ECOLOGY AND MANAGEMENT OF CALIFORNIA GRASSLANDS
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PRESENTATION ABSTRACTS

(FIRST AUTHOR'S EMAIL IN PARENTHESES)

Abraham, Joel K.[1], Jeffrey D. Corbin[1], and Carla M. D'Antonio[1,2]. [1]UC Berkeley; [2]USDA-ARS, Reno, NV. (jabraham@uclink.berkeley.edu). **The effects of phenology and seedling competition on regeneration of perennial grasses in California exotic annual grasslands.**

The conversion of California grasslands from perennial-dominated to an exotic annual-dominated ecosystem has been well-documented. More recently, exotic perennial g h

drain soil resources before native perennials can use them, preventing regeneration. If true, the success of exotic perennials might indicated a different interaction with exotic annuals than seen with native perennials. We hypothesized that decrease annual density and delaying annual-seedling emergence would increase perennial performance, while nutrient availability would interact with these conditions. We also predicted a higher competitive ability of exotic perennials than native perennials. To test whether nutrient access and competition in early life stages of annual and perennial grasses are important factors in grassland community composition, we set up a greenhouse experiment in which an exotic annual grass (*Bromus diandrus*) was grown in competition with native perennial grasses (*Nassella pulchra* or *Festuca rubra*) or an exotic perennial grass (*Holcus lanatus*). We maintained *Bromus* at three competitive densities (0, 20, 50/pot). We manipulated N levels and manipulated emergence time by delaying planting of *Bromus* seeds. As predicted, above-ground productivity of *Bromus* was lower in competition with *Holcus* than with *Festuca* or *Nassella*. Increasing the density of annual competitors decreased perennial aboveground productivity. Delayed annual emergence increased aboveground in *Nassella* and *Holcus*, but had no effect on *Festuca*. These results indicate that seedling competition between annuals and perennials may be a critical stage in the regeneration of native grasses in California.

Amatangelo, Kathryn L.[1],Jeffrey S. Dukes[2], and Christopher B. Field[3]. [1]Stanford University; [2]University of Massachusetts, Boston; [3]Carnegie Institution of Washington. (kamatang@stanford.edu). **Annual grassland responses to litter manipulation**

Global changes are likely to change the amount and type of plant litter produced in California annual grasslands; therefore it is important to understand how litter affects community structure and biomass production. We tested the potential physical and chemical effects of senescent litter by manipulating litter and light levels in 35 plots. Standing litter was removed from some plots and added at double litter levels to others. The effect of physical shading by litter was tested though shade cloth, and the nutritive impacts of decomposing litter were evaluated through adding litter ground in a mill. Functional group germination was measured, and community composition and biomass were evaluated at peak biomass. We found that the addition of ground litter had no significant effects on community biomass or composition. However, the other treatments changed the community significantly. Total biomass was highest in control plots, and species richness was highest in litter removal plots. High litter levels and shading decreased grass germination and establishment, increasing relative proportions of other functional groups. Individual species responded variously through both changes in stem number and plant size. Over one growing season, the physical impacts of litter are more significant in shaping community structure and biomass than the nutritive impacts.

Amme, David[1] and Joe Morris[2]. [1]California Native Grass Association, [2]T. O. Cattle Company. (seed@tdl.com). **Stewardship Grazing: Managing California's Coastal Prairie and Foothill Grasslands on Public Lands**

While it is universally accepted that the California grassland and savanna landscape evolved with and are shaped by the processes of grazing, rest, and fire, very little is known on how these processes can be applied to manage for restoration and conservation goals, especially for public open space lands. Without fire or periodic grazing to reduce and recycle the buildup of undecomposed plant litter, the thatch can reach in excess of 20,000 lbs per acre snuffing out grassland richness and diversity. More often than not, fire and mowing are costly and unrealistic options on public parks and openspaces. The only practical option available is grazing management, which controls the season, frequency, duration, and intensity of livestock grazing: a stewardship grazing program. This type of livestock management adds a level of sophistication typically not found in grazing practices in the California. There are many impediments to grazing on public lands including the cost and design of badly needed infrastructure improvements, the cost and coordination of moving livestock between isolated grasslands often under different ownerships, public access and conflicts, and accurate monitoring needed for program adjustments.

