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Research and Management: Bridging the Gap

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Foreword

The California Invasive Plant Council's 15th Annual Symposium was held in Rohnert Park, Sonoma County, California, on October 5-7, 2006, focusing on the theme "Bridging the Gap between Research and Management". Solving California's invasive plant crisis requires rapid translation of research results into management actions. In addition, natural resource managers are often the first to identify interesting questions that become compelling research topics. The 2006 Symposium explored commonalities and conflicts at the interface of research and management, with invited speakers from both realms. It included two invited sessions on the main theme, one including researchers who work to make their results accessible to managers, the other with land managers who use research to inform their projects. This Proceedings contains abstracts and submitted papers from these sessions, as well as notes from a concluding panel that brought our invited speakers together with other invasive plant experts. The 2006 Proceedings contain the Bridging the Gap sessions as well as contributed papers, Laws and Regulations, posters, notes from working and discussion groups, and an attendee list. We have also included two papers that were inadvertently left out of the 2005 Proceedings.

Riparian and Aquatic Invasives

Team Arundo del Norte's arundo eradication and coordination program, a regional approach: Uniting weed management and research through interlinking adaptive management feedback loops

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The *Arundo donax* Eradication and Coordination Program is a regionally coordinated invasive plant eradication program consisting of ten watershed-based eradication projects around the Bay-Delta region, programmatic permit development, research on control methodology and restoration success, and Arundo distribution mapping and eradication prioritization. Program Partners implement local eradication efforts and monitor and report survey and treatment data using the Weed Information Management System (WIMS). Both partner data and independent research data are input into WIMS, providing a feedback loop for the steering committee of scientific advisors, partners, and program coordinators to review, interpret, and disseminate information to eradication partners so they can adaptively manage their control and restoration methodology. This presentation will provide up-to-date progress on the program, WIMS development, programmatic permitting, mapping, and eradication prioritization.

Layering: A 'new' mode of spread in *Arundo donax*

John Boland, Tijuana River Valley Invasive Plant Control Program, Imperial Beach, CA. JohnBoland@sbcglobal.net

Arundo donax is currently thought to spread rapidly via rhizomes and fragments only. But a two-year field study in the Tijuana River Valley showed that layering also occurred and was common. Layering is the adventitious sprouting of stem tips in contact with the ground. It can be considered both lateral expansion of a clump (while the layering stem is alive) and asexual reproduction (after the layering stem dies).

When viewed as clump expansion, layering was seven times faster than the expansion via rhizomes. When viewed as reproduction, layering produced 25 times more new recruits than fragments. In 2005, most of the clumps in the flood zone (79%) had > four layers (n = 100). Layering was therefore the most important means by which *A. donax* was spreading within the flood zone.

These Tijuana River Valley results challenge the current "top-down" management policy, which presumes that most new recruits come from upstream. The results show that, on the contrary, most new recruits come from within the habitat, via layering.

Literature Cited

Boland, J.M. 2006. The importance of layering in the rapid spread of *Arundo donax* (giant reed). Madroño 53 (4): 303-312.

Potential for augmentation biological control of *Arundo dona*x

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A biological control program for the suppression of Arundo donax is in an intermediate stage of development, with several candidate agents currently being studied in USDA quarantine facilities in France and Texas. However, we recently discovered that one of these agents, a stem-boring wasp (*Tetramesa romana*), is already present in southern California. Densities can be as high as 34 individual larvae per 100 cm of stem, and culm mortality is common in the field. Only smaller diameter primary or secondary stems less than ca.10 mm. are attacked, but damage may still reduce growth and metabolite storage by the plant. This wasp appears to have no alternative hosts, and may be an excellent candidate for augmentative biocontrol, an approach to enhancing the local abundance or regional distribution of natural enemies already present in order to provide weed suppression. Current studies are intended to verify that this insect is an efficacious specialist on Arundo, will not adversely affect other plants, and that it is amenable to re-distribution to other infested ecosystems in the western U.S.

Upper Santa Clara River Arundo/ Tamarisk removal plan

Noreen Cabanting, Ventura Resource Conservation District, Somis, CA

The Ventura County Resource Conservation District (VCRCD), as lead agency for the Ventura County Arundo Task Force and Weed Management Area, recently completed a long-term programmatic removal plan for arundo (*Arundo donax*) and tamarisk (*Tamarix* spp.) in the upper Santa Clara River watershed. The goal of the project was to complete a programmatic Environmental Impact Report (EIR) to comply with the California Environmental Quality Act (CEQA). This project was funded by a Proposition 13 Grant from the State Water Resources Control Board. The project area was over 16,000 acres and included the 500-year floodplain of the mainstem and tributaries. The VCRCD completed vegetation mapping with a modified Sawyer/ Keeler-Wolfe classification system. Arundo and tamarisk were mapped according to density. Four categories were used: 0-25%, 26-50%, 51-75%, and 76-100%. The long-term plan includes a wide range of methods for removal and disposal in order to accommodate a potentially diverse set of eradication projects. In addition, best management practices were also developed to reduce the impacts of individual projects to the environment. Individual projects that follow the guidelines of the long-term plan, may utilize the programmatic EIR rather than needing to prepare individual CEQA documents. The VCRCD is also working with funding from the Santa Clara River Trustee Council to develop programmatic permits to simplify the regulatory process.

Hydrilla eradication efforts in the Chowchilla River and Eastman Reservoir in Central California: A success story

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Hydrilla (*Hydrilla verticillata*) is an invasive, non-native aquatic plant that is a serious threat to the water resources of the State. It reduces the storage capacity of lakes and ponds, impedes movement in streams and canals; clogs pumps and hydroelectric generators; degrades wildlife habitat; and can even endanger public health by creating mosquito breeding habitat. Hydrilla can reproduce by stem fragments that root and form mature plants; turions that form in the leaf axils; and most troubling, tubers that form on the end of rhizomes in the spring and again in late summer through fall. These tubers can survive in the hydrosoil for several years or more. Following the first introduction of hydrilla into California, in 1977 the California Legislature mandated that the CDFA Secretary initiate a detection program for hydrilla and to eradicate it wherever "feasible". This mandate is stated in the California Code of Regulations.

The discovery of hydrilla in Eastman Lake and the Chowchilla River presented new challenges to the CDFA. Previous infestations had occurred primarily in locations that were easily accessible and where the water could be controlled. This infestation was the first to be seen in a free flowing seasonal river. The Chowchilla River originates in the Sierra Nevada foothills in Mariposa County. The three forks of the Chowchilla fill Eastman Lake, an 1800-acre reservoir owned by the U.S. Army Corps of Engineers. Eastman is used primarily for flood control, irrigation, recreation and wildlife preservation.

Hydrilla was first detected in Eastman Lake on June 20, 1989, during a routine survey by CDFA and Madera County Department of Agriculture personnel. Plant samples were collected, sent to the State Diagnostics Lab and confirmed as *dioecious hydrilla*. Initially the infestation appeared to cover approximately 100 gross acres in the northern section of the lake. CDFA acted immediately to prevent hydrilla spreading to other local lakes or into the irrigation canals by requesting that the U.S. Army Corps of Engineers close off the northern portion of the lake to recreational activities on June 23. Just five days later the entire lake was placed under quarantine as many more plant sites were found along the eastern shore line.

While Eastman was being inspected, additional teams of biologists started a delimitation survey to discover the full extent of the problem. When they discovered hydrilla in the Chowchilla River in a few easily accessible places upstream of Eastman Lake, it was clear that personnel needed to follow the river upstream to find the source of the infestation. This was not as simple as it sounds. Since the Chowchilla flows completely through private land, property owners had to be contacted in order to gain access to the river. Most owners granted permission immediately but others had to be persuaded to allow people on their property. Government types aren't exactly welcomed in many of the foothill and mountain areas of California, especially when questions are being raised about precious water resources. When the most upstream site of the infestation was located in the West Fork of the Chowchilla River, 26 miles upstream from Eastman Lake, the entire West Fork of the river was closed, restricting all water related activities.

Right at the beginning of this project there were many who questioned the "feasibility" of eradicating hydrilla from the Chowchilla River. It flows through some extremely rugged terrain, with steep hills and deep canyons. Just getting to the water in many places involves driving on a rugged 4-wheel drive road, then hiking for a ½ mile or more on cattle trails through oak grassland or chaparral, sometimes through stands of poison oak. Biting and stinging insects, rattlesnakes, the occasional mountain lion or bear, the not so occasional wild pig, and even people with guns, add to the adventure of just getting to the water! Once in the river personnel are faced with the daunting task of staying upright on slippery rocks, or hacking through thick stands of cattails or willows. In the early years of the project, all of this was done while carrying a backpack sprayer with 40 pounds of liquid herbicide sloshing around! Weather is another big challenge. Summer temperatures in these foothill canyons can easily reach 105 degrees Fahrenheit and beyond, with hot afternoon winds that feel like they are right out of a blast furnace; winter days can be just as miserable with thick fog and wind chill down into the 20's. In spite of these logistical environmental roadblocks, a Scientific Advisory Panel, convened in July 1989, concluded, "anything less than an eradication effort is unacceptable". It was therefore deemed "feasible" to eradicate hydrilla from the Chowchilla River and Eastman Lake.

Work began immediately. Within a month after the initial detection, seasonal staff was hired to work with CDFA Biologists. The first step was mapping the river and lake. This was before we had GPS so the primary tools were a topo map, a compass and a good sense of direction. The river system was divided into 38 management units. While the river was mapped, several crews of 3 to 4 people surveyed foot by foot, looking at every pool and puddle. Hydrilla was found in every management unit, ranging from single plants to large masses filling entire ponded areas.

Chemical control was an essential tool early in the project, so any plants found were treated with Komeen®, a copper based contact herbicide used to control the top growth of hydrilla plants. Crew members had to learn the terrain and river access points, and also how to use the herbicide, and how much to carry each day. By the second season crews were surveying the entire river every two weeks, treating as necessary. A number of heavily infested ponded sites were measured and treated a number of times with predetermined amounts of Komeen. During 1989, 1990 and 1991 an average of 450 gallons of Komeen per year were applied to ponded and slow moving water in the river.

In the meantime, work at Eastman Lake was progressing. In 1989 mats and individual plants of hydrilla were detected, marked with bamboo stakes, and removed by hand. Plant site areas were netted to catch any fragments that might break off. Project officials also started a chemical treatment program. Komeen was applied to pre-measured sections of the lake using a custom boom sprayer system with weighted down dragger hoses to get the material down into deep water, and a spray gun for the more shallow areas along the shoreline. In the years 1990 through 1992, 1000 to 2000 gallons of Komeen were applied to the lake per year, during regularly scheduled treatments. In addition to the Komeen treatments, in 1990 the upper lake delta area was fumigated with Vapam®. This area was heavily infested with hydrilla and held a massive reserve of tubers. Vapam is a soil fumigant that kills tubers, roots and stems of plants in the soil. The lake water level was drawn down to dry the sandy soil of the delta. Private contractors brought in sprinkler irrigation pipes to apply the Vapam to the area. This treatment was highly successful, as very few plants were later found in the treated area.

Along with the herbicide treatments, personnel were hand-removing plants. The herbicides eliminated the huge mats, so by 1990 individual plants could be counted. Crewmembers literally waded, swam and even snorkeled in the water of the river and lake to look for plants. And not only did we have to find hydrilla plants, but also find and identify them among many other aquatic plants, often in deplorable water conditions. When plants were found they were gently pulled out of the soil, often still attached to the tuber from which they grew. When tubers broke off they were removed by sifting the soil material through hardware cloth welded inside a metal ring. This became known as the "shovel and sift" method. When large numbers of plants were found in one area, we would shovel and sift, then use suction dredges to remove more tubers from the soil. Dredging requires a lot of manpower, not only to get the equipment to the site, but also to simply look through the material to find the tubers. Use of our 4-inch intake dredge was highly successful at the site of the source of the infestation, where in the span of five weeks in 1991, approximately 35,000 tubers were removed.

Up through 1996, this routine continued: survey, pull plants, shovel and sift, treat and dredge, and survey again. Plant numbers declined dramatically. In 1993 over 6,000 plants were removed; by 1997 we saw a major drop to 562. In 1997 we were given a new weapon – Sonar®. Sonar is a selective systemic aquatic herbicide that causes the breakdown of chlorophyll. At the end of 1998 we saw another major drop in plant numbers – down to 49! We frankly did not expect that dramatic a reduction in one season. We ascribe this to several factors: effective use of Sonar, removing plants, which prevented the production of new tubers, and the fact that the existing tuber bank was being exhausted. Hand removal became our primary tool and only two plants were found in 2002!

While all this work was conducted in the lake and river, additional detection work was done in a corridor two miles wide on both sides of the river. All stock ponds, fire ponds, and creeks within that corridor were thoroughly checked. The Middle and East Forks of the Chowchilla River, and the outflow from Eastman Lake were also surveyed. No hydrilla was ever found in any other body of water in the area.

A bio-control agent, the weevil *Bagous affinis*, was released in the river, but unpredictable water flows made the attempt impractical. Besides, as a tool for this project the very nature of bio-control is inconsistent with the mandate to eradicate all hydrilla plants.

Mother Nature helped us too. Several periods of drought during the project years left many sections of the river dry for much of the season. Even if hydrilla plants sprouted they did not have the opportunity to grow or produce new tubers before the water evaporated or disappeared underground.

The dry years also helped to reopen Eastman Lake by leaving dormant tubers high and dry above the water level. Even after a small number of plants appeared in July 1992, CDFA officials were so confident that the hydrilla was well under control they worked with officials from the U.S. Army Corps of Engineers and the State Department of Fish and Game to open the west shoreline for fishing in August 1992. Hundreds of happy anglers lined up elbow to elbow along the shoreline to catch those bass that had been growing undisturbed for two years. In 1995 almost the entire lake was opened to all forms of water activities. A small portion of the lake remains closed today to protect nesting bald eagles that moved in when the lake was closed.

We are excited that zero hydrilla plants have been found in the Chowchilla River and Eastman Lake system since 2002. Native aquatic vegetation is thriving in the river, enticing wildlife in the region. Because the plants found in 2002 were located approximately 20 miles upstream from Eastman Lake, the entire system must still be considered infested, and the river remains under quarantine. In 2004 and 2005 each management unit of the river was surveyed at least two times and Eastman Lake was thoroughly checked four times. Sonar herbicide treatments were completed in 2005. This summer (2006) the entire river system was surveyed once and we are cautiously optimistic that our hard work will be rewarded by two more years of negative hydrilla finds, the minimum required before eradication can be declared.

The first key element to successfully eradicating hydrilla is early detection and rapid response. The Chowchilla River/Eastman Lake infestation was estimated to be about four years old, and while portions of the river were thickly infested, the amount found in the lake was not yet completely out of control. Irrigation and recreational activities would have been severely impacted if CDFA had not acted immediately. Another key element in eradication is a complete commitment to the project by all parties involved. And in this respect the Chowchilla project really stands out. CDFA made a full time commitment to attacking this problem, supplying not only financial resources, but a dedicated staff as well. The U. S. Army Corps of Engineers, Madera and Mariposa County Departments of Agriculture and other agencies continue to supply financial and logistical support. But it is not only the financial resources that made this project a success; it is the legion of dedicated people who have made the difference. People who were willing to immerse themselves in algae covered water that was pretty disgusting; willing to encounter dead animals, fish, and smelly rotting vegetation and endure being literally covered in hydrilla plants! People who used every tool - swimming, snorkeling, using herbicides, hand pulling, dredging, and surveying again and again – to eliminate hydrilla. And that is the final key point – hydrilla cannot be ignored, it requires constant attention. To be successful, we cannot afford to turn our backs on current projects and we must be vigilant, always looking for new infestations, finding them early, and acting on them quickly. Only by doing so can we keep the vital water resources of the State of California free of this noxious pest.

No weed left behind: A GPS method for conducting a complete weed inventory

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When managing a weed infestation over a large area, taking a complete inventory of a target weed population can seem impossible. We have tackled this problem by using the "tracks" function on Garmin® GPS units to record the area surveyed by each team member each day. By exporting these data to a GIS, we create maps illustrating the extent of our daily inventory. We then use these maps to visually identify which areas within our targeted survey area may have been missed. By overlaying our track data with previously identified weed locations in ArcMap, we can also determine if we have identified all pre-existing weed occurrences in our current surveys. We can then use these track data to delineate total area surveyed, using a minimum convex polygon delineation method. This integrated GPS method allows us to complete our inventory with no weed left behind.

Incorporating weighted hierarchical criteria and uncertainty into invasive plant prioritization schemes: A case study from the National Park Service Klamath Network

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Ranking invasive non-native plants is a fundamental step for setting management priorities, conducting risk assessment, and developing predictive models to aid in early detection monitoring. We describe an invasive plant ranking system that was designed to meet three goals: (1) to have enough flexibility to be applied at local and regional scales, (2) to be explicitly linked to different phases of the invasion process, and (3) to incorporate uncertainty into the scoring system. Our strategy was to evaluate existing systems and select those we felt had the greatest potential for flexibility, then integrate their strong points with the Analytical Hierarchy Process (AHP). AHP is a hierarchical decision-making process with a strong mathematical foundation that objectively weights criteria nested at different levels. We reviewed fifteen existing prioritization systems and determined that a ranking system developed recently by Randall et al. in conjunction with the 2006 Cal-IPC inventory provided a flexible framework to integrate with the AHP. The basic structure of the procedure consisted of one primary level with four or five primary criteria, and one secondary level with 16 to 20 secondary criteria. We applied the procedure at three scales in the National Park Service's Klamath Network; individual management units (parks, monuments, and recreation areas), the network, and the region. Based on analyses of pre-existing data and consultation with park and other experts, species were categorized as being in the colonization, establishment, or spread phases and separate rankings were done for each phase. A preliminary evaluation indicated that the system has good potential for general application and standardizing prioritization programs within a well-developed administrative structure such as the National Park

Service's. While this is encouraging, the utility of the procedure could be improved by directly integrating site-specific criteria into the structure, as well as evaluating the procedure on lands managed by organizations with fewer resources than the National Park Service's.

Utilizing differential quantitative mapping technologies and traditional botanical knowledge to assist Brazilian waterweed management in the Sacramento-San Joaquin Delta: An example from Frank's Tract

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Control of Brazilian waterweed (*Egeria densa*) in the complex waterways of the Sacramento-San Joaquin Delta (SSJD) presents many challenges. Rapid tidal fluxes, varying and often strong current patterns, sediment composition, changing water temperature and turbidity, and a host of other factors can all influence the efficacy of aquatic herbicide treatment regimes. Understanding how and why submerged macrophyte cultures of *Egeria densa* react to management efforts throughout growing seasons in the SSJD is key to realizing the best methodology to use in regulating invasive growth. The semi-diurnal tidal flux and significant turbidity of SSJD waters has historically rendered empirical measurements of *Egeria* coverage and biovolume unreliable. Hydroacoustic plant mapping technology, applied in Delta waters since 2003, has helped provide a breakthrough in solving this problem.

Hydroacoustic measurements of *Egeria* coverage and biovolume have proved instrumental in evaluating efficacy. A key asset of the technology is that it yields a very rapid, verifiable characterization of the entire water column beneath the transducer. Combining hydroacoustic transects with underwater photographic surveillance and traditional physical point sampling techniques provides the most complete picture to date of submerged vegetation conditions in the SSJD. Eighteen sites in the central Delta have been monitored since 2003 for submerged vegetation species, health, biomass, biocover, and biovolume. The goal of this ongoing monitoring approach is to better measure actual efficacy and the factors that influence efficacy on Brazilian waterweed. Efficacy is determined by comparing the aggregation of acoustic-based plant-coverage and biovolume models, photographs, and physical data at each treated site with control sites. Yearly summaries strongly contribute to adaptive management decision making.

Within the operational context of the goals of the California Department of Boating & Waterways *Egeria densa* Control Program, this presentation briefly describes the applied scientific assessment methodologies utilized and analysis results from Frank's Tract Site 173, a 140-acre treatment site located in the central SSJD.

Economic impacts of yellow starthistle on California ranchers

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The environmental damages caused by alien weeds are documented, but the economic impacts of individual invasive weeds are poorly understood. Yellow starthistle, *Centaurea solstitialis* L., (YST), a widespread non-crop weed in California, causes serious damage to forage on natural range and improved pastures. A survey of California cattle ranchers targeted YST infestation rates, losses of forage quantity and value, and control or eradication efforts. Estimates of county-wide economic losses for three focus counties as well as state-wide economic losses from YST in California were generated from the survey and other available data. It is estimated that total losses of livestock forage value on private land within California due to YST infestations amounts to $7.96 million per year, with an additional $9.45 million spent by ranchers out-of-pocket to control the weed. The total of these two sums is equivalent to 6 to 7% of the total value for harvested pastures annually in the state. Such losses, although relatively small compared to the total agricultural production in California, show that the infestation of YST significantly constrains California's livestock grazing sector.

The need for increased cooperation and coordination in yellow starthistle invasion management in Sierra Nevada foothill rangelands

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Despite available methods for controlling yellow starthistle (*Centaurea solstitialis*), its range is increasing in the Sierra Nevada foothills. This invasion often heavily affects cattle ranchers, but a variety of factors compromise their ability to respond to it. We interviewed 40 cattle ranchers in California's Amador, Calaveras, Tuolumne, and Mariposa counties about their experiences with yellow starthistle and mailed surveys to over 850 more, with a response rate of approximately 20%. After preliminary analysis of survey and interview responses, we invited ranchers, agency representatives, cooperative extensionists, agricultural commissioners, and academics to a September, 2006, symposium on yellow starthistle management and impacts on ranchlands. Symposium sessions identified a need for increased cooperation and coordination among disparate land management entities, confirming survey and interview results. Specific recommendations developed by symposium participants will be presented to legislators, weed management areas (WMAs), and resource conservation districts (RCDs) in the form of policy briefs and white papers.

Our surveys and interviews identified local dynamics of yellow starthistle control on rangelands, including individual rancher responses and the management constraints they face. Ranchers report that yellow starthistle causes significant economic harm to their operations. Yellow starthistle has forced over a quarter of respondents to buy more hay, while another 13% report that it directly reduces the number of cattle they are able to pasture. Nearly 95% of respondents believe that controlling yellow starthistle will be economically beneficial for their operation over the long-term. Respondents also identified primary barriers to yellow starthistle control: 39% of ranchers reported that lack of money limits their control ability, while 32% blamed lack of time and 21% cited ineffectiveness of available control measures. Ranchers used different yellow starthistle control methods and reported some as more successful than others. Transline®, hand removal, and grazing ranked as the most successful methods attempted by respondents and were all perceived as significantly more effective than Roundup®, mowing, or burning (ANOVA, p<0.0001). Eighty-seven percent of respondents believe that yellow starthistle control responsibility should rest with landowners. These ranchers also feel that other entities should play a role, with 66%, 58%, and 35% believing that county, state, and federal governments, respectively, should share control responsibility.

These findings highlight regional factors contributing to yellow starthistle impacts, as well. Three information sources suggest that increased coordination and cooperation among land managers is necessary to prevent or slow the spread of yellow starthistle and to permit successful control efforts. When interviewees were asked in an open answer format which factors make yellow starthistle control most difficult for them, the most frequent response (73% of interviews) was lack of cooperation and coordination. In addition, 50% of survey respondents that provided optional, open-answer information at the end of the survey identified spread across property boundaries and lack of cohesive regional control efforts as factors that inhibit control efforts on their own property. Finally, when directly asked to indicate sources of starthistle spread, surveyed ranchers overwhelmingly (75%) cited adjacent roads and neighboring lands as sources, suggesting again that invasion across borders is an ongoing challenge.

The lack of coordination and cooperation, both between ranchers and government agencies and among the agencies themselves, became apparent during panel discussions at the September 2006 symposium. County agricultural commissioners, cooperative extension personnel, and CalTrans representatives all agreed that a lack of coordinated regional efforts inhibit efforts to control yellow starthistle. Furthermore, symposium discussions identified measures to enhance cooperation in order to improve management. First, attendees noted that WMAs are extant bodies dedicated to cooperation and coordination, and have had notable successes in some areas. However, few surveyed ranchers have had positive interactions with WMAs (only 18% of respondents reported that WMAs are trustworthy sources of information); this could be due to a general lack of familiarity with WMAs on the part of ranchers. In contrast, both ranchers and advisors attending the symposium reported that Resource Conservation Districts (RCDs) are trusted and valued by ranching communities, but because their focus is much broader than simply invasive species, RCDs are rarely a source of influential cooperative efforts against rangeland weeds. The symposium output will therefore acknowledge that both WMAs and RCDs are important venues for the development of coordinated regional efforts focused on better weed control across boundaries. Recommendations issued to legislators and WMAs will encourage making WMAs better funded, more inclusive, and more well-known in their regions. Recommendations issued to RCDs will include targeting weed control efforts so that local work will correlate with regional needs and awareness. Both WMAs and RCDs should also become aware of and take advantage of local volunteer groups and share success stories and lessons with each other in order to fully utilize available resources.

Our surveys, interviews, and symposium suggest that increased coordination and cooperation among land managing entities, combined with perennial subsidies for yellow starthistle control, could greatly reduce the negative impacts of yellow starthistle in the Sierra Nevada foothills. Furthermore, our findings suggest that while ranchers did not report positive interactions with WMAs, they did maintain high levels of trust for agricultural commissioners and the cooperative extension agents (well over 60% of ranchers in the study area found these advisors trustworthy). A majority of ranchers surveyed also suggested that both county and state agencies should play a role in the control of yellow starthistle. Since many county agricultural commissioners and extension agents are members of WMAs, these individuals could likely facilitate the interaction between ranchers and WMAs, creating the potential for a more coordinated and effective approach to yellow starthistle control.

Bridging the Gap: Research

Measuring performance of invasive plant management efforts

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Abstract

Although there is growing enthusiasm for 'performance measurement' in government, meaningful measures remain rare in weed work. But that need not be the case. Several cost-effective and straightforward performance measures are available for efforts involving eradication, elimination, or containment management objectives. Since progress towards these objectives is often preceded by the gradual elimination of some infestations, evaluating trends in site status (whether above-ground plants are present or absent) and site population size (based on complete censuses) may help weed workers to evaluate whether they are making progress towards what is often a distant objective. These performance measures are illustrated using long-term datasets from California and New Zealand.

Introduction

There is growing enthusiasm for performance measurement in government. This is particularly true in New Zealand, where radical structural reforms during the late 1980s led to the enshrinement of 'new public management' with its strong emphasis on management objectives and performance measures. During the 1990s the New Zealand example gave courage and inspiration to new public management advocates elsewhere. Examples familiar to California weed workers include the federal Government Performance and Results Act of 1993 (GPRA) and Governor Arnold Schwarzenegger's California Performance Review.

The spread of new public management has led to a cottage industry among academics. There are dozens of articles on performance measurement, including articles on the three broad aims of performance measurement (Bird et al. 2005), five characteristics of performance measure targets (Her Majesty's Treasury et al. 2001), seven pitfalls to avoid (Theurer 1998), eight specific purposes (Behn 2003), and eleven ways to make them more useful to managers (Hatry 1994). There are so many articles on the subject that a major journal (*Public Administration Review*) pointedly notes that it is no longer very interested in articles on performance measurement unless they break new ground. Rather than review that literature carefully here, I offer my own list of seven useful attributes: Effective performance measures for weed workers are those which are annual, quantitative, non-statistical, inexpensive, straightforward, capable of being aggregated across species or regions, and suitable for graphical display.

Despite so much academic interest, there is relatively little research on the use of performance measures in the environmental field, particularly in conservation. Some leading conservation organizations, including the Department of Conservation in New Zealand and California State Parks, have adopted performance measurement in principle, but measures focusing on visitor services and recreation are often much more developed than those relating to biodiversity conservation.

The Nature Conservancy (TNC), the world's largest conservation organization with an annual budget of $600 million dollars a year and a board full of representatives from large corporations, is particularly keen to adopt performance measures. TNC is finding it far more challenging than it expected. A few years ago, it was forced to conclude that "we still lack a comprehensive scientifically rigorous system of measures at scales appropriate to our mission, and problems with accountability, duplication, and external credibility have diluted our efforts" (TNC 2002). TNC scientists were prompted to expand their search for scientifically rigorous measures of success in 2000 after a wealthy California venture capitalist asked TNC scientists, "How do you know you're having an impact? Why should I donate millions of dollars and time if it isn't possible to reach this goal?" (quoted in Christensen 2002).

Developing performance measures in conservation is both worth doing and difficult to do. Its difficulty is in part due to the tremendous natural variation across time and space that affects the plant and animal populations that are often the target of performance measures. This has led conservation biologists to focus much of their research on sampling and statistical techniques in an effort to detect what is often a weak signal amid all the background noise. As a result, the term 'monitoring' – the systematic collection of data over time – is often thought to require sampling and statistics.

But what if managers believe that they cannot afford monitoring involving sampling and statistics? They might naturally then turn towards the systematic collection of data that does not require sampling or statistics, such as presence/absence data or complete censuses. What's surprising, though, is that research scientists advising managers sometimes argue that such data are not rigorous enough.

We might understand this unfortunate dynamic by thinking about three different doorways that managers can go through in order to learn from their experience. Behind door 1 is 'rigorous' monitoring requiring knowledge and expertise in sampling and statistics in order to collect and analyze. Research scientists strongly recommend that door, but managers often don't believe they can afford to enter it. So they move towards door 2, which leads to the systematic collection of data that does not require sampling or statistics. But as they try to do so, research scientists bar the way. 'Don't go in there; it's not rigorous enough!' they exclaim. So managers are left with only one option, door 3, which leads to anecdotal data and personal experience. Despite being tremendously valuable, personal experience alone seldom convinces funding agencies and upper-level management that the desired objectives were achieved.

This talk is all about door 2. Presence/absence data and complete counts, when combined with measures of effort, can give managers and weed workers the effective performance measures that are being demanded of them by funding agencies and upper-level management. By calling them 'performance measures' rather than 'monitoring' we also may be able to evade the rigor police who seem to guard door 2.

Key management objectives: Eradication, elimination, and containment

When an invasive plant species is relatively rare, capable of spreading widely, and thought to be capable of causing significant economic or ecological impacts, it often makes sense to adopt one of the three management objectives listed above. In each case, the objective for a particular site is to drive the population extinct. I use the term 'site elimination' to describe this site management objective. If the overall objective is 'eradication,' then the aim is to eliminate all sites in a region where there is a very low probability that the species will reinvade from outside the region. If the objective is 'elimination,' then the aim is to eliminate all sites in a region even though there may be a reasonable probability that the species will reinvade. (In New Zealand, weed workers have adopted the term 'zero-density' to describe this objective.) Finally, if the management objective is containment, then the aim is to eliminate all outlier sites.

But these three objectives can often take a long time to achieve. If the seed bank is particularly long-lived, it may take a decade or more to achieve eradication. So we need to find a measure that will help us evaluate whether we're making progress towards what is often a distant goal.

The key insight here is that the elimination of some sites often precedes the elimination of all sites. Since the goal for each site is elimination, it's easy to track whether progress is being made: Is the targeted plant present or absent during each year or site visit? We can supplement this basic presence/absence data with additional information about the number of individuals removed at each site or how much effort it required to seek out and destroy every targeted plant at each site. As will be shown below, only a few columns in a spreadsheet are required to generate a meaningful performance measure that has all the desirable qualities listed above. I will illustrate that weed workers are capable of collecting this type of data by providing two examples, one from California and one from New Zealand. Additional examples, along with a more detailed description of this approach, can be found elsewhere in the peer-reviewed literature (Holloran 2006).

