip to your site, and you will get expert opinions on some things you might find there and what you need to do.

### Current Efforts

**Survey of Ag Commissioners:** 46 County Ag Commissioners in PG&E service territory were contacted to see if there are existing certification programs for straw and hay. Most counties have a program in place and are doing some inspections; although there is not a lot of demand, some are willing to start. When asked about gravel and fill, it was found there were just a couple who are actively doing this but there is just not a lot of demand. Because of lack of resources, they didn't want to jump into it. However, if the community saw this as a need, they would be willing to get behind it.

**Outreach to CalTrans and Resource Conservation Districts (RCD's):** An effort was made to see if they have information about vendors. Some information was gleaned about vendors/sources to learn who these vendors are. It is important to share those lists and coordinate needs. Who are the end-users? Connect with them. There may be a way to increase demand. MOU was signed between BLM, Ag Commissioners, CDFA, NPS and USFS

There is an effort underway to resolve inconsistencies across these different agencies. The MOU set to expire. Getting this signed again would be good. Maximum MOU time is five years for NPS. Quick action would be needed here, especially if the solicitors need to check it over. Acceptance might happen quickly only if there were no modifications. However, probably any changes should be made while this is still fresh. Ag Commissioners need to make sure folks wil make this happen. Parties need to be contacted and pulled back in to re-sign. Who are key players?

### Overall continuing efforts

- Public outreach. Get the information on a Web site, revise it a few times a year. It shouldn't entail too many man-hours
- Whomever is selling weed-free hay should be on a map, as should NPS, FS areas that require weed-free hay. Include information about which counties are doing inspections. There needs to be something for equestrians visiting the park about where to get weed free hay and what a certificate looks like.

### *Statewide framework is now in a comment period.

- Can we go to the next level with State certification process?
- It could be clearer and have more teeth.
- There has been an email regarding this through WMAs and listening sessions.
- There was nothing in the framework on this (weed-free certification) topic

    Couch under prevention for all invasive species?

### Look at this and provide comments, highlight this issue

- Where would weed-free fit on the document (it's pretty high-level, so it should be obvious where it should fit)?
- Email Peter if you cannot find the document
- This legislation may affect where this falls in the level of priorities
- Entomologists should add to this, as it is for all species; Argentine ants are included.

    Landscape materials, dirt and sand problem

Please see Additional Documents/Materials from this session provided by Mr. Hutten and others. Available

2007 MOU

Weed-Free Material Information from PG&E

Contract specifications and heavy equipment inspections

How they do that in-detail

Survey of Weed-Free regulations in Parks

CDFA Policies regarding Weeds

Adjourn.

## Communicating Your Message

**Moderator**: Yvonne Menard- PAO, Channel Islands NP

**Participants**: Meghan Owen, Bob Butler, Chelsea Carey, James Roberts, Jennifer Tiehm, Charles Blair

**Notetaker**: Lynn Sweet

### Key Steps for Creating a Communication Plan

**Underpinning**

- Instilling a sense of resource value for public
- Gain understanding of, for example, a restoration project
- How can you share and talk about a project with possible controversy?

**Identify People Involved**

Players may have different strengths/resources (connect a scientist with a communicator who understands audience perspective)

**Identify Desired Outcome**

In terms of audience differences/diversity

- Identify Strategy
    - Briefing statement (background, status, etc.)
    - What materials and events?
- Communications
    - Know bounds of facts to craft a message
    - Make the message clear, concise and consistent
- Evaluate Effectiveness of Message/ Communication Strategy
    - Survey of public opinion
    - Reevaluate lessons learned

### *Presentation/Case Study*

Rat eradication program on Anacapa Island in order to protect native rodent

Difficulties:

- Rodenticide, Sensitive Species
- News articles primarily negative headlines

### Underpinning: (Commonly based on Mission of Parks)

"Interpretation": Give meaning to a resource

- Opportunity for audience to learn "why I should care."
- Relate to something essential/important for them

Comment: *"Framing" message for different audiences*

- Universal messages: beauty, patterns, balance and stability
    - E.g. Beauty of a restored area
    - E.g. Ecosystem services/ interdependence

### Identify People Involved

Make sure it is all in line with partners (all on the same page)

Gather pre-information about project, issues and audience

- Who are local and national media? Who are political players?
- What are target organizations?
- Reach out to this whole spectrum

Go ahead of time and outreach if you anticipate interest from a particular group, e.g. prescribed fire in a new location

- Always make sure that employees know about spokespeople
- Sometimes researchers can be too close to project/not best spokesperson, but that depends on the organization

Identify the key person who knows how to carry out communication strategy

- Choose a communicator, a person with sensitivity to the audience, who will protect scientists and control lines of communication
- Call, follow up, have information, get the media excited and informed
- This is their job; researchers aren't necessarily the best trained

### Identify Strategy

Choosing elements of message

- Pamphlet showing components of problem/ timeline (e.g. Island Fox)

- Graphics showing pictures of plants/animals (e.g. pigs, eagle, fox)
- Language clarification (e.g. re-introduced, re-established, introduced)

Comments: *Graphics are very important (even though they might be expensive)*

- Full magazine-style pamphlet telling story of problem
- Video produced locally
- Webcams can engage audience

Comment: *Conundrum for Restoration is that in-progress restoration can look "bad."*

- Message here is that the story still in development
- How do you explain what your goal is?