Anderson, John H.[1], Rachael Long[2], and Sean Kenady[1]. [1]Hedgerow Farms, [2]UC Cooperative Extension. (Hedgefarm@aol.com). **Using Selective Herbicides to Control *Lolium multiflorum* and *Avena fatua* in Native Grassland Restoration**

A number of exotic annual grasses are the cause of native perennial grass establishment failure in restoration projects and the degradation of natural stands. *Lolium multiflorum* and *Avena fatua* are two of the most troublesome. Both can rapidly establish and completely overwhelm restoration sites especially in the first season of planting. The herbicides Hoelon (diclofop-methyl) and Puma (fenoxaprop-p-ethyl) are agricultural products used to control these as well as other grass weeds in wheat and barley production. We tested the tolerance of 13 species of established California native grasses: *Nassella pulchra, N. cernua, N. lepida, Elymus glaucus, E. trachycaulus,E. multicetus, Leymus triticoides, Hordeum brachyantherum, Festuca idahoensis, Koeleria macrantha, Melica californica, Poa secunda, and Vulpia microstachys.* We found all of them to be tolerant to both herbicides. We also tested seedlings of 12 of the same grasses and found only 2 to be partially impacted by Hoelon (N. pulchra and M. californica). Our tolerance findings as well as using these products in seed production fields and restoration sites clearly demonstrate their usefulness for restoring and managing native grasslands. We will report the results of testing an additional herbicide Osprey (mesosulfuron) not yet on the market but is being developed for selective *Lolium* and *Avena* control.

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Anderson, Sean. Stanford University. (pongo@stanford.edu). **The value of phased, experimental designs for California grassland restoration**

We are developing a phased, experimental approach to restoring degraded communities wherein the results from previous phases inform the design and implementation of subsequent phases. Both examples are from a 300 ha grassland reserve in the coastal foothills of the San Francisco Bay Area. The first project is an attempt to modify soil seed banks to restore native grasslands. The second project is an effort to augment amphibian populations with a series of seasonal wetland/grassland breeding sites. By beginning at small spatial and temporal scales, both projects have been able to rapidly incorporate site-specific results into the design of subsequent restoration phases and dramatically increase the likelihood of a successful restoration. Restoration performance is compared to a network of 35 grassland reference sites throughout the San Francisco Bay Area we have monitored annually for three years. These reference arrays help define a variety of functions (seed bank density and diversity, native cover, insect productivity, etc.) with which restoration performance is evaluated.

Barry, Sheila J. UC Cooperative Extension. (sbarry@ucdavis.edu). **Opportunities for Using Livestock to Restore and Manage California's Native Grasslands**

A recent, comprehensive review of the literature on California's native grasslands found that few studies have examined the impact of livestock grazing on native plants and many of these studies lacked replication of treatment and controls for quantitative analysis. Although grazing studies are inherently difficult to design and conduct, additional studies should consider prescribed grazing strategies to achieve restoration and management goals. Current research using GIS collars on livestock is helping range animal scientist understand grazing patterns on California's grasslands. Similarly, recent research on diet preference is not only helping animal behaviorist predict which plants a grazing animal will consume but also how a grazing animal can be enticed to consume undesirable plants. Using the latest research on grazing animal behavior and management can a successful grazing strategy be developed and tested to work towards restoration and management of California's native grasslands? This presentation will examine considerations for a successful grazing strategy, including 1) species and class of livestock to be used; 2) the season of use; 3) the intensity of use. Examples of how these grazing strategies are being applied for restoration and management of California's native grasslands will be discussed.

Bartolome, James W.[1], Barbara Allen-Diaz[1,] and Randall D. Jackson[2]. [1]University of California, Berkeley, [2]University of Wisconsin-Madison (jwbart@nature.berkeley.edu). **Response of a native perennial grass stand to fire and seasonal livestock grazing in California's Coast Range Grassland**

We examined potential for native species enhancement by experimentally manipulating the seasonal timing and presence of grazing and autumn burning, and measuring species cover for 6 years in a stand of native perennial grasses on a California Coast Range Grassland. We subjected the species matrix to classification (TWINSPAN) and ordination (CCA) and tested the treatments with linear mixed effects models. We found no treatment effects on diversity. Composition depended heavily on both random environmental variation and initial starting conditions. We found no significant burning effects on composition. Grazing removal shifted the plant community from more annual- dominated towards more perennial-dominated vegetation. *Nassella* spp. increased gradually over time regardless of grazing treatment. *Nassella pulchra* (purple needlegrass) increase was greatest under spring grazing and *N. lepida* (foothills needlegrass) was greatest with grazing removal. *Danthonia californica* (California oatgrass) had little response over time under seasonal grazing treatments, but increased with grazing removal. Under relatively mesic weather conditions, it appears that grazing removal from Coast Range Grasslands with existing native perennial grass populations can increase their cover. However, if *N. pulchra* is the sole existing population, spring-season restricted grazing should be equally effective at enhancing cover of the native grass species.