Measuring eradication performance: *Coincya monensis* in Humboldt County, California

Star-mustard (*Coincya monensis*) was first detected in California in early 1997. Within weeks after its identity was confirmed, weed workers in Humboldt County began eradicating it from the region. They had learned that it was invasive elsewhere in the US and had not yet been detected in the West (Martin 2000). The infestation is limited to a series of small patches in the vicinity of Manila in Humboldt County. Those individual sites are searched multiple times each year. Implementing and documenting the entire eradication effort requires only 15 to 30 hours per year (A. Pickart, pers. comm., 2006). With the exception of 1999, when no records were kept, staff and volunteers have recorded the number of individual plants removed at every site during each year. Data for a single site is shown in Table 1.

Table 1..

Number of *Coincya monensis* plants removed at Site A, Manila, Humboldt County, California

Species	Site	Year	No. plants removed
C. monensis	Site A	1997	6,000
C. monensis	Site A	1998	1,470
C. monensis	Site A	1999	n.a.
C. monensis	Site A	2000	487
C. monensis	Site A	2001	1,132
C. monensis	Site A	2002	481
C. monensis	Site A	2003	511
C. monensis	Site A	2004	174
C. monensis	Site A	2005	274
C. monensis	Site A	2006	49

The trend in Table 1 is clear and resembles exponential decay when shown on a graph: a fast decline in the number of plants removed annually, followed by a long right tail that takes some time before it approaches zero. (In the case of Site A, it has yet to hit zero.) This same pattern holds true when the data is aggregated across all sites. As a performance measure, tracking the number of plants looks great during the early years; it doesn't look as good during subsequent years. But that's exactly when we need to convince funders and managers that we're making progress.

Rather than aggregating plants across all sites, we can use the key insight mentioned previously and examine site status instead. Of the nine known sites in 2006, only four were 'Active.' (An 'Active' site is one where the targeted plant appeared above-ground.) The other five were either under 'Surveillance' (sites where the targeted plant did not appear above-ground) or have been at zero for long enough (in this case, three years) that they are deemed 'Historical.' (This method of designating sites using these three categories has been used in New Zealand for more than a decade.)

The stacked bar graph in Figure 1 graphically illustrates that progress towards the eradication management objective is being made. Although not all sites have been eliminated, some have. Not surprisingly, those sites under 'Surveillance' are also the smallest sites. The site designation problem is perhaps the most difficult and challenging aspect of this approach to measuring performance. If the entire Humboldt County infestation of *C. monensis* is treated as a single site, then the site would remain 'Active' until the very last plant was removed. If, at the other extreme, every single plant were recorded as a site, then we would simply be left with the mirror image of the exponential decay figure and a very large spreadsheet. Neither extreme is satisfactory; deciding where to land in the middle is more art than science.

At some point, the decision about the boundaries of a patch or site or infestation is an arbitrary one. But in general, the larger the site, the longer it will take before it is eliminated. If all sites are large, then it might be difficult to demonstrate progress towards elimination of all sites using this approach. Four out of the five sites classified as under 'Surveillance' or 'Historical' are sites D1 through D4; D5 is still 'Active.' If those working for its eradication had decided to aggregate the data for D1 through D5 into a single site D, then they wouldn't be able to show as much progress as they have. The lesson here is to err towards designating small sites, but not so small that collecting data then becomes infeasible or locating the site boundaries in the field becomes too difficult.

Measuring eradication performance: *Carthamus lanatus* in Marlborough, New Zealand

Woolly distaff thistle (*Carthamus lanatus*) is under eradication in the Marlborough region of New Zealand. It is listed as a 'Total Control' plant pest under the Marlborough District Council's most recent Regional Pest Management Strategy (MDC 2001). As such, MDC staff visit every known site at least once per year and remove every plant found, at no cost to individual property owners. Since 2000, MDC staff have collected data like that shown in Table 1, but with an extra column for the number of person-hours. (They also collect data for each site visit rather than aggregating data across all site visits per year, which is what happens in Humboldt County. In practice, though, it amounts to the same thing; most woolly distaff thistle sites are visited once annually when the plant is easiest to detect, in this case during the period of peak flowering.)

Collecting that extra column provides weed workers with another useful tool for evaluating and reporting progress towards a distant objective. Table 2 illustrates how data can be presented in tabular form rather than a stacked bar chart. The first two rows present basically the same information as would be found in a stacked bar chart like Figure 1. (In this case, only two site status categories are used, 'Active' and 'Surveillance.' Sites under 'Surveillance' are interpreted here as 'eliminated.') The second two rows indicate how much effort MDC staff have devoted to achieving the long-term objective of eradication from the region. The spike in staff time in 2002 may reflect a shift to service delivery (staff carries out the eradication) from occupier control (staff inspect to insure that property owners remove all plants).

Table 2.

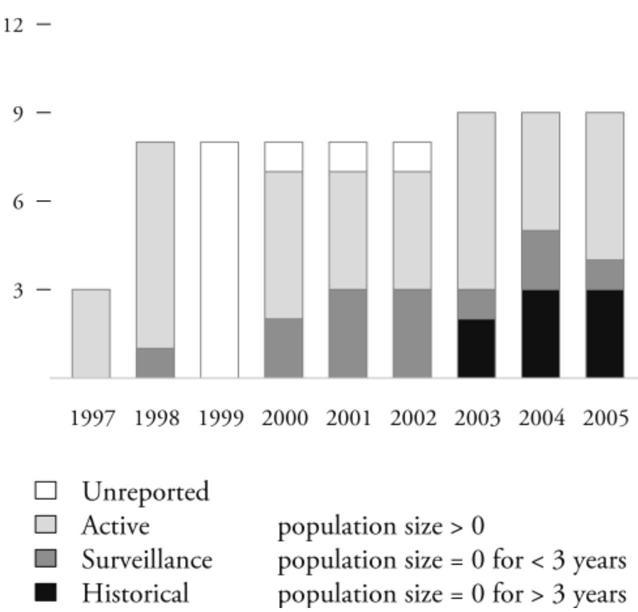
Site status and eradication effort, *Carthamus lanatus*, Marlborough, New Zealand

Perf. measure	2000	2001	2002	2003	2004	2005	2006
number of sites	8	10	14	16	16	17	18
% sites eliminated	63%	50%	64%	44%	69%	59%	56%
person-hours	31	31	146	173	172	132	106
person-hours/site	3.9	3.1	10.4	10.8	10.8	7.8	5.9

Two key trends are visible here: the percentage of eliminated sites is not changing that much, but the number of hours required to achieve the annual site objectives (searching for plants at all sites, removing any plant where found) is falling. When presented in tabular form, this method of evaluating performance can be rolled up across multiple species. For example, MDC staff could produce an expanded version of Table 2 providing similar data on all five species targeted in their Regional Pest Management Strategy as 'Total Control' plant pests.

Figure 1.

Site status of *Coyncia monensis* in Humbolt County



Conclusion

Performance measures based on complete counts and presence/absence data hold great promise for managers. They are inexpensive, straightforward, and address the growing need for performance measures in government. They can clearly be implemented without great cost, as these examples from California and New Zealand demonstrate. They may represent an example of how going through door 2 can be useful.

A caveat, though: these measures are focused on an organization's performance at eliminating known sites; they provide little information about how effective an organization is at detecting unknown sites. This is the surveillance or delimitation problem (Lawes and Panetta 2005). More research is needed (preferably focused on door 2).

Despite this caveat, even these performance measures provide some indication that the number of new sites is leveling off. A third trend is also visible in Table 2: rapid increase in number of sites (from 8 sites to 16 in just 3 years) followed by relative stability in the number of sites (16 sites to 18 over the next 3 years).

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Climate change, species interactions, and invasion resistance: Ecological implications for management

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Invasive species management in California takes place in an ever more complex ecological context. Increasingly, invaders have transformed ecosystems in ways that complicate restoration; systems are affected by multiple, interacting invaders; and invasions occur against a backdrop of many other directional environmental changes. How can research help managers anticipate and navigate these challenges? I will discuss examples from integrated action-research projects, field experiments, and forecast models with an emphasis on the implications of climate change in California. Climate disruption is likely the most widespread directional change affecting invasion ecology in the state, with implications for planning and management. Ongoing climate changes are expected to extend exotic distributions to higher elevations, increase wildfire and ecosystem diebacks, and expand certain heavily invaded ecosystem types like grasslands. Climate changes also could affect the competitive balance between exotics and natives in California grasslands through both ecological and evolutionary pathways. The increasing challenges of accelerating changes like these underscore opportunities for researchers and managers to work more closely together to develop long-term solutions for tackling invasions.

Identifying research priorities and implementing science-based management

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Conducting scientifically rigorous research is fundamental to management of non-native invasive plant species. Research can develop new information about how to close and manage invasion pathways, how the invasive processes works, how to assess the risk of a new plant species becoming invasive, and the benefits vs. the costs of various preventive activities. Research can contribute information on best practices to minimize plant invasions in land management activities such as road maintenance, recreation, and range and forest management. Research at multiple scales is needed to comprehensively examine invasive plant problems but it is difficult to define and implement, especially at the landscape level. Understanding the basic biology and demography of non-native invasive plants is also critical to the development of effective management techniques. A research program that integrates experiments and informs managers and researchers working together within an adaptive management philosophy is an effective way to implement such a research effort. We present a framework for research on non-native invasive plants using our ongoing research program as an example. This program is focused on the invasive plant sulfur cinquefoil (*Potentilla recta*) in the interior Pacific Northwest. Methods for detection, landscape risk and range expansion assessments, habitat- and species-level experiments, and containment and restoration studies in affected areas are generally described.

Ecological approaches for weed management

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The discipline of weed science employs both basic and applied research and technology in the development of methods to control weeds. Although agroecosystems have been the primary focus of weed scientists for the past 50 years, many advances in weed control are directly applicable to the management of invasive plants in wildlands. The greater challenge in both agroecosystems and wildlands is applying fundamental knowledge of weed biology and ecology to the development of sustainable, ecologically sound management techniques. This systems approach requires cooperation of researchers and managers; research without implementation cannot realize its potential, while management without research is neither prescriptive nor likely to be reproducible. For example, research on artichoke thistle, *Cynara cardunculus*, showed that establishment of new populations is largely by seeds, which may be dispersed more than 40 meters in open areas or disturbed sites. Current control typically focuses on adult plants, while seedlings often go unchecked. Management of artichoke thistle and other wind-dispersed species may be improved by prioritizing mature populations upwind of open or disturbed areas and minimizing the removal of vegetation during dispersal. In addition, adult plants appear to inhibit seedlings in their immediate vicinity up to 80 cm away. Land managers seeking to control this species may improve long-term effectiveness by expanding management efforts to include a two meter radius around adult plants to prevent seedling recruitment rather than treating adults alone. This and many other examples demonstrate the critical importance of basic research in developing effective management of weedy and invasive species.

Successful non-chemical management of spotted knapweed through partnership

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Within the Klamath National Forest in far northern California lies the Salmon River watershed, at one time home to the second largest infestation of spotted knapweed in the State. The infestation was discovered in 1997, and the local community, the Salmon River Restoration Council, and the Forest Service mobilized to inventory the extent of the infestation, and start treatment. The problem seemed daunting, with the increase in populations discovered over the next two years, the density and remoteness of those infestations, and the fact that this is an A-rated species, requiring mandatory eradication. The Forest Service launched NEPA analysis for all treatment methods, and a decision was finally made in November of 2000: allow the Salmon River community, who is strongly opposed to chemical treatment, to hand dig plants as long as certain criteria were met, and steady progress towards eradication was being made, as shown by monitoring.

The monitoring protocol consisted of two methods applied to the most heavily infested sites: random ring tosses to estimate density, and static transects to estimate frequency. The baseline infestation level, averaged over all monitoring sites in 2000 was a density of 1.03 plants/sq. ft., and a frequency of 78%. Over the next three years, the percent reduction of the infestation averaged 69%, 29%, and 55% respectively. Some sites were reduced as much as 98%, while others as little as 34%. After four years of hand digging, the infestation levels had been reduced so much that the original monitoring methods were no longer accurate, and we changed to actually counting all plants on the sites at a designated time before hand digging commenced for the year. The site with the highest density in 2000, at 1.42 plants/sq. ft. has declined to .001 plants/sq. ft. at the close of 2005. Overall, the project has been very successful at reducing the spotted knapweed infestation level and is extremely labor intensive – areas with infestations under similar conditions may not have the funding sources and/or volunteer labor available for such an extensive effort.

This presentation describes the project from the beginning to the present, summarizing the successes, pitfalls, and monitoring data over the last six years.

A new spurge could become the scourge of the West: Using research to inform management of terracina spurge in Southern California

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Terracina spurge (*Euphorbia terracina*) is an invasive perennial closely related to leafy spurge (*Euphorbia esula*). This species was identified on NPS property in the Santa Monica Mountains in the late 1990s and has been actively managed since 2003. Terracina spurge is currently confined to coastal southern California and Pennsylvania in the United States but is a major wildland weed in Australia. Recent years have shown rapid expansion of this species both east and west along the coast and inland into hot, dry climates. The rapid spread and range of areas colonized indicates that this species has the potential to occupy a wide variety of climates and habitats throughout California and may be entering a phase of exponential expansion. Here we will discuss what we know about the biology of this species from published research in Australia and how we have used this information to inform *Euphorbia* management on NPS lands in the Santa Monica Mountains. We will also discuss results of our own research into the distribution and management of this species including effectiveness of mulching, native plant restoration, and planting arrangement on *Euphorbia* control.

Central Valley vernal pools invaded by waxy mannagrass (*Glyceria declinata*)

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Waxy mannagrass (*Glyceria declinata*) has rapidly invaded deep vernal pools along the entire eastern side of California's Central Valley. The invaded vernal pools are some of the most important natural resources in California and contain both federal and state listed endangered plant and animal species. Waxy mannagrass was first collected in California in 1953 from a vernal pool in Stanislaus County and during the last twenty years has rapidly spread through vernal pools, swales, stock ponds, and roadside ditches throughout the Central Valley. Its seed appears to be spread by waterfowl. In its home range in Spain and Portugal waxy mannagrass is a dominant species of vernal pools and large playas as well as a weed of rice fields. It is also an invader of seasonal wetlands in the Mediterranean-type climate areas of Australia. Its population dynamics in Central Valley vernal pools are erratic but it often establishes dense populations of large plants which both shade-out the much smaller endemic species and eliminate the bare ground the native species require for germination and establishment. Between 2001 and 2006 the cover of waxy mannagrass in one large vernal pool increased from 2% to over 90%.

Field-testing an invasive plant species early detection protocol in the San Francisco Area Network of National Parks

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The San Francisco Area Network of National Parks (SFAN) includes Point Reyes National Seashore, Golden Gate National Recreation Area, Pinnacles National Monument, and several smaller parks. The network supports collaborative monitoring of nonnative plants in a wide variety of habitats. A draft protocol for the early detection of invasive plant species was field-tested at Golden Gate in the summer of 2006. Park units were broken into management units: geographical subunits that allowed managers to identify and quantify baseline invasive plant information. Subunits were ranked by number and degree of current infestations, risks of further infestation, priority of resources present, and other characteristics based on inventory information available and management priorities. Invasive plant species were ranked based on ease and feasibility of control, and high-priority species placed on lists for early detection throughout the park, or detection in currently uninfested areas. Surveys were targeted in high-risk or high-priority areas, and plant occurrences mapped according to the Weed Information Management System (WIMS) protocol. Negative data were collected for priority species, and presence/absence by subunit gathered for lower-priority invasive species. Rankings and survey results will also be used to inform restoration and removal activities.

Does horse manure harbor invasive plants?

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Invasive plants cause widespread damage to California's native ecosystems. Because chemical and mechanical control of exotic populations is extremely costly, determining potential prevention measures is key. We are investigating the role horse manure may have on introduction and spread of non-native plants in Califoria's natural areas. In an initial study using manure samples collected in the San Francisco Bay and other Central California areas, five out of the six species that emerged were non-native. Of these, three (*Hirschfeldia incana*, *Lolium multiflorum*, and *Medicago polymorpha*) were found on Cal-IPC's revised invasive species list. A larger study involving samples from several National Parks in northern California followed, and 27 species germinated in that experiment. Of those 27 species, 19 are non-native to California, and ten appear on the revised Cal-IPC list. Six of these are listed at the moderate level, including *Hordeum marinum*, *Lolium multiflorum*, *Mentha pulegium*, *Rumex acetosella*, *Trifolium hirtum*, and *Vulpia myuros*, while the remaining four species are listed at the moderate level, including *Hypochaeris glabra*, *Lythrum hyssopifolium*, *Medicago polymorpha*, and *Poa pratensis*. To avoid barring access to horses in California wildlands, we suggest a prevention program that promotes the potential benefits of certified weed free feed (CWFF). However, a survey of California county agricultural commissioners verified a lack of CWFF supply in most counties. If this potential vector for invasion is to be minimized, federal, state, and county agencies must work together and with the public to provide reasonable regulations as well as adequate supplies of CWFF.

Two years of Ludwigia control in the Laguna de Santa Rosa – process and progress

Thomas J. McNabb[1]*, Julian Meisler[2] Clean Lakes, Inc.[1] & Laguna de Santa Rosa Foundation[2]

The Laguna de Santa Rosa Foundation (Foundation) spearheaded a three-year control effort aimed at reducing the area and density of the aquatic weed *Ludwigia* sp. within selected areas of the Laguna de Santa Rosa (Laguna) watershed in 2005. The infestation hampers efforts to control mosquito vectors of West Nile Virus that pose a health threat to humans and wildlife; out-competes native wetland species; and is believed to impair both the water quality and the flood-control functions of the Laguna.

First year control efforts spanned July to October, 2005 and will resume mid-June 2006 and 2007. Control occurred at two sites comprising some 130 acres within the Laguna and included three principle elements: herbicide treatment, harvesting of biomass, and disposal of biomass. The three-year effort is the first step in a larger attempt to restore ecosystem process and function in the Laguna making it more resilient to invasion. While the Foundation does not expect that control efforts will remove 100% of *Ludwigia* from the Laguna, it does expect the control effort to reduce the *Ludwigia* population to a point where restoration of natural ecosystem processes and vegetation can maintain it as a minor rather than dominant component of the natural community. In this presentation we discuss the methods used to control *Ludwigia* in this challenging and complex wetland environment and present preliminary results of the control effort.

Response of the endangered San Diego ambrosia (*Ambrosia pumila*) to removal of competition from non-native plants

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San Diego ambrosia (*Ambrosia pumila*) is a federally endangered plant found only in San Diego and Riverside Counties, CA, and in Baja California, Mexico. Successful sexual reproduction has never been documented; the species spreads vegetatively through rhizome-like roots, forming distinct and probably clonal patches. Although the primary threat to the species is loss of habitat to development, remnant populations may be susceptible to competition from non-native plants. We investigated whether competition from non-native plants negatively affects *A. pumila* in southwestern Riverside County. Competition was reduced in one m^2 quadrats in the field by hand-pulling all non-native species or hand-clipping all vegetation to five cm above the heights of *A. pumila* stems to simulate mowing. These two treatments and a control were replicated five times using a randomized complete block design within five distinct *A. pumila* clonal patches. Patches differed in the percent cover of *A. pumila* and the composition of the non-native plant community. However, *A. pumila* in all patches responded similarly to each treatment. Overall, in April 2006, *A. pumila* had 73% higher percent cover in the hand-pulling treatment compared to the control, but there was no significant response to clipping. In June 2006, there were no differences among treatments when percent cover was compared, but quadrats that were hand-pulled had 344% more *A. pumila* stems with flower stalks than the control, while clipping did not significantly increase the number of *A.*

pumila with flowers. We plan to implement a large-scale hand-pulling effort within *A. pumila* patches in 2007.

Factors that control non-native plant species within shaded fuelbreaks at Whiskeytown National Recreation Area

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Abstract

Whiskeytown National Recreation Area has implemented a progressive and ambitious fuels management program that protects high value areas through a multi-faceted approach. As a portion of this program, the park has implemented the construction and maintenance of over 1,940 acres of shaded fuelbreaks. The combination of fire and ground disturbing activities associated with the construction and maintenance of these fuelbreaks may create conditions favorable to the invasion of non-native plant species. As most public agencies have discovered, there is a lack of information on how to minimize the spread of non-native species while simultaneously reducing hazardous fuels. Preliminary examination on the effects of shaded fuelbreaks on vegetation indicates that canopy cover, the percent cover of litter, and litter depth are the most important variables for distinguishing "desirable" and "undesirable" conditions on the park's shaded fuelbreaks. The location and age of the fuelbreak was also determined to play a role in the presence of non-native plant species; however, their relative importance could not be determined by this preliminary evaluation.

Background

Whiskeytown National Recreation Area borders an urban interface that is being rapidly developed within an assemblage of chaparral, knobcone pine, and oak woodlands. The combination of volatile fuels, hot and dry summers, steep slopes, and frequent fire starts has created a situation in which fire is inevitable. It is because of the threat of wildland fire that Whiskeytown has begun the implementation of a multi-faceted fuels management program to protect high value areas. A major component of this approach is an extensive network of shaded fuelbreaks. At present, there are over 1,940 acres of fuelbreaks along roadsides and ridgelines. The purpose of these fuelbreaks is to reduce the size and spread of wildfires, provide a defensible space for wildland firefighters, and serve as prescribed burn unit boundaries.

Although the biological consequences of creating such a network of fuelbreaks are unknown, the cumulative and long-term ecological impacts could be considerable. As the relationship between fire, ground disturbance, and non-native plant species becomes more evident, resource managers are increasingly concerned that the reoccurring soil disturbance, repeated burning of brush piles, and reduction of canopy cover on fuelbreaks may create conditions favorable to the invasion of non-native plant species. Additionally, these fuelbreaks may act as a conduit for the introduction and spread of non-native and invasive plant species into the more pristine areas of the park.

This goal of this project was to investigate the role of shaded fuelbreaks in the introduction and spread of non-native plant species and evaluate which thinning practices and structural characteristics minimize this spread into chaparral, knobcone pine, and oak woodland plant communities. Results from this project were used to educate and inform resource and fire managers as to what thinning practices and prescriptions minimize the introduction and spread of non-native plant species.

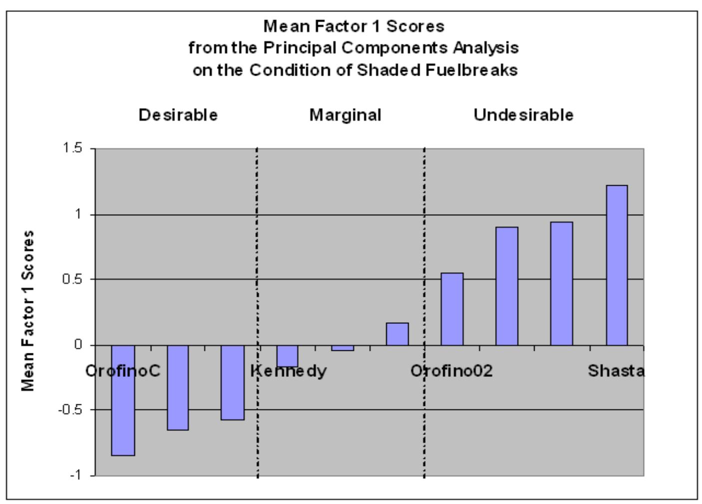
Materials and Methods

A stratified random approach was used to select vegetation plots within fuelbreaks that exist along roadsides and on ridgelines. Five thirty meter transects were randomly located within fuelbreaks, and five one-square meter quadrats were randomly selected along each transect. Vegetation sampling in plots consisted of cover estimates for substrate (leaf litter, bare ground, and woody debris) and all higher plant species (Daubenmire 1959), measurements of canopy cover, litter depth, cover and size of large woody debris, and heights of the tallest species in each of four plant groups (grass, herb, shrub, and tree). For each plot, distance to the nearest road, trail, or known non-native plant infestation was recorded and to further characterize each transect, microhabitat parameters such as slope, aspect, and elevation were recorded.

Fuelbreaks were grouped into three categories for analysis: 1) "desirable", representing ideal ecological conditions; 2) "marginal", representing intermediate conditions; and 3) "undesirable", representing the least desirable conditions for a fuelbreak. A desirable fuelbreak had few patches of bare or hydrophobic soil and few invasive plants. An undesirable fuelbreak had a reduced overstory, signs of erosion, bare or hydrophobic soils, and established invasive plant species. Because of multiple intensive treatments, including bulldozer use, it was assumed that the fuelbreaks beneath the Pacific Gas & Electric (PG&E) lines would have the highest potential for invasion and these were included to provide a frame of reference when compared to the other fuelbreaks. The purpose of this spectrum of condition categories was to identify and quantify the structural characteristics that make up desirable and undesirable fuelbreaks. With the desirable fuelbreaks serving as the ecological goal for fuelbreaks, the characteristics of these fuelbreaks were analyzed to provide management recommendations.

Results

A Principal Components Analysis (PCA) was used to characterize the fuelbreaks in terms of the percent cover of native and non-native plant species and microhabitat characteristics such as canopy cover and litter. The analysis included data from fuelbreaks that were sampled in 2001 and 2002, as well as data from control plots. Shaded fuelbreaks with low Factor 1 scores were considered desirable and had a very low percent cover of exotic plant species, a high percent cover of litter, high canopy cover, and a deep litter layer. Shaded fuelbreaks with high Factor 1 scores were considered to have undesirable characteristics and had very little canopy cover, a low percent cover of litter, a shallow litter layer, and very few shrubs. The mean Factor 1 scores were graphed (Figure 1)



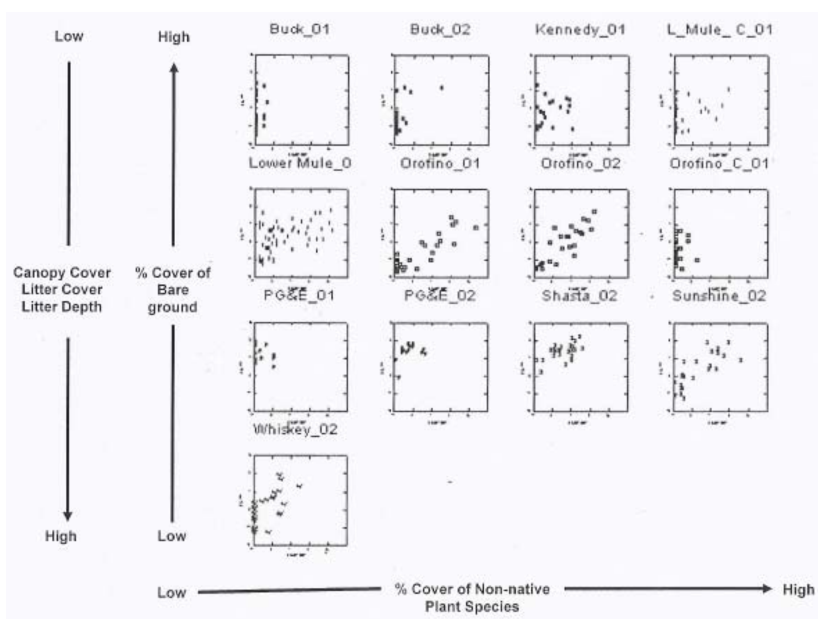
and categorized into desirable fuelbreaks (scores between -0.25 and -0.75), marginal (scores between -0.25 and 0.25), and poor conditions (scores between 0.25 and 1.25). The Shasta fuelbreak was in the worst condition of the fuelbreaks sampled and the Buck was considered to be in the best condition.

A One-Way Analysis of Variance (ANOVA) on the mean PCA Factor 1 scores characterizing non-native plants on the fuelbreaks determined that there was a significant difference (P<0.001) between fuelbreaks (Table 1). The first contrast from the ANOVA illustrated a significant difference (P = 0.010) between control plots and plots located within the fuelbreak, with control plots having more desirable conditions. The second contrast demonstrated that there were significant differences (P = 0.016) in the mean Factor 1 scores between roadside fuelbreaks and ridgeline fuelbreaks. With the exception of the Buck fuelbreak, fuelbreaks that are located along roadsides were more desirable than fuelbreaks along the ridgelines. The third contrast found that there was a significant difference (P < 0.001) between old fuelbreaks and fuelbreaks that have been constructed within the past five years, with recently constructed fuelbreaks having more desirable conditions.

A Canonical Correlation was used to determine which microhabitat characteristics were related to the percent cover of non-native plant species (Figure 2, Table 2). Root 1 for non-native plant cover scores were negatively related to canopy cover, the percent cover of litter, and litter depth, and positively related the percent cover of bare ground. High percent cover values for non-native plant species was associated with low canopy cover, low percent cover of litter, and very little litter depth.

In the shaded fuelbreaks sampled, approximately 23% of the grass and herbaceous species were non-native. Plots with a high percent cover of non-native plant species also had high species richness. There were no non-native shrub, subshrub, or tree species found within the fuelbreaks sampled. Non-native species with the highest cover included *Aira caryophyllea* (silver hair grass), *Vulpia bromoides* (fescue), *Gnaphalium luteo-album* (fragrant everlasting), *Hypochaeris radicata* (hairy cats ears), *Bromus madritensis* (foxtail chess), and *Gastridium ventricosum* (nit grass). Native species with the highest cover included *Heteromeles arbutifolia* (toyon),

Source	**Sum-of-Squares**	**df**	**Mean-Square**	**F-Ratio**	**P**
Fuelbreak	113.738	9	12.638	17.575	<0.001
Roadsides vs. Ridgelines	4.237	1	4.237	5.892	0.016
Old vs. New	20.331	1	20.331	28.276	<0.001
Control vs. Treatment	4.857	1	4.857	6.755	0.010
Error	165.381	230	0.719		



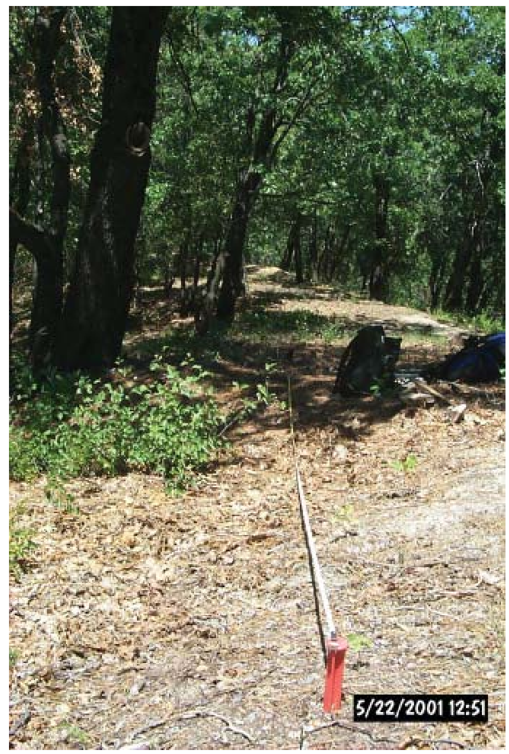
Canonical Root 1	R(exotic*environmental) = 0.477		P<0.001
Exotic Plant Variables	**Loadings**	**Microhabitat Variables**	**Loadings**
Percent Cover of Exotic Grass species	0.885	Canopy Cover	-0.969
Percent Cover of Exotic Herbaceous species	0.943	Bare Ground	0.288
		Litter Depth	-0.246
		Percent Cover of Litter	-0.546

Toxicodendron diversilobum (poison oak), *Ceanothus lemmonii* (Lemmon's ceanothus), *Styrax officinalis* (snowdrop bush), and *Lotus micranthus* (small flowered lotus).