  Tell about value of returning diversity to community

Comment: *It's important to have formulated an answer in advance*

- Focus points and don't be unprepared

Messages/Talking Points are internal, between resource staff and PAO's

- Prepare lead messages, along with supporting facts
- Clearly define this first in ways that are understandable
- Refine language into a succinct message to come back to
- "Quotable" items are likely to be used in the media
- Takes patience and persistence

### Communication

Media: Be responsive and respectful and get back to them in a timely manner

- START with lead message (don't bury it at the end)
- Media/news message is different than a scientific paper
- Provide concrete images, etc.

  Imagery is one of most powerful assets/tools
- If media person is focused on supporting a preconceived "lead story" that isn't correct or isn't consistent with the message, acknowledge it is a legitimate point of view, then go back and demonstrate why lead message is more important.
- Be prepared to tell message and counter arguments

Comment: *Foresee alternate viewpoints, have talking points ready-to-go*

Comment: *Public attitude can often be: "If it's green it's good."*

- There is a challenge to explain Mediterranean climate and invasive plants
- Educate the public to see value in what they are not accustomed to
- Invasive plants can be pretty!
- Removing plants and replacing with native is going to benefit ecosystem

### Case study: Negative Media Attention

Media focused on killing of pigs, personal attacks on NF scientists

What could have been done to mitigate this?

They did reach out in advance to several organizations and individuals who expressed disagreement

Effort and energy spent to maintain positive message by focusing on that

Methods and how they are portrayed are very important to message

Maintain credibility by being honest and disclosing, be up-front about errors and failures

### Evaluate Effectiveness of Message

All along- monitor strategy and complete your plan, identify milestones of success

- Use and take advantage of opportunities to do this

Survey public opinion

- Plan time for approval of a public survey in a federal government setting

Media trips can be important as they are often looking for news

- Document positive reactions from stakeholders and others

### Specific Tips about Materials and Strategies

Talking points are always internal, always labeled draft

- FAQ's for media and public

Media

- Identify likely events for media
- Revise and keep updated the information available to media
  - Example: Signs about trail-building disruption
- Media event: Presentations and panel
  - Have people at different displays available for questions
  - Mediation sessions
  - Often people are genuinely interested in the project. Use it as an opportunity
- Prepare public and media for a visible event or change so that outgoing information is accurate and on-message
- 60-70% find out about your project through a newspaper
  - Spend time crafting materials and graphics for them
  - Primary packet should be a brief summary of what you're doing and why
- Full Media packet contains briefings, factsheets, background, image sheets
  - Press release and disk of images; ftp site or online
  - A lot of supportive material is already out there; that might make the difference about whether it gets in the news
- Relationships with media important
  - They will come to you for stories if you are reliable, honest and open
  - Web: Links to partners, background, images, methods, etc.

Don't underestimate the power of nature to help capture and engage the public!!

## Designing Restoration Projects to Meet Invasive Plant and Wildlife Goals

**Moderator**: Tom Dudley, UCSB

**Notetaker**: Chelsea Carey

**Structure of the discussion**: Each person introduced themselves and talked about any issues they are struggling with regarding restoration and wildlife goals and/or any suggestions that they have for meeting those goals.

*What are the issues that people have in their restoration programs? Don't need to specifically focus on Arundo and Tamarix.*

Arundo in Santa Clara system - 17 endangered species in that watershed. How do we manage timing of arundo control so that it doesn't interfere with wildlife concerns, particularly since timing of sensitive periods for different species are not the same and can be conflicting?

Removing arundo at a watershed scale – monitoring program for baseline measures of wildlife impact is essential to validate benefits of approach.

How do we deal with endangered species? Need to think about after removal, what do we revegetate with? How do we want to have the landscape organized such that the habitat is conducive for native animals?

**Napa County Flood District:** Arundo removal around Napa River. Replaced by poison hemlock when Arundo was renived. In the hemlock, there is allelopathy – need to replant with seeds and acorns and the success of the establishment of the propagules is inhibited by allelopathy. Hoping to get any suggestions for this.

**City of Pasadena Park and Resources:** manage habitat restoration projects in active restoration areas. Invasive removal is "hit and miss": funding is not consistent. Currently developing management plan – don't do wildlife monitoring because don't have a biologist on staff. Recent fire – totally changed the whole topography of the area because of sedimentation. Arundo now in places that it hasn't been in 10-15 years.
Los Padres National Forest – After fire, can only get money to treat weeds for up to one year after

the fire. Used to be three years of funding for treating weeds.