Batten, Katharine M. and Kate M. Scow. University of California, Davis. (kmbatten@ucdavis.edu). **Soil Microbial Communities Associated with an Invasive Grass Negatively Impact Native Plant Fitness**

Invasive plants significantly change the soil microbial community in invaded areas. This study is one of the first to show that invasive plant-induced changes in the soil microbial community negatively impact native plant fitness. Previous work has shown that *Aegilops triuncialis* (barb goatgrass) changes the soil community in serpentine soils. We used a greenhouse experiment to test the effects the of soil microbial communities associated with *A. triuncialis* and two native plants (*Lasthenia californica* and *Plantago erecta*) on invasive and native plant fitness. Soils were "primed" to contain microbial communities associated with each of these plants by growing plants in individual pots; all possible invasive and native soil microbe/plant combinations were then planted into these primed soils. Phospholipid Fatty Acid Analysis (PLFA) was used to examine soil microbial community composition during the experiment. *L. californica* and *P. erecta* fitness were reduced when these plants were grown in *A. triuncialis* soil compared to native soil. *A. triuncialis* fitness was unaffected when grown in invaded or native soil. These results suggest that changing the soil microbial community in invaded areas may be a mechanism of increased plant invasion.

Bobzien, Steven, Joseph E. DiDonato, and Amy Bohorquez; East Bay Regional Park District, (sbobzien@ebparks.org). **Evaluating pond habitat suitability and the influence of predacious aquatic hexapods on the California tiger salamander (*Ambystoma californiense*) in the East Bay Regional Park District.**

Within the East Bay Regional Park District (District), California tiger salamander (*Ambystoma californiense*) occurs from near sea level to above 3,600 feet. They are widely distributed in grazed grasslands and oak savanna of eastern Alameda and Contra Costa Counties. To evaluate aquatic habitat suitability we have systematically surveyed over 275 freshwater ponds and documented California tiger salamander breeding in 70 distinct ponds. Our data and statistical analysis suggests that California tiger salamanders are most reproductively successful in ponds with relatively low aquatic biodiversity. On District lands, California tiger salamander breed exclusively in seasonal and perennial stockponds. Overall, these ponds tend to have no or very little emerged or submerged vegetation, and they support few invertebrate or vertebrate species. The effect of predacious aquatic hexapods on California tiger salamanders reproduction, larvae development, and overall reproductive success is not well understood. However, California tiger salamanders were generally not present in ponds occupied by Belostomatidae, Dytiscidae, Nepidae, and/or Anisoptera (nymphs). There was a negative association with the presence of these predacious aquatic hexapods and the occurrence of California tiger salamanders. In addition, we examined the relationship between other aquatic herpetofauna and California tiger salamander on District lands.

Buisson, E.[1], E. Corcket[2], T. Dutoit[3], K. Holl[4], and S. Anderson[5]. [1]IMEP- Mediterranean Institute of Ecology and Paleoecology, Marseille, France; [2]Université de Bordeaux; [3]Ecologie des Invertébrés, Avignon, France; [4]University of California, Santa Cruz; [5]Stanford University. (elisesf@hotmail.com). **How do plant interactions and livestock grazing influence the restoration of native perennial species in degraded grasslands? An intercontinental experiment.**

One strategy to restore degraded ecosystems efficiently is to initiate restoration by improving environmental conditions and re-introducing keystone species. In coastal grasslands of California, degraded by agriculture and over-grazing, *Danthonia californica* and *Nassella pulchra* were once dominant perennial grasses. In the steppe grassland of La Crau (Provence, France), degraded by melon and cereal cultivation, *Brachypodium retusum* and *Thymus vulgaris* have been identified as structuring the steppe community. The aim of this study was to determine the role of biotic factors, such as plant interactions and livestock grazing, in restoring these four perennial keystone species in today's hostile grasslands invaded by annual weeds. We set up a factorial experiment to test two treatments on seedlings and planted seedlings: Plant neighboring effects. We weeded non-native annual grasses and forbs (CA) and annual arable weeds (La Crau) to test their effects on focal species. Livestock grazing. Half of the seedlings were protected from grazing. Preliminary results showed that all four focal species grew faster without annual plant neighbors. Planting seedlings was more successful for *Danthonia, Brachypodium* and T*hymus* due to low germination rates. *Thymus* and *Brachypodium* growth was greatly inhibited by grazing. We plan to continue monitoring these species for another year, at which time we will harvest biomass.