Discussion

This study suggests that the strongest correlation between non-native and invasive plant species on shaded fuelbreaks is with the amount of canopy cover and litter cover and depth. As the Canonical Correlation demonstrated, non-native plant cover scores were inversely related to canopy cover, the percent cover of littler, and litter depth. The reduction of overstory trees and shrubs through hand-thinning and prescribed burning increased the amount of direct sunlight and reduced the amount of litter on the soil surface. Research on fire alone has demonstrated that recently burned areas are considered vulnerable to exotic invasion because competition from established plants may be reduced after fire (Tyler and D'Antonio 1995) and fire can dramatically increase the amount of bare ground available for germination and establishment (Boyd et al. 1993).

Disturbance is believed to enhance the probability of non-native plant establishment in native plant communities and the combination of fire and treatment with hand crews could have a cumulative effect (Rejmanek 1989, Hobbs 1991). The repeated disturbance of maintaining fuelbreaks every two to three years could continue to support these infestations or spread them throughout the fuelbreak. The activities associated with hand crews may favor invasions by transporting propagules,



disturbing the soil surface, and creating gaps that allow the spread of invasives into uninfested areas (Brooks 2001). This is supported by this project's examination of old and relatively new fuelbreaks, with older fuelbreaks having greater non-native plant cover.

The PCA determined that the Buck fuelbreak (Figure 3) was the most ideal condition for the shaded fuelbreak system at Whiskeytown. The Orofino and Shasta fuelbreaks (Figure 4) were the most undesirable and in need of rehabilitation. The average canopy cover (X = 70%) for the

Buck fuelbreak was used as a target for the other fuelbreaks. It was assumed that this canopy cover would provide the desired litter layer and depth as well. In order for the highly undesirable (X = 7%) Shasta fuelbreak to reach this target condition, canopy cover should be increased by 63%. In fuelbreaks that were somewhat marginal in condition, such as the Lower Mule (X = 55%), canopy cover should be increased by 15%. For the fuelbreaks that have been identified as undesirable and marginal, thinning and broadcast burning within the fuelbreak is not recommended for the next five to ten years.

Continued monitoring and evaluation of these fuelbreaks over time will provide further insight into the risks this fuelbreak network may pose in terms of non-native invasion and into the effectiveness of the recommended treatment levels. Future evaluation and method refinement are critical to the park's adaptive approach to managing both fire and invasion risks in the urban interface.

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Restoration of retired San Joaquin Valley farmlands using herbicides and activated charcoal

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Introduction / Background

A significant portion of western San Joaquin Valley (California) agricultural land (200,000 acres) has been targeted for retirement from irrigation and/or cropping through the U.S. Bureau of Reclamation's (BOR) Land Retirement and Demonstration Program (LRDP) via purchase of water rights by BOR and/or Westlands Water District (WWD) (ILRT 2005). These lands are characterized by high salinity, limited rainfall (ca. 25 cm yr^{-}), depauperate native seed banks, poor drainage, and high concentrations of selenium and boron (ILRT 2005). Restoration of native plant communities is being explored as one measure among several mandated to reduce contamination of valley groundwater and drainage by selenium, boron, and other toxic elements.

Weed management is the overriding limitation to revegetation on LRDP retired lands (ILRT 2005). Restoration of these lands is extremely problematic because of immediate encroachment of annual grass (*Bromus*, *Avena*, and *Vulpia* spp.) and broadleaf (*Brassica*, *Sisymbrium*, and *Atriplex* spp.) weeds upon cessation of cropping. Chemical weed control methods can be particularly problematic, as many potential herbicides exhibit activity on seeded species. Tapping technology from the turfgrass seed and horticultural sectors (OSU 2005, William 2004, Lee 1973), we evaluated use of activated charcoal to ameliorate effects of herbicides in seeded species germination zones. Banding charcoal over the drilled seed row before broadcasting herbicides has been successfully practiced in ryegrass and other turfgrass seed industries (Lee 1973). We extended this technique to drilled applications of native species. Other integrated strategies such as grazing, fire and/or mechanical control are also being evaluated, but have limited utility or windows of opportunity during seeded species establishment periods. Use of pre-emerge herbicides (i.e., longer residual soil activity) in conjunction with native seed/seedling safeners provides a strategy to maximize establishment windows.

Our research addresses native plant community establishment on dewatered cropland, involving evaluations of species selection and mixture formulation, species propagation and seed increase, seed conditioning, seed harvest and planting methods, soil amendments, and weed control. Study objectives emphasize subsequent development of revegetation prescriptions for land owners throughout WWD, with emphasis on restoration of native, salt-tolerant shrub/forb plant communities that a) enhance habitat values for endangered species [e.g., San Joaquin kit fox (*Vulpes macrotis mutica)*; kangaroo rat (*Dipodomys* spp.)]; b) provide grazing resources compatible with habitat goals; and c) result in site stabilization and weed suppression.

Methodology

The study site was a retired cropland field approximately seven miles (11 km) southwest of Tranquillity, CA in the central San Joaquin Valley (SJV). The site is characterized by sandy clay loam to clay soils with less than 0.5% slope, and exhibiting mean topsoil (0-6 in; 0-15 cm) values of 1.3% organic matter, pH 7.7, EC_e 8.4 mmhos cm^{-1}, and SAR 8.5 meq L^{-1}. Long-term mean annual precipitation (MAP) for the site is 9.5 in (24.1 cm), of which approximately 80% (19.3 cm) is received during the winter monsoonal period of November through March. Precipitation during the 2004-05 seeding establishment period (August through July) was 31.0 cm, or 128.7% of MAP.

We installed a replicated factorial [6x3] study on 2.2 acres (0.9 ha) in December, 2004. Four native, SJV-endemic species (Great Valley phacelia, *Phacelia ciliata* (PHCI); Great Valley gumweed, *Grindelia camporum* (GRCA); Mojave seablight, *Suaeda moquinii* (SUMO); and cattle saltbush, *Atriplex polycarpa* (ATPO)) were seeded into a fallowed site dominated by London rocket (*Sisymbrium irio*) and annual saltbushes (*Atriplex argentea*, *A. rosea*).

The study site was previously treated in November 2004 with Roundup™ (glyphosate) to control existing weed growth and reduce variability between plots.

To protect the germinating seedling within the drill row from pre-emerge herbicides, agronomic-grade (powdered) activated charcoal (Gro-Safe®; Norit Americas, Marshall, Texas) was applied at 300 lb ac^{-1} (336 kg ha^{-1}). Seed were drilled either a) without charcoal safener (control); b) precisely within an incorporated 3-inch (7.5 cm) wide charcoal powder band applied through the seed drill; or c) beneath an over-sprayed 3-inch (7.5 cm) charcoal slurry band applied over the drill row immediately post-seeding. All species were seeded at 12 in (30 cm) row spacing in four rows per plot at 35 pure live seed (PLS) per linear foot of row. In addition to a control (no herbicide), we applied five pre-emerge herbicide treatments (Table 1) to compare season-long control on the mixed weed composition, and relative impacts on seeded species under the charcoal safener treatments. If significant levels of control can be achieved using natural precipitation to activate and move the herbicides into weed root zones, with activated charcoal serving as safener for seedling natives, special local need permits may be pursued for selected successful herbicides for broad-scale use within the Land Retirement Project.

We conducted monitoring for weed control efficacy and seeded species emergence and productivity (via canopy cover estimation). Data collection occurred during two different periods in 2005: late April to early May for early-season Great Valley phacelia, and mid-July for late-season Great Valley Gumweed and Mojave seablight. Allscale saltbush (ATPO) establishment was poor across controls and treatments; therefore, this was species was excluded from sampling. Statistical analyses employed ANOVA procedures using the Statistica® package (StatSoft, Inc. 2002; Release 6.1; Tulsa, OK).

Results

Oxyfluorfen significantly reduced the average cover of non-native weeds while increasing establishment of native species (Figure 1). Clomazone and sulfentrazone showed similar results on selected species (SUMO, and GRCA/PHCI, respectively). Chlorsulfuron and [chlorsulfuron + sulfome-

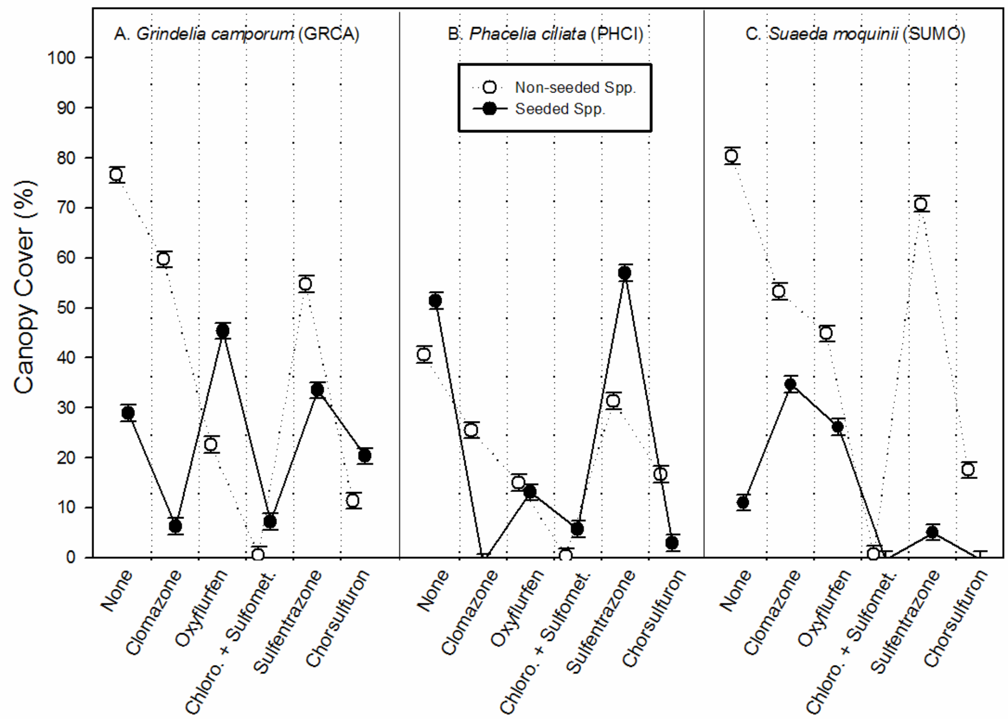
Trade Name	Chemical Name	Applied Rate (Product)	Manufacturer	Mode of Action
Goal 2XL (liquid)	Oxyfluorfen	2.0 pt ac^{-1} (2.3 L ha^{-1})	DowAgroScience	Cell membrane disruptor; PPO inhibitor
Landmark MP (dispersible granule)	Chlorsulfuron + Sulfometuron methyl	2.25 oz ac^{-1} (0.16 kg ha^{-1})	DuPont de Nemours	Amino acid synthesis inhibitor (ALS)
Telar DF (dispersible granule)	Chlorsulfuron	3.0 oz ac^{-1} (0.2 kg ha^{-1})	DuPont de Nemours	Amino acid synthesis inhibitor (ALS)
"**Broadrange**" (dry granule)	Sulfentrazone	12.0 lb ac^{-1} (13.5 kg ha^{-1})	Wilbur-Ellis	Cell membrane disruptor; PPO inhibitor
Cerano 5MEG (dry granule)	Clomazone	24.0 lb ac^{-1} (26.9 kg ha^{-1})	Wilbur-Ellis	Pigment (diterpene) inhibitor

Table 1.

Applied herbicide treatments – herbicide / activated charcoal trial (2004), Tranquillity, California.

Figure 1.

Herbicide treatment effects on seeded and non-seeded species – herbicide / activated charcoal trial (2004), Tranquillity, CA. Vertical bars indicate 95% confidence intervals. $F(10, 40) = 22.42$; $p = 0.0000$.



turon methyl] were extremely effective on all weeds, but also severely constrained emergence and/or growth of seeded species, even with charcoal safening. Oxyfluorfen exhibited good weed control except for apparent, late-season releases of common lambsquarters (*Chenopodium album*).

In combination with charcoal safening, oxyfluorfen was especially effective across all seeded species in reduction of weed cover simultaneous with increases in native species establishment and performance. Emergence of seeded species in the chlorsulfuron and [sulfometuron methyl + chlorsulfuron] treatments was poor, but may be herbicide rate-dependent. Outrun areas at the end of these plots where less product was applied as the sprayer was being shut off exhibited increased emergence while maintaining excellent weed control.

Differences in cover of seeded species (combined) and non-seeded species were detected between charcoal treatments and control [$F(10,40) = 2.75$; $p = 0.0112$)], but only for oxyfluorfen where both charcoal treatments significantly increased seeded species emergence and performance while reducing weed establishment in comparison to controls. No differences were observed between non-control charcoal treatments.

Discussion/Conclusions

Charcoal banding over the seed row (dry powder or slurry) appears to be an effective measure for multi-species weed control, and protection (safening) of native seedlings from the herbicides applied. No difference in seeded species emergence and performance between charcoal application methods suggests that the slurry band application holds greatest potential because of simplified equipment setup for band application. Oxyfluorfen appears to provide the best interaction with charcoal safening under these environmental and application conditions for the native species evaluated. Chlorsulfuron and [chlorsulfuron + sulfometuron methyl] offer potential for improved efficacy using reduced application rates. Sulfentrazone and clomazone are granular formulations that possibly reduced the opportunity for surface-applied charcoal to deactivate the herbicide within the drill row, thereby potentially increasing injury to seeded species. These latter herbicides hold promise if uniformity of product distribution over the soil surface is enhanced by application using a liquid formulation. Further interpretation awaits analysis of 2006 field data. Future research will focus on refining herbicide and charcoal formulation and rates, expanding target weed applicability, and expanding the suite of test (native) species.

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Restoration of desert wetlands dominated by tamarisk and pampas grass

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Mitigation for potential loss of wetlands is one component of the All American Canal Lining project and involves the creation and enhancement of 44 acres of wetland and riparian habitat within the approximately 2,000-acre wetland complex. The wetland complex area developed subsequent to the rise of the seepage induced groundwater ridge to near or above local ground elevation. In response to numerous fires, many natural communities have been type converted to first and secondary successional vegetative communities. These type-converted communities consist primarily of arrowweed (*Pluchea sericea*) and tamarisk (*Tamarix* spp.) stands, which all are maintained by frequent fires. Many of the fringe areas between freshwater marsh and riparian/tamarisk woodland have been colonized by thick stands of the invasive pampas grass (*Cortaderia selloana*). The distribution and density of these species within the restoration area have determined the removal techniques. Generally, the lowest cover by nonnative occurs within the saturated wetland areas in the center of the restoration area. In polygons of less than 30 percent nonnative cover these species have been removed by hand using primarily the cut stump method. In polygons with greater than 50 percent cover, mechanical methods have been used in conjunction with a foliar herbicide application. The final category includes areas of greater than 50 percent nonnative cover that occur within areas to be enhanced for riparian habitat. The area will be excavated using dozers, which will also mechanically remove non-natives species. Subsequent to the initial removal efforts, continued weed control will be performed for 5-10 years. Lastly, a hydrological regime that simulates natural desert wetlands will be implemented to provide natives a competitive advantage.

Laws and Regulations

California's Noxious Weed rating system explained

Courtney Albrecht, Senior Agricultural Biologist, Plant Health and Pest Prevention Services, Pest Exclusion Branch, California Department of Food and Agriculture (916) 653-1440

The Action-Oriented Pest Rating System provides guidance from the California Department of Food and Agriculture to county and state agricultural inspectors on regulatory actions to take when a plant pest is detected or intercepted in trade or in the environment. Under the system, plant pests are assigned a rating (A, B, C, D, or Q). The rating designates the recommended regulatory action, ranging from eradication and containment to release at the discretion of the county agricultural commissioner. Although not codified as a law, the Plant Pest Rating System is a policy that enables inspectors to carry out laws intended to protect California's agriculture against pests.

Within the nursery industry, consumer demand has risen for new, unique, and hardy ornamental plants for backyard landscapes and water gardens. The California nursery industry has responded to this demand by offering a wide variety of terrestrial and aquatic ornamentals to consumers. However, some ornamental plant species or varieties have invasive attributes, such as rapid growth, spreading above or below ground growth habits, the ability to reproduce vegetatively (i.e. fragmentation), ease of seed or fragment dispersal, and a high tolerance for varying environmental conditions. Although these attributes may contribute to the success of certain plants as ornamentals, they may also allow certain species to become invaders into areas of natural vegetation, agricultural crops, natural waterways, and irrigation systems.

The California Food and Agricultural Code loosely defines a "pest" as an organism harmful to agricultural. Under this definition, the invasive attributes of certain ornamental plants can be used to designate them as "pests". However, the term "pest" has long been thought of as an organism that infests or infects a commodity, not the commodity itself. Designating a desirable, ornamental plant a "pest" posed a regulatory challenge for inspectors, policy makers, and industry members. In order to meet this challenge, a new rating, "H" was added to the Action-Oriented Pest Rating System. The "H" rating is assigned when a potentially invasive plant is being sold as nursery stock. The recommended action conveyed by the "H" rating is a temporary hold pending further evaluation by a Pest Rating Working Group. Plants issued an "H" rating will undergo evaluation, and a permanent rating of A, B, C, or D will be assigned within 30 days.

New pesticide use regulations: What do they mean for us?

Bruce McArthur, Sonoma County Agricultural Commissioner's Office.

Over the past year or so, California Department of Pesticide Regulations (DPR) has adopted or proposed several important new rules or rule changes that may impact herbicide use as typically done by many Cal IPC members.

Enforcement Response Policy (ERP)

There has been a growing concern in the Legislature that actions taken by some County Agricultural Commissioners against violations of pesticide use laws and regulations lacked sufficient uniformity and rigor. ERP is DPR's effort to address these concerns through regulations. ERP specifically prescribes when violators receive a written notice of non-compliance and/or a fine. Under ERP, fines will be proposed when they previously were not. Special emphasis is placed on response to repeat violators and violations that pose an actual or reasonable possibility of a health or environmental hazard. ERP will affect anyone using any pesticide. At this writing, these regulations are still in the public comment phase and final wording is in flux. However, County Ag Commissioners have already been directed by DPR to enforce the regulations as now proposed.

Wellhead Protection

Some preemergent herbicides have been found to be both mobile and persistent in groundwater. As a result, use of these herbicides are prohibited within 100 feet of any wellhead unless it is protected by a soil berm – or natural features – from contact with surface runoff water. The herbicides are listed in DPR's "6800 (a) & (b) Lists" and include some used by Cal IPC members (e.g. Telar®) but not others (e.g. Transline®). Further, mixing, loading, or storage of any pesticide within 100 feet is forbidden without the above protection. This regulation is now in effect.

Clopyralid Use

In 2002, Clopyralid (e.g. Transline®) on lawn clippings, etc. used in mulch was shown to be the cause of crop losses. As a result, only "licensed or certified operators" may now purchase a Clopyralid product that includes lawn and turf uses on the label. Further, the buyer must sign a form provided by the pesticide dealer stating that if the Clopyralid label allows lawn and turf use, they won't apply it to sites where clippings could leave the property. This regulation is now in effect.

Respiratory Protection Program

In the past, part of respirator use training for employees also included a medical exam or a document signed by them, which stated they did not have certain listed medical conditions that could be aggravated by wearing a respirator. Now all such employees will need to submit a multi-page confidential medical history questionnaire for independent medical review. This regulation will not apply to employees who supply and use their own respirator when it is not required by the pesticide label or employer policy. This regulation is expected to go into effect in the near future.

Making CEQA work for you

(David Chang for) Rachel O'Malley, San Jose State University. romalley@sjsu.edu

The California Environmental Quality Act is a statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, whenever a public agency is involved in the discretionary approval of a project. A very good place to go for answers is the California Environmental Resource Evaluation System's CEQA website, http://ceres.ca.gov/ceqa. CEQA is a self-executing statute. Public agencies are entrusted with compliance with CEQA and its provisions are enforced, as necessary, by the public through litigation and the threat thereof. The first phase in complying with CEQA is to conduct a preliminary review. Determine whether your actions would be considered a project subject to CEQA review. If so, then determine the lead agency.

Your project may be categorically exempt. Categorical exemptions are descriptions of types of projects that have been determined to not usually have a significant effect on the environment. Categorical exemptions are found in Article 19 of the CEQA Guidelines. Class 1 is the "existing facilities" exemption (Guidelines

§15301). Class 2 consists of replacement or reconstruction of existing structures and facilities (Guidelines §15302). Class 3 consists of construction of small structures (Guidelines §15303). Class 7 consists of actions taken by regulatory agencies as authorized by state law or local ordinance to assure the maintenance, restoration, or enhancement of a natural resource (Guidelines §15307). Class 8 consists of actions taken by regulatory agencies to assure the maintenance, restoration, enhancement, or protection of the environment where the regulatory process involves procedures for protection of the environment (Guidelines §15308). Categorical exemptions are documented in a Notice of Exemption that can be filed with your county's Clerk Recorder's office.

If you cannot claim a categorical exemption the next phase is an initial study to determine whether you need to write an environmental impact statement or a negative declaration. If you reach this phase then consultation with the responsible and trustee agencies is recommended. CEQA's intent is to ensure that projects do not adversely impact society and the environment. If well-timed – start early – compliance with CEQA need not be onerous.

Fish and Game permitting for weed control projects

Bill Cox, California Department of Fish & Game. bcox@dfg.ca.gov

CA Fish & Game Code § 1600-1616 specifies authority for CDFG to regulate work that may substantially divert, obstruct, or change the bed, bank, or flow of a river, stream, or lake. Anyone proposing to engage in an activity, even a restoration project, that could substantially alter the bed, bank, or flow of a river, stream, or lake must enter into a 1602 Streambed Alteration Agreement with CDFG to ensure no net loss of stream or lake habitat values.

The jurisdiction of the CDFG can be broader than the jurisdiction of the US Army Corps of Engineers. CDFG jurisdiction extends over streams, perennial, intermittent, or ephemeral from which fish or wildlife derive benefit; vegetated or unvegetated riparian corridors (if no riparian vegetation then to the top of bank); artificial drainages, if they provide fish and wildlife habitat; and lakes & ponds, natural or artificial, (size matters, may not include vernal pools).

The 1602 Streambed Alteration Agreement process requires that anyone proposing work that would substantially alter the bed or bank of a stream must submit a Notification of Streambed Alteration to the appropriate Department of Fish and Game regional office. Within 30 days the CDFG is required to determine that your application is complete. Within 60 days of the submission of a complete application, the CDFG is required to return a Draft Agreement.

In some cases the Department may do a pre-consultation to determine whether a formal notification is necessary, and to identify specific concerns relative to impacts to fish or wildlife.

For more information consult your local CDFG regional office and visit the department's 1600 website at: www.dfg.ca.gov/1600/qa.html.

Spartina and Lepidium

Self-fertilizing cordgrass hybrids (*Spartina alterniflora* x *S. foliosa*) drive local invasion of San Francisco Bay tidal flats

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Hybrids of native cordgrass *Spartina foliosa* and introduced *S. alterniflora* have spread widely in the intertidal of San Francisco Bay (SFB) since their origin 35 years ago. We investigated whether increased hybrid self-fertility may contribute to the rapid spread of SFB hybrid cordgrass, and whether dispersal of floating hybrid seed occurs primarily via long-distance dispersal as seen in *Spartina* elsewhere. Our results showed that neither wind-pollinated parent species set viable seed inside experimental pollen exclusion tubes in SFB, while hybrids set on average [s.d.], 65 [88] (range: 0 to 313) self-fertilized seed per inflorescence (n = 62). Analysis of cordgrass spatial genetic recruitment via 17 microsatellite loci showed that all 299 seedlings sampled randomly from 5801 mapped along an 18 km shoreline transect south of Oakland during 2003 and 2004 were hybrids. Seedling survival to one-year averaged 22%. Despite the dynamic nature of the intertidal environment seedlings were distributed along tide lines and/or in the lee of established plants. Positive spatial genetic structure up to ~ 200 meters and parentage analyses supported highly local seed dispersal. Isolated tidal flat adults alongshore produced most seedlings, one single individual parenting up to 29% and 46% of all surveyed seedlings at two locations, mainly by self-fertilization. Increased self-fertility due to hybridization so allows individual hybrid colonizers to quickly found large populations in isolation. These locally expanding nascent foci illustrate how hybridization between natives and their exotic congeners can contribute to higher spread rates of invading species.

Spartina control in the San Francisco Estuary: Progress toward estuary-wide control and eradication

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The spread of non-native *Spartina* (cordgrass) and its hybrids through the San Francisco Estuary has been a concern of regional land managers and ecologists since its original introduction in the early 1970's. Impacts to tidal wetlands, restoration sites, flood control structures and other tidal marsh functions have been well documented from analogous infestations all over the world. In an effort to slow and eventually reverse this invasion, the San Francisco Estuary Invasive Spartina Project was formed by the California Coastal Conservancy in 2001 to coordinate region-wide control and eradication of Spartina. 2006 represents the third season of Spartina control efforts in the San Francisco Estuary, and the first season where permitting, funding, planning, and treatment approaches allow for the opportunity to treat all known infestations of *Spartina* in the Estuary. This work will be accomplished by hundreds of regional stakeholders, including public and private land managers, volunteers, Federal, state and local agencies, private contractors, non-profit organizations and other groups.

The results of the 2006 Treatment Season will be presented, along with the efficacy of the 2005 effort, progress toward the goal of eventual eradication, endangered species responses to control, and a summary of the Spartina Project's Monitoring Program which tracks the spread and distribution of *Spartina* in the Estuary, endangered California clapper rail distribution, efficacy of treatments and water quality.

Invasive species removal in an urban environment: Pitfalls and lessons learned

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Introduction

Because invasive species are not restricted to public lands, eradicating many populations requires the involvement of private landholders. We can be effective in engaging private landholders even when they have no economic interest to remove their invasives (e.g. agricultural or ranch land). Getting support of private landholders requires a multi-faceted approach.

Friends of Corte Madera Creek Watershed (Friends) is an all-volunteer, non-profit organization whose mission is to protect and enhance the remaining natural ecosystems around Corte Madera Creek Watershed (Marin County, CA). Corte Madera Creek (CMC) extends from San Francisco Bay into the foothills of Mount Tamalpais along an urbanized corridor. Land ownership includes public and private agents, and much of the public land includes heavily used multi-use pathways.

As a sub-project under the Coastal Conservancy's Invasive Spartina Project (ISP), we are implementing the removal of all invasive cordgrass (*Spartina* spp.) along Corte Madera Creek. A large proportion of infested property is privately held - there are approximately 200 private landowners in the invasive *Spartina* affected areas. We offer two treatment options to private landowners: treating with an herbicide containing imazapyr or digging out the plants. We also are offering native plants for replanting.

Public outreach program

We had three populations we needed to educate:

- Private land owners: we needed permission to treat.
- Public land users: we needed to educate users of the local parks and multi-use paths.
- Adjacent land owners and residents: we needed to notify anyone residing within 500 feet of treatment zones.

When securing permission to treat from private landowners, we used a variety of methods. First, we targeted groups of individuals. We mailed a letter to every landowner from whom we needed treatment permission. We explained the project, requested, permission and supplied a permission form. If we received no response, we placed at least one phone call to the residence. Site visits were offered upon request to confirm the property had invasive *Spartina* and discuss treatment options with the owner. Next, we targeted groups of individuals. We held a general public meeting, we attended homeowner's association meetings and we met with small groups of neighbors whenever possible. Lastly, for neighborhoods with poor response, we went door-to-door before treatment seeking permissions.

While we were trying to secure voluntary permissions, we realized that a subset of people could not be reached, wouldn't respond, or would say no. Since our goal is eradication, not containment, we needed to treat all infected lands. We identified all agencies with possible jurisdiction to enforce compliance, and enlisted the support of multiple agencies. We obtained letters from both Marin County Department of Agriculture and Marin County Flood Control District that stated we were required to treat individual properties. We also received support from the Board of Supervisors and the County's Integrated Pest Management Commission. Our intention was to use this tool only as a last resort.

We developed a variety of informational materials that we had available for private property owners including general fact sheets with general information about the project, information about native plant alternatives and where to purchase them, and information about the herbicide. These fact sheets were useful when answering questions from the public. We also developed very specific signs that were posted prior to treatment and had an organization member on site during treatment to answer any questions. We developed treatment maps with pictures of homes that had not given treatment permission so we would have no accidental spraying. We included a contact phone number on all materials.

Results

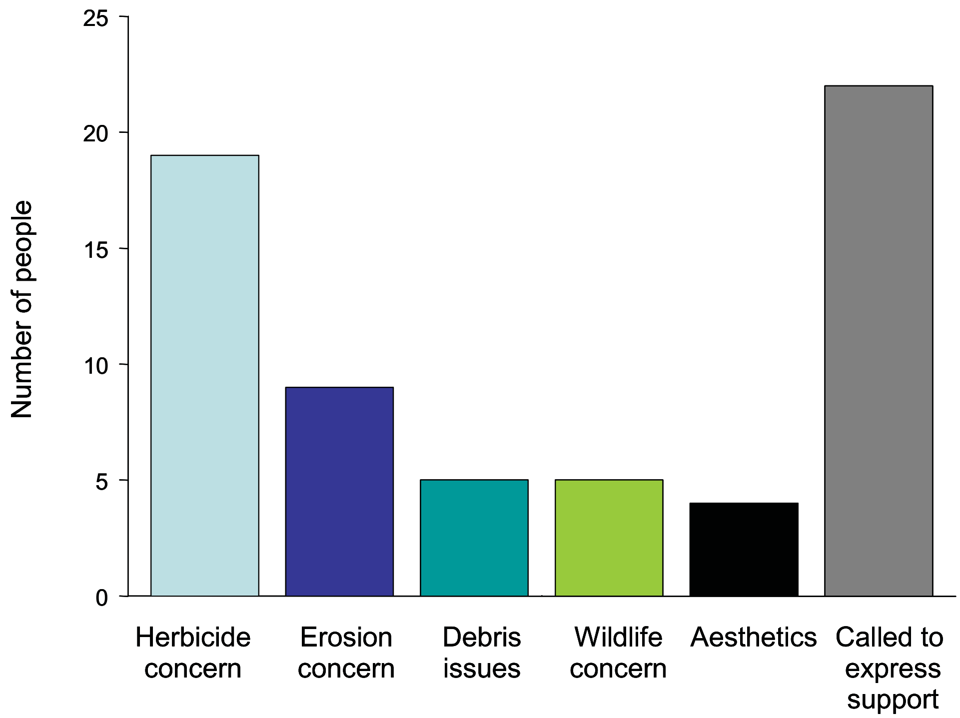
Because of issues other agencies have had in Marin County concerning public perception of herbicide use, we thought that there would be quite a bit of opposition to chemical treatment. We also felt that people would not be receptive to herbicide or manual treatment because of aesthetics: *Spartina densiflora*, the predominant species in the area, is markedly different and lusher than the native vegetation. We also felt that private property owners would be reluctant to allow us to alter their private property when they had no economic incentive to do so.

We have completed one year of a two-year public outreach campaign. We have had one full treatment season and one partial season. We originally sought permission from 233 private property owners, but have reduced this number to 175 after confirming the absence of *Spartina* on over 50 targeted parcels. Everyone has received at least one permission request and one follow-up phone call. We have done 79 site visits to private residences upon request, most taking 5 to 10 minutes each. While at a residence, we are also able to survey the neighbors' properties for invasive *Spartina*. We have attended 5 homeowner's association (HOA) meetings and hosted one general public meeting. The general meeting was poorly attended with only five citizens participating. We have had 92 phone conversations with private property owners and sent letters to 1,381 adjacent residents within 500 feet of the treatment zones. Most importantly, we have developed a detailed database that records every interaction with a resident, including all their available contact information, when their property was treated and whether they have requested native plants. We can sort this database by treatment zone, neighborhood, date and type of interaction.