**Bureau of Land Management in NE California:** Sage Steppe restoration.

**UCCE: invasive plants and fire. Works in the desert:** doesn't focus on wildlife as much

**Bioresource consultants:** invasive plant removal. Monitor effects on wildlife during the removal. Santa Clara river project: Arundo removal for their wastewater removal plant. Not a lot of conflict yet because only doing baseline vegetation surveys so far. Going to start Arundo removal soon – haven't had any nests in the restoration area so no direct effects to deal with thus far.

**CCC:** Stealhead restoration project. Runs into invasive plant issues: impacts that the nonnative plants have on the creeks.
Nature's Image – habitat restoration company. 80 active projects.

Biocontrol agent is doing pretty well to manage Toadflax

**San Bernandino National Forest:** several projects going. Want to put together a watershed level project with many options for treatment; will include wildlife considerations. Currently working with tamarisk and Arundo.
Watershed projects – site specific even though its watershed-sized. But can do watershed as a "sight".

*How do you deal with situations that have different sensitive species with different reproductive timings? Ice plant eradication was put on hold during some wildlife breeding species. No direct conflict with wildlife.*

**Landscape architecture:** projects involve invasive removals and restoration. Construction also involved in projects. So far, no major interaction with wildlife.
**UC Riverside:** Research with Lynn and Kai. Worked with Arundo ecology and physiology for the past 15 years. Now looking at a community approach; how to restore a native community that resists Arundo establishment? Don't evaluate wildlife directly but any kind of experimental approach takes into account herbivory (rabbits and pigs), timing of reproduction and migration of wildlife.
Beavers also present at many Arundo sites. They favor willows and cottonwoods – promote invasion by Arundo because of selective feeding and dam construction using native woody species.

**California State Parks:** Stanislaus river has had a large removal project of invasive species. Do it in areas where rabbits and woodrat weren't using the habitat. Will go back afterwards to see the impact of their work on the wildlife – will do it in small blocks so that the rabbits have "refuge".

*Any wildlife issues with Ailanthus – only with having woodrat nests at the base of them. Overall not a lot of wildlife concerns with Ailanthus.*

**Station fire area:** 150 miles worth of Tamarisk pulled

**USFWS:** funds volunteer restoration on private property. Interested in how to minimize wildlife impacts.

**Volunteer work in Sonoma county with state parks:** A pond with red legged frogs and vernal pool habitat with rare plants that has been invaded by velvet grass that is impacting the rare species. Azolla growth covering the entire pond – something to do with increased nutrient capacity within the pond. Does anyone have any information about long-term, sustained Azolla control? It is a N fixer, maybe something has depressed the N in the pond allowing for the N fixer to take advantage of the low nutrient system. Hand pulling velvet grass (so its not impacting the red legged frog).

**Sarah Sweet, TNC:** typically a wildlife component mixed in with restoration project. The riparian forest restoration; the yellow billed cuckoo is a bird of concern and in the wet zones, there is a problem with rats (nonnative). Waterfowl a concern in seasonal wetland. Open areas with yellow starthistle problems; tried goat control which worked really well. Natural wetlands have a population of garter snake that are genetically distinct from surrounding populations – have a water primrose problem. The garter snake does well with moderate levels of primrose, but once it gets higher then there is a negative impact on the garter snakes (exclusion, changing of habitats). Have you run into a problem with the primrose plant on the snakes? Not yet. Excavated one-acre pond that removed the primrose and there was a very dramatic response – before, there were no garter snakes, after – there were more garter snakes present.

Need to think about soil disturbance and weeds that get tracked in; how can you get people who are focused on animals to include and think about other parts of restoration (i.e. soil erosion) as well?

What is the level of permitting that you deal with? We have to do it project-by-project because a large consortium of project partners are involved. Have to do NEPA evaluation for every project no matter what type of land it is on (private, public, etc).

**Camp Pendleton:** Pacific pocket mouse. Biggest issue: invasive species expanded into the site – some people from USGS said that the seed source may be important for the pocket mouse so had to wait for the results before they could eradicate.

Thatch removal and iceplant removal helps restore the pocket mouse recovery – needs open space.

**Sonoma Ecology Center:** Target species: steal head trout and freshwater shrimp. It is hard to do invasive removal in habitats that house the wildlife, particularly because some non-native plants do provide in-stream cover for aquatic sensitive species.

**Ventura Hillside Conservancy:** need to restore upper watershed in order to restore lower watershed. Need to design a restoration project that convinces funders that it's not useless to eradicate watershed downstream. Target the locations that have the most at stake; places that have the potential for wildfire.

Hobo Jungle: homeless camp. How do you restore ecological and social function back to a socio-ecological system?

**Sequoia and Kings Canyon NP:** reed canary grass removal. Replanting with bull rush. No wildlife monitoring component. Want to know how to do this in the future? No listed species in that area, but just wanted suggestions on good practice.

Bugs, bears, birds and frogs are managed separately from vegetation. Would like see wildlife co-managed with plants.