Chadden, Andrea, Laura Turner, and Edyta Dowksza. University of California, Santa Barbara. (achadden@bren.ucsb.edu). **Adaptive Management of Southern California Grasslands**

Southern California’s remaining grassland communities are threatened by a multitude of influences, including degradation by exotic species, urbanization, public recreation, habitat loss, fire suppression, changes in grazing regimes, climate change, and pollution. The interactive nature of these influences creates uncertainty for managers of grassland areas seeking to maintain or restore habitat quality and native species composition and richness. Adaptive management is a technique that can address this uncertainty but which is rarely applied effectively due to financial concerns and time constraints, among other factors. Adaptive management stresses learning as a goal of management, and involves identifying management goals and targets, developing methods to establish a baseline of current conditions within a site, forming recommendations for management interventions and monitoring methods, and developing feedback mechanisms that inform the next iteration of management. Through a comprehensive literature review and informational interviews with 35 southern California grassland managers and experts, we have created an adaptive management framework for use by managers to ease the process of designing adaptive management plans for specific sites. This framework can be tailored to different grassland areas and circumstances. We have applied this framework to a case study site, the Santa Rosa Plateau Ecological Preserve in Riverside County, as a demonstration of the guidelines and tools contained in the framework.

Corbin, Jeffrey D.[1] and Carla M. D’Antonio[1,2]. [1]UC Berkeley, [2]USDA-ARS, Reno NV. (corbin@socrates.berkeley.edu). **Nitrogen cycling, retention and leaching losses in a coastal prairie grassland: importance of vegetation productivity, phenology, and tissue chemistry**

Differences in growth rate, phenology, and tissue chemistry between native perennial bunchgrasses, exotic perennial grasses, and exotic annual grasses have the potential to change nitrogen dynamics in California grassland ecosystems as community composition shifts. In 1999 we established field plots to compare N retention and N leaching loss rates between experimental communities dominated by each group of species. We had hypothesized that, because of differences in litter decomposition rates and

native species in the surrounding community were perennial, so managing for perennial species will help maintain native communities. Furthermore, restoration efforts should focus on allowing native species to self-regenerate while limiting exotic seed inputs.

Espeland, Erin K. UC Davis. (ekespeland@ucdavis.edu).
Characterizing forb competition in California grasslands: implications for plant evolution

While grassland forbs occur within a matrix of grasses, these forbs are often clumped in their distribution. How often do individual plants compete with members of their own species, and how often do they compete with members of other species? The modal condition of plant populations under field conditions is an important consideration when evaluating the importance of competition on plant evolution. In this talk I will discuss a preliminary study of 20 California vernal pool and grassland forbs where individuals of a species had a 'typical' intraspecific distance, and individuals of the same species were often found within a 10cm neighborhood of a focal plant. By contrasting inter- and intraspecific plant densities at this small scale, we can predict the relative importance of each type of competition on evolution in plant populations. The finding that intraspecific plant distributions do not vary significantly from location to location but appear to be inherent to each individual species has important implications for experimental design of competition studies as well as evolutionary research. The California annual grassland, with similar life histories of all competing plants, offers a unique and highly successful environment for examining these questions.

Eviner, Valerie T.[1] and Charles Vaughn[2]. [1]Institute of Ecosystem Studies, [2]Hopland Research and Extension Center, Hopland, CA. (evinerv@ecostudies.org). **Seedling thinning contributes as much to internal N cycling as does decomposition of senesced litter**

In most terrestrial ecosystems, litter senesced at the end of the growing season is assumed to be the main internal source of carbon and nutrients. We demonstrate the importance of a previously overlooked input of labile C and nutrients, self-thinning of grass seedlings. In California annual grasslands, 70% of aboveground plant N is retranslocated from senescing litter to seeds. Over 90% of these seeds germinate the following fall. Intense seedling competition through the growing season results in mortality of 75% of the seedlings. These young seedlings have a low proportion of structural compounds, and thus are highly labile, releasing their C and N quickly. The timing of peak self-thinning leads to the release of readily-mineralizable N precisely at the time of peak plant competition, when only relatively recalcitrant, low N litter remains. Thus, it appears that thinning seedlings are a major source of nutrients for growing plants. Over the growing season, the cumulative inputs of N from seedling thinning are equivalent to the amount of N released from litter that senesces at the end of the growing season. These data suggest that restoration projects may benefit from high density seeding as a major source of plant N.