The actual concerns of private property owners did not match expectations. Of all residents with whom we spoke, including people needing only to be notified of treatment and those from whom we needed permission, most people called simply to express their support of the project (Figure 1a). Many had herbicide concerns, but were satisfied once they received our fact sheet on the herbicide and were able to discuss the project with us. Most residents wanted to know that we had given thought to possible side effects of the herbicide and had tried other treatment options. The next largest concern was erosion. Since many of these properties are built on fill and are somewhat degraded, erosion is a valid concern once we remove the invasive *Spartina*. We did include some information about combat-

Figure 1a.

Actual concerns of private property owners. Total is number of discussions with all residents near treatment area (92 total)



ing erosion on our native plants fact sheet, but ideally we would have a better erosion mitigation plan. Some people liked the way invasive *Spartina* keeps debris from the Creek off their property and a few just like the way it looked.

Of those people from whom we needed permission, we spoke with 68 on the phone (Figure 1b). Again, most property owners called simply to express their support. As would be expected, herbicide concerns were proportionally higher, but most were satisfied after receiving more information. Some owners were concerned about erosion and the local wildlife.

Examining the outreach data by neighborhood revealed important information about where outreach efforts should be concentrated (Figure 2). The majority of the private property owners who have denied us treatment permission come from one neighborhood (Riviera Circle), including two owners who rescinded their permission. We attended their HOA meeting and it was very contentious. We have discovered a couple of owners who are actively encouraging others to not sign their forms or to rescind their permissions. This neighborhood was built on fill and erosion is a big concern. One person even told me that a city engineer had come out and told him not to remove the invasive *Spartina* because their property would erode. Still, we had 75% voluntary support in this neighborhood. Our biggest problem with getting permissions was achieving contact: residents may get their mail but do not respond, and we often could not find a phone number. We went door-to-door in this neighborhood and were able to obtain a number of permissions this way.

One neighborhood along the Creek has 19 condominium complexes and they have one of the lowest voluntary compliance rates (Figure 2) - just 58%. Their HOA's are very hard to contact. We have tried many avenues, including taping notices to mailboxes and stopping residents on the streets. Two HOA's have denied us permission, one of which cited erosion concerns and the other herbicide concerns (they agreed to dig up the plants themselves).

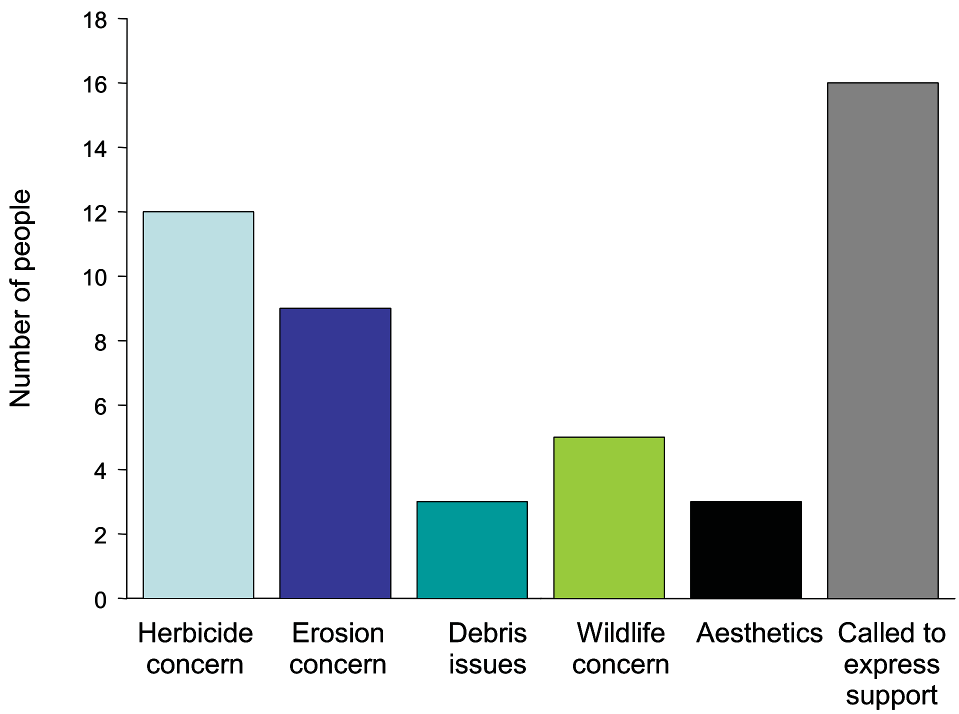


Figure 1b.

Actual concerns of private proerty owners. Total is number of discussions with owners from whom we need permission to treat (68 total)

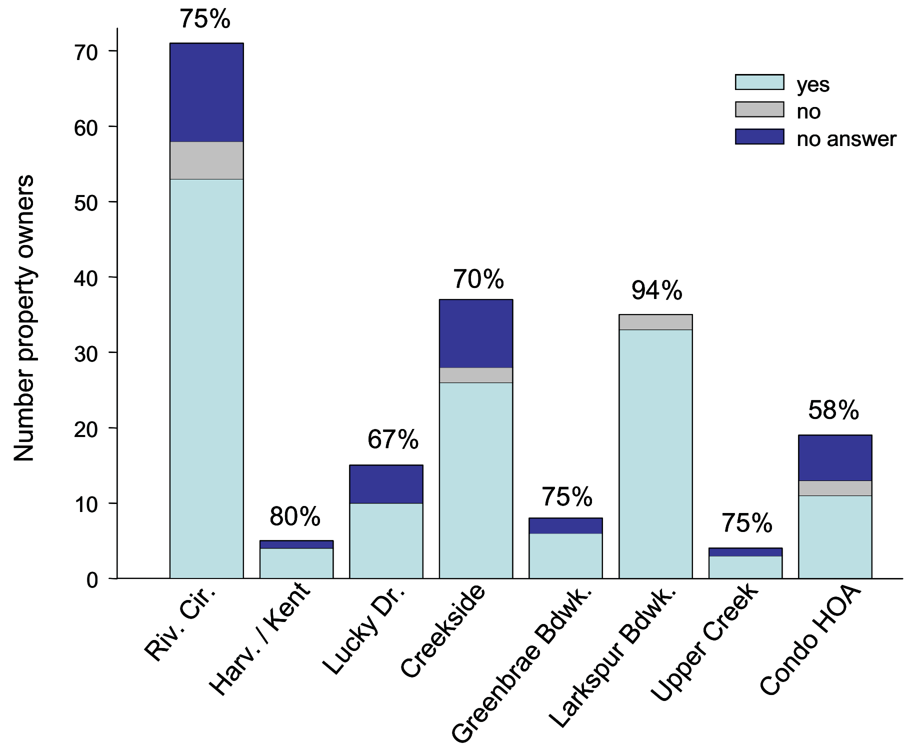
One neighborhood, Larkspur Boardwalk, was the most supportive, with 94% voluntary compliance (Figure 2). This neighborhood is unusual in that it is made of old houseboards now secured on pilings. The invasive *Spartina* here is growing underneath individual homes - we predicted considerable resistance to herbicide use, but ecountered little. We had two permission denials, one of which cited herbicide concerns and one of whom removed the plants themselves. The reason our campaign here was so successful was because we had the early help of the HOA president who is well liked and respected in his neighborhood. He personally went to those owners who would not answer our phone calls or letters and obtained their permissions. The one owner who denied us permission because of herbicide concerns actively tried to get others to rescind permission, but was unable to accomplish this, primarily because we had such strong support from other residents.

After one year of outreach, we have received the voluntary participation of about 77% of all private property owners. Nine owners have denied permission, but two of these had already removed all their invasive *Spartina* and allowed us to survey their property. Erosion concern is the primary reason people are choosing not to treat, not aversion to herbicide use. Of all private property owners, only five requested us to dig the plants rather than treat with herbicide. However, five others expressly requested that we not dig but use herbicide. We were unable to get a response from 32 owners, mostly because we were unable to contact them besides through the mail.

This year, we tested a pilot of our compulsory participation program. We chose a neighborhood where we had trouble contacting owners - the Creekside area with many apartment buildings and condominiums (see Figure 2). We sent a letter informing them we would treat and included the letter from Marin County Flood Control District giving us authority to do so. Forty-eight individual owners representing seven properties targeted for treatment received

Figure 2.

Voluntary participation per neighborhood. Note that Creekside neighborhood includes the Condo HOA entry. Percentage at top are the number of owners who have voluntarily complied with the treatment plan



our letter. Most were condominiums where we needed to treat the common property. No one responded and we successfully treated the land with no complaints.

Some aspects of our program were not worth the money we put into them. Since only 14 owners requested we replant with natives, it was not effective given the cost of growing the plants. Also, because the general public meeting was so poorly attended (five people), and the smaller meetings so much more effective, we should have concentrated our efforts on these.

The most important lessons learned were that small community groups are the most effective way of swaying neighbors. Neighbors have much influence over each other. Enlisting their help in swaying others is vital. Homeowner's associations are an invaluable way of garnering support for the project. If one does not exist, get together a small group of neighbors. Neighborhood presence is important - organization representatives should always be present during treatment to answer questions. We also believe a multi-faceted approach is vital - while we could get most people voluntarily, there are some who are resistant. For eradication, we may need to force compliance as a last resort. But the most important lesson we learned is that herbicide use is not as scary to local communities as we often believe. Public agents usually only hear from those passionately against herbicide use and they are in the minority. Their concerns should be addressed, but they need not dictate policy decisions. Finally, our project shows that private property owners with no economic incentive will participate in an invasive species eradication project if given sufficient education.

Is glyphosate a good choice for perennial pepperweed *(Lepidium latifolium)* control in tidal wetlands in the San Francisco Estuary?

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Land managers have been using glyphosate to control perennial pepperweed (*Lepidium latifolium*) in tidal marshes in the San Francisco Estuary since at least the mid-1990's. Despite common usage, a pepperweed control and marsh recovery plan will necessarily extend beyond a simple spray program to context-specific considerations of environmental and ecological implications for the invaded community. Research indicates that salinity is a dominant factor governing vegetation response, and that the biologically adapted species pool declines as salinity increases. Pepperweed and other vegetation responses to control efforts may likewise vary along the salinity gradient. We hypothesized that herbicide efficacy would improve as salinity increased, as would native recolonization of the treated areas. To test this theory, we examined response to herbicide treatments, the influence of stand density, and post-treatment changes in abundance of native vegetation at three tidally-influenced sites in the estuary: a freshwater site (Cosumnes River Preserve), a brackish site (San Pablo Bay National Wildlife Refuge), and a saline site (Don Edwards National Wildlife Refuge). Statistically significant cover reduction was achieved at all three sites, but treatment outcomes varied dramatically, and were highly dependant on site-specific species pools and physical conditions. Our results indicate that glyphosate provides a large reduction in cover, particularly in high density pepperweed patches, but that recovery of native vegetation is not predictable along the salinity gradient alone. Plant community composition strongly mediated post treatment recovery, therefore individual site characteristics must be taken into account to optimize treatment efficacy.

Tall whitetop control on the 102 Ranch and implications for other applications

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Work on the 102 Ranch and baseline studies along the Truckee River in northern Nevada were initiated by Western Botanical Service Inc. (WBS) and Shannon Peters (PhD candidate, Berkeley) in 2002. The initial research tested the hypothesis that large stands of *Lepidium latifolium*, tall whitetop (TWT, a.k.a perennial pepperweed), lack mycorrhiza inoclula in the soils, important to the re-establishment of native plant communities. In fact no mycorrhiza was found in the soils or on TWT plants and additional bioassay work supported the hypothesis. Related research confirmed mycorrhiza symbiosis with native floodplain species. This led to the development of demonstration plots at the 102 to test the hypothesis that native plant establishment might be enhanced with inoculation. Plots included 1) irrigated vs. non-irrigated, 2) coated (charcoal) and inoculated, vs. non-inoculated seed, 3) mowed only, and 4) mowed with herbicides. Although seed coating did not appear to enhance germination or initial plant establishment, root samples indicated that successful inoculation of the grasses has occurred. *Leymus triticoides* (creeping wildrye) has become well-established where irrigated but not herbicided and herbicided plots were dominated by *Salsola tragus* (Russian thistle). This methodology of mowing, irrigating, inoculating, and not applying herbicides shows promise for re-establishment of graminoid species in solid stands of TWT.

Integrated management strategies for perennial pepperweed

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Perennial pepperweed (*Lepidium latifolium*) is invasive throughout California. It thrives in a wide range of environments and is a common weed in floodplains, pastures, wetlands, and roadsides. In disturbed areas, perennial pepperweed rapidly forms monoculture stands that prevent favorable vegetation establishment. This experiment examined management strategies that control perennial pepperweed and re-establish desirable vegetation. The experiment was started at two sites in Lassen County California in fall 2002. Study sites were heavily infested with perennial pepperweed and lacked competing vegetation. The experiment was a split-split plot with four replications. Whole-plot treatments evaluated the usefulness of winter burning, mowing, grazing, or fall disking for removing accumulated thatch to facilitate herbicide application and re-seeding. Sub-plot treatments examined chlorsulfuron, 2,4-D ester, or glyphosate efficacy applied at the flower-bud stage. Sub-sub-plot treatments evaluated the influence of no-till seeding native perennial grasses for preventing weed re-invasion. All herbicides reduced perennial pepperweed cover compared to the control, but some herbicide + whole-plot combinations provided better control than others. Averaged across sites, chlorsulfuron, 2,4-D, or glyphosate applied alone, and chlorsulfuron, 2,4-D, or glyphosate in combination with burning, mowing, or grazing provided the best perennial pepperweed control. Disking before herbicide application decreased perennial pepperweed control compared to using herbicides alone. Before reseeding, winter burning in combination with yearly 2,4-D or glyphosate applications, spring mowing in combination with yearly 2,4-D or glyphosate applications, and disking in combination with yearly 2,4-D or glyphosate applications resulted in the highest native grass establishment. Applying 2,4-D in early summer the year of re-seeding improved grass establishment by suppressing perennial pepperweed re-sprouts and annual broadleaf weeds during seedling grass growth. Chlorsulfuron caused chlorosis and stunting to western wheatgrass, basin wildrye, and beardless wildrye seedlings when applied the spring before seeding, but in other trials, chlorsulfuron was safe on these native grasses when applied after the 4 leaf stage. No herbicide offered 100% control after two years of treatment suggesting multiple follow-up herbicide applications are needed for long-term weed suppression and vegetation restoration.

Bridging the Gap: Management

Research: Applying what works for you

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As land managers we often have a myriad of research findings at our fingertips – from the compilations of literature reviews to detailed dissertations. These findings, when applicable, can inform the development of successful control and management strategies as well as guide and influence adaptive management actions. The challenge often lies with selecting what scale of research and monitoring is relevant and achievable for each project. Performing true research with clearly articulated hypotheses, statistically valid designs and rigorous sample sizes may be impractical due to limited resources. However, conducting appropriately scaled research and monitoring actions can greatly benefit both a project and the weed control field as a whole.

The Golden Gate National Recreation Area (GGNRA) performs varying levels of research, adaptive management and monitoring as a part of its weed management program. The level is based upon funding, project goals, staffing, available outside (university, agency, etc.) support, and priorities. For example, literature and database reviews, critical tools for building a baseline understanding of species ecology and previously successful control methods; these are typically performed with every project. Additionally, establishing experimental test plots within a project provides a mechanism for tracking effectiveness, understanding nuances and modifying approaches. Associated monitoring findings are essential when evaluating responses to new techniques or working with new species.

This presentation will highlight four weed control projects in the GGNRA, the approaches used for selecting the type of supporting research and monitoring, and how the research findings were integrated into the project's planning, design, implementation, and subsequent adaptive management.

Fifteen years later: What were we looking for and what did we get?

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Cal-IPC was formed in 1992 when interested individuals from the researcher, land manager, and volunteer stewardship communities came together with common interests to find answers to shared questions. Over the years Cal-IPC has worked to answer those original questions and is continually pursuing answers to new ones. Cal-IPC products such as publications, listserves, and species initiatives facilitate the flow of information between the two communities. The annual conference provides the forum for land managers, volunteers, and researchers to bridge the gap between their disciplines and experiences, and move forward to stem the tide of invasive plants in California wildlands. Mike Kelly, one of the founders of Cal-IPC and an active land manager, shares his perspective on how he has utilized Cal-IPC's information sharing forum to effectively manage the lands he stewards from invasive plant species such as artichoke thistle, fennel, salt cedar, palms, and Cape ivy.

Using large-scale research to inform rangeland management decisions

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On conservation lands, rangeland managers face an incredible challenge in their daily jobs of maintaining a working landscape while ensuring that biodiversity is also protected. This challenge is made even more difficult by the amount of uncertainty and lack of data available on which to base their operational decisions. Often, research projects are met with justifiable skepticism by these managers who need quick answers to management questions that affect multiple rare species and dozens of natural communities on their property. I will describe how I bridged this schism between research and management at the Cosumnes River Preserve using carefully planned research and monitoring projects to answer the big-picture questions that I faced as both the land manager and research scientist responsible for over 20,000 acres of rangeland habitat. I will discuss the 1) political impetus driving the need for the research projects, 2) how I decided what to study and why, 3) the general outcome of these projects, and 4) lessons learned from the process.

Pseudo-replication, no replication, and a complete lack of control: In praise of dirty data for weed managers

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Introduction

Weed managers sometimes consider data collection to be an uneconomical expenditure of scarce resources, particularly when institutional focus, resource limitations, site conditions, or overarching management objectives preclude our ability to meet the requirements of peer-reviewed research. Having taken the lessons of formal science training to heart, we are reluctant to waste effort collecting quantitative data if we cannot maintain controls or replicate treatments. However, on-the-ground weed managers are in possession of crucial quantitative information regarding weed control efforts: we know (or should know) how much specific treatments cost under specific circumstances, how long they take, and how effective they are relative to each other. If we take the time to compile this information and supplement it with even the most rudimentary field data, we are able to allocate our scarce resources more efficiently. Perhaps more importantly, we are better able to clearly communicate what is at stake in the struggle to control invasive species.

The Marin Municipal Water District owns and manages approximately 22,000 acres of watershed lands in Marin County. The nearly 19,000-acre Mt. Tamalpais Watershed is located on an urban-wildland interface, immediately adjacent to the communities of Mill Valley, Sausalito, San Rafael, and Fairfax. Over 120,000 acres of public wildlands are immediately adjacent. The Mt. Tamalpais Watershed is highly diverse, with at least 85 unique plant communities, 900 plant species including six endemics, a large population of northern spotted owls,the densest known concentration of breeding osprey in California, and a host of other biological and scenic wonders. Included within our holdings are no fewer than 900 acres of land infested with French broom (*Genista monspessulana*).

The Marin Municipal Water District faces many of the limitations that land owners experience with regard to our capacity to do research or formal adaptive management as we control weeds. The institutional focus is on drinking water production, not land management or biodiversity protection. Planning resources are limited with less than one staff person dedicated to orchestrating and analyzing weed work. Our historic land management activities have been highly variable and poorly documented, making it difficult to identify sites that may reasonably serve as replicates or controls. The organizational work ethic is that of "getting the job done," not "studying how to do the job," leaving few opportunities to develop a study design or collect pre-treatment data. Our weed management objective is sustained weed suppression: leaving sites unmanaged as "controls" can increases future management costs at those sites and threatens progress made elsewhere when controls produce propagules. Finally, our increasingly motivated crews and volunteers are so focused on eliminating outlier populations that we frequently lose control plots to their diligence.

Out of necessity, we focus our data collection and analysis efforts on getting to the heart of our weed management program. We address the most basic questions:

- How bad is the problem really?
- Why is French broom worse than other plants?
- How long will it take to fix the problem?
- Which treatments work?
- What does it cost?

This information is critical not only for MMWD resource management staff, but also indispensable for our board of directors, who hold the purse strings. It is also of great value to adjacent land managers (state parks, national parks, and local open space districts) as well as the local fire fighting agencies. Finally, it's important for the general public.

Without permanent field staff, we at MMWD must take advantage of any and all available data collectors. We make heavy use of interns and volunteers, ranging from highly skilled botanists within the local California Native Plant Society chapter to the less-than-skilled but eager students of the local elementary schools. Because of the limitations our field crews bring, we must rely on quick-and-dirty, yet robust, data that gets right to heart of what we most need to know.

How bad is the problem really?

Quick-and-dirty distribution mapping

The data we collect as we map are similar to that the core weed information identified within the California Department of Food and Agriculture's Weed Mapping Handbook (2002) and The Nature Conservancy's Weed Information Management System (WIMS): species, location, approximate patch size, relative abundance, and site conditions. However, the emphasis is placed on broad characterizations of static management units rather than capturing the boundaries of shifting weed populations. We then translate our map statistics into a metric easily understood by the general public: football fields. To date, we have surveyed approximately 3,000 acres and delineated over 700 acres of French broom within 150 management units. Based on aerial photos and historic maps, we estimate another 200-300 acres of broom have yet to be mapped. All told, we estimate five percent – or the equivalent of 870 football fields – of the Mt. Tamalpais Watershed is infested with French broom.

Quick-and-dirty stem density sampling

This approach supplements mapping and provides a rough estimate of broom abundance in particular management units. We decided to measure stem density since it is an easy measure for our district board members to understand and for our primary field data collectors to gather. Field crews (typically a junior high school or high school class- randomly set out long rectangular quadrats (5m x 0.2m) following a straightforward protocol and count the number of broom stems. Between 20 and 40 quadrats, are sampled in each management unit. The data then undergo strict quality control measures. (Quadrats with "6 million" stems indicate observer boredom rather than high densities.) When combined with our mapping work, stem density data enabled us to uantify the problem and yield the very crude but eye-opening estimates of 24-44 million broom plants on the watershed (Table 1).

five miles of fuelbreak that had been mowed siz months previously. The results of this one-hour sampling investment have persuaded many in the local fire community that French broom within our fuelbreak system cannot be ignored.

How long will it take to fix the problem?

Quick-and-dirty measurements of effort per acre

We can obtain quick-and-dirty estimates of person hours per acre per broom treatment method by looking at our work order and payroll data, which are organized by vegetation mapping units. With five years of records for 60 sites, we can calculate a reasonably accurate average cost per acre despite substantial differences in site conditions (e.g., topography, weed density, vegetation type). We also measured productivity of volunteer weed workers by counting the number of stems that volunteers pulled in five minutes. Since we have this data for hundreds of volunteers across five years and 15 sites, we can be reasonably certain that the variability is accounted for. These data (cost per acre for staff and volunteers), when combined with stem density data, us to project how long it would take to clear one acre of established stands of French broom using various treatment methods (e.g., handpulling, mowing, herbicide). We can then combine these projections with our map data to predict how many acres we can treat using various methods, given our current budget and staffing levels.

Table 1

The extent of the French broom problem on MMWD land.

Abundance	Stems per acre	Extent (acres)
sparse (<10% cover)	5,000-20,000	95
low (10-35% cover)	20,000-40,000	295
medium (36-65% cover)	40,000-80,000	185
high (66-90% cover)	80,000-130,000	125
unclassified	-	200

Why is French broom worse than other invasive plants?

Quick-and-dirty quantification of fuel loading

Reducing fire risk is a critical objective for MMWD and neighboring land management agencies. Local fire districts have been slow to perceive French broom to be any different from other woody vegetation since it is not prone to sparking or exploding like chamise (*Adenostema fasciculatum*). But French broom grows so much faster than native woody vegetation that it doubles or even triples fuelbreak maintenance costs. To demonstrate this, we did some very quick-and-dirty sampling by measuring the heights of native shrubs (average = 24.2 cm, n=100) and French broom (average = 95.9 cm, n=100) along

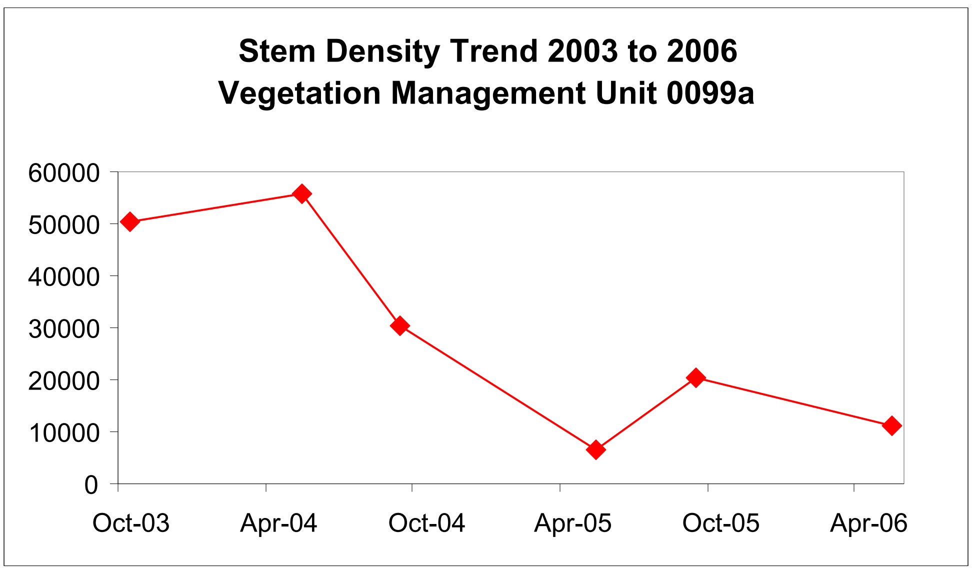
Quick and Dirty Estimates of Time Until Restoration

By combining our broom distribution data, broom stem density data, and effort data, we have identified 5000 stems per acre as a rough threshold of success. At this density, using highly selective control methods, we can prevent seed production with less than 16 person hours an acre. It is at this point that we consider reintroducing native perennial species to particularly species-poor sites. Although we have insufficient data to compare the speed with which different treatment options bring a site to this "restoration" stage, stem density data collected at the same site over multiple seasons does allow us to confirm that we are trending in the desired direction and approaching the restoration threshold (Figure 1).

tion, ecological protection, and invasive species spread control). The results of trials are often fairly self-evident, requiring only visual inspection. For example, annual winter mowing that results a meter or more of regrowth within six months is clearly not meeting our fire, ecology, or invasive spread control goals.

Not-so-quick-and-dirty trials

We do occasionally opt for a formal trial with controlled monitoring plots. Two recent undertakings illustrate the difficulties we often encounter when striving to execute formal studies. In 2001 the Marin Municipal Water District conducted a goat grazing trial. The initial study was designed to measure broom mortality in both treatment (grazed) and control (ungrazed) plots. However, the on-the-ground reality



Which treatments work?

Quick-and-dirty assessments of methods

We try everything. Sometimes we conduct a single test, other times we conduct more extensive trials. Our focus is on how well a particular method meets our management goals and how it ranks according to a wide range of criteria (cost per acre, retreatment interval, time to restoration, logistical limitations, wildfire risk reduc-

changed the focus of the study. The goats exhibited a strong preference for madrone bark, and did not graze broom as quickly as predicted, leaving half of the treatment plots untreated at the end of the trial. The study focus shifted to madrone mortality. Although we failed to monitor ungrazed "control" trees, we observed that 20% of the madrones girdled by goats died within a year. This information contributed to our assessment that, within our management context, other treatment options are preferable to goats.

We also conducted a formal, multifaceted trial of the Waipuna hot foam in 2006 following a limited trial in 2003. The 2003 trial (unreplicated and without controls), suggested the Waipuna system was between 90 and 100% effective at killing small French broom resprouts. In the 2006 trial, we wanted to look at mortality for larger stump sprouts, as well as impacts on the seed bank, impacts on soil macro-nutrients and mycorrhizal activity. We also wanted to track cost, and water usage . We established four replicates of the treatment and controls at three different locations. We then ran the Waipuna machine in production mode for three months, during which time it proved to be prohibitively expensive and slow. We therefore discontinued the seed bank and soils study. The broom mortality plots are still being monitored, and the results will be presented in 2007.

Table 2.

Estimated per-acre costs for different French broom treatments, MMWD, 2001-2006.

Methods	Labor Source	Person Hours an Acre	Cost / Acre (One Treatment)	Cost / Acre Ten Years
Currently Employed Methods				
Excavator / Tiger Mower	MMWD	5	$ 350	$ 3,500
Power Brushcutting	Contractor or MMWD	20	$ 500	$ 4,875
Prescription Burning	MMWD	Insufficient data	$ 1,500	$ 8,850
Mulching	MMWD	16	$ 475	$ 1,825
Propane flaming	Contractor or MMWD	75	$ 1,975	$ 6,025
Handpulling	Contractor or AWOP or Volunteer	300	$ 2,400	$ 9,850
Experimental Methods				
Terra Torch	Contractor with MMWD	7	$ 725	$ 2,775
Grazing (goats)	Contractor with MMWD	10	$ 975	$ 5,300
Waipuna Hot Foam	MMWD	110	$ 3,550	$ 6,800
Suspended Methods				
Cut Stump Treatment	Contractor or MMWD	30	$ 750	$ 2,825

What does it cost?

Quick-and-dirty measurements of effort and cost per acre

Using work order and payroll data in combination with density and distribution data enables us to calculate overall costs per acre for each treatment method. Included in these estimates are crew costs, vehicles, fuel, equipment, lease fees, and capital expenditures. Although these figures are rough, they are averaged across five years and 60 sites, which should provide a reasonable estimate of per-acre costs for French broom treatment on MMWD land. For our organization, labor and vehicle use are the most expensive components. Organizations with a different salary structure may have radically different results. We found that of the four major types of workers (MMWD staff, contractors, adult offender work program participants, and volunteers), the contractors were far and away the most efficient. Volunteers are the most costly, but they bring a culture of advocacy and stewardship to the vegetation management program that is invaluable. The estimated value of their labor can also be credited as matching funds for grants. Having a table comparing costs for each treatment (Table 2) is one of the most valuable tools we have.

Conclusion

The quick-and-dirty data described here may not satisfy academic research scientists, but such data have helped us improve the efficiency and cost-effectiveness of weed management here at MMWD and inform our district board members and the general public about the costs associated with particular treatments. We currently spend $250,000 a year for on-the-ground weed control (excluding planning, monitoring, and mapping). With Table 2, the district's board members can make an informed choice about whether to increase spending to $750,000/year (what it would take to treat all 870 football fields of broom) or improve our efficiency by allowing once again the use of cheaper and more efficient methods such as cut-stump herbicide treatments. (In 2005 the district board banned the use of herbicide for vegetation treatment.) Quick-and-dirty data has helped us demonstrate our ability to reduce broom densities down to a level where we can begin restoring native plant communities, but only if we have enough funding and the right tools to do so.

Bridging the Gap: Concluding Panel

Moderator: Dan Gluesenkamp, Audubon Canyon Ranch

Panelists:
Catherine Parks, USFS Pacific Northwest Research Station
Erika Zavaleta, UC Santa Cruz
Jodie Holt, UC Riverside
Pete Holloran, UC Santa Cruz
John Randall, The Nature Conservancy, Invasive Species Initiative
Joe DiTomaso, UC Davis
Carla Bossard, St. Mary's College of California
Jaymee Marty, The Nature Conservancy, Cosumnes River Preserve
Mike Kelly, Penasquitos Canyon Preserve
Janet Klein, Marin Municipal Water District
Christy Brigham, Santa Monica Mountains National Recreation Area

DG*: What are some hot research topics, and some top management needs?*

CP: The International Mountains Invasives Research Network is doing interesting work with high elevation invaders (see www.miren.ethz.ch/)

EZ: It's important to know about change scenarios, so that we don't spend time working to restore habitats to conditions that can't persist in the future.