Velvet grass removal on 15 river miles stretch. Hasn't incorporated wildlife considerations but recognizes that it would be a good thing to do. Need to think about canopy cover for small mammals and birds. How far up in elevation has the invasion gone? into golden trout habitat.

**SF Bay National Wildlife Refuge:** restore communities adjacent to the tidal marsh. Most of the habitats are nearly extirpated; can't use herbicide because the area is too large.

Monitoring grazing: people don't like seeing grazing animals near their homes or where they hike.

Ecosystem approach until you are dealing with a specific listed species then it turns to a species specific approach.

**Coastal wetland and dune restoration:** having listed species might influence agencies not to use herbicide but how do you measure the residual/baseline soil contamination so that you can determine if the contamination is from your project or from previous projects. Look into Elkhorn Slough: they have dealt with this problem before (after a levee break moved contaminated soil onto their land).

**Joshua Tree NP:** How do we incorporate invasive species management with wildlife projects? Brassica tournefortii is a big issue – the desert tortoise is federally listed – not a lot of research but apparently the brassica is a bad source of food for the tortoises

**San Francisco Peninsula Watershed:** restoration for red legged frog. Each site has a different spin on how much emergent vegetation there should be in the pond. The young require sunny areas and the adults require cover – waiting to see which ponds are successful based on how emergent the vegetation is.

**Volunteer in San Diego:** Tecalote canyon. Can't do restoration work in certain areas because of the homeless population along the river – need police escort. Arundo resides in a lot of backyards as well. A problem with palm trees in San Diego riparian areas (they are invasive in this area) – people like palm trees so get a lot of resistance from the public. What about use by orioles? Haven't seen a lot of orioles in the canyon and the issue has not come up.

**Golden Gate National Park Conservancy:** Palm trees with orioles here. There is a lot of diversity of song birds – when I remove the invasive species, how do I maintain the high bird diversity? How do I maintain good habitat while doing large restoration efforts? You can use artificial structures and nest boxes. If the birds are using scrub, you could plant more scrub. If there are nonnative plants that aren't invasive and "drop out" efficiently after native seeding but that are good habitat maybe you can think about keeping those in your plots.

Stagnation of data sets because have to stay consistent with previous methodology in order to compare. Trying to develop more protocols for monitoring wildlife that allows for dynamic flexibility. Suggestion: do updated method simultaneously with old method and compare to see if they give you consistent results, or so that the biases of either method can be accounted for.

How do nonchemical techniques such as hydroblasting affect the wildlife and soil erosion of an ecosystem? Can use concentrated seawater which is not a mixed compound so it's not regulated – but would there be negative effects on the ponds? What about soil salinity? Is not species or genera specific – may kill all of the plants that are present. Salt bush and salt grass showed up more and monkey flower came back. After a few years most of it leached out, restoring the soil salinity. Check with Joe Trumbo with Fish and Game regarding toxicity of glyphosate against amphibian larvae, which are not regularly tested for toxicity because EPA standards do not rely on amphibian responses.

**UC Davis McLaughlin Reserve:** The reserve was recently an industrial gold mining site and previously mercury mining site. Mining restoration project. Foothill yellow legged frog needs to be preserved during revegetation.

## Minimizing Non-target Effects of Herbicide Use

**Moderators**: Susan Kegley, skegley@pesticideresearch.com, Pesticide Research Institute and Marc Lea, mlea@co.slo.ca.us, San Luis Obispo County Department of Agriculture

**Notetaker**: Michael Bell

There were approximately 60 people in attendance. Most of them were interested in learning new techniques to reduce impacts and improve public reaction when spraying around endangered species and to reduce impacts on sites with long term herbicide application.

### General tips to reduce impacts

- Use the minimal application rate
- Preclear the area. Don't have dead material laying around that can spread fire or take up extra herbicide that can wash off
- Limit the number of applications that you apply per year
- If there is a change in policy of number of applications per year or pounds per year, then the decisions have to go through the board

- Once a population has been controlled, follow-up treatments can be from mechanical means
- Limit the amount of herbicide transported to a site. Don't carry it all, because if there is a crash, it all spills in
- Have a spill response plan. Be prepared for your worst case scenario
- Designate a dry stream crossing when working near waterways. If you have herbicide on your feet from walking through treated plants and then you cross a stream, the herbicide will run off
- Pre/Post notification of herbicide application for visitors. By making them aware that the spraying is occurring, they can choose to avoid the area if they are concerned about personal health
- Wear PPE and have a wash station setup
- Mix and load herbicide in a protected area
- Contain any spills
- Keep application standards

## Information on herbicides

### *Glyphosate/Roundup*

Bacteria, fungi, and moisture break down glyphosate. Sunlight and hydrolysis also increase the rate of degradation. There are published reports of the half life of herbicides with and without sunlight. Glyphosate is easily biodegradable, even in the human body. In the past one applicator used to bring a jar of it to outreach sessions and drink it directly to show that it does not have a negative biological effect. Studies have been done using glyphosate with different surfactants to determine the rate that each degrades.