Goerrissen, J. H. UC Davis. (jhgoerrissen@ucdavis.edu). **Habitat Associations of Grassland Birds in Native and Exotic California Grasslands.**

California's grasslands underwent a major type-conversion in the early 1800's from grasslands dominated by perennial bunchgrasses to grasslands dominated by exotic annual grass species. Although the demise of California's native grasslands has received much attention in the last decade, differences in grassland bird use between native and exotic grasslands has not been studied. I am investigating current patterns of grassland bird use on native perennial bunchgrass, exotic annual, and restored grasslands throughout central and southern California. Abundance of two grassland generalist species is significantly greater during the winter months than during the breeding season. Savannah Sparrows (*Passerculus sandwichensis*) and Western Meadowlarks (*Sturnella neglecta*) were the most abundant grassland species throughout the winter in the Central Valley. Savannah Sparrow abundance tended to be greatest in grasslands that had a forb component, irrespective of grassland type. No clear patterns were observed for Western Meadowlarks with respect to grassland type. Western Grasshopper Sparrows (*Ammodramus savannarum perpallidus*), a grassland specialist species, were consistently more abundant in perennial bunchgrass grasslands than in grasslands dominated by exotic annual grasses during the winter, and breeding territories occurred exclusively in native or restored grasslands.

Griffith, Stephen M. USDA-ARS, Corvallis, OR. (griffits@onid.orst.edu). **Grassland Restoration with Native Perennial Grasses in Yolo County, California.**

Restoration of native perennial grasses into California grasslands dominated by non-native and invasive weed species is desirable to improve rangeland conditions. Research plots were established at three grasslands; one site had no native grasses (AGR), one was sown with native grasses in 2002 (NPGR), and another in 1992 (EPGR). Changes in plant species composition, plant biomass, and selected soil and plant characteristics were documented to provide a better understanding of factors that affect stand establishment under restoration conditions. The species sown at NPGR were Nassella pulchra, N. lepida, Elymus glaucus, Bromus carinatus and Melica californica and at EPGR was N. pulchra, E. glaucus, Hordeum brachyantherum, and Poa secunda. In 2003, N. pulchra (5% cover) was the only native grass species present at NPGR and at EPGR, only N. pulchra (41% cover), E. glaucus (3% cover), and H. brachyantherum (2% cover). At EPGR, P. secunda failed to establish and H. brachyantherum showed weak persistence 3 to 4 years following establishment. In 2003, NPGR produced the greatest aboveground biomass, 7.4 tons/ac, compared to 5.3 tons/ac for EPGR and 4.3 tons/ac for AGR. Only half as much biomass was produced in 2002, a drier year, but relative proportions remained the same among the sites. Earlier season plant growth, and possibly soil and plant factors associated with planting, contributed to higher stand biomass production at NPGR and EPGR, compared to AGR. If restoration of native perennial grass species is to succeed under California dryland conditions, improvements in plant establishment and persistence must be developed.

Griggs, Tom[1], Dan Efseaff[1], Helen Swagerty[1], Ryan Luster[2], and Joe Silveira[3]. [1]River Partners; [2]The Nature Conservancy; [3]US Fish & Wildlife Service. (tgriggs@riverpartners.org). **Native Grass Restoration in the Riparian Zone along the Sacramento River.**

Native grasses have been incorporated into 12 different riparian restoration projects along the Sacramento River since 1999. The goal has been to restore an herbaceous understory composed of native species that will replace the ubiquitous non-native weed community. The projects have been implemented on sites representing a wide array of ecological settings. Site factors including different soil textures, local hydrology, and aggressive non-native weeds have presented different challenges for the establishment of native grasses. We report on the range of responses by different native grass species to the type and timing of management actions across the various restoration projects. The need for long-term (post-establishment) management will be evaluated and possible management tools that will work within the woodland or savanna matrix will be presented.