PH: The social science aspects of restoration are wide open. It is key that we make strides in increasing cost effectiveness and efficiency so that we make the best use of our limited resources to address the problem, and so that we can make the most convincing case to decision makers in order to maintain support. Simple project tracking, aka "careful counting," can provide a lot of what we need.

JH: The biological factors that make some plants invasive can be a very fruitful area. Designing research to be straightforward and practical is important, and a good check on that is whether you are able to explain it in layman's terms to your mother. In many cases, researchers and managers are in two distinct camps, and there's a need for translation in between. A good model to bridge the gap between basic research and applied management is the "research-outreach continuum", which is the basis of the land grant university system that includes Experiment Station faculty, Cooperative Extension (CE) Specialists on campuses, and CE Farm Advisors located in the counties. This model works well for agriculture and could provide a template for organizing research teams to bridge the gap when dealing with invasive plants.

JD: We need to know more about the ecosystem impacts beyond just vegetation community. How about other trophic levels, soil structure, etc.?

JR: We need research that supports the tough decision making we are called on to make. At Hawaii's Volcanoes National Park, they decided on restoration goals that left out some species and communities, because that was all they could accomplish within the limitations.

Carla B: Climate change is going to be extremely important for understanding processes and setting appropriate goals.

JM: Working to connect research priorities and management needs is key, so that both communities get what they need.

MK: We may already be faced with a triage situation, where we have to make hard decisions to let some things go (maybe the condor, for instance). One thing we need to do for supporting both research and management is to increase funding. Cal-IPC has made some progress on this, but we need to be included in future parks bonds. We can also look to local opportunities, like the expanded mitigation funds added by conservationists to a recent Transportation Project sales tax vote in San Diego that will provide $5M/year for conservation over the next forty years.

JK: We need to know about the effectiveness and cost of control measures. It would be ideal to get grad students tied into programmatic concerns, perhaps by requiring a practicum.

Christy B: It would be useful to have more information on the impacts of each invasive, to help prioritize control efforts in a given location. Getting researchers involved can tricky, since they're often driven to theorize at a level that is not necessarily useful on the ground. Research is useful to me when it actually changes how I do things. We also need to work more on disrupting the cycle of invasion, where removing one weed simply results in another moving in.

How can managers best pose questions for researchers?

JM: Be careful about just saying, "We have a system to study." Make sure to emphasize that you also want to know how to manage X on your preserve. Line up your specific, practical questions early, and stay in communication with researchers so you can help guide their work.

EZ: It's possible to address both basic ecology and applied needs—the recent study on invasive rats in the Aleutian Islands is a good example, looking at trophic cascades while also providing practical guidance for management. Researchers need to work on this, connecting theory to practice.

What are ways to access scientific literature, given that many managers don't have easy access to online databases? Is "dirty data" accessible anywhere?

PH: The Cal-IPC proceedings are one place to find "dirty data" from project performance, and people should continue to contribute that information.

EZ: You can email authors for a pdf of their articles, but I encourage all researchers to simply post pdfs of their articles on their websites. This makes them easily accessible.

JH: The UC Department of Agriculture and Natural Resources has a lot of materials that distill research results; similar outreach materials are needed for invasive plant issues.

JK: This kind of synthesis is very useful, because there's not enough time to read articles. Web sites like tncweeds are very useful for accessing these types of syntheses.

For collecting "dirty data", what are ways you've found to motivate volunteers? Is there social science literature on this?

PH: There is a deep literature in consumer change, and there are some studies specifically on weed control efforts, though these aren't published. Cal-IPC should consider maintaining a level of social science at the Symposium.

JD: National research panels are open to funding this type of research.

How can we increase funding?

MK: It's key to have a product that tells a compelling visual story for legislators.

We should also make sure we're fully tied into lobbyists from TNC, CNPS, and other aligned groups.

PH: Bond funding can be useful, but they're not appropriate for ongoing maintenance, so we also need to think about money from the general fund, fees, etc.

Sometimes it seems like researchers are not satisfied with data generated by managers or volunteers. How can we make it work?

MK: Don't let anyone say that volunteer-collected data is not useful. The San Diego bird atlas and plant atlas mapping has done incredible work with volunteer surveyors.

JK: We don't need academic approval for all research. It needs to be appropriate for the intended purpose and audience. It doesn't have to be rigorous, as long as you only present conclusions that are safely within the limits of the data.

Carla B: Researchers get contacted all the time for advice on setting up experimental design, and they typically enjoy getting involved. Anecdotal data can be very useful – not everything needs to be "published." Perhaps Cal-IPC could provide a directory of "experts" willing to help.

JR: Managers often bring really interesting hypotheses to researchers, which is a good symbiosis.

JH: What's important is getting information out there so others can benefit from it. Not everything needs to be academic.

JM: We need to recognize when our data collection is no longer useful, so that we don't spend time monitoring only to find that we cannot draw useful conclusions.

CP: It can be key to interact early in the process, so that researchers and managers can determine which data to collect, how to institute a control, etc. Sometimes a simple modification at an early stage can make a big difference in how useful your information is later.

DG: We also need to explore the philosophical and ethical questions that we face so that we have a foundation for the tough work ahead.

2006 Cal-IPC Weed Alerts

Plants on the Increase, Recent Horticultural Escapes and New Introductions

Joseph M. DiTomaso

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jmditomaso@ucdavis.edu

Weed Alerts represent either plants that are known to be invasive, but appear to on the increase or potentially new species that appear to be escaping from cultivation and are becoming invasive in some area of the state. It is important that Cal-IPC members report potentially significant invasions of plants new to an area. Not only does this provide the society with an initial time frame for the invasion, but also alerts land managers in other regions of the state to the potential threat. Rapid action on a new invader can potentially save millions of dollars with preventative control or even eradication.

New reports should be made to the main office of Cal-IPC. This information will then be transferred to the individual presenting the Weed Alerts talk at the following symposium. The visual presentation of the talk will be included on the Cal-IPC website (www.cal-ipc.org) for future reference.

The 2006 Weed Alerts include:

- *Geranium purpureum* (little robin)
- *Echium plantagineum* (Pattersons-curse or vipers bugloss)
- *Glyceria declinata* (waxy manna-grass)
- *Buddleja davidii* (butterflybush)
- *Macfadyena unguis-cati* (Cat's claw vine)
- *Cuscuta japonica* (Japanese or giant dodder)

Geranium purpureum (little robin)

is a native to Europe and is not included in the 1993 edition of The Jepson Manual. As a result, it is often misidentified as the similar non-native species, *Geranium robertianum* (herb-robert). In the USDA Plants Database, it is referred to as *Geranium robertianum* ssp. *purpureum*. It can be distinguished from *Geranium robertianum* by its smaller petals (5-9 mm long) compared to the 9-13 mm long petals of herb-robert. In addition, it has yellow pollen (herb-robert has orange pollen) and the petals are more uniform in color compared to the striated petals of herb-robert. Finally, the foliage is generally a lighter green and less red- or violet-tinged than herb-robert. Although it is generally an annual, it can also act as a biennial is more favorable habitats. Little robin has spread very rapidly and is quite common in many riparian and woodland areas of the inner North Coast Ranges, especially Napa County, generally in the same habitat as the invasive *Vinca major* (big periwinkle).

Echium plantagineum (Pattersons-curse or vipers bugloss)

is a winter annual or biennial native to southern Europe. It is one of the most significant invasive species in Australia, where it is estimated to cause economic losses of about $30 million per year. Like other members of the Boraginaceae, it contains potent alkaloid liver toxins that can kill all forms of livestock. Although it has been in California for several years, it has not spread to become an important invasive species. However, recently it has formed two larger infestations in Oregon, one occupying two acres and the other 100 acres. Thus, it is a species that land managers need to watch carefully in California.

***Glyceria declinata* (waxy mannagrass)**

is a perennial grass of vernal pools, moist canyons and meadows. It is native to Europe and Africa. In California, however, it acts as an annual and is adapted to long periods of inundation. Its greatest threat is to rare and endangered native species of vernal pools. Although it can resemble Italian ryegrass (*Lolium multiflorum*), it more closely resembles native species of *Glyceria*, particularly *Glyceria occidentalis*. Despite its inclusion within the Flora of California, by Munz and Keck, it was omitted from the more recent Jepson Manual. In addition, The Jepson Manual incorrectly describes the lemma tip of *Glyceria occidentalis* as jagged or irregular, which is typical of *Glyceria declinata*. This has created a problem because spreading invasive populations of *Glyceria declinata* have been mistakenly identified as native populations of *Glyceria occidentalis*. *Glyceria declinata* is found mainly in the Central Valley, from Shasta to Fresno County, as well as in vernal pools in Mendocino County.

***Buddleja davidii* (butterflybush)**

is an evergreen or semi-deciduous shrub native to China. It is recognized as a problem in England and New Zealand and has become more widespread in forest plantations of Oregon. Indications are that it is becoming a bigger problem along the North Coast of California, and more recently has spread to the Central Coast and Bay Area. In riparian areas, it has been shown to displace native willows essential to native butterflies.

***Macfadyena unguis-cati* (Cat's claw vine)**

is a subtropical to tropical viny perennial ornamental that has become very problematic in Florida and other parts of the world. It is native to Mexico, and the West Indies to Argentina. The plant has large tubers and leaves with two leaflets and a three clawed tendril (the cat's claw) growing between them. It has recently been reported to be invasive in Capistrano Beach in Southern California.

***Cuscuta japonica* (Japanese or giant dodder)**

is a newly discovered invasive species that is native to Asia, where it is commonly cultivated as a herbal remedy. Like other species of *Cuscuta*, it is a parasitic plant that generally lacks chlorophyll. Its main difference from *Cuscuta* species in California is its wider range of host plants. It can not only infect herbaceous species, as do other *Cuscuta* species, but very commonly parasitizes woody trees and shrubs. Thus, it is a treat to riparian areas where it can infect such species as elderberry, willows and oaks, as well as orchards and other tree fruits and woody ornamentals. Thus far, *Cuscuta japonica* has not been shown to produce flowers or viable seed in California. The stems are considerable larger (at least 2x wider) than those of other dodders, and it can grow very fast rate, up to six inches a day. It was first reported in California in 2004 and currently is found in seven counties, generally associated with Hmong communities, where it may be intentionally grown for its medicinal properties. Its transport around the state has not been determined and may also be due to movement by birds.

Posters

Invasive aquatic weeds: Implications for mosquito and vector management activities

Charles E Blair, MD*, Trustee, Mosquito and Vector Management District of Santa Barbara County (MVMDSBC) and active member of Cal-IPC & CNPS , Lompoc, CA blairce@sbceo.org

Healthy natural wetlands are far less likely to be breeding areas for disease-carrying mosquitoes than degraded ones. Degradation of these bodies of water by invasive aquatic weeds and other influences can result in their being potential habitat for mosquitoes that can carry the West Nile Virus, encephalitis, and other diseases. Control of these invasive plants can be an important part of the Integrated Weed/ Pest Management efforts of both Weed Management Areas and Mosquito and Vector Control Agencies. Adverse effects of Water Hyacinth, *Eichhornia crassipes*, Water Primrose, *Ludwigia* spp., Smooth Cordgrass, *Spartina alterniflora*, and other species on water quality and facilitating mosquito breeding will be shown along with the importance of healthy vernal pools. Presentations on the importance of *S. alterniflora* in San Francisco Bay were made at recent statewide Cal-IPC and Mosquito and Vector Control Conferences. Demonstration of these relationships can enhance both agency and public awareness of their importance.

Invasive plant monitoring using volunteers: A nationwide effort

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The spread of invasive species is one of the greatest challenges we face in the National Wildlife Refuge System (NWRS). Non-native invasive species spread at an estimated rate of 14 million acres per year, making them the number one threat to the 100-million acre NWRS. At the heart of any control program should be initial assessment of an invasive species and development of methods to evaluate control actions. These tasks can be daunting, requiring a huge investment of human resources but they are critical to long-term success. In 2004, the Cooperative Volunteer Invasives Monitoring Program was launched by the NWRS to train volunteers to identify invasive plant species and use global positioning systems to map their extent on refuges. National partners include the Nature Conservancy, U. S. Geological Survey, and the National Wildlife Refuge Association. Several refuges across the nation now participate in the program, including San Pablo Bay National Wildlife Refuge (SPBNWR). The data collected at SPBNWR is entered into a national database maintained by the National Institute of Invasive Species Science. Current efforts at SPBNWR focus on *Lepidium latifolium*. These data are being used to study characteristics of *L. latifolium* in tidal environments, guide development of a control program, and will be used to evaluate the success of future control efforts. Volunteers at San Pablo Bay National Wildlife Refuge have contributed over 600 hours to mapping *L. latifolium* in over 1000 acres of tidal marsh.

The Salmon River experience: Tools of the trade

Petey Brucker*, Salmon River Restoration Council, Sawyers Bar, CA

Over the last 12 years the Salmon River Restoration Council (SRRC) and its partners have developed an unusually effective model using a well stocked Tool Kit for controlling several priority invasive plant species at a watershed scale in the Salmon River, approximately ½ million acres. Through its' Salmon River Cooperative Noxious Weed Program (CNWP), the SRRC has developed an adaptive approach that includes some basic guiding principals and 13 Steps to apply to attain effectiveness. The guiding principals that our community and partners have rallied around include: Early Detection, Rapid Response, Thorough and Persistent Management, and the Use of the Appropriate Tools. We are currently controlling 12 targeted species of noxious weeds and are having a high level of effectiveness with our signature species being spotted knapweed which we have reduced by over 95% at more than 250 sites throughout the Salmon River wildlands watershed. The SRRC has found that there are certain tools that are most appropriate to effectively manage different species in varying habitats. The SRRC tools are used for digging, mulching, burning, cutting, pulling, bagging and mashing the targeted plants. Members of our local community have been fabricating a line of tools, including the "Super L" digging bar, that are used by the SRRC's paid and volunteer crews, Drivers That Care, and Adopt An Area programs.

Testing the effects of flaming as a method of medusahead (*Taeniatherum caput-medusae*) control on the Plumas National Forest

Michelle Coppoletta, USDA Forest Service, Plumas National Forest, Quincy, CA, mcoppoletta@fs.ca.gov

Introduction

At present, noxious weed species occupy an estimated 17 million acres of public lands in the Western United States (USDA 1996). Invasive species pose a significant threat to biological diversity due to their ability to displace native species, alter nutrient and fire cycles, decrease the availability of forage for wildlife, and degrade soil structure (Bossard, Randall, and Hoshovsky 2000). In 2003, the United States Forest Service identified invasive species as one of four critical threats to the Nation's ecosystems (Bosworth 2003). In order to successfully conserve and manage public lands, managers must have the necessary tools to effectively prevent and control the spread of invasive species into native plant communities.

Over the past ten years, managers of public lands in the western United States have witnessed an explosive spread of medusahead (*Taeniatherum caput-medusae*; Bisson 1999). Medusahead is a winter annual grass; its seeds germinate with the first rains of fall, overwinter as seedlings, flower in late spring to early summer, and set seed and die by late summer or early fall. This species reproduces by seed, which is primarily dispersed by wind and water, although it can be dispersed to more distant sites by grazing animals, machinery, vehicles, and clothing (Bossard, Randall, and Hoshovsky 2000). Medusahead is able to grow in a wide range of climatic conditions and has been documented in plant communities up to 7,000 feet in elevation.

The Plumas National Forest occupies approximately 1.15 million acres in the northern Sierra Nevada of California. It supports a diverse assemblage of plant communities, which provide habitat for over 120 threatened, sensitive, and special interest plant and animal species. Since targeted noxious weed surveys began in 2000, medusahead has been documented at roughly 70 locations within the forest and is presently estimated to occupy over 25 acres. Individual occurrences average 0.5 acre and range in size from a few hundred individuals to over a million. Most medusahead occurrences are found in relatively disturbed areas along roadsides and railroad tracks; however this species has also been documented in a few native plant communities. Medusahead is a species of significant concern on the Plumas National Forest because it occurs in areas of high project activity where there is increased potential for spread. Traditional treatment methods (mechanical, chemical, biological, etc) are also not practical or effective for control.

One relatively recent and innovative approach to weed control is flaming, a heat treatment method that utilizes a propane torch to kill individuals but not ignite them. Flaming, also known as wilting or blanching, has traditionally been used in agriculture to control weed seedlings in row crops (i.e. Rasmussen 2003). In California, this method has shown variable levels of success in controlling infestations of French broom (Klein and Fiala 2005, Moore 2004), poison hemlock (Bossard et. al 2005), and yellow starthistle (Moore 2004, Rushmore 1995).

The goal of this study was to test the effectiveness of flaming as a method of medusahead control on the Plumas National Forest. Specifically, this study examined the following questions**:**

1. Does flaming reduce the percent cover of medusahead in experimental plots?
2. Is the timing of the treatment an important component for effective control? Are treatments conducted in the spring more effective than those conducted in the winter?
3. Are multiple flaming treatments in one year more effective at reducing medusahead density than a single application?

Methods

During summer 2005, three medusahead infestations were selected to serve as experimental study blocks. Infestations were selected based on size, accessibility, and a minimum separation distance of two miles. Within each block, five permanent plots (1 m^2) were established and randomly assigned to one of three treatments: (1) winter flaming, (2) spring flaming, and (3) a multiple flaming treatment with one application in the winter and one in the spring. The first two treatment types were designed to test the effect of treatment timing (winter vs. spring) on medusahead density. The third treatment type was intended to test the necessity and effectiveness of repeat application.

In July 2005, the percent cover of all species within the plots was recorded, photographs were taken, and environmental variables, such as slope and aspect, were recorded. Treatments were conducted in December and April 2006 using Weed Dragon™ backpack propane torches (100,000 BTU). To decrease the potential for seed dispersal from infested areas immediately adjacent to the plot, the total area treated consisted of the experimental plot as well as a small area surrounding the plot. In July 2006, the plots were revisited and data collected.

The change in percent cover of medusahead following treatment was analyzed using two-way ANOVA. The change in percent cover was used as the response variable and block (n=3) and treatment timing (n=2) or number of applications (n=2) were included as independent variables. Interactions between the two independent variables were also examined.

Results

All flaming treatments, regardless of treatment timing or the number of applications, reduced the percent cover of medusahead in the experimental plots by an average of 74% (± 28%). Treatment timing appears to be an important factor to consider when determining the effectiveness of flaming as a method of medusahead control. There was a significant difference between winter and spring treatment effects (n=12, p=0.01). Spring flaming treatments reduced medusahead by an average of 95.9% (± 0.9%) cover, while winter treatments reduced medusahead by an average of 56% (± 30.9%) cover (Figure 1).

This study did not show a significant difference between plots that were treated once and those that were treated twice. This is likely due to the fact that only three plots were treated twice during the growing season, which did not provide a large amount of experimental power for analysis.

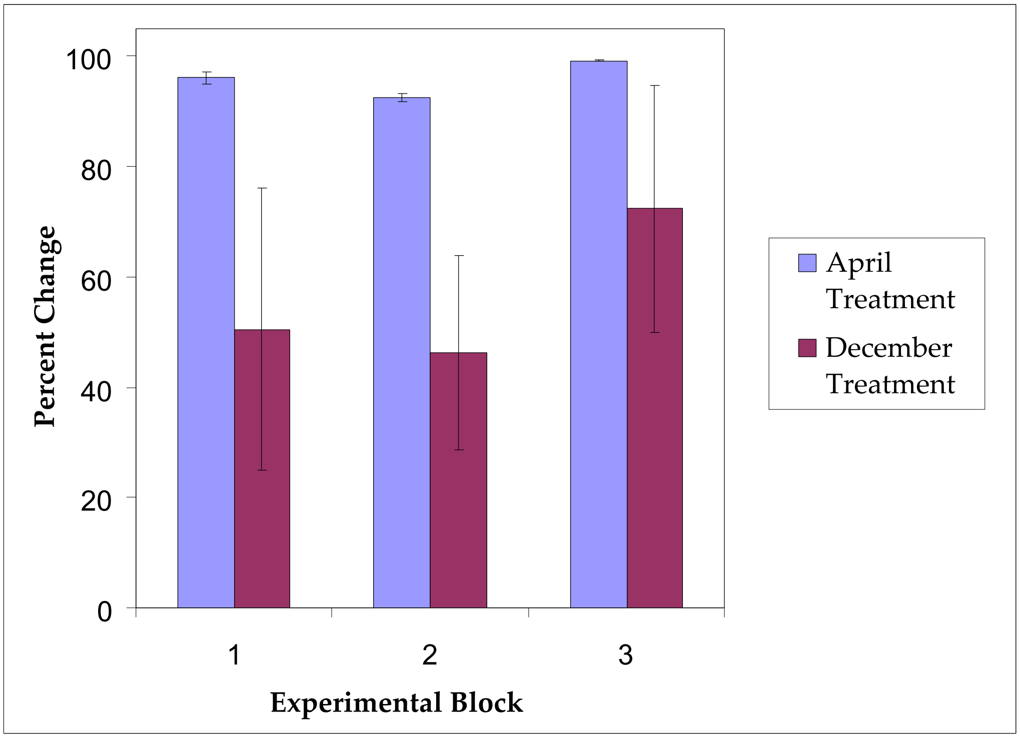

Figure 1.

Mean percent reduction (± 1 SE) in medusahead cover in experimental plots in response to winter and spring treatments. Difference between treatments was significant (n=12, p=0.01)

Conclusions

These preliminary results suggest that, when timed correctly, flaming may be a useful tool for medusahead control. The equipment required to conduct the treatment is inexpensive, relatively easy to operate, and requires little maintenance (Moore 2004). It presents a selective alternative to chemical treatment, has very minimal environmental impact, and does not result in ground disturbance that usually favors invasive species colonization (Moore 2004). However, it is very important to note that this method does present a number of limitations. In some areas where fire danger is high, there may be a limited window of opportunity for treatment. In addition, in the case of an annual grass such as medusahead, this treatment may only be practical on very small, isolated infestations.

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Developing a handbook summarizing the use of livestock as a tool in noxious weed management programs in the western United States

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Researchers and grazers have long known that livestock grazing can be used as a tool to manage some noxious weeds. This knowledge however, has not been collected, summarized and shared in a useful format with other interested parties.

University of Nevada Cooperative Extension specialists, collaborating with a University of Idaho weed scientist, assembled, summarized, and distributed "state-of-the-art" knowledge concerning livestock grazing as a noxious weed control tool in nine western states. The information was compiled using a literature review and interviews with weed researchers, managers, and grazing management practitioners. The information is presented in a binder consisting of color photos, descriptions of each weed and guidelines for using grazing as a management tool. The handbook was distributed to every Cooperative Extension and Natural Resources Conservation Service office in the targeted states. The handbook is also being presented at numerous venues in the targeted states.

An evaluation process will consist of a telephone survey of end users at six months and one year after the handbook is distributed. The evaluation data will include estimates of: 1) usefulness as a resource to CE, NRCS and others; 2) degree of use of the handbooks by the end users; 3) changes in awareness by CE and NRCS personnel; 4) increases in knowledge concerning livestock use as a weed management tool by; and 5) increases in the willingness to use or the actual use of livestock as a weed management tool that can be attributed to the handbook.

The invasion of *Eupatorium odoratum* in secondary tropical monsoon forest in the watershed of Bian-Kumbe in Merauke, Papua Indonesia

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Abstract

The forest watershed of Bian-Kumbe in Papua is a tropical monsoon forest, characterized by scars of sporadic-forest floor and tree trunk fires. This forest was logged in 1980. The forest area is very important in supporting forest floor fauna such as cassowary birds that feed on the seeds from the tree canopy. Many large openings in this forest have been occupied by *Eupatorium odoratum*. Open forest areas of about five

ha, next to the freshwater marsh, were one hundred percent covered by *E. Odoratum*, and no seedlings of canopy trees were found. These shrubs are 3 meters tall, and after dry season fires they grow quickly, utilizing both basal re-sprout and seeds strategy. This *E. odoratum* invasion is threatening the natural re-growth of the secondary tropical monsoon forest at Bian Kumbe in Papua.

Key words: invasion, *Eupatorium odoratum*, tropical monsoon forest, Papua

Introduction

The watershed of Bian-Kumbe at Merauke in Papua Indonesia is characterized by many types of forest ecosystems. Like all tropical monsoon forests, Bian-Kumbe forest watershed has very distinct wet and dry seasons. These tropical monsoon forests experience natural fires every year. During the dry season, fires sporadically occur in these forests on a small scale. The small-scale natural forest fires are important in maintaining forest-species diversity. Small-scale disturbance in the forest by natural fires acts to maintain the forest. Cassowary birds (*Casuarius sp*.) live on the forest floor live and depend on seeds from the forest trees. The presence of many species of forest canopy trees is critically important to the birds. In intact forests with full canopies, the fires stay small but in forest gaps without a canopy, the scale of the fire accelerates (Djohan et al. 2004).

In 1980, large areas of the forests in Bian-Kumbe were logged. In 2001, in an attempt to increase the local income, a large part of the forest next to Rawa Bian (*rawa* = wetlands) was converted to a cacao plantation. However, one year after creation of the plantation, it was burned in a natural fire (Matius Omak Mahuse, and Andreas Ndayau Mahuse of Muting District. 2004: pers. comm.). Rawa Bian is a freshwater marsh, which was dominated by 99.9 % of wild rice (*Zizania* sp.). Every year during the dry season, part of the *Zizania* catch fire, especially in peripheral areas, where the water level is below the soil surface. Dead leaves and stumps of *Zizania* are a good material to initiate fire. That is why these young cacao trees did not survive even the first dry season.

After the cacao plantation fire, this area was invaded by *Eupatorium odoratum*. The local people (native Papuan) have very good knowledge of ethno-botany, and they have native names for all native plants. However, they do not have native names for the introduced species. Since they did not have a name for *E. odorautm*, they called this shrubby plant, Rumput dua ribu (rumput = grass; dua ribu = two thousand). They said this plant came to Merauke in 2000 do not like it, because it takes over the open areas in the forest, and during summer it burns easily. The purpose of this research was to study the occupation of *E. odoratum*, in open areas and logged over forest in the Bian-Kumbe watershed next to Rawa Bian.

Methods

Locations for study were selected in the Rawa Bian area of the Muting District, Merauke using Landsat ETM 2003 (Figure 1). These locations were Bian 1 and Bian 2 with geographic positions as follows:

Bian 1.3	Bian 1.4	Bian 2.1	Bian 2.2	Bian 2.3
045117	0450193	0455399	0455457	0455418
9190169	9189988	9185559	9185641	9195992

Bian 1 was located next to the Rawa Bian, and Bian 2 was farther away from the forest. At Bian 1, two sites were chosen, Bian

1.3 and Bian 1.4. Formerly Bian 1.3 and Bian 1.4 were forested areas, but the forest at Bian 1.3 was converted to cacao plantation, while Bian 1.4 was a secondary forest. Similarly, Bian 2 is also secondary growth, logged-over forest, since 1980. During the logging era, Bian 2.1 and Bian 2.2 were converted to log storage yards, while Bian 2.3 was secondary, logged-over forest. Bian 2.2 was located between the sites of Bian 2.1 and Bian 2.3. This study was carried out on October 2004, when the secondary forest was being logged again.

At each site, the number of individuals and heights of *E. Odoratum* were collected using 30m x 30m quadrat plots. At each site, soil samples for nutrient analysis were collected from five sample composites. Soil nutrients were measured, including NO_3. NH_4, N total, PO_4, P total, and K^+ (mg/kg), as were pH, soil moisture, and soil and air temperatures. The number of species and their life forms also were recorded in these plots (Djohan et al. 2004). Density of *E. Odoratum* was analyzed by comparing the converted-forest areas, logged yard, and logged-over forest.

Results and discussion

Discussion

E. odoratum covered 100% of the former cacao plantation (Bian 1.3), and no seedling tree canopy was found there (Figure 2). Similar results occurred in the former logged yard-areas (Bian 2.1 and 2.3). Based on the *E. odoratum* density, at former cocao plantation area was slightly than the former cacao plantation (Bian 1.3), 113 %. The numbers of individuals per 900m^2 at the former cacao plantation (Bian 1.3) and log-storage yard (Bian 2.1) were 94,678 and 107,280 with heights of 1.7 $\pm$ 1.3m, and 0.67 $\pm$ 0.50m, respectively. In the secondary forest at Bian 2.3, *E odoratum* was not present, but the in secondary forest at Bian 1.4 contained 419 individuals per 900m^2

Natural fire burns *E. odoratum* shrubs with no canopy very easily. After the fire, their growth increases, with their growth strategy, basal re-sprouts and seeds, and ash nourishing the soil even better. In the low canopy trees, Bian 1.4, the shrubs also invaded the area, but secondary tree

Table 1.

The soil quality of NO_3. NH_4, N total, PO_4, P total, K^+ (mg/kg), and soil moisture, pH, and soil and temperature. Nd = not detected

Sites		NO_3	NH_4	N total	PO_4	P total	K^+	pH
Bian 1.3	Former chocolate plantation	Nd	106,54	5584.0	230.4	751.81	361.03	7
Bian 1.4	Logged-over (secondary forest	Nd	114.15	3467.0	174.1	568.09	394.16	7
Bian 2.1	Logged yard	Nd	68.46	2731.0	86.65	282.75	377.52	7
Bian 2.2	Logged yard next to the logged-over forest	Nd	106.43	3109.0	125.21	408.58	398.89	6.8
Bian 2.3	Logged –over forest, secondary forest	Nd	53.69	2978.0	206.63	674.23	311.72	6.98

Table 2.

The parameter measured of soil and air temperature (C^0), soil moisture(%), soil textures (%), and light intensity (lux).

Sites		Temperature		Soil moisture	Soil textures		
		Soil	Air		Silt	Sand	Clay
Bian 1.3	Former cacao plantation	32.5	33.5	0.0	24.53	42.43	33.04
Bian 1.4	Secondary forest	26,25	33.5	2.89	37.94	29.34	32.72
Bian 2.1	Log yard	33.8	32.8	4.47	32.59	30.0	37.41
Bian 2.2	Log-storage yard next to the secondary forest	25.20	29.2	3	39.03	38.20	22.27
Bian 2.3	Secondary forest	26.72	28	7.79	24.63	31.09	44.28

canopy prevented their distribution. At this area, it appears all their energy was put on the taller growth, 3.5 m.

Light intensity had a significant role in the invasion process. Light intensity in the secondary forest at Bian 2.3 was very low (21 lux) compared to the logged-over forest at Bian 1.4 (272 lux), and the others were 500 lux. The light intensity in the forest floor relates to the tree canopy, thus the tree canopy prevented the invasion of *E. odoratum* in the forest floor of secondary forest of Bian 2.3. In the open areas of this forest that are covered with *Eupatorium* sp., the normal tree species of the canopy are highly suppressed and this will affect the forest animals, such as cassowary, that are highly dependent on tree canopy seed for their food supply.

Conclusion

Undisturbed tree canopy will prevent the distribution of *E. odoratum*, but creation of large open areas in the forest of the watershed of Bian-Kumbe will threatened the future existence of the tropical monsoon forest and its animals.