It takes a long time to get glyphosate runoff into streams. It adheres to the soil and needs to lose soil to erosion for it to get into streams.

Roundup has been reported to be an endocrine receptor, but the tests that were performed appear to have reached conclusions not supported by data. The experiment was done by a lab in France (Serloni) and has very unrealistic tests where they soak human cells in glyphosate. Arotemase production goes down in the experiment, but they did not use any positive controls. Considering glyphosate is so widely used, you would probably already see reactions if it happened.

Glyphosate hits soil and it binds. The best way topavoid this is to apply it differently. Avoid spraying it into the air. Dow Agro online has different ways to get the herbicide into the plant.

### *Imazapyr*

Imazapyr is not toxic to humans but highly to plants. It is long lived in terrestrial environments and has preemergent effects. It is short lived in water. When used near the coast, a foot difference in tidal zones can have an extremely different effect. It is hard to test Imazapyr in the lab, because it contaminates glassware.

Triclopyr can be absorbed through the skin. It is hazardous to women of childbearing age and has been shown to cause birth defects. You can use either an ester or a salt as a surfactant. The ester breaks down quickly to the salt form of the herbicide, which then takes several months to a year to fully degrade.

Competitor is a vegetable oil based surfactant.

Garlon has the highest risk profile compared to glyphosate (Roundup products) and Transline

Clopyralid requires a very low application rate but is quite persistent and can contaminate compost made from treated vegetation because of its persistence

### *Alternative herbicides*

Matran and Scythe are short risk herbicides. They are made from clove oil and pelargonic oil respectively. They break down in about three days, but are somewhat more hazardous to the applicator. They are both burn-down herbicides and work most effectively on young plants but need to be applied at high rates which increases costs.

## Risk Assessment Examples

USFS Risk Assessment: www.fs.fed.us/foresthealth/pesticide/risk.shtml

Invasive Spartina Project: www.spartina.org. Risk assessment for project compared with glyphosate

San Pablo National Wildlife Refuge: Perennial pepperweed and Imazapyr Risk Assessment. www.fws.gov/invasives/staffTrainingModule/pdfs/assessing/SPBNWR_Control_Plan_061807.pdf

New Zealand Environmental Risk Management Authority (NZERMA): NZERMA has a rating risk for human, risks, vertebrates, invertebrates, aquatics, etc. for all hazardous substances and new organisms in NZ. It also includes health and safety information and the type of PPE that you need to use chemical. This guides the storage, transport, use and PPE of all substances in NZ. www.ermanz.govt.nz/

The United Nations is working on a Global Harmonization System for pesticide products and active ingredients to make sure data is available and comparable worldwide.

Marin Municipal Water District: Watershed around Mt. Tamalpais is used for drinking water for much of Marin County. There are invasive brooms, star thistle and other invasives The residents are concerned about the potential herbicide effects on water supply. In order to reduce effects of spraying, they have assumed the worst possible outcome and have premitigated for scenarios. In a typical risk assessment, EPA assumes that everything goes correctly and label instructions are followed and assess the risk involved in the activity. Before beginning their work, MMWD did risk assessment for the worst case scenario (i.e. everything that they spray washes into the watershed or a truck full of herbicide is turned over on the road) and determined how you would react and respond. This sets limits on how much contamination is possible from vegetation management activities and helps in planning for those events to NOT happen. www.marinwater.org/controller?action=menuclick&id=437

### Planning

Need to log your experiences at a site. Record what you see and analyze change over the course of one year, three years and five years. Knowing what has happened in other areas will help minimize costs in the long term.

It's hard to get a true "cost" of herbicide application. If you remove insect populations during application, the long term ecosystem service loss may increase the price of your restoration. Generally the long-term costs of restoring an area after a monoculture of weeds has been removed will be greater than the short-term cost of removing them. Some sites can passively recover, while others have no capacity due either to reduced seedbank or slow growth of native species.

The other issue is funding long-term projects. Most money is for five years. You can get as much done as you can in the short term but most of these projects will need long-term follow-up. Bramble and Burns wrote a paper on a utility road project that took place over the course of 20 years.

You also need to evaluate your project after three years. If you are not having success with your treatment, then you have to switch to other management options, such as a different chemical or technique. Consistent and long term monitoring will allow managers to implement adaptive management. Comparing restoration at similar sites can also improve results.

It would be useful for funding agencies to evaluate effectiveness of projects so that they are more likely to fund projects that have proven to be effective in the past.

### Regulation limitations:

Some areas are limited by regulations against herbicides. In these instances, it is more difficult to manage your species. In one case, a manager is trying to control yellow starthistle with mowing with no effects. Fish and Wildlife will not allow herbicide on the land so they need another method. A manager from Yosemite said that they have done timed mowing of some of their star thistle plots and it had been effective. Another recommendation was to set up a demonstration plot using herbicide and to test whether or not the herbicide is an effective method.

If you have sufficient time, you can approach your problem experimentally and set up different methods to determine which is the most effective.

You should also do research to determine what types of research have already been completed.