Groves, Jessica S.[1], John H. Anderson[2], and Ed G. Burns[3]. [1]Natural Resources Conservation Service, Colusa, California; [2]Hedgerow Farms, Winters, California; [3]California Waterfowl Association, Sacramento, California. (jessica.groves@ca.usda.gov). **Restoring Native Grasses on Northern Sacramento Valley Floodplains.**

In the floodplains of the Northern Sacramento Valley, the Natural Resources Conservation Service (NRCS) and its partners have been working to reestablish native perennial grasses and forbs to provide upland habitat for wildlife. In the last 3 years, NRCS has planted native on over 600 acres of private land in Colusa, Yolo, and Glenn counties. The projects are located on poorly drained soils within frequently and occasionally flooded zones (based on the soil survey) which are inundated for a 7-30+ day period during November thru February. The planting mixes include local ecotypes of *Leymus triticoides, Hordeum brachyantherum, Elymus glaucus,* and *Elymus trachycaulus.* Based on observations of survival and growth, all of these species appear tolerant of moderate flooding and a long period of saturation (7-30 days) during the winter immediately following a fall planting. On sites with substantial flooding and a very long saturation period (> 30 days) in the first year, *Hordeum brachyantherum* was the primary species to establish followed by *Leymus triticoides*. Prolonged inundation during establishment also appears to reduce initial weed competition. After flood waters recede the natives initial recovery is slow, but the germination and establishment of the annual weeds is slower. We will continue to monitor the growth, survival, success, and sustainability of these species in the active Sacramento Valley floodplains.

Hayes, G. F.[1] and K.D. Holl[2]. [1]Elkhorn Slough National Estuarine Research Reserve. [2]UC Santa Cruz. (coastalprairie@aol.com). **The Effects of Cattle Grazing Disturbance and Implications for the Conservation of Native Plants in California Coastal Prairie.**

Over the last 250 years, cattle became a dominant component of disturbance regimes in coastal prairie, while exotic plants proliferated. To investigate the impact of cattle grazing on the native plant community, we combined manipulative experiments examining grazing-related disturbances with field surveys of grazed and ungrazed coastal prairie sites. We conducted a factorial experiment in winter 1999 through spring 2003 at three coastal prairie sites near Santa Cruz, testing a combination of clipping frequencies and secondary disturbances (litter removal and soil disturbance) on the abundance of native and exotic plant guilds. While secondary treatments had no effect, increased clipping frequency tended to increase native grass and decrease exotic grass and exotic forb abundance, although the effects were site-specific. During a 2-year field survey, we surveyed cattle grazing impacts in 25 paired grazed/ungrazed sites spanning a 670-km range of coastal prairie plant community, focusing on native annual dicots. Results suggest native annual dicot species richness and cover was higher at grazed sites, concomitant with decreased litter depth and vegetation height. Conversely, native perennial forbs decreased and exotic annual species increased in grazed sites. These results implicate the need for landscape-level planning to target disturbance regime restoration to maintain different guilds of native plants.

Holl, K. D.[1] and G. F. Hayes[2]. [1]UC Santa Cruz. [2]Elkhorn Slough National Estuarine Research Reserve. (kholl@ucsc.edu). **Restoring the endangered annual forb *Holocarpha macradenia* (Santa Cruz sunflower) through managing disturbance regimes and reintroduction.**

Holocarpha macradenia (Santa Cruz sunflower) is a late-season native annual forb endemic to central California grasslands. It is a federally- and state-listed endangered species represented by only nine natural populations and is therefore of critical management concern. In winter 1999 we initiated a factorial experiment at three coastal prairie sites near Santa Cruz to test a combination of clipping frequencies, litter removal and soil disturbance on *H. macradenia*. We introduced both seeds and plants of *H. macradenia* in two years and have monitored various demographic stages in experimental plots for the past five years. In the first three years of the study, clipping strongly benefited *H. macradenia* by enhancing seed germination and seedling survival, whereas litter removal and soil disturbance had no effect. In the fourth and fifth year, we recorded few plants in any of the plots, which raises questions about the suitability of these sites for *H. macradenia* reintroductions. We are currently continuing monitoring, quantifying the seed banks, and modeling demographics to determine whether populations may increase in the future or whether survival rates and fecundity were too low to result in a viable population. These results should help guide managers on both reintroduction and management of *H. macradenia* populations.