Acknowledgements

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Progress and regress in the biological control of tamarisk in California

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The 1999 cage releases and 2001 field introductions of a chrysomelid leaf beetle, originally identified as *Diorhabda elongata*, for the biological control of *Tamarix* spp. has led to successful establishment of the agent in several states, substantial target mortality at a Nevada release site, and numerous 'desired' responses by ecosystem and community elements. Despite repeated introductions of two ecotypes from the *D. 'elongata'* species complex at four California locations and proposed introductions at six others, there remains no field population at this time. There are three ecological factors, and several interacting socio-political factors, that account for this absence. Failures at the release sites are because: 1. some ecotypes from higher latitudes enter reproductive diapause in response to daylength too early in the season for populations to establish; 2. invertebrate predation can inhibit population establishment, particularly where developmental responses are not ideal; and, 3. the target species in some regions is a poor quality host for the approved agents. Several other populations of beetles from the *D. elongata* complex may provide phenotypic traits that allow successful establishment, and in testing they do not appear to differ with respect to potential unintended impacts to non-target species. However, the program is

stalled, with no imminent introductions of any agents at present because of regulatory considerations that may depart from a balanced assessment of risks and benefits of weed biocontrol. These considerations are placed in the context of proposing a more effective and co-operative approach to biocontrol of tamarisk and other invasive plants.

The Invasive Species Program at the California Department of Fish and Game

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The Invasive Species Program is a relatively new program located within the Habitat Conservation Planning Branch at the California Department of Fish & Game (DFG). Its mission is to reduce the impacts of nonnative invasive species on California's natural resources. Nonnative species reduce the native biodiversity in this State through predation, parasitism, disease infection, competition for resources, and habitat degradation. The Invasive Species Program works throughout California with agencies at all government levels, the academic community, professional organizations, community and interest groups on cooperative planning and actions to achieve their mission. We work on plants and animals in terrestrial and aquatic environments. Recently, under the direction of the Program's Coordinator, Susan Ellis and Abe Doherty of the State Coastal Conservancy, the draft "California Aquatic Invasive Species Management Plan" has been completed, undergone public review and is now being finalized. The "Draft Rapid Response Plan for Aquatic Invasive Species in California" was also recently completed by Invasive Species Program staff.

Prior to the formation of the Invasive Species Program, invasive species control within DFG focused primarily on weed control on staffed DFG Wildlife Areas and enforcement of laws that regulate the importation, transport or possession of non-native species. As more decision-makers around the country became aware of the problems posed by non-native invasive species, it became important for DFG to have a centralized program to connect with the coordination, planning and funding entities that have mushroomed around this topic in the approximately last fifteen years. The Invasive Species Program fills that role and also works to support invasive species detection, control and enforcement efforts carried out through various DFG programs. We will work with others in DFG to implement best management practices for invasive species control in all DFG programs. Related state-wide programs within DFG include the Pesticide Investigations Unit and the Ballast Water Program, both of which are located in the DFG Office of Spill Prevention and Response. We also work frequently with DFG Marine Region staff on efforts to detect and control the spread of non-native marine species in coastal areas.

Salmon River cooperative noxious weed program

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The Salmon River Restoration Council (SRRC) was created in 1992 to enlist stakeholder cooperation to restore the anadromous fisheries of the Salmon River, a tributary to the Klamath River in northern California. The SRRC and its partners recognized that a large part of fisheries health is based on the many factors impacting the watershed. A comprehensive watershed restoration strategy was completed in 2002 to prioritize and address key limiting factors for fisheries. The strategy identifies addressing noxious weeds as an action needed for fisheries recovery. The SRRC, with its partners, have created the Salmon River Cooperative Noxious Weed Program (CNWP) to effectively control priority invasive plant species throughout the Salmon River wildlands watershed., approximately ½ million acres in size.

The Salmon River CNWP has lead to the successful control of several species of priority noxious weeds throughout the Salmon River area. Early detection, rapid response, persistent and thorough treatment, and use of the appropriate tool are the basic underpinnings of our approach, with thirteen specific steps used to guide the CNWP. The priority species being managed include: spotted, diffuse, meadow knapweed; Italian thistle; white top; Scotch and French broom; tree of heaven; Marlahan mustard; fennel; yellow and Malta star thistle; jubatagrass; and leafy spurge.

Monitoring results for all of the species shows a sharp decline in several of the species range and population size for several of these targeted species, highlighting the elimination of meadow knapweed, the reduction of spotted and diffuse knapweed plants by over 90%, reduction of broom by over 70 %. An adaptive management approach is being applied to identify and develop the most appropriate tools, techniques and timing to manage each target species.

A biological basis of plant invasions: Can seedling relative growth rate predict invasive woody species?

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Understanding causal factors of exotic species invasions is important for managers. Here, we report the potential use of seedling relative growth rate (RGR) and specific leaf area (SLA) as predictive tools for screening potentially invasive exotic species. For seedling growth analyses, invasive woody species were contrasted with less-invasive woody species commonly cultivated in California with both cross-species (28 species) and phylogenetically corrected (13 sets of related species contrasting in invasiveness) procedures. Invasive species were hypothesized to have higher seedling RGR and SLA than related less-invasive species. No significant results were found with cross-species analyses. However, phylogenetically independent contrasts (excluding distant contrasts between families) showed that high seedling RGR and SLA have significant positive associations with woody plant invasiveness.

To confirm the utility of seedling RGR and SLA as predictors of invasiveness, we performed another seedling growth study of 40 exotic horticultural woody species making up thirteen phylogenetically independent contrasts. Additionally, we tested the growth and survival responses of 19 species (eight contrasts) to two levels of nitrogen (low nitrogen- representing typical California wildland levels, and high nitrogen- representing input from pollution sources such as atmospheric nitrogen deposition and agricultural runoff) and to three levels of drought (none, intermediate, and high). Optimization of fast seedling growth (high RGR) associated with opportunistic resource acquisition (high SLA) and increased root allocation to survive summer drought is critical for success of plant invaders in regions with mediterranean climates. A seed germination study complements this study of invasive and much less-invasive related woody species.

The cost and effectiveness of small-scale fennel control methods

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Abstract

This study examined which of three methods will most effectively kill a small-scale fennel *(Foeniculum vulgare)* infestation for the lowest cost in two sites in Salinas. The methods used were: digging out individual plants with a shovel, chopping plants repeatedly during the summer with a machete, or chopping plants and immediately spraying the stumps with an application of the herbicide Rodeo (glyphosate). I discovered that the most effective method was digging each plant individually, with chopping and spraying a close second. The chopping repeatedly method was not effective at all with a mortality rate very similar to my control group. I also found that the least expensive method was chopping and spraying with chopping repeatedly a close second. Digging individual plants was the most time consuming and therefore most expensive.

Introduction

Part of the restoration process at Natividad Creek Park and Upper Carr Lake in Salinas, California involves removing the invasive plant species in the park, including fennel (*Foeniculum vulgare)*. Although the fennel in the park is currently not as widespread as in other places, it has the potential to become a much larger problem. Many studies on the control of invasive fennel have been done on Santa Cruz Island, California, where heavy agriculture practices introduced and spread fennel throughout the island's central valley. Fennel removal practices have been on a large scale and have included controlled burns and the aerial application of herbicides (Cronk, 2001). Burning was determined to be effective only in removing dead stems from the previous year to prepare the stand and make it more susceptible to herbicide applications (Erskine Ogden, 2005). Cutting the plant before applying herbicide has also been reported not to lead to a greater reduction in fennel cover, and in some cases cutting the plants inhibited the effectiveness of the herbicide because cut stems blocked the spray from coming in contact with the new growth (Brenton, 2002). Herbicides that have been determined to be effective are amine and ester formulations of triclopyr (Garlon 3A and Garlon4) and glyphosate (as Roundup), with all treatments most effective in the spring (Bossard et al., 2000).

The purpose of this project is to determine which control methods work most effectively at killing or preventing the spread of fennel in Natividad Creek Park in Salinas. In light infestations, such as those in Natividad Creek Park and Upper Carr Lake, manual and mechanical methods seem to be most effective. However, these methods are labor-intensive since individual plants must be dug out or chopped repeatedly in order to exhaust the resources in the large taproot (Bossard et al, 2000). Additionally, the heavy clay soils in Natividad Creek Park and Upper Carr Lake are very difficult to dig in, which makes the method of digging out each plant very time consuming.

This project attempted to determine which of the available physical, chemical, and mechanical methods removed *Foeniculum vulgare* in Natividad Creek Park and Upper Carr Lake with the greatest frequency of success and lowest monetary and labor cost. Three different treatment methods were tested and compared to a group of control plants. The three treatment methods were, 1) digging the plant out with the intent to completely remove the root, 2) chopping the plant every two weeks during the summer months, and 3) chopping the plant once and then applying the herbicide Rodeo® (glyphosate) to the chopped plant. Additionally, the time required for each method was recorded as were other costs, such as the price of Rodeo.

Methods

Site Description

Natividad Creek Park in Salinas extends from Boronda Road to Las Casitas. This area has many common city park facilities as well as several open fields with a mix of native and exotic plant life. The area from Las Casitas to Laurel Drive is known as Upper Carr Lake, a large pond frequented by water birds and other species, and bordered by native plant restoration sites. This area also has a bike path. Both areas are characterized by heavy, hard-packed clay soils.

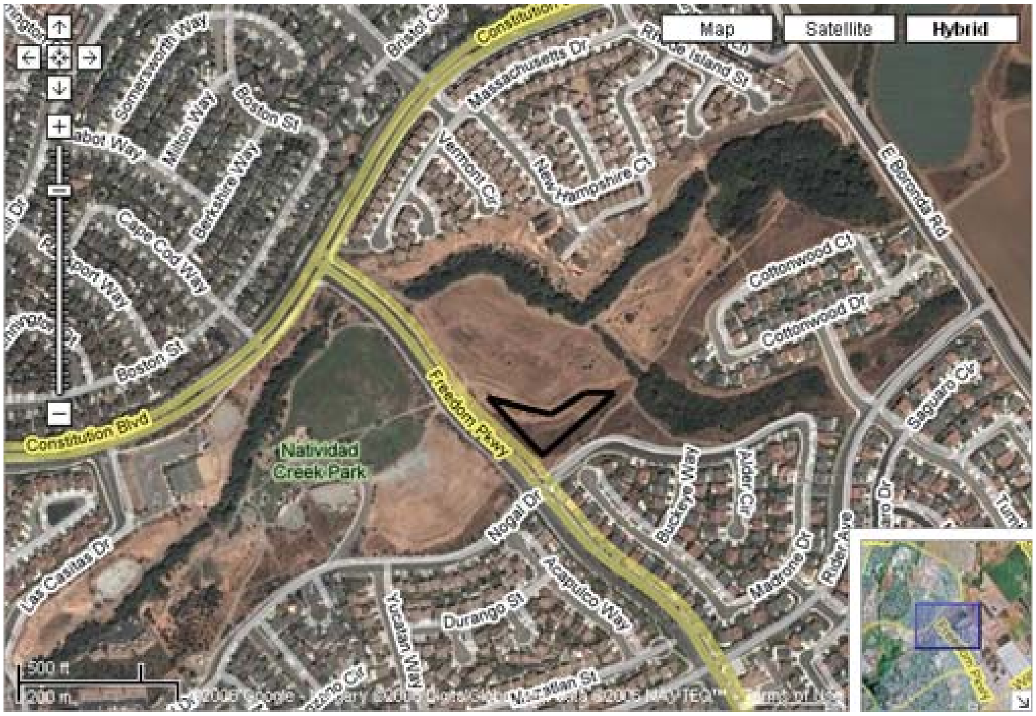
Experiment Design

Fennel plants were chosen at random in each of the two study sites and were assigned to one of four groups: a control group, a group dug up with shovels, a group chopped every second week throughout the summer, and a group chopped and immediately sprayed with a small amount of the herbicide Rodeo. Digging was done with the intention to remove the entire root crown and as much of the remaining root as possible. In both chopped groups the plants were chopped with a machete down to 20 cm above the ground. The amount of time spent on each plant was recorded. The control plants were left alone, except for the careful removal of any flowering heads to prevent seed production.

The sites used in this study were a hillside above Upper Carr Lake, and a hillside bordering a burned field in Natividad Creek Park. Figures 1 and 2 show aerial photographs and roadmaps of Site 1 at Upper Carr Lake and Site 2 in Natividad Creek Park with both sites outlined in black (Google 2006).

Choice and Application of Herbicide

Although both of the herbicides Rodeo and Roundup are formulations of glyphosate, which is effective in killing fennel, Roundup contains a surfactant, which has been shown to be lethal to amphibians (Relyea 2005, Trumbo 2005). Therefore, in order to reduce impact on native species



in the study sites and surrounding areas, the herbicide Rodeo was used, without the addition of a surfactant.

Application method was a 2.5% solution of Rodeo and water in a one-liter spray bottle. To reduce the chance of drift, the nozzle was set on "stream" rather than "spray." This herbicide solution was applied only to the cut stems of fennel plants immediately after they were chopped with a machete. While no research suggests that chopping the plant prior to application increases effectiveness of the herbicide, in this study the plants were chopped first to reduce the amount of herbicide necessary for each application. For safety, the herbicide application was accomplished by a two-person team – one person to chop the plant, and one wearing mask and gloves to apply Rodeo. Labor time for two workers was figured into the data for this treatment method. (The other methods were based on labor of one worker.)

Data Collection

DETERMINATION OF SAMPLE SIZE

Within the two Salinas sites there were individual fennel plants at different stages of development. The sites were visually surveyed on March 24, 2006 to determine an appropriate sample size. It was determined that the study should include one hundred plants, with fifty plants per site and twenty-five plants in the control group and in each of the three treatment groups.

SAMPLING PROCEDURES

On June 26, 2006, one hundred fennel plants were selected. The position of each plant was recorded using Trimble® GPS equipment and each plant was flagged and then randomly assigned to either a treatment method or the control group. Treatment began on July 10, 2006, and monitoring was conducted every two weeks during the summer months. Monitoring included chopping any new growth on the plants in the "chop repeatedly" group, and removing the flower heads from the control plants. All plants were evaluated on September 4, 2006, to measure the effectiveness of each treatment method. The plants were categorized as either "dead," "stressed" or "alive." To be considered dead, a plant could not have any new growth or any green on its stem. The term "stressed" was applied to plants with wilted, yellowed leaves or drooping stalks. Plants with green leaves and stems and any sign of new growth were categorized as "alive."

DATA ANALYSIS

The data collected was recorded in Microsoft Excel and analyzed. The total time spent on each plant, as well as mean time per method, was computed. This was converted into mean cost per method by assuming a pay rate of $10 per hour for a single person. The survivability of plants per method was tallied in Excel and imported into SPSS. A chi-squared test was run on the data of the survivorship versus the method used.

Results

Effectiveness at Killing Fennel

The most successful treatment method, resulting in 100% mortality, was digging ~~out~~ individual plants. Chop and spray was a close second with 96% mortality. The method of chopping each plant repeatedly was completely ineffective, resulting in survivability very similar to that of the control plants (Chi-Square = 67.706, $p<0.001$) (Figure 3).

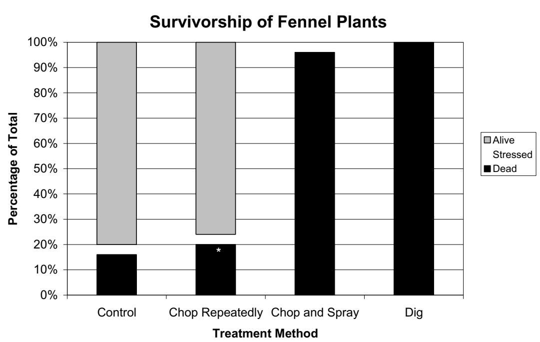


Figure 3.

The cumulative percent of fennel survivorship in each of the four treatment methods.

*Two of the plants listed as dead in the chop repeatedly method were missing during the assessment.

Cost per Method

The most expensive method was digging, with an average cost of $3.49 per plant. The least expensive was to chop and spray each plant, with an average labor cost of $0.16 per plant. This does not include the cost of herbicide used. Chopping each plant repeatedly was also fairly inexpensive. (Figure 4, Table 1)

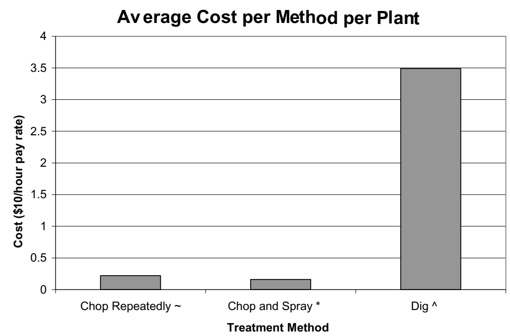


Figure 4.

The average cost of labor for each method (not counting the control), assuming a pay rate of $10.00 per hour.

~ Includes cost to chop 5 times (every 2 weeks from July 10th to September 4th).

* Does not include cost of Rodeo. Includes cost of two people per plant.

^ Assuming $10/hour using a shovel. Time may be different with other digging tools.

Discussion

These results show that chopping and spraying each plant with herbicide was the most effective and least expensive method. However, this did not take into account the cost of the Rodeo used. About half of the one-liter mixture was left after treating all 25 plants in the chop and spray group. Rodeo sells for about $50.00 - $60.00 per gallon. Digging was the most effective at killing the fennel plants but it was extremely time consumptive with each plant averaging about 20 minutes to dig out and one notable plant taking over an hour – 68 minutes – to dig out.

The tools used in this study were a shovel and a machete. It is possible that the time needed to dig out individual plants could

	Chop Repeatedly	Chop and Spray	Dig
Average Cost	0.22	0.16	3.49
Minimum Cost	0.06	0.06	0.36
Maximum Cost	0.77	0.31	11.33

Table 1.

The average cost of each method per plant, as well as the range of cost. (Note the maximum cost for digging). Each method involved 25 plants.

have been reduced by the use of a Pulaski; however, it would have been difficult to judge how much of each plant's root was removed. The machete was chosen for its ability to chop through an entire plant in a couple of seconds; however, pruning tools might be more effective on plants that have tough, dead stalked mixed in with live growth or stems growing along the ground.

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The proliferation of *Arundo donax* in Arroyo Las Posas

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This study examines the growth of arundo (*Arundo donax*) in the Arroyo Las Posas section of Calleguas Creek. The arroyo is a formerly ephemeral stream which now carries water on a perennial basis due to increasing development in the region. In this investigation, a series of aerial photos taken between 1980 and 2005 was used to map vegetation and other landcover in the river channel and its immediate environs. Changes in the areal extent of riparian vegetation and the open channel area were assessed quantitatively using a GIS system.

Precipitation and stream gauge data for the 25-year period were obtained and evaluated for their role in vegetation establishment and growth, as well as in channel scouring and erosion. The proportion of vegetation attributable to arundo was determined for the photos where the quality of images permitted, and its progression mapped. Temporal changes in the abundance of arundo were quantified and possible factors contributing to these changes were assessed.

The results of the study show the increasing establishment of vegetation in the channel since 1980. Although channel vegetation has been periodically diminished during episodes of heavy precipitation, and the accompanying heavy flow volumes, vegetation has increased more than threefold between the years of 1980 and 2005. Arundo now constitutes a significant part of all channel vegetation, and by 2005 more than half of the area mapped was infested. In contrast, the total area covered by all types of channel vegetation in 1980 constituted less than one-third of the area mapped.

The effect of native forb abundance on invasion resistance in California grasslands

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Yellow starthistle (*Centaurea solstitialis*) negatively impacts California grasslands through losses of forage quality, native species, and landscape aesthetics. We investigated whether shifts in native species' abundances affect the susceptibility of grasslands to starthistle invasion. This is important because changes in species abundance are more common than species extinctions, and ecosystem functions such as invasion resistance may be mediated by such changes.

We created simplified grassland microcosms consisting of varying abundance levels of the native tarweed *Hemizonia congesta* subs. *luzulifolia* and a functionally contrasting, dominant grass, *Bromus diandrus*. We invaded half the microcosms with starthistle and measured plant biomass, soil moisture, nutrient availability, and starthistle flower and Hemizonia seed numbers.

Declining *Hemizonia* abundance increased microcosm susceptibility to starthistle invasion, with a non-linear relationship between Hemizonia abundance and invasion resistance: small declines in *Hemizonia* abundance produced little loss of function, but larger declines produced an accelerating loss of invasion resistance. Starthistle invaded even at high *Hemizonia* abundances, indicating that restoration using solely supplemental *Hemizonia* seeding may not control invasion. Interestingly, *Hemizonia* continued to contribute to invasion resistance at low abundances, indicating that even rare forbs may be important in protecting California grasslands from invasion.

Ventura River arundo removal demonstration project

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The Ventura County Resource Conservation District (VCRCD) and the Ventura County Watershed Protection District (VCWPD) have conducted a cost-analysis study of four removal methods for arundo (*Arundo donax*) on a demonstration site on the Ventura River. The project is funded by the Wetlands Recovery Project Task Force, Coastal Conservancy, California Department of Fish and Game, and Ventura County Watershed Protection District. A five-acre site was divided into four different sections with each section utilizing a specific removal method as listed: 1) cut-stump application of herbicide and biomass removal; 2) foliar application of herbicide with no biomass removal; 3) biomass removal only; and 4) hand-removal of all vegetative matter including rhizomes. The costs of labor, materials, and equipment were extrapolated to show the range of total expenses for each method when density and acreage are similar. While Method 1 was the most expensive, it was also the most efficient initial removal method. Methods 2 and 3 were similar in cost. However, Method 2 requires biomass removal after the arundo stand is dead to avoid wildfire fuel build-up and flood debris build-up, which is an additional cost. Method 3 removes the biomass, but does not have any effect on the regrowth of arundo, as stands will regrow to their former heights within a year or less. Method 4 was effective on the removal of biomass, but any missed rhizome pieces regrew to form new arundo canes. Method 4 was also exponentially more expensive than the other methods utilized.

Preventing horticultural plant invasions through collaboration: The Cal-HIP model

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Many government and environmental groups have made headway removing invasive plants once they've taken root, but what if we could prevent invasions before they start? The horticultural industry is starting to answer that very question. The California Horticultural Invasives Prevention (Cal-HIP) partnership is a collaborative effort to prevent garden and landscaping plants from invading California's natural wildlands. Nurseries, landscapers, wholesalers, retailers, scientists, environmental groups and governmental agencies have joined forces to find voluntary solutions to the invasive plant problem – solutions that can protect the environment and strengthen the gardening community. Sustainable Conservation, a San Francisco-based environmental organization, manages this collaborative effort. Cal-HIP is creating tailor-made solutions through a transparent, participatory process for the horticultural community to self-regulate the growing and selling of invasive plants.

The poster will contain details on how Cal-HIP partners are finding practical ways that gardeners and the industry can make the transition from invasive plants to non-invasive alternatives. The Cal-HIP collaborative model can work in other states across the nation that are seeking voluntary, win-win solutions to the threat of invasive garden plants, and similar efforts in other states (including CT, MA, FL, and WA) will be presented. The poster will feature Cal-HIP's accomplishments to date and outreach materials will be made available.

Water, salt, and pepper: *Lepidium latifolium* invasion potential along a salinity and moisture gradient

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Lepidium latifolium is an exotic species that invades upland and wetland sites in both salt and freshwater. This study examined how *L. latifolium* characteristics such as inflorescence number, seed production, seed viability, seed longevity, and dispersal influence the susceptibility of these landscapes to invasion. Three sites in the San Francisco Bay Estuary were chosen with varying salinity and moisture levels. Results demonstrated that inflorescence number was unaffected by salinity ($P=0.4105$) or soil moisture ($P=0.4590$). Seed production was significantly affected by salinity ($P=0.0428$) and moisture levels ($P=0.0005$). Salt water seed production was reduced by 29% from freshwater sites. Seed production at the wet site had an 89% reduction from the dry site. Seed viability was reduced by both salinity ($P<0.0001$) and soil moisture ($P=0.0005$). Viability at the highest salinity site was reduced by 49% from freshwater sites. Viability was reduced by 8% from the wettest to driest sites. Seed longevity showed no decline in viability seven months after dispersal at all sites. Seed dispersal was compared only to salinity and showed a 0.5 m increase at freshwater sites, but was not statistically significant ($P=0.1163$). With the increased seed production and viability, drier freshwater sites experience much greater propagule pressure. Although dispersal distances were not significantly different between sites, with the increased propagule pressure, even a minor increase may result in increased invasion potential. Therefore, land managers must be extra vigilant in drier freshwater sites to prevent the accelerated spread of *L. latifolium.*

Riparian revegetation outcomes on California north coast ranches

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We are researching revegetation effectiveness and restoration trajectory of riparian habitat in coastal California. Our poster compares species specific results and vegetation groups using preliminary results from 102 sites surveyed in a cross-sectional post project analysis. Project sites of various ages have been characterized to compare site outcomes given the original methods of restoration utilized. Project sites selected were tributary stream corridors in Marin, Sonoma, and Mendocino Counties ranging from four to forty years since revegetation was initiated.

Validating desired outcomes from conservation projects and measuring unanticipated results is an important step to preserve California's floristic diversity. Our preliminary results indicate native tree density and species richness have a direct relationship with project age; however, perennial exotic cover also increases over time. Conversely, annual exotic species are often abundant at young project sites, their cover is significantly less at the older project sites. Vegetation management may become a more important consideration as restoration sites mature. Our results are also identifying temporal opportunities for Himalayan blackberry *(Rubus discolor*) management. Specifically, the 10 to 20 year age group may offer points of intervention to limit floodplain invasions of *R. discolor.*

From our results, it is clear that practical tools are needed to combine weed management with landowner concerns, which may increase participation in watershed restoration efforts. The question that needs to be answered is, how can vegetation management be effectively utilized in riparian corridors as a tool for optimizing floristic diversity while maintaining other riparian functions?

Testing methods of weed management in the restoration of Riverside County old fields

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The high rate of urban development in California has put increasing pressure on open spaces to accommodate mitigation. In the case of the Quino Checkerspot butterfly (QCB), a federally endangered species, old fields in western Riverside County were used as mitigation under an agreement to restore the area from exotic grassland to native plants important to the QCB. Restoration experiments were conducted for two years in order to determine the best site-specific method. Experiments included five m^2 plots using disking plus post-disking treatments of grass-specific herbicide, mowing, or winter solarization, seeded with a mix of natives. In the second year, herbicide and mowing treatments were repeated on first year plots with new control and solarization plots. Treatments were evaluated using percent (%) cover, diversity and biomass of native and nonnative plants. Disking alone reduced nonnative grasses, but solarization was most effective in reducing nonnatives in both years. Solarization also produced the highest percent cover of natives in both years, including natives important to the QCB. Native diversity was greatest in solarization plots in the first year, but equal between first year solarization and herbicide plots in the second year. Herbicide application reduced nonnative species and increased native species over disking or mowing, but produced higher exotic forb biomass than solarization plots in the second year. Mowing reduced grass biomass and cover in both years, but did not improve native establishment over disking. Results suggest that solarization is the most effective restoration method, but that grass-specific herbicide is a useful alternative.

Invasive plant management and restoration at the landscape scale: Assessment and mapping techniques

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Invasive plants pose a significant threat to riparian and wetland habitats. The remaining riparian and wetland habitat in the Russian River watershed is undergoing a rapid transformation as plant invasions modify various ecological processes within these biologically diverse areas. In collaboration with our partners and funders, we have developed a landscape-scale program to reverse the impacts of *Arundo donax* in the Russian River riparian corridor. This watershed approach to invasive plant management is unique, in that it comprehensively addresses the entire infestation in the Russian River basin (over 300 acres) by integrating scientific research, landscape-scale mapping and GIS analysis, landowner investment and engagement, community education and active riparian habitat restoration. Mapping consists of an initial screening assessment via aerial flight and low-level photography, followed by detailed ground reconnaissance using ArcPad technology. All information is then entered into a GIS database. In collaboration with Sotoyome and Mendocino RCD, we have developed a broad partnership of supportive landowners, natural resource agency staff and funders. Together, we have made a long-term commitment to removing this highly invasive exotic plant and restoring native riparian habitat in the Russian River watershed.

Molecular evidence supporting the horticultural origin of invasive jubata grass (*Cortaderia jubata*)

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Jubata grass, a native of the Andes of South America, has become an aggressive invader of natural areas in many parts of the world, including California, Hawaii, New Zealand, Australia, and South Africa. It is believed to have been introduced into California through the horticultural industry but, unlike the widely planted, invasive pampas grass (*C. selloana*), jubata grass has a limited history of cultivation. To gain insight into jubata grass's introduction pathway, we analyzed genetic variation in invasive and native populations. Using nuclear microsatellite markers, we genotyped 235 plants from 22 populations throughout California, 28 plants from the island of Maui, 16 herbarium specimens from New Zealand, 80 herbarium specimens from Ecuador, Peru, and Bolivia. All invasive plants from California, Hawaii, and New Zealand consisted of a single genotype, i.e. a single clone, consistent with jubata grass's asexual reproduction by seed. A native clonal genotype found to be widespread in the southern part of Ecuador matched the invasive genotype. The geographical distribution of this clone in Ecuador includes the area from which native jubata grass seed was brought into cultivation in Europe. Molecular data suggest that the introduction of this clonal genotype from South America into cultivation in Europe was probably followed by horticultural introductions of jubata grass from Europe to California and New Zealand. In contrast, the more recent invasive populations in Maui may have originated by dispersal from invasive populations in other invaded areas.

Assessment of treatment effectiveness and relative cost of giant reed (*Arundo donax*) removal in the Tijuana River Valley

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Over the last two years, EcoSystems Restoration Associates has been treating giant reed (*Arundo donax*) in the Tijuana River Valley as part of the Southwest Wetlands Interpretive Association efforts to control invasive weed species in the river valley. In the Tijuana River Valley giant reed occurs in a patchy distribution in comparison to the large, dense stands that are more typical in San Diego County. The patchy distribution of giant reed, which occurs amongst native riparian woodland, and open water areas has created a challenging situation to cost-effectively control giant reed. The control techniques utilized included foliar herbicide treatment on intact and trampled stands of giant reed, as well as cut-stump treatment. The foliar herbicide treatments included the applications of 6% and 8% glyphosphate. The greatest control was achieved through foliar application of 8% glyphosphate, which resulted in complete dieback within 3 weeks. The 6% glyphosphate application generally resulted in approximately 60-80% dieback of the stand. Lastly, the cut-stump treatment was overall unsuccessful with nearly 100% re-growth, although these results varied by year and appeared to be affected by increased rainfall. From a cost perspective, the cut-stump treatment was approximately equal in cost to the 8% herbicide treatment. These results are contrary to our original expectations. We attribute the small cost differential to the increased herbicide usage in the foliar treatment and the need to traverse the approximate 130 acre treatment area on foot to locate the giant reed stands.

Prospects for biological control of Russian thistle (tumbleweed).

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Russian thistle (tumbleweed, *Salsola tragus*, Chenopodiaceae) is an alien weed that first appeared in North America in the 1870s and has invaded about 100 million acres in the western U.S. Because it is alien and is not closely related to any native North American species, it has been targeted for classical biological control (Goeden and Pemberton 1995, Pitcairn 2004). The plant is native to central Asia and historically has been called *S. australis*, *S. iberica*, *S. kali*, and *S. pestifer* (Mosyakin 1996). Similar weedy species in North America include *S. paulsenii* (barbwire thistle) and *S. collina* (slender Russian thistle). Two species of moths (*Coleophora klimeschiella* and *C. parthenica*) were introduced in the 1970s (Goeden 1973). These became widespread, but predators and parasites prevent them from being abundant enough to control the weed (Goeden et al. 1987, Müller et al. 1990). Further foreign exploration in the Mediterranean Region led to the discovery of several prospective new biological control agents (Table 1). Evaluations conducted by R. Sobhian (USDA-ARS, European Biological Control Laboratory) demonstrated that two of these are specific enough to warrant further evaluation, and that two should be eliminated from further consideration.