### Application

When herbicide companies set their maximum application rates, they are being conservative by an order of magnitude. The amount of poison is often in the dose, but Susan hasn't always found this to be true in her research. Endocrine disruptor chemicals can have an effect at very low doses. 2,4-D and some of the surfactants in products (those that contain nonylphenol ethoxylates) are endocrine disruptors that you may encounter.

You should check independent sources when learning about the herbicides you use. Read the label for basic information, then check websites such as www.extoxnet.edu or www.pesticideinfo.org as well as some of the community sites where herbicide use is not favored, so that you know what people are concerned about when dealing with herbicides.

### Secondary Impacts (Wildlife)

One of the risks involved with herbicide application is impacting wildlife. You can carry a spray bottle with you to try to make up for mistakes during spraying, but some of the collateral damage is unavoidable and has to be calculated into your assessment. You have to determine if minor take of wildlife is better than a course of no action.

### Herbicide in wildlands

Wildlands use less than 1% of herbicides used nationwide. Some agricultural lands get up to 20 applications a year. The majority of effects on the environment are not from these wildland applications. Newspapers can make a big deal out of spraying on public land but they don't take the scale into account. People are very unaware of what is happening and are out of touch with how their fruits and vegetables are grown. In order to make it palatable to the public, it is important to keep records of reduced herbicide use over time at a site so that the public can see the effectiveness of the treatment. People lose perspective of the goals of treatment.

It is important to have a plan to get the weeds out and keep them out. You have to be timely with your applications to reduce the number of times that you have to visit a site. If you miss an application, then you are instantly behind and will usually have to use additional herbicide to catch up. If you allow plants to go to seed, then you will quickly begin losing the battle. Providing a source of desirable plants to the area is important, so they can begin to out-compete the weeds.

### Public Perception

People currently separate out herbicides used by other people from chemicals we use in everyday life. Much of what some people are resistant to is the fact that it was not their choice to be exposed to an herbicide, whereas their use of medications, smoking, etc. is their own choice that presumably comes with some benefit to them. Whenever people hear that there is a chance of cancer they get scared. The fear of the unknown is the biggest enemy. Education can help, but there will always be a few people who are not able to hear the information and/or make the choice anyway to do what they can to prevent any exposures, no matter how benign they might appear to be in an isolated context (which is how they are tested).

### Public Interactions

When dealing with the public, it is important to remember that there will always be people who will not change their mind and it will be impossible to get them to agree to treatment no matter how much data is presented. While it can be frustrating, it is very important to listen to them, because it will be possible to get idea of an alternative treatments and quell some of their concerns. You must listen to their concerns and care about their view. Go into public meetings with your eyes open and stay off your high horse.

In addition to educating people about herbicides, it is important to share information with them. If you are approached by a visitor seeking information, some of the key things you should know are:

- The long term effects of the herbicide
- If herbicide is going to be a regular part of maintenance

- Will the herbicide saturate the soil and have preemergent effects?

Dow Agro has a new DVD available called "How to Train a Trainer". It teaches applicators how to talk to different members of the public including farmers and people concerned about roadway spraying. It gives tips on how to positively react to public inquiries and prepares you for these interactions. It is important to train the entire crew so that everyone is prepared to answer questions. This can prevent the situation from escalating from zero to bad very quickly.

Most applicators make plans to share their information with others, but there isn't always follow through.

### Breakdown Products?

It is important to know what your herbicide breaks down into and where the breakdown products can be found. If you are going to test for AMPA after application, then it is necessary to pretest for it, so you have a baseline to compare it to. The Fish and Game office in Rancho Cordova does this test and accepts samples from outside organizations.

Some of our simple projects don't test for long-term aggregate effects. We need good science and we need better than one-year site studies.

### Risk Assessment

We need to determine acceptable levels of risk. When you are dealing with cancer, there obviously is no acceptable level to the individual. As a society, we have determined an acceptable level of cancer risk in the population as one in one million people, but if you're the one who gets the cancer, you probably won't think it's acceptable.

It is important to make a list of alternative assessments.

- What is the risk of no action?

  The plants in the ecosystem may not create habitat for other species.
- What is the risk of heavy equipment?

  This can be serious for operators of the equipment and failures of equipment might be worse than herbicide effects.
- Estimate costs without herbicides

  Can be a factor of ten or more higher using mechanical means

### Cal-IPC.org and herbicides

Cal-IPC is considering having links to herbicide information on their Web site, but in doing so may alienate some members due to differences in opinion. Even if they try to make it a clearinghouse of information, it risks inferring a position based on the articles and information chosen.

Because of this, it makes it a touchy subject and causes some people not to want it listed there

### Sharing Information

The hardest part about sharing information about your weed projects is finding the time to do it. Most managers are already busy enough and adding another "report" to a project gets difficult. CalWeedProjects tried to create a wiki site to share application information but it wasn't used, so they shut it down.

Perhaps a Web site with a form-like interface, so not much writing needs to be done.