Hooper, E. Bickford, Member, Park Advisory Committee, East Bay Regional Park District. (hooper1@llnl.gov). **A Physicist's Comments on the Scientific Literature Related to Grazing**

There is extensive literature on the effects of grazing on grasslands and other ecosystems. As a member of the EBRPD PAC and a physical scientist, the author decided to undertake a review of the literature so that he could judge options for park management and could interpret claims of (often conflicting) advocates for decisions on the application of grazing to achieve goals such as fire mitigation. For the purposes of the review a set of subtopics was chosen: biological diversity ("biodiversity"), fire, nutrient generation and recycling, riparian and wetland communities, water quality, and native and invasive plant species. This led to a significant set of deeper topics, including judging the importance of biodiversity on a local ecosystem (as differentiated from global), evaluating the difference responses to grazing in nutrient rich and nutrient poor ecosystems, the existence of equilibria in ecosystems and whether weather and other perturbations make the question moot, our ability to quantify the effects of grazing on mitigating fire hazards, the role of soil quality and the emerging understanding of coupling between above-ground grazing and the subsurface rhizosphere, effects of grazing on riparian ecosystems, the trade-offs between possible biological contamination of water systems and the possibility of significant erosion from a major fire which might be limited by grazing, and the competition between native and invasive grasses. A first conclusion is that the system is complex and not fully quantitative as yet. It is clear that science cannot be used to *determine* management decisions. Nevertheless, it is also clear that science can give significant *guidance* to management. At the most simple level, heavy grazing is usually damaging to the environment, but plants have evolved in the presence of grazing so that no grazing by large mammals, either wild or domestic, is also usually damaging. The difficulty arises in judging the optimal level for a given ecosystem. An iterative solution is clearly needed to optimize the level of grazing. This requires careful definition of the goals; subsequent measurements of the effects; and their interpretation in the context of the goals, recognizing that lag times for effects and annual variations in weather mean that multiyear evaluations will be needed. In the long term, quantitative modeling using computers will be useful, probably requiring models that include spatial patchiness at all spatial levels, stochastic temporal effects, and application of game-theoretic methods to describe competition among species when the consequences affect their environment.

Hopkinson, Peter. UC Berkeley. (phopkin@nature.berkeley.edu). **Are East Bay hills grasslands a historical artifact?: phytolith evidence and likely candidates for the true East Bay vegetation types**

Abstract: A soil-phytolith analysis casts doubt on the widely-held belief that fragments of grassland in the East Bay hills of the San Francisco Bay Area, California, are the relictual remnants of formerly continuous perennial grassland, dominated by bunchgrass species

such as *Nassella pulchra* and *Danthonia californica*. These two species produce a phytolith morphotype not produced by the exotic, annual grass species that now dominate California's Coast Range Grassland type. For 13 sites in the hills, soil samples were analyzed for the presence of this phytolith morphotype; few were found, suggesting that bunchgrasses have not been dominant in the hills for centuries. Several lines of evidence are presented to support the proposition that *Baccharis*-dominated northern coastal scrub may have been the primary vegetation type in the East Bay hills prior to settlement by the Spanish.

Immel, Diana. UC Davis. (dlimmel@ucdavis.edu). **Historical and Ethnoecological Considerations for the Ecological Restoration of Showy Indian Clover (*Trifolium amoenum*)**

Showy Indian clover (*Trifolium amoenum* Greene; Fabaceae) is a robust and showy native annual clover endemic to low elevation coastal grasslands in several counties surrounding San Francisco Bay. Currently, there is only one known extant population of a previously unknown recumbent coastal bluff form. Factors thought to have contributed to the near loss of the plant are habitat loss, livestock grazing, and competition from introduced species. However, native clovers were an important food resource for tribal people in the area, and were traditionally managed by small-scale burning. I have experimentally planted seeds from the historically more widespread upright inland form (for which there are no known extant populations) at two sites in in order to: 1) characterize habitat requirements and threats, and; 2) quantify the effects of indigenous burning regime on new populations. I found that both sites experienced high seedling mortality at the cotyledon stage due to herbivory by the gray field slug, *Deroceras reticulatum*. The introduction of *D. reticulatum* into California in 1891 may have been the final blow to remnant populations pushed into marginal habitats. To test the impact of *D. reticulatum* populations on the decline of *T. amoenum,* I will conduct slug exclusion experiments this fall along with prescribed burns.

Leger, Elizabeth A.[1], Kevin J. Rice[1], and Eric E. Knapp[2]. [1]UC Davis. [2]USGS Western Ecological Research Center. (ealeger@ucdavis.edu). **Effects of cross-pollination with non-local genotypes on the restoration of purple needlegrass in the Sierra foothills.**