The blister mite destroys young growing tips, stunting the plant and preventing development of flowers. The blister mite has been evaluated for host plant specificity and its ability to damage the plant in quarantine experiments at the USDA-ARS quarantine laboratory in Albany, CA. These studies demonstrated that the mite attacks only a few closely related species of *Salsola*, all of which are invasive alien weeds. A petition was submitted to TAG in December 2004 (Smith 2005), and TAG recommended approval of release in August 2005. An application for a release permit was submitted to USDA-APHIS-PPQ in November 2005. APHIS has not yet completed review of the permit application.

The moth, *Gymnancyla canella*, commonly attacks Russian thistle on beaches of southern France. Larvae feed on developing seeds and stems, causing extensive damage. Host specificity tests have been conducted for several years at Montpellier France and in the Albany quarantine laboratory and are expected to be finished in another year.

Foreign cooperators are exploring new regions in Central Asia (Turkey, Kazakhstan and Uzbekistan) and have discovered many species of beetles attacking Russian thistle. Several of these are thought likely to be host-specific (Table 1). Initial experiments to evaluate host plant specificity are beginning conducted by cooperators in Russia and Italy. Access to this region greatly improves our chances of finding safe, effective biological control agents.

These new biological control agents should help reduce the populations of this weed to innocuous levels over extensive regions. Successful biological control would provide self-perpetuating long-term management of this weed, reduce the need to apply pesticides, and increase the productivity and utility of millions of acres in the western U.S.

In anticipation of obtaining permission to release the blister mite. We have begun to select sites in a variety of climatic zones in California and collect baseline data on *Salsola* abundance.

Table 1.

Status of prospective biological control agents of Russian thistle.

Taxonomic name	Common name	Current information
Evaluated species		
Aceria salsolae (Acari: Eriophyidae)	blister mite	The mite attacks developing tips. Petition "approved" by TAG, release permit submitted to APHIS (Smith 2005).
Gymnancyla canella (Lepidoptera: Pyralidae)	seed and stem moth	Caterpillar feeds on seeds and young branch tips. Host specificity testing almost completed.
Colletotrichum gloeosporioides	rust	More damaging to Russian thistle type A than to type B (Bruckart et al. 2004). Being evaluated by W. Bruckart USDA-ARS, Maryland.
Uromyces salsolae	rust	Damages Russian thistle type A (Hasan et al. 2001). Being evaluated by W. Bruckart USDA-ARS, Maryland.
Kochiomyia (=*Desertovelum*) *stackelbergi* (Diptera: Cecidomyiidae)	gall midge	Uzbekistan strain attacks *Salsola* type A more than type B. Apparently requires a yet unidentified fungal symbiont to reproduce (Sobhian et al. 2003b). Research suspended.
Lixus incanescens [=*salsolae*] (Coleoptera: Curculionidae)	stem weevil	Adults feed on many plants in choice test at Montpellier, France (Sobhian et al. 2003a). Rejected.
Piesma salsolae (Hemiptera: Piesmatidae)	plant bug	Develops on beets in no choice lab test at Montpellier, France (R. Sobhian pers. com.). Rejected.
New species		
Anthypurinus biimpressus (Col.: Curculionidae)	jumping weevil	Found in Tunisia in 2004. Larvae and adults feed on leaves. Biology is unknown.
Baris przewalskyi (Col.: Curculionidae)	weevil	Abundant on *Salsola* in Kazakhstan in 2004. Biology is unknown.
Salsolia morgei (Col.: Curculionidae)	weevil	Found in Kazakhstan in 2004. Reported to be monophagous.

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Managing rangeland invasive plants with Aminopyralid (Milestone™)

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Abstract

Aminopyralid (Milestone™) is a new herbicide developed by Dow AgroSciences for use in rangeland, pasture, wildlands, and rights-of-way to control susceptible herbaceous broadleaf plants including Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*), spotted knapweed (*Centaurea maculosa*), yellow starthistle (*Centaurea solstitialis*), diffuse knapweed (*Centaurea diffusa*), and Russian knapweed (*Acroptilon repens*). Research trials were initiated in 2000 to 2006 on rangeland sites in western and Midwestern states to assess the response of key invasive and noxious plant species to aminopyralid. Herbicides were applied with a backpack sprayer delivering 15-20 gallons per acre. All plots were evaluated for percent visual control at least in the season of application and the summer following treatment. Aminopyralid at 3 fl oz product/acre provided excellent control on bolting musk thistle and rosette yellow starthistle. Aminopyralid at 6 fl oz product/acre applied to bolting spotted knapweed provided excellent control of established plants and preemergence control of seedlings for two years after treatment. Aminopyralid at 5 to 7 fl oz product/acre at pre-bud to bolting growth stages provided excellent control of Canada thistle, diffuse knapweed, and Russian knapweed for at least one year after application. Aminopyralid controls these invasive plants at reduced use rates compared to rates of current commercial herbicides, including 2,4-D, picloram, clopyralid, and dicamba, required to achieve the same level of control. Over 20 perennial grass species have shown excellent tolerance to applications at labeled rates. Aminopyralid will have an excellent fit in invasive plant management systems designed to restore degraded USA rangelands.

Introduction

Aminopyralid (DE-750®) is a new pyridine carboxylic acid herbicide intended for use in rangeland, permanent grass pastures, industrial vegetation management areas (including rights-of-way for roads, railroads and electric utility lines), natural areas (wildlife management areas, natural recreation areas, campgrounds, trailheads and trails), grazed areas in and around these sites, wheat, barley, sorghum and oil palm and rubber plantations. This Dow AgroSciences compound was designed and developed specifically for the control of noxious and invasive weed species in rangeland, pastures and industrial vegetation management sites. Aminopyralid is a new generation active ingredient that is effective at very low rates as compared to currently registered herbicides with the same mode of action, including 2,4-D, clopyralid, triclopyr, picloram and dicamba. Aminopyralid is a broadleaf weed herbicide that provides systemic, postemergence control of noxious and invasive annual, biennial and perennial weed species, agronomically important weeds and certain semi-woody plants. Aminopyralid can provide residual control, thus reducing the need for re-treatment, depending on the rate applied and the target weeds. Currently aminopyralid has a federal EPA registration and once California registration is completed will be offered for sale in the state. There are federal registrations as a stand-alone product (MilestoneTM) and in a premix with 2,4-D (ForeFront™ R&P). Globally there are also registrations with aminopyralid alone and with mixtures of fluroxypyr or triclopyr.

Unmet Needs in Rangeland and Pastures, Rights-of-Way and Wildlife Management Areas

One of the most serious problems facing landowners and land managers for rangeland and pastures, rights-of-way and natural areas is the rapid spread of noxious and invasive plants. Non-native invasive plants have been introduced into new habitats without the natural enemies that limited their reproduction and spread in their native habitats. These invasive plants are spreading rapidly in many areas. The infestation rate on Federal lands in the U.S. is now approximately 4,600 acres per day. The U.S. Geological Survey reports that some $20 billion in damages can be linked to invasive plants. When left uncontrolled, invasive weed species are a form of biological pollution and produce many direct and secondary negative effects. These effects include the creation of plant monocultures that negatively impact endangered species, crowd out native species that are essential to properly functioning ecosystems, reduce production of forages used by game and livestock through competition and allelopathy, reduce rangeland carrying capacity, increase livestock production costs, increase soil erosion, increase rights-of-way maintenance needs and degrade the aesthetic qualities of desired plant communities.

Properties of Aminopyralid

Mode of Action

Plant growth is a complex process that is controlled, in part, by a variety of plant growth regulators, including auxin compounds. To ensure proper growth, plants produce very controlled amounts of these materials. Auxins bind to specific cell surface receptor proteins, turning on and off vital plant processes. Aminopyralid is an herbicide possessing auxin-like qualities. Aminopyralid moves systemically throughout the plant and deregulates plant growth metabolic pathways affecting the growth process of the plant. This disruption of plant growth processes, by binding of aminopyralid at receptor sites normally used by the plant's natural growth hormones, results in control and death of susceptible plant species.

Absorption/Translocation

Aminopyralid is a systemic, phloem and xylem mobile herbicide that is rapidly absorbed by the leaves and roots. The compound translocates throughout the plant and accumulates in the meristematic tissue, resulting in uneven cell division and growth.

Herbicidal Activity

Symptoms are typical of those for the auxinic mode of action. Within hours or days of application, depending on the weed species, aminopyralid causes symptoms such as thickened, curved and twisted stems and leaves, cupping and crinkling of leaves, stem cracking, narrow leaves with callus tissue, hardened growth on stems, enlarged roots and proliferated growth. Most annual susceptible weeds are controlled within four to eight weeks after application. Complete kill of main stems and the root systems of woody and semi-woody plants may require two or more months after application. Plant growth will stop within 24-48 hours after treatment.

Crop Tolerance

Aminopyralid offers a high level of tolerance on a wide range of temperate and tropical forage grasses and on small grain cereals. More than 20 different forage grasses evaluated in field trials from 1999-2004, with aminopyralid applied at rates up to 2 times the maximum use rate, demonstrated tolerance to aminopyralid. The grasses evaluated included *Agropyron sp.*, *Andropogon gerardii*, *Andropogon saccharoides*, *Andropogon scoparius*, *Bouteloua curtipendula*, *Bouteloua gracilis*, *Brachiaria bryzantha*, *Brachiaria decumbens*, *Bromus inermis*, *Buchloe dactyloides*, *Cynodon dactylon*, *Cynodon nlemfuensis*, *Cynodon plectostachyus*, *Dactylis glomerata*, *Digitaria decumbens*, *Eragrostis ciliaris*, *Festuca sp.*, *Lolium sp.*, *Panicum maximum*, *Panicum virgatum*, *Paspalum notatum*, *Phleum pratense*, *Poa sp.* and *Sorghastrum nutans.*

Summary

Aminopyralid at 4 to 7 fl oz product/acre at bud to bolting growth stages provided excellent control of Russian knapweed. This flexibility in control will result in a wide window for applications, from bud through fall. Overall management of Russian knapweed infested areas must include re-vegetation if no under story grass/grass seed is present. Aminopyralid at 5 to 7 fl oz product/acre at the pre-bud growth stage provided excellent control of Canada thistle for at least one year after application. Spring bolting and fall regrowth application timings have typically provided similar levels of control. Canada thistle control with aminopyralid was equal to picloram and clopyralid alone. Canada thistle control with aminopyralid was better than other common treatments. Aminopyralid at 3 fl oz product/acre also provided excellent control of rosette stage yellow starthistle for at least 1 year after application. Applications on seedlings and rosettes have typically controlled plants and newly emerging seedlings for one plus years.

Aminopyralid (Milestone™) will provide excellent postemergence control of a large number of broadleaf weeds including many noxious and invasive plants. It will also provide residual control of new seedlings. Additionally, it has exhibited excellent tolerance on a wide range of warm- and cool-season forage grasses and will have an excellent fit in integrated plant management programs.

Control of Phalaris aquatica on lowland coastal terrace prairie in Richmond, CA

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The Richmond Field Station supports one of the last remnants of coastal terrace prairie within the surrounding San Francisco Bay Area. This prairie contains remarkable diversity, comprised of over 55% native plant cover in the grassland's interior. Large infestations of invasive *Phalaris aquatica* surround the prairie, and pioneer populations have begun establish in the core section. In order to reduce the spread of this species, and to inform restoration efforts in similar habitats, test plots were established to evaluate different control techniques. A spatial analysis of locally rare plant distribution data was first used to rank and prioritize patches *P. aquatica* for removal. Control methods include hand-removal, herbicide application, mowing, brushcutting, and recycled carpet cover. After two seasons of implementation, preliminary monitoring indicates that treatment effectiveness varies widely. With the combined experimental *P. aquatica* treatments, and this prioritization strategy, this project aims to develop an effective and adaptive approach for restoration in an environment of limited resources.

Determining the best management technique for Italian thistle

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Negative impacts on various native plant communities in California have been recorded for the Italian thistle (*Carduus pycnocephalus* L.). As its impacts (and control) may be closely related to community type, we investigated the efficacy of various methods of control in a coastal sage scrub preserve (Coyote Hills East) in Fullerton, Orange County, CA. We studied the impacts of five mechanical and chemical treatments (nested within two more general conditions of biomass removal) on control of Italian thistle and effect on native plant species. Three plots were selected and each divided into 36, 1 m^2 quadrats. On half of the quadrats, all dead biomass was removed to determine if biomass removal improves efficacy of other treatments. Within each 18-quadrat block, five treatments and a control were replicated three times. Treatments consisted of: 2% Round-up Pro applied to basal rosettes, hand-pulling basal rosettes, and mowing with 1%, 5%, or 10% of thistles flowering. All treatments significantly decreased the number of flowers and percent cover of thistle compared to the control by at least 66%. Herbicide was most effective with a 99% reduction in the number of thistle flowers, regardless of whether or not biomass had been removed. Mowing when 5% of the thistles were flowering was the second most effective with a 97% decrease in the number of thistle flowers. The dead biomass seemed to have a mulching effect, reducing the overall cover of thistles, but there was also evidence that it could be suppressing the native California sagebrush, *Artemisia californica*.

Working and Discussion Groups

Horticulture

Facilitator: Mark Newhouser, Sonoma Ecology Center and Cal-IPC Board of Directors

Note Taker: Terri Kempton, Sustainable Conservation

Meeting objectives:

- discuss strategies to prevent the introduction of horticultural invasives
- share experiences working with nurseries
- create a list of best practices in working with nurseries on the issue of invasive species

Terri Kempton gave an update on the California Horticultural Invasives Prevention (Cal-HIP) partnership.

Cal-HIP has 20 steering committee members that represent the horticultural industry, environmental groups, academics, arboreta, and government agencies. The group adopted objective, scientific criteria for assessing the invasiveness of horticultural plants in wildlands that were developed by the California Invasive Plant Council. The steering committee reviewed these independent scientific assessments and vetted their findings with the Cal-HIP stakeholder communities.

Because California is such an ecologically diverse state, Cal-HIP decided to address horticultural invasive plants on a regional basis. The group wanted to avoid creating a state-wide list of invasives that wouldn't apply to all areas and could be easily disregarded. After careful consideration of the major ecosystem types in the state, and the need to clearly communicate the message about invasive plants, the group settled on a five-region system for California, based on the Sunset Garden Climate Zones: North and Central Coast, South Coast, Central Valley, Sierra Nevada, and Desert.

Some invasive species have outstanding questions, and Cal-HIP is guiding research to fully investigate their biology, dispersal mechanisms, and ecological impact. A complete list of the invasive plants (to be regionally listed) and the plants under investigation, see Appendix A.

The Cal-HIP Steering Committee, working with professional marketing consultants, is developing a unified outreach campaign called "Plant Right" to educate the industry and the public about how they can prevent invasive plant introductions through horticulture.

First, Cal-HIP will focus on outreach, education, and support of the California horticultural industry to provide information and assistance to growers, nurseries, and landscapers as they phase out invasive plants and promote non-invasive alternatives. To ensure that consumer demand reflects these changes in the industry, Cal-HIP will then lead a campaign to educate and motivate the gardening public to purchase and plant non-invasive species. Materials may include a dynamic website and informational brochures, posters, FAQ sheets, and wallet cards. "Plant Right" information can be included in curricula, landscape certification programs, and trainings for nursery professionals and home gardeners.

By the next Cal-IPC Symposium, Cal-HIP should have "Plant Right" materials to share with attendees and could run a workshop to train interested members to work with nurseries to eliminate horticulture as a vector for invasive plant introductions.

The group identified two tactics to approaching nurseries and affecting their decisions regarding invasive species: top-down (like Cal-HIP) and bottom-up (grassroots efforts). The latter was the focus of this working group.

Betty Young has been working with Kate Symonds on an action plan devised by the Marin/Sonoma Weed Management Area (WMA). Since demand drives retail choices, this group worked with the local RCD, landscapers, the Sonoma Ecology Center, and CNPS to develop materials in hard-copy and CD-ROM to educate the public about horticultural invasives. They web researched and used suggestions of non-invasive alternative plants from Cal-HIP and adapted them to the Marin/Sonoma area. The materials they created explain the importance of horticultural invasives, giving the general public good reasons to change their behavior.

One of the materials is a questionnaire that serves as a guide to non-confrontational conversation with nurseries about invasives. Members of the WMA divided all of the nurseries in their area between them for direct contact. While passive observing of nursery stock is an easy task, recruiting volunteers for this type of conversation has proven difficult.

The working group discussed grassroots efforts to affect nursery decisions about invasive plants. Participants agreed that repetition of the message will be critical, and that the more sources saying the same thing about horticultural invasives, the more effective that message will be. The group identified the following list of best practices and further needs:

- Staff members to conduct outreach
- Backup of consistent Ag. Commissioner response to specific invasive plants
- Master Gardeners to conduct outreach and education
- Potential program to be developed: "Adopt a Nursery" to pair volunteers with nurseries
- Speakers at CANGC meetings and other trade events
- Correcting recommended plant lists that currently include invasives
- Supporting research to isolate weedy cultivars

The group then set goals for where they would like to see things by next year:

- More volunteers talking with nurseries
- Distributing more regional materials to nurseries and the public
- More participation in horticulture sessions in the 2008 Cal-IPC Symposium
- A workshop to train Cal-IPC community on working with nurseries, presented by Cal-HIP and the PlantRight program
- Participants in this working group returning to their communities, reviewing the Marin/Sonoma WMA materials, and generating their own goals for outreach in the coming year

Mapping

Facilitator: Steve Schoenig (CDFA)

Topic leader: Jason Giessow (DENDRA, Inc)

Note taker: Jason Casanova (Los Angeles & San Gabriel River Watershed Council)

10:30am/Introductions

10:35am Updates on Current Mapping Projects (NSDI, UC IPM)

Steve Schoenig began the discussion with a review of recent mapping subcommittee projects.

Statewide map of Arundo (underway)

- Southern California (data being currently being assembled through WMA funding)
- Team Arundo del Norte (funding for mapping provided by Calfed)
- Central Coast Mapping – San Luis Obispo County data being assembled by Marc Lea at the County Agricultural Department.

NSDI Grant

Deanne Dipietro (Sonoma Ecology Center) wrote a grant proposal on behalf of Cal-IPC for USGS NSDI (National Spatial Data Infrastructure) funding. Cal-IPC received $20,000 to coordinate data aggregation statewide through a consortium. The mapping workgroup met in June 2006 to discuss existing mapping efforts, standards, data sharing, and planned consortium initiatives. The group is currently developing a set of web resources (see *Mapping* on the Cal-IPC site) as well as a metadata portal to the CERES (California Environmental Resources Evaluation System) catalog. Other short term efforts include developing presence-absence maps for Cal-IPC listed weeds.

UC IPM Grant

Cal-IPC received a grant from the Statewide Integrated Pest Management Program to develop spatial predictive models for select invasive species. Criteria for the model will include temperature, rainfall, biology, etc. Results will show where each weed is predicted to survive and can lead to large-scale estimates of impact and removal cost.

11:00am Cataloging, Coordination, and Sharing of Existing Data

Jason Giessow led the discussion on data sharing. To avoid reinventing the wheel, Cal-IPC is proposing two existing avenues that could be used to host data online:

1. California Dept of Fish and Game is currently hosting an ArcIMS called BIOS (bios.dfg.ca.gov). Intuitive site with infrastructure in place. Contains comprehensive base data layers. Could potentially be used for posting locally-driven “Red Alert” species as well as statewide datasets (*Arundo donax*, *Brassica spp., etc.*)
2. Calflora. Site currently hosts latitude/longitude coordinates for plant sightings and associated photos. Could be used to input new weed sightings (photo input makes it useful for identifying “Red Alert” species).

Other methods for sharing data could include a) hosting data on your own site or b) linking data through the Cal-IPC site.

Question*:* Is there a statewide map for yellow starthistle?

Answer (Steve)*:* Yes, CDFA has baseline data for A-rated weeds (~25 species) throughout the state (based on records from roughly 400 collaborators comprised of WMAs and Ag Departments throughout the state). Cal-IPC efforts stemming from the mapping group have also produced "red sesbania" data for most of the state (venues are currently being examined for hosting the data online).

Question: Are CDFA maps online?

Answer (Steve): No, there currently is no IMS (Internet Mapping Service) hosting the data. There are privacy concerns from landowners in regards to making the data publicly available online.

Steve reiterated the Cal-IPC presence/absence mapping effort. Cal-IPC will be sending lists to WMA to collect coarse data on ~30 species. Jason then raised the question regarding what species we should focus our mapping efforts on. And what object type should we use? Points? Polygons? Raster?

Brainstorming session began for recommending plant species. The group came up with the following list:

Also, include RED ALERT species in priority list. Several questions arose after the list was developed.

Question: Why can't Cal-IPC include a more comprehensive list of plants with some amount of detail? *(beyond just presence/absence.)*

Answer: Localized data collection will be geared toward project-specific goals and therefore each dataset will vary in detail. Cal-IPC's initial goal is baseline information and will be refined in the future to include additional information. *(Question noted for future discussion.)*

Question: Is there a site for surveyors to enter points into a database?

Answer: We are looking into options to have this functionality (see BIOS and Calflora above). *(Question noted for future discussion.)*

Comment: Google Earth should be examined to conduct rough mapping at both a local and statewide level. It's free and fairly intuitive.

Question: How often should maps be updated?

Answer: Updates will vary on the project and will be goal-driven. It will also depend on whether or not eradication will follow any field mapping efforts.

Question: Should we collect a select list or focus on RED ALERT species?

Answer: *(Question noted for future discussion.*

Question: What data model should we use?

Answer: Again, it will be goal-oriented (project-dependent). The NAWMA (North American Weed Management Association) standard has been adopted by Cal-IPC. The WIMS (Weed Information Management System) data model (similar to the California Natural Diversity Database - CNDDB) is one option that can be used for inventory, monitoring, and control. Attributes are based on the NAWMA standard (see follow-up on WIMS at the end of meeting).

11:30am 2007 Weed Mapping Field School Discussion (Brainstorming Session)

Steve Schoenig gave a brief introduction regarding the intended objectives of the field course. It is anticipated that the school will be 1-2 days. He then opened up the floor to any suggestions regarding workshop topics and class structure.

Audience suggestions for workshop topics:

- Assess how class participants may be using the data they collect in the field.
- How will the information they collect in the field translate into the statewide database?
- How can we collect and incorporate negative data into our database? Demo "tracking" function on the GPS.
- Cover GPS background (triangulation, location, navigation.). How do we assess the accuracy of the data (PDOP, differential GPS)?
- Include discussion on projections/ datum types
- Resolution (imagery resolution needed for field work); Scale (At what scale should we be mapping?)
- Cover map compilation basics in the GIS (re: final output maps)
- The audience was given two options on how the class could be presented: "hands-on" or a "how-to" presentation w/ follow-up questions. Majority vote was for the "hands-on" approach.
- Create web-based training items (tutorials via PowerPoint, PDF, etc.)
- Data types (vector vs. raster)
- Raster imagery types (true color, IR, hyperspectral, etc.)
- Resource links (Related tutorials, data sources, etc.)
- Differentiate the class sessions between inventory vs. monitoring (A quick survey of the audience showed low interest in a monitoring component; most were interested in general inventory).
- Include overview on metadata standards and metadata development
- Tools and/ methods for data collection (WIMS, Geodatabase, Mylar-Hardcopy, etc.)
- Suggestion was made to test data collection methods simultaneously ("head-to-head")
- Discuss costs associated with each method (purchase costs vs. operational costs)
- Discuss creating symbology for map output (differentiating species, portraying percent cover, etc.)
- Cover data management (discuss BMPs for data structure and organization; geodatabase setup; etc.)
- Discuss standards for field data collection (i.e. NAWMA) to create consistency amongst mappers statewide.
- Some participants recommended that the field course should be targeted toward beginners. Others suggested breaking the field class into two tracks: a beginners group and an advanced group.
- One framework suggested for the class structure:

Day 1 – GPS field class (morning session)

Importing data from the field (classroom session)

Day 2 – General issues: GPS background, data structure, map compilation (classroom session)

12:00pm Wrap-up discussion on WIMS (Weed Information Management System)

Steve briefly described WIMS to the new members of the group. WIMS is an MS Access-based database application that allows one to inventory and monitor weed infestations based on NAWMA standards. The application can be installed on a handheld unit (ex. Pocket PC), and used in conjunction with a GPS and ESRI's ArcPad to collect and update data in the field. The WIMS structure matches closely with the CDFA weed inventory database. Two-day courses are currently being offered by the Nature Conservancy and its partners on an ad-hoc basis. The software is available free for download:

WIMS 2.2b -http://tncweeds.ucdavis.edu/products/wims/installation.html
WIMS 3.0 beta - http://gforge.casil.ucdavis.edu/projects/wims

He then gave an update on the current status and future of WIMS. The current version (WIMS 3.0 beta) includes a variety of "back-end" database upgrades as well as a new interface that will insure better data integrity. WIMS 2.2 and 3.0 versions are currently not interchangeable. Databases cannot be shared between the two versions at this time. There is still some additional functionality that is planned for WIMS 3.0. Funding is being sought to continue development and provide additional training.

Outreach

Notes: David Chang

Facilitator: Peter Brastow and Wendy West

Topic Leader: Jenny Drewitz

Outreach accomplishments that are a result of suggestions from the 2005 Cal-IPC outreach working group:

- Government affairs committee, more input by Cal-IPC in legislative activity
- State and National Invasive Weed Awareness campaigns
- Expanded website, more user-friendly and functional
- More field courses
- New publications
- Speaker's bureau, with prepared talks; State divided into regions with coordinators for each region

Ideas that didn't happen from the 2005 Outreach working group include:

- More participation in events, flower shows, conferences
- Media outreach
- Mail campaign
- Documenting success stories
- School and student outreach

Outreach Suggestions/Brainstorming Session

- Reach out to California Native Plant Society meetings. Nearly every chap ter has a weed coordinator. Suggested that every CNPS weed coordinator should be identified.
- Put Speakers Bureau presentations on Cal-IPC website
- Post success stories on website. Add contact info to allow follow-up. Control strategies used by success stories could be emulated.
- Distribute brochures more widely. Have one-page printout for distribution.
- Create Cal-IPC specific listserve
- Conduct training in media outreach. Various methods to train include

media field course; symposium session on media relations. It was noted how the different audiences – landscapers, volunteers, politicians, kids, media, other environmentalists - may need customized messages.

- Make webpage to link to resources
- Put resources into newsletters
- Cal-IPC to provide support to those orgs that don't have their own resources
- Produce spots for public TV
- Produce slides for movie theaters to play while patrons wait for movies to start
- Create step by step outreach manual
- Create templates for outreach
- Create communication plans for pro jects. Social science needs to be involved. Utilize academics to teach us.

Recruitment: A sign-up list was passed around for people who were interested in helping on the Speakers' Bureau.

The group's thoughts on resources and needs were compiled into charts. Here is a summary of the charts:

Outreach Resources We Have

1) Books

   Invasive Plants of California's Wildlands (C. Bossard)

   J. DiTomaso's Aquatic and Terrestrial weeds

   Weed Worker's Handbook

2) Brochures

   Don't Plant a Pest

   Biological Pollution (introduction to invasives)

3) Cal-IPC website

   Newsletters, Symposium proceedings, Brochures, links

4) Other websites:

   UCD Weed Resource Info Center (http://wric.ucdavis.edu/)

   TNC ESAs - detailed and com plete reviews of the biology, ecology, and current best management practices for a particular species

   CDFA website, encycloweedia

5) IVM Guide by S. Daar

6) Cal-IPC Speaker's Bureau

7) Listserves: CalWeedTalk, CalWMA

8) Current conversations with nursery industry

9) Member experience! With education and outreach, with specific weeds, projects, more!

Outreach Resources We Need

1) Accessible, comprehensive list of resources

2) Multi-lingual info

3) Outreach listserve – Cal-IPC based

4) Specific plant fact sheets, with safety tips

5) List of restoration species

6) Media training, including how to contact the media

7) How to talk about invasives

   Vocabulary to use

   Audience: talking to those who know about/don't know about the issue

   How to talk about invasive plants that are "pretty"

   How to talk about herbicides

8) Piggy-back on other group's messages

9) Statewide commercial, get on TV!

10) Permits: education

11) Step by step tips/approach to outreach

12) A mechanism to gather informa tion from members – including experiences with education and outreach, success stories

13) Social science research, under standing the public perception of issue

Top Outreach Needs (as voted by participants)

1) Accessible, comprehensive list of available resources (15 votes)

   Members help assemble, Cal-IPC helps and houses

   Links to documents

   Organized by target group

2) Media (10 votes)

   Field course on outreach and media

   Consistent language: messages for those who know/don't know about the issue

   How to talk to the media – Good questions and how to answer them

3) Documenting Success stories (10 votes)

   Contributed by Cal-IPC members, housed on Cal-IPC website

   Stories have links and follow-up contact information

California's Top Weeds

Topic Leaders: Jim Dempsey (JD), Mark Heath (MH)

Notetaker: Marla Knight (MK)

Discussion of good general resources:

- Weed Workers' Handbook
- The Symposium, both networking and reviewing old proceedings
- Invasive Plants of California's Wildlands (book)
- The Nature Conservancy's invasives website tncweeds.ucdavis.edu.
- Cal-IPC website, and others linked from there
- CaliforniaWeedTalk listserv for accessing a community of weed workers

Question: is there a web site for planting recommendations after weed elimination?

Answer: Not really. Resource Conservation Districts, environmental consultants, nurseries, Google scholar might be good places to find advice and/or links to resources. Local experts are best, they know the local conditions and might know what works best for your area.

Question: What are the state's dirty dozen?

Answer: It depends on your area. Call your County Ag commissioner for the weeds that are a concern locally.

JD presented *Ailanthus* control as an example. He uses specialized tools for girdling. While conifers are killed completely by girdling, *Ailanthus* requires that herbicides are included with girdling. Young plants can be pulled, and this can be effective if you get the root.(Reference: 2003 paper by Joe DiTomaso on *Ailanthus* control). For a fall application, use: basal oil carrier for "caution level" herbicides (State Park rules only allow "caution" level chemicals) such as Garlon 4 (triclopyr), Amazapyr, Stalker, Chopper, and Arsenal. In the spring, water based treatment such as 50%-100 Roundup, Stalker, Habitat.

Question: How big a diameter can be girdled?

Answer: Diameter of 3-4 inches.

Question: How wide a band do you girdle?

Answer: Not very wide, just enough to injure. 6-12 inches.

Question: What bout figs? They are rep-routers, so you can't just cut them.

Answer: Have to come back with chemicals on resprouts. First time treatment is preferred. Or you can leave standing dead trees, which can provide habitat, but is often not OK due to hazard and aesthetics. Or you can try to shade out new growth with shade cloth—solarization.

Question: What about black locust?

Answer: Same deal.

Question: Do natives just come back after treatment? Or do you plant? What happens after treatment?

Answer: It really depends on the situation. In some cases, other weeds tend to come in. In other cases, there's a strong native seed bank that can come back. When you do play out natives for restoration, it's important to use local seed sources. And of course you need to keep following up.

Question: Describe the process for approaching a weed problem? What do you do?

Answer: First you need to define your objective. Then you take a look at the recommended approaches for dealing with the specific types of weeds you want to address—this is where the extensive resources through Cal-IPC help. Then you look at what level of resources you have available to support the work, and decide on the best fit.

Question: What about seed bank issues?