Dow has a Techline Newsletter of field experiences. There is information available but not an effective way to get it to people who need it.

CalWeedTalk (www.cal-ipc.org/resources/index.php) is a listserve where you can ask questions over email and be quickly answered by experts and your peers in the field. It is a great place to get feedback about a project or information about a new species in your area.

## Job Skills for Natural Resource Management and Tailoring Your Resume to a Job Announcement

**Panel Members** (seating order): Shea O'Keefe (Natural Resources Conservation Service, NRCS), Dr. Jutta Berger (Irvine Ranch Conservancy, IRC), Brent Johnson (National Park Service, NPS), Marc Blain (BonTerra Consulting, BC) and Julie Horenstein (California Department of Fish and Game, CDFG)

**Commencement**: 1:30 pm

**Introductions**: 5 minutes

*What is the mission of your organization? How much do you interact with other organizations and the public? What types of positions are available within you organization?*

**Shea O'Keefe**; Our Mission Statement is to help people help the land. NRCS first started in soils conservation and now works on both public and private lands where its goal is to improve natural resources (air, water, soil, and wildlife). It employs within the fields of agronomy, range, biologists, GIS, engineers, and technical positions.

**Jutta Berger**: Our Mission Statement is to preserve the natural communities and habitats in order to connect the people with the land. IRC has a commitment to nurture the connection between the public and the natural world. It is part of a larger organization (Nature Reserve of Orange County), which connects open space within parks and nature reserves with local cities, the public and regulatory entities like CDFG and US Fish and Wildlife Service (USFWS). IRC develops educational programs for the public and also provides invasive species management and habitat restoration with the help of its on site native nursery. IRC employs within general administration, field operations, and also offers volunteerships.

**Brent Johnson**: Our Mission Statement is to protect natural resources for future public enjoyment. Brent mentioned he had worked previously for Yosemite National Park and now works for Pinnacles National Park. NPS employs a wide variety of job types including physical scientists, air quality analysts, hydrologists, geologists, archeologists, anthropologists, soils scientists, biologists, engineers, GIS, mechanics and technical positions.

**Marc Blain**: BC is a private consulting firm which has several departments. Jobs revolve around the needs of the client. Clients seek out BC when there is a concern about negatively affecting a natural resource. It is the job of BC to find the solution to the problem, leaving both the client and the resource agencies pleased. At a minimum the goal for any project is to have zero net loss of natural resources. This can be a challenging process and may require a novel solution. Someone who can think "outside of the box" is welcomed. Public interactions are few but generally take place at public meetings. Environmental Impact Reports and Environmental Impact Statements are written and reviewed frequently. BC works closely with resource agencies like CDFG, USFWS, and Regional Water Quality Control Boards. Positions include wildlife biologist, botanist, restoration ecologist and other permitting positions.

**Julie Horenstein**: Our Mission Statement is to manage the diverse resources (fish and wildlife) and habitats on which they depend for the use and enjoyment by the public. CDFG is the trustee for California's resources and has a broad regulatory role on private and public (non-federal) lands. Environmental review of documents for cities and counties, issuing "take" permits, creating land management plans and regulations, vegetation mapping, sensitive species surveys and managing hunting and fishing programs are frequent duties for CDFG staff. There is limited public interaction for most scientists. Positions include wildlife biologist, botanist, educator, natural lands manager and various administrative jobs.

*What are the three main themes of your job that you encounter on a regular basis?*

Shea O'Keefe

1. Habitat restoration on private lands involving work with NGO's
2. Design projects: crops, range, organic practices, sustainable foods
3. Contract management and paperwork

Jutta Berger

1. Invasive species control and habitat restoration
2. Sensitive species monitoring to maintain sustainable populations
3. Manage human recreation and preserve natural lands

Brent Johnson

1. Project management requiring invasive species control and habitat restoration
2. Proposal writing for funding
3. Compliance with laws and regulations that requires wearing a variety of hats, including GIS
4. Supervisory activities
5. Work with local tribes

Marc Blain

1. Client management. The challenge falls with clients who are opposed to working with regulatory agencies. Working with regulatory agencies always benefits clients.
2. Knowledge of state and local regulations and which regulatory agencies is the lead on your project
3. Thinking outside-of-the-box or bigger picture thinking

Julie Horenstein

1. Liaisons between state level to local offices in regards to the Lands Program involving six terrestrial regions and one marine region
2. Regulation changes
3. Property acquisition requiring federal funds
4. DFG lands management
5. Oversee grants for private lands management, more hunting oriented

*Briefly, what are the steps to applying for a job with your organization? What are some things that someone can do to strengthen their resume prior to applying? Are you hiring or do you predict you will be in the next few years?*

**Shea O'Keefe:** Job postings can be found on USA Jobs (www.usajobs.gov). Specific courses may be required within biology. These requirements are important so pay attention to postings. General requirements are an undergraduate degree in biology and one year of experience, or a masters degree in biology. Student Career Education Program (SCEP) is a paid program and stepping stone into NRCS. There is a current posting for a wetlands biologist.