Restoration of habitats with non-local sources of seed can be well intentioned, but may have negative affects on remnant populations of native plants. This study examines the effect of cross-pollination with non-local populations of purple needlegrass, *Nassella pulchra*, at the UC Sierra Field Station, Yuba County, CA. Local plants were crossed with populations from the Santa Rosa Plateau, Riverside County, CA, and planted in common gardens at the local site, along with local and non-local plants as controls. We measured size and fecundity traits in this gardens for two years. Because first generation hybrids between disparate populations can show increased vigor that can disappear in future generations, we grew the progeny of these cross-population hybrids with local plants as a control in a similar common garden. We measured size and fecundity traits in this garden for one year. Multivariate analyses identified differences between hybrid plants and their parents, with the greatest difference being that hybrid plants made larger seeds than either parent in both years. There were significant differences between the offspring of the hybrid plants and the local populations, and again the largest difference was that the offspring of hybrid plants made larger seeds than local plants. Our results show that there are effects of cross-pollination with non-local genotypes, but the effect might be a positive one, with both hybrid plants and their progeny producing larger seeds than local plants. One must keep in mind, however, that these are results from a short-term study of a perennial plant, and that long-term monitoring of this site could reveal further differences between genotypes.

Lulow, Megan E.[1], Truman P. Young[1], and Jeanne L. Wirka[2]. UC Davis and Audubon-California (melulow@ucdavis.edu). **Variation in the Success of Seeded Native Bunchgrasses in Rangeland Foothills: the roles of Aspect, *Erodium botrys*, and Soil Type**

We investigated the roles of key environmental variables in the establishment success of native bunchgrasses seeded across rolling rangeland topography. Six species of native grasses were drill seeded in the fall of 1999 after the land had been prepared for seeding with a spring burn and fall application of glyphosate. In spring 2001 and 2002, cover was significantly greater on northern aspects for native bunchgrasses, with no significant trends in other grassland groups. Native bunchgrasses, non-native grasses, and native forbs all had significantly greater cover outside vs. inside patches of *E. botrys* at the end of the second growing season. Cover of grassland groups was also compared across two soil types differing in fertility, organic matter, and acidity. With the exception of *E. botrys* having greater cover on the less fertile soil, no trends emerged among grassland groups. *Nassella pulchra* stood out among the native bunchgrasses as the only species that lacked a preference for northern aspects and a response to patches of *E. botrys*, reinforcing its reputation as a species that can tolerate extreme conditions. This study supports ideas that native grasses prefer northern aspects, and additionally suggests that edaphic conditions, rather than reduced competition, account for this difference.

Luster, Ryan[1] and Fred Thomas[2]. [1]The Nature Conservancy; [2]CERUS Consulting. (rluster@tnc.org). **Weed control techniques for establishing native grasslands in the Middle Sacramento river floodplain, California.**

The Nature Conservancy's Sacramento River Project focuses on the protection and restoration of riparian and aquatic habitats along California's Sacramento River. This poster presents preliminary results from a grassland establishment experiment investigating the effectiveness of biological, chemical, and mechanical weed control methods and seeding timing for successful native grass establishment. The goal of the experiment is to determine the most effective weed control techniques in the experimental plots that can be applied to grassland restoration projects in the Sacramento River floodplain. In this experiment we are asking several questions: 1) Is glyphosate the most effective herbicide for preparing a site for native grassland establishment? 2) Is glyphosate plus a broad-spectrum broadleaf herbicide more effective in controlling weeds than glyphosate alone? and 3) Are two herbicide treatments followed by direct seeding more effective than one herbicide treatment followed by direct seeding? Answers to these questions will aid grassland restoration practitioners to better understand the importance of herbicide treatment and timing of direct seeding for successful establishment in abandoned agricultural fields of the Sacramento River floodplain.

Malmstrom, Carolyn M. and H. Scott Butterfield, Michigan State University (malmstr1@msu.edu). **Big Brother or Good Buddy? Using remote sensing and a web-based tool to help landowners assess the impact of management activities on rangeland forage dynamics.**

As a society, we are becoming accustomed to the idea that cameras have proliferated and that satellites can count the number of vehicles in our driveway. But how do landowners respond when biologists use similar imaging technology to assess conservation efforts on their property? We will discuss this question in the context of our research experience using satellite technology to evaluate forage dynamics over large areas of private ranch holdings, as part of Audubon-California's Landowner Stewardship Program in the Willow Slough watershed.

Marty, Jaymee T., The Nature Conservancy. (jmarty@tnc.org). **Managing for diversity in California vernal pool grasslands.**

The majority of California's vernal pool grassland habitat is currently and has historically been used as range for cattle. Conservation organizations have historically supported grazing as a compatible management practice in this habitat, but scientific information regarding the impacts of grazing on vernal pools is limited to anecdotal information and unreplicated studies. This study is designed to quantify the community-level changes that occur when cattle grazing is removed from vernal pools. Plant and