Answer: With plants like gorse, a leguminous plant whose seeds can last about 30 years, you need to eliminate the seed bank to consider the infestation fully eradicated. One tactic is to treat in a way that causes the seed bank to flush (like fire), then come back with another treatment.

Question: What are considered the top weeds?

Answer: (from group participation)

- Yellow starthistle
- Arundo
- Brooms
- Pampas/jubata grass
- Tamarisk
- Tumbleweed (Russian thistle)
- Vetch
- Annual grasses, cheat grass.
- Beach grass, ice plant
- Sahara mustard in the desert
- Cape ivy, vinca in riparian areas
- Blackberry

Thing that makes some plants really bad is their ability to re-engineer the environment. For instance, the ability of annual grasses to alter fire regimes. But regional differences dictate what the biggest problems are in a given area—California is diverse.

Question: Is tarping an effective method?

Answer: It can be. Permalon is cheaper than plastic, and more durable.

Obscure Weeds

Facilitator: John3Knapp, Catalina Island Conservancy

Leaders: Joe Di Tomaso, U.C. Davis, Carri Pirosko, CDFA, John Randall, The Nature Conservancy

Note Taker: Gina Darin, U.C. Davis

Introductions- Who, affiliation, and location.

How to search for control information on an obscure weed – Joe DiTomaso.

The first thing to do (before calling an expert) when faced with an obscure weed is to be an Internet detective. These are the four main avenues Joe DiTomaso uses to find information about obscure weeds, and plus a few additions from group attendees:

1. Internet

- "Google it," i.e. "plant name" or "scientific name" or "genus" and "control."
- Global Invasive Species Database – based in New Zealand and gives literature citations, www.issg.org/database.
- Global Compendium of Weeds – literature on control, www.hear.org/gcw.
- The Nature Conservancy's Invasive Species Initiative – species summaries that focus on control (select species need to be updated), tncweeds.ucdavis.edu/esadocs.html.
- Aliens listserv - maintained by the IUCN (to join that listserve, send the message "subscribe Aliens-l" to listadmin@indaba.iucn.org).

2. CalWeedTalk – a listserv run by Cal-IPC focused directly on information about California. To subscribe, send a blank e-mail to californiaweedtalk-subscribe@topica.com

3. Interview people who have done the work, herbicide representatives are a wealth of information.

4. Try controlling the weed yourself – test different methods and send this anecdotal information out (on CalWeedTalk) so others can use it, too.

You may need to use information on related species when there is none available for your particular species.

Obscure Weeds of Interest and the Group's Experience with Control Techniques.

- Italian thistle (*Carduus pycnocephalus*) - not so obscure as it's found throughout the state. Controls discussed were transline, glyphosate, milestone (newly registered), cutting (although it does resprout). Lincoln Smith discussed a biocontrol agent, the weevil *Rhinocyllus conicus*. Cathy Voth discussed training cows to graze it, which sets back seed production. Mow before seed production and graze a week later. Flaming tiny seedlings didn't work too well. Cut at the soil after bolting before flowering.
- Arum root (*Arum italica*) – found in Chico, San Francisco Presidio, Marysville. Roundup was said not to be effective control. Mechanical methods spread it. Cut off bulbs as soon as they show, sieve two feet deep in the soil for bulbs, takes three years to clear one square meter.
- Smilo or rice grass (*Piptatherum mileceum*) – found in Santa Monica

Mountains, southern California, Channel Islands, Sonoma, does move inland. Roundup was noted to both be effective and only kill above ground biomass, but not the plant. Cutting makes it prostrate. Dig it out at the end of summer when the roots die back. Fusillade II herbicide at young plant stages.

- Japanese dodder (*Cuscuta japonica*) – found in seven counties including Sacramento, Shasta, LA and the Bay Area. Remove host – controversial due to killing mature oaks and trees of value. Many attendees felt that this was not a viable option. Is it possible to kill the vine and not the host tree? Many felt this is a high priority area for research.
- Velcro weed (*Torilis arvensis*) – found in San Luis Obispo county and Channel Islands. Goats will graze it. Glyphosate, dicamba, 2,4-D.
- Mexican hair grass (*Stipa tenuissima*) – Monterey. Hand pull.
- Pokeweed (*Phytolacca americana*). First cut berries and collect in trash bags, then dig out the plant getting the base or it will resprout.
- St. John's wort (*Hypericum canariense*) – found in San Mateo, San Juan Capastrano, San Diego, Santa Cruz, Nevada counties. Dig it out, shallow roots. Can't use Weed Wrench because it has multiple stems. Hack with Pulaski on backside and pull down.
- Mattress wire-weed (*Muhlenbeckia complexa*). Cut the biomass and wait for resprouts. Follow-up with herbicide. Found at Lands End in San Francisco.
- Buffel grass (*Pennisetum ciliare*) - found in San Diego, Imperial and Riverside county. Used as a forage species. Hand pulling. Herbicide treatments.
- New Zealand Spinach (*Tetragonia tetragonoides*)- Hand pulling effective. Found on Catalina Island.
- Other species discussed but not in-depth: African malacolinia, *Conicosia pugioniformis*, scarlet wisteria, reed grass, onion weed, calla lily, fluellin, and herb Robert.

Herbicide as a Restoration Tool

Facilitator: Joanna Clines, Sierra National Forest

Topic Co-leaders: Dave Bakke, USFS, Region 5 Pesticide Use Specialist and Joel Trumbo, California Dept. of Fish & Game Pesticide Use Coordinator

Note taker: Jennifer Erskine Ogden

[Handout of Cal-IPC draft policy statement on herbicide use handed out by Joanna Clines, directing any comments to Doug Johnson.]

Introduction:

Four themes to discuss in session:

1. Basing herbicide use on "best available science" – what is "real" science and what is emotional based "science."
2. Interagency policies – what are the IPM policies for different agencies and different land use?
3. What are the hurdles to using herbicides in different areas? A discussion on the lack of ability to control weeds

because assessment takes too long for rapid response on new weeds.

4. Information for land managers–Websites to find relevant information, etc.

Dave Bakke, located at USFS regional office as the Pesticide Use Specialist for Region 5 (CA, Hawaii, Pacific Islands). He's the invasive plants specialist for state and private forestry. His background is in forestry, and is involved in forest ecological health—helps forests get through planning and process for using herbicides.

Forest service Risk Assessment (RA) sheets (see www.fs.fed.us/foresthealth/pesticide/risk.shtml) are generally a notch above others because USFS has access to pesticide companies' CBIs (confidential business information) which include formulation information given to EPA but not accessible to the general public for patent reasons. The general public has free access to these USFS risk assessments of herbicides, and they're a good source of information. The abstracts are 20-30 pages long and are condensed reports and easily accessible. The RAs also cover surfactants (including a 2003 RA of NPE surfactants) and dyes. The RAs are conservative – they represent a worst case risk (i.e. a naked child runs through a spray stream, or an entire truck of herbicide tips into a creek while someone is drinking from the creek). The EPA uses only literature submitted to them, while USFS also looks for the latest science out there. Databases used include BIOSIS, DIGITOP, National Ag Library, EPA Iris, extoxnet, USFS risk assessment, Extension sites, monthly journal table of content alerts.

Joel Trumbo, with CDFG, helps with herbicide recommendations on CDFG lands. Does research on herbicides and surfactants mostly on frogs and fish. Sees himself as a manager more than a researcher. Has 20+ years of experience on pesticide use. Believes the worst move someone can do is make decisions based on assumptions, erroneous information, etc. Herbicide use decisions should not be based on philosophy, just good science.

Discussion

Peter Warner (State Parks): There is a lot of erroneous information out there. This type of information can be latched onto by those with political clout which can make life difficult for managers. Science is behind the eight ball when it comes to herbicide use.

Charlie Blair (CNPS): CNPS is making a policy statement on herbicide use. He finds it's best not to belittle the philosophy commentators but to address specific concerns/questions.

Jean (consultant at Vandenberg Airforce base): What can be used as a surfactant, if one prefers a non-NPE surfactant?

Dave Bakke: While NPE has issues with endocrine disruption, the dose/exposure time is the issues. The list of non-NPE surfactants is small.

Joel Trumbo: You can't just look at the toxicity of a compound but also need to look at exposure time.

Lew Strigger (NPS): The NPS uses Roundup on everything because certain herbicides are "listed" for specific plants and banned in specific areas, and it's too difficult to get permit use for other herbicides. Someone recommended challenging assumptions being made by NPS and to look at the herbicide list for SF (on SF website) as a model because it's larger than the herbicide manufacturers' lists.

Gerald Moore (Petaluma Wetlands): Trying to get rid of Perennial Pepperweed (*Lepidium latifolium*) – how can he deal with it in permanent wetlands (with standing water).

Scott Johnson (Wilbur Ellis): Try newly registered Habitat (Imazypr) + non-NPE surfactant. Also Renovate (triclopyr based).

Charlie Blair: A general question about suppression of shrubs for timber production for DB. One type of forestry is to take out trees for timber and establish a new forest; In CA, because it's a Mediterranean climate, there are issues with summer drought/water relations/competition of tree seedlings with shrubs. Herbicides are one type of tool used for the purpose of forest reformation. In the mid-1990s the USFS was using quite a bit of herbicides because of fires and clearcuts, but they are not doing it as much. The Sierra National Forest is a multiple use agency thus they do use them at times.

Tom (CNPS, SF) The Corte Madera Spartina Project should be used as an example of how to deal with a potentially unfriendly public when using herbicides. Have homeowner groups "meet the weeds."

Joanna Clines: I did the same thing with yellow star thistle in Sierra NF – did field trips with the public so they could see what the issues were, and what the USFS was dealing with.

Unknown: Is there a place/website to find neutral sources of information?

Joel Trumbo: Extoxnet is a good site as well in university extension informational websites. Need to use an adaptive management strategy because recommendations differ depending on site and infestation.

Ed Stanton (private land management firm): Went to the city he's working in and they didn't have an herbicide policy and neither did the public. Any suggestions?

Janet Klein (Marin Municipal Water District): Has 1,000 acre broom infestation. Spoke to public about ounces/acre, not how much gross herbicide using. Start out with good PR and keep it going. She was shut down because her field guys didn't speak English and someone became hysterical when they saw the spraying occurring on the side of the road but couldn't get information out of the sprayers.

Walt Decker (Mendocino Coast WMA): When dealing with people that have some bit of an open mind, you must have a process and explain the process to the public and why you are following that process.

Bill Winans, (San Diego County): What is a "site-specific" recommendation? In other words, what defines a site?

Joel Trumbo: Look at a site and what is there – legally, is there water, rare and endangered species, etc. What is the nature of the site?

Unknown: If treating a large area, try different methods to see what works best. Look at representative area. Write a suite of recommendations and get pre-audited by the Ag Commissioner's office.

Athena (Sequoia/Kings Canyon NPS): Plateau is used to control cheat grass but is not labeled in CA. What to do?

Answer: Look and see if there is a special local need label, and talk more with others.

Brendan O'Neil (State Parks): Do you need an aquatic NPDS permit on water?

Answer: Yes if on water. If the application is next to and not on water, it's outside NPDS needs.

Drew Kerr (Invasive Spartina Project): We got a special use permit for Habitat on Spartina but what about using it for other species?

Answer: CA requires state generated data for each species. Tests are currently being done on other species.

Cindy Burrascano (SD CNPS): Lots of turnover in USFWS folks on the ground – new employees are anti-herbicide and not based on science.

Attendees of the 2006 Cal-IPC Symposium

Aakre, Chad, Restoration Resources, Rocklin
Abreu, Mario A., Mendocino Botanic Gardens, Albion
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Akers, Patrick, California Dept. of Food and Agriculture, Sacramento
Albertson, Joy, USFWS, Newark
Albrecht, Courtney, CDFA, Sacramento
Alford, Christine, Yolo County, Woodland
Alford, Rachel, Presidio Park Stewards, San Francisco
Allen, Kasey, National Park Service, Point Reyes Station
Alvarez, Jeff, The Wildlife Project, Sacramento
Alvarez, Maria, GGNRA, Sausalito
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An, Chanthy, GGNRA - Habitat Restoration Team, Sausalito
Annese, Tom, San Francisco RPD Natural Areas Program, San Francisco
Archbald, Gavin, San Francisco State University, San Francisco
Archbald, Greg, Nevada City
Arenander, William, Sonoma County Regional Park, Santa Rosa
Aslan, Clare, UC Davis, Sacramento
Athan, Tara, Mendocino Coast WMA, Redwood Valley
Austel, Andrea, Cygnet Enterprises West, Inc., Concord
Ayres, Debra, UC Davis, Davis
Baba, Barry, Teichert Aggregates, Sacramento
Babin, Alyssa, Presidio Park Stewards, San Francisco
Badzik, Bruce, National Park Service, San Francisco
Bakke, David, USDA Forest Service, Vallejo
Ball, Regina, SRS Technologies, Lompoc
Band, Patrick, Laguna de Santa Rosa Foundation, Santa Rosa
Bankosh, Michael, Midpeninsula Regional Open Space District, Los Altos
Bates, David, Bureau of Land Management, Hollister
Bauman, Heather, Circuit Rider Prod., Windsor
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Beatty, Jerome, USDA Forest Service, Prineville, OR
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Bentley, Jacob, CA State Parks, Soquel
Blair, Charles, CNPS, Lompoc
Block , Gisele, US Fish and Wildlife Service
Boland, John, Tijuana River Valley Invasive Plant Control Program, San Diego
Bossard, Carla, St. Mary's College of CA, Davis
Boughter, Daniel, California Exotic Plant Management Team, Point Reyes Station
Bower, Michael, UC Davis, Davis
Brady, Heather, Big Sur Land Trust, Carmel
Bramham, Chris, Marin Open Space, San Rafael
Bramkamp, Jack, UAP Timberland LLC, San Dimas
Brastow, Peter, Nature in the City, San Francisco
Brierley, Casey, Target Specialty Products, Santa Fe Springs

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Kempton, Terri, Sustainable Conservation, San Francisco
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Omori, Greg, Agri Chemical & Supply, Oceanside
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Pitcairn, Mike, CDFA, Sacramento
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Robison, Ramona, UC Davis, Sacramento
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Roe, Dave, UC Santa Cruz , Santa Cruz
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Ruch, Scott, ReMetrix LLC, Berkeley
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Sasaki, Tamara, CA Dept Parks & Recreation, Tahoe City
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Schoenig, Steve, CDFA, Sacramento
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Protecting public lands: Progress in incorporating prevention practices into agency policy

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There are over 14 million acres of federally-owned wilderness in California, and much of this area is free of invasive non-native plants acres. California's federal land management agencies recognize the importance of active prevention measures in protecting these and other weed-free acres and are formulating weed prevention policy at all levels: individual parks and forests, regions, and agency-wide. In 1996, the Bureau of Land Management (BLM) issued agency-wide prevention guidelines and stated "prevention and public education are the highest priority weed management activities" (BLM 1996). An important feature of the BLM prevention guidelines is a prevention schedule, which assigns specific responsibilities for prevention tasks to particular BLM field office personnel. In 2001, The U.S. Forest Service (USFS) issued an agency-wide "Guide to Noxious Weed Prevention Practices" (USDA Forest Service 2001). This document contains extremely detailed and comprehensive best management practices for preventing the introduction and spread of invasive plants during all types of activities undertaken by the U.S. Forest Service. The National Park Service plans to issue agency-wide prevention guidelines in 2007. In the meantime, individual parks and regions are setting local policy and implementing weed prevention measures. In this paper, we will present a sampling of the weed prevention measures being implemented by Sequoia and Kings Canyon National Parks and Yosemite National Park. We will also discuss common themes that emerged from interviews with BLM, USFS, and NPS invasive plant specialists about their experience implementing weed prevention measures.

Yosemite National Park and Sequoia and Kings Canyon National Parks are located in the central to southern Sierra Nevada. Together, the parks comprise nearly 1.5 million acres of wilderness, most of which is weed-free. Both NPS units consider the protection of these weed-free areas to be the highest priority of their invasive plant management programs, and both have begun planning and implementing weed prevention measures. In 2004, the superintendent of Sequoia and Kings Canyon National Parks issued a directive to prevent the introduction of weeds into the park, and the spread of weeds from infested developed areas to weed-free wilderness areas. In 2005, Yosemite National Park began work on an Invasive Plant Management Plan that will incorporate weed prevention practices as a major component of the plan. In taking these prevention measures from the planning to the implementation phase, both parks have encountered challenges to implementing ideal prevention measures. Solutions to these challenges are presented below.

Both parks experience high visitation – 3.5 million visitors in Yosemite and 1.5 million visitors in Sequoia and Kings Canyon annually – and constructing and maintaining the infrastructure to support this visitation is a major, ongoing activity in both parks. Construction activities have a high risk for non-native plant introductions and spread, particularly the use of earth fill materials originating outside the parks as well as the use of fill materials originating from weedy locations within the parks. Ideally, construction contracts would contain detailed specifications of weed prevention measures, and contracts would impose penalties for weeds imported to a project site as a result of a contractor's failure to follow specifications. Contractors would be responsible for removing imported weeds for a defined period following construction, providing them with a strong incentive to practice clean construction. However, it is difficult to say with certainty that a contractor's activity resulted in a particular weed introduction. Assessing penalties would also raise the cost of contracts, because the contractor's risk must be estimated and included in the contract price. Both parks have instead relied on including and enforcing contract specifications for equipment washing, inspecting sources of fill material, and conducting post-construction early detection surveys.

Implementation of these construction-related prevention measures has its challenges. Ideally, proposed quarry sources of rock, gravel, sand, and other earth materials would be inspected for invasive plants before the material is purchased. Only materials purchased from weed-free quarries would be accepted for import to the parks. Park staff would work with quarries to develop weed management plans, and quarries would have an incentive to maintain weed-free quarries because their weed-free products would command higher prices. However, we found that all local quarries we inspected were contaminated with non-native species not present in the parks. Also, there is little overall demand for weed-free fill materials and the parks are not major customers, so quarries do not have much incentive to provide weed-free products. As a result, the parks have relied on risk management. Earth materials that have been stockpiled only a short period of time are considered to have a low risk of containing seed (depending on the time of year). Some coarse materials, such as gravel and rock, can be washed prior to use. Seed-containing topsoil can be carefully scraped away before materials are quarried. Even when these measures are carefully implemented, non-native propagules can still be introduced, so post-construction early detection surveys are crucial.

Ideally, all construction equipment entering the parks, or equipment moving from place to place within the parks, would be inspected for seed-containing soil and plant propagules, and dirty vehicles would be thoroughly cleaned. However, it can be costly in the short term to implement such practices for both the land managers and the contractors. It is also very difficult to ensure that large equipment is entirely free of any potential source of invasive plants. Although adding equipment inspections to a project may contribute to the overall cost of the project, it is far less costly than controlling an invasive population that became established as a result of the construction.

Sequoia and Kings Canyon National Parks and Yosemite National Park are prime destinations for hikers and backpackers, who can easily transport plant propagules into weed-free wilderness. Ideally, backpackers would be required to certify that their shoes, clothing, and equipment are free of mud, seeds, and plant parts as a condition of receiving a wilderness permit. However, permit requirements are already lengthy, and backpackers often don't comply with basic requirements such as camping 100 feet from water and not using soap directly in rivers and lakes. It is also virtually impossible to enforce such regulations in remote and expansive wilderness locations. Using educational tools at trailheads and wilderness kiosks is a practical and effective way to inform visitors to wilderness areas. Boot cleaning stations could also be placed at popular trailheads. These stations would not only provide a way for visitors to participate in preventing the spread of new species, but also inform them that they are potential vectors.

There were common themes that emerged from interviews with BLM, USFS, and NPS weed managers about the success and difficulty of weed prevention measures. First, prevention is most successful when it can be incorporated into enforceable documents, such as contracts and special use permits, and into routine planning, such as standard operating procedures and environmental compliance. As weed prevention starts to be routinely incorporated into these documents, it becomes part of the regular work cycle, rather than something extraordinary. Second, prevention measures encounter the greatest difficulty when they affect others – they require a new regulation, cost someone money, or change the way someone does business – or when they require reaching a great number of people. In these situations, education and outreach is the key necessary activity. Third, prevention measures often fail when they are unrealistic. Weed managers may not understand the problems that prevention measures present to others. It is important to explain the purpose of and need for the measure, to listen to others' perspectives, and to work together to find a common solution. Finally, weed prevention can be time-consuming and difficult, and in most cases, comprehensive prevention measures can not be implemented in a year or even several years. It is helpful to prioritize weed-free sites that can benefit most from prevention, to analyze vectors of introduction, and to focus on vectors that present the highest risk to the high priority sites.

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Controlling European beachgrass (*Ammophila arenaria*) using prescribed burns and herbicide

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Abstract

Experiments on European beachgrass during the last decade have demonstrated successful control using manual or mechanical methods, but such methods remain relatively costly on a per-hectare basis. At Sunset State Beach, where European beachgrass is dominant in the foredunes, serious funding constraints led the California Department of Parks and Recreation (DPR) to experiment with less costly methods. DPR staff relied on its in-house expertise with prescribed burning and herbicide use to substantially reduce control costs. Recognizing that fire reduces thatch and stimulates regrowth, DPR staff conducted prescribed burns in the fall, allowed native annuals to grow and set seed, and then treated the resprouting European beachgrass with glyphosate several times, beginning approximately 1 year after the burn. In certain conditions easy site access, in-house expertise with prescribed burns and herbicide use, and remnant native plant communities or seedbanks to facilitate regeneration this integrated approach may be an effective

way to substantially reduce the per-acre cost of European beachgrass control to as low as $4,000/hectare.

Introduction

Dense stands of European beachgrass (Ammophila arenaria) are common in coastal dunes along the Pacific Coast and exclude many native plant and animal taxa, including many rare species. In California, it reproduces primarily through vegetative reproduction, rarely establishes by seed, and grows most vigorously when subject to sand accretion. When sand supply or transport is limited, dense thatch can accumulate (Aptekar 2000). Treatment efforts contend with two key issues: thatch removal and resprout control. A wide range of treatments have been tested experimentally (Aptekar 2000, Pickart and Sawyer 1998), but most large-scale efforts in California tend to rely on either repeated manual digging (Pickart and Sawyer 1998) or mechanical burial (Peterson 2004, Pickart and Sawyer 1998). Such methods remain costly on a per-hectare basis. Manual removal costs range from $36,600/hectare to $69,001/hectare in Marin County (Peterson 2004) and up to $86,703/hectare in Humboldt County (Pickart and Sawyer 1998). Mechanical burial can be substantially cheaper, but not always. At one demonstration project, it cost $13,246/hectare (Peterson 2004) but another effort at the same site cost $38,769/ha (Jane Rodgers, pers. comm.).

At Sunset State Beach, the California Department of Parks and Recreation (DPR) targeted European beachgrass for removal to address three main objectives: restore native foredune plant species richness, expand nesting habitat for the federally listed Western Snowy Plover (Charadrius alexandrinus nivosus), and create additional habitat for the federally listed Monterey spineflower (Chorizanthe pungens var. pungens) that does occur in European beachgrass-dominated foredunes but is much more abundant in its absence.

Severe budget constraints forced DPR to explore alternative methods that would achieve control at lower cost. DPR staff decided to experiment with a two-stage treatment that relied on prescribed fire to remove thatch and stimulate regrowth and a combination of herbicide treatment and manual removal to control resprouts. By itself, fire is not an effective treatment since it stimulates regrowth (Pickart and Sawyer 1998), but by removing thatch it may under some conditions reduce the time required to conduct subsequent treatments (Miller 1998). In particular, reducing thatch and stimulating regrowth creates ideal conditions for effective and efficient herbicide treatment: a greater proportion of the chemical is delivered to receptive plant tissues that will then translocate it to the rhizomes.

DPR's in-house expertise in prescribed fire and herbicide use made this approach possible. DPR was able to conduct all the work itself rather than contracting it out. The Santa Cruz District, which includes Sunset State Beach, is the home base for a Regional Fire Crew, one of three such crews in the DPR system. DPR staff are also well-versed in herbicide use, with three staff members certified as Pesticide Control Applicators. Moreover, public opposition to herbicide use by resource agencies is relatively muted in the Santa Cruz District compared to other regions in California. It's hard to know why that might be, but agriculture in the county continues to utilize high levels of herbicides and pesticides despite increasing acres being devoted to organic farms. Immediately adjacent to Sunset State Beach are strawberry fields where herbicide and pesticide use tends to be high. The approximately 23 lbs. of glyphosate used annually for this project represents less than 1% of that used by agriculture in the county, which totaled 5,542 lbs in 2003 (DPR 2003).

Project Description

At Sunset State Beach, European beachgrass occupy a narrow (55- to 83-meter-wide) foredune strip bounded by the beach on one side and a parking lot and gravel service road on the other. Pedestrian traffic between the parking lot and beach is so heavy that restoring native vegetation in the area may require building boardwalks or low fencing to reduce trampling and allow native plants to recolonize the area. DPR therefore concentrated its initial removal efforts on the less-traveled area adjacent to the service road.

Previous efforts, beginning in the mid-1990s and continuing up to the present day, have concentrated on manual removal of European beachgrass adjacent to a small remnant patch containing significant native plant diversity. This effort, conducted mainly by California Native Plant Society volunteers, demonstrated that removal did not lead to excessive sand transport and that native plants (particularly Camissonia cheiranthifolia) readily revegetated the now open sand. Although they work immediately adjacent to and occasionally within burned areas, most of their efforts are focused on European beachgrass outside the three polygons described below. The value of their donated labor effort is therefore not included in cost estimates.

Prescribed fire

DPR treated a total of 4.2 hectares (ha) in three stages following prescribed burns on 28 September 2000 (0.93 ha), 25 October 2002 (1.66 ha), and 23 October 2003 (1.6 ha). Prescribed burns took place in the early fall and cost roughly $2,500 each to implement (Table 1). European beachgrass, especially older colonies with considerable thatch, readily burns, especially in central California where it typically doesn't rain between May and November. The burn prescription was for a relative humidity of 20-80%, air temperature of 40-75°F, wind speed below 15 mph, and wind direction from any quadrant. It was relatively straightforward to get permits from the Regional Air Quality Control Board. The three fires were readily contained, in part because lines were cut in each case on the east and west ends by handdigging beachgrass from a 5-meter wide swath. On burn day, three state park ecologists typically carried out ignition. They were joined by two engines (three people/engine) and a hand crew (four park aides/

Table 1.

Staffing levels and estimated cost for a typical prescribed burn at Sunset State Beach, 2000-2003 (n=3)

Staff	***Task***	***Hours***	***Estimated Labor Cost***
project manager	write burn plan, get permits	24 x 1 = 24	$679.20
hand crew	hand dig line in Amar	6 x 4 = 24	$371.52
burn boss	boss fire	5 x 1 = 5	$201.55
ignition crew	ignite fire	5 x 3 = 15	$334.40
engine crews	monitor fire	5 x 3 x 2 = 30	$546.20
hand crew	monitor fire	5 x 4 = 20	$309.60
patrol and mop up	monitor after engines leave	4 x 2 = 8	$226.40
	total	126 hours	$2,668.87
	estimated cost/ha		$1,906.34

crew). (One of the engines was provided at no cost by the Aptos/La Selva Fire District.) Ignition took place in the morning after the dew dried off, and the burn was more or less completed by lunch. Flame lengths averaged eight feet.

Resprout Treatments

Initial experiments with a grass-specific herbicide (Fusillade) did not lead to adequate control, so we used 7% glyphosate (Roundup) to treat European beachgrass regrowth approximately one year after burn. The delay enabled native plants, particularly annuals, to germinate, reproduce, and disperse prior to herbicide treatment. Resprouts not killed in the initial herbicide treatment were then sprayed 6 and 12 weeks later in two additional treatments using 7% glyphosate. Up to three additional followup treatments were required to achieve 100% control. The amount of herbicide used tapered off considerably in the subsequent treatments. For an idealized version of treatment schedule, see Table 2.

Treatment of all three burn sites required a total of 29.4 gallons of Roundup which cost roughly $1,055.68, or $251/ha. Total treatment costs were therefore approximately $3,937/ha. Actual costs as measured by time cards and work-performed sheets were somewhat higher ($4,606/ha) due to the usual challenges associated with doing something for the first time and working with a large seasonal workforce characterized by significant year-to-year staff turnover. In retrospect, DPR would rely on more highly trained applicators to conduct follow-up herbicide treatments. In its future efforts to control European beachgrass at Sunset State Beach and elsewhere in the district, DPR should be able to achieve costs approaching $4,000/ha. One reason its costs are much lower than other efforts: its travel costs are minor since worksites are immediately adjacent to a parking lot, unlike other efforts which require considerable travel by workers to the workface.

In this case, despite reassurances from those who promote private contracting as the answer to reducing the cost of service delivery by government agencies, contracting out European beachgrass removal would be much more expensive. It costs DPR $28.30/hr (including overhead) for its staff members to treat European beachgrass with

Staff	*Task*	*Hours*	*Estimated Labor Cost*
2 applicators	1st treatment after burn (100 gallons of 7% glyphosate in spray rig)	2 x 2 x 8 = 32	$905.60
1 applicator	2nd treatment (6 backpacks containing 2.5 gallons each of 7% glyphosate)	1 x 3 x 8 = 24	$679.20
1 applicator	3rd treatment (4 backpacks containing 2.5 gallons each of 7% glyphosate)	1 x 1 x 8 = 8	$226.40
1 applicator	4th treatment (2 backpacks containing 2.5 gallons each of 7% glyphosate)	1 x 1 x 8 = 8	$226.40
1 applicator	5th treatment (1 backpack containing 2.5 gallons of 7% glyphosate)	1 x 1 x 8 = 8	$226.40
1 applicator	6th treatment (1 backpack containing 2.5 gallons of 7% glyphosate)	1 x 1 x 8 = 8	$226.40
	total	88 hours	$2,490.40
	estimated cost/ha		$1,778.86

Table 2.

Staffing levels and estimated cost for a typical herbicide treatment following prescribed burn at Sunset State Beach, 2000-2003 (n=3 herbicide. It would cost DPR at least $100/hr to pay outside contractors to carry out the control treatment, with no assurance that they would be as sensitive to natural resources as DPR staff. Contracting out just the herbicide treatment would more than double the total cost per ha to $8,442/ha.

Outcomes

DPR staff measured effectiveness using photomonitoring and presence/absence surveys for European beachgrass. It is now almost entirely absent (<1% cover) from all three treatment areas. Native annual plant species, early-successional woody shrubs such as Lupinus arboreus, and the non-native Cakile maritima readily invaded the treatment area. Remnant woody vegetation along the rear dunes suffered significant damage from both prescribed fire and herbicide treatment. Baccharis pilularis and Ericameria ericoides in particular were hit hard by the fire and then again by herbicide treatment since they were interspersed among resprouting European beachgrass. Several native animals, including legless lizards and Aptostichus spiders, have been detected in the treatment area, but there has been no formal or informal assessment of impacts to wildlife following treatment. Treatment areas have been increasingly used by Western Snowy Plovers as refugia for their broods (Ryan Degadio, pers. comm.).

Conclusion

In certain conditions easy site access, in-house expertise with prescribed burns and herbicide use, and remnant native plant communities or seedbanks to facilitate regeneration this integrated approach may be an effective way to substantially reduce the per-acre cost of European beachgrass control to as low as $4,000/hectare. In the future, DPR will conduct additional adaptive management trials in an effort to drive per-hectare costs even lower. By doing so it may demonstrate the feasibility of large-scale removal efforts (such as eliminating European beachgrass from Aña Nuevo) that had been previously thought to be impossible.

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