**Jutta Berger**: Fewer openings for jobs. You should have a cover letter and either a resume or CV. Natural resource management and field experience should be strengths within your resume in particular habitat types. You can volunteer within IRC if you are lacking field experience and work toward getting hired. Experience with using various pieces of equipment is also an important skill. There is a current posting for a restoration manager position.

**Brent Johnson**: Job postings can be found on USA Jobs. Seasonal (eg.- surveying for plants) and intern positions are available. For summer student jobs there is the Student Temporary Employment Program (STEP) hire program. This gives the student an introduction to the various jobs available and may lead to a full time position. Your resume should be long and detailed, including descriptions of your classes taken. Since it is first reviewed by human resources (likely non-biologists) class titles may not suffice. Within the job posting there are strict requirements you must have, so use the "buzz" words in the posting to tailor your resume. Consider having two different resumes, a concise 1-2 page version and a 5 page version for federal postings. When in doubt evaluate yourself as high as you feel comfortable.

**Marc Blain**: Provide a concise resume and contact a manager so he/she has that personal contact with you. Personal contact and name recognition will get you a long way. Make apparent in your resume all relevant field work including endangered species and sensitive habitats you have worked with and any permits or certificates you have received. Junior biologists usually spend a majority of their time in the field. There are currently several positions open for wildlife biologists and botanists.

**Julie Horenstein**: For seasonal job postings check the CDFG website (www.dfg.ca.gov) and for permanent positions (www.jobs.ca.gov). The jobs site gives you all of the available state positions. There are state exams that are sporadically offered in order to get onto the civil service list. Open exams are offered every one to two years. Keyword search for "environmental" and "biologist". Look for the "open" exams not the "promotional" exams. The exam bulletin has you fill out a questionnaire. Use the buzz words (the verbs) from the exam bulletin to fill out the questionnaire. No resume required. If you are lacking field experience you can volunteer. CDFG is not currently hiring.

11/18/10: Additional information from the CDFG Human Resources Branch: "The Enivornmental Scientist is updated continuously.  As people take it they are added to the list instantly.....We are in the process of preparing the Biologist series. It is anticipated that the Biologist exam will be administered in the next six months. Once we release the bulletin it will be posted on our website and State Personnel Board.".

*What type of training is available on the job? What skills and coursework would you recommend students try to obtain prior to applying?*

**Shea O'Keefe**: NRCS provides cross-training to staff. As a staff you can go to a variety of training opportunities (10 per year). Examples of training opportunities that are beneficial to have are the Wetland Delineation Certification (US Army Corps of Engineers) and any special status species permits.

**Jutta Berger**: IRC offers staff training and workshops to staff. Permits for special status species and GIS training are good to have.

**Brent Johnson** :GIS skills and database management are important and encouraged. Offsite training is infrequent and currently discouraged due to budget constraints. Occasionally parks will swap crews. During these events one crew observes and participates in the work of another crew. Online trainings are also available.

**Marc Blain**: BC highly encourages staff training. Special status species permits and certifications are important to have and offered on the job. GIS training is always beneficial to have, but even if you do not have GIS training you should know what it is all about. There is a GIS department at BC. Cross-training is encouraged and it is important for wildlife biologists to know their plants and botanists to know their wildlife.

**Julie Horenstein**: CDFG primarily does in-state training. UC Extension classes are available where you can take classes in environmental regulation, technical writing, budget, and grant management. Being able to write well is very important. Other important skills to have include database, GIS, and PowerPoint software. Experimental design is also an important skill.

## Audience Question and Answer Session:

*How would you structure your resume and what job skills are important to have in your job?*

**Jutta Berger**: Keep your resume dry. Organize newest to oldest and include teaching and schooling associated with the position of interest. Write to your audience and be concise with the most important points toward the top. Format the whole document for neatness and be careful about spelling. Misspellings look very bad. Go to your career development office to receive resume guidance.

**Brent Johnson** :It is important to grab the reader quickly. Use USA Jobs to know what are important criteria for your resume and be very specific about your skills.

**Marc Blain**: Definitely have a cover page where you include a nice summary of your resume. Be as concise as possible because employers don't want to spend too much time sifting through your writing to find the important points. Make sure to use "buzz" words. Organize from most recent to oldest.

**Julie Horenstein**: Use the exam bulletin and job announcement to learn about the type of work that would be involved. In an interview, you will almost always be asked how your education and experience are relevant, so review your background in light of the information you have about the job and the employer and plan your answer in advance. Utilize the Internet to learn about the potential employer so you can flaunt a little knowledge and ask relevant questions. This will show that you take initiative, are capable of fact finding and are seriously interested in the job. After an interview, it is nice to write a thank you note to your possible employer.

*What is the size of our company/firm?* [Addressed to Mr. Blain]

**Marc Blain**: Our firm has approximately 70 employees. Firms which are strictly environmental can be much larger in size and found within multiple countries.

Adjourn: 3:00 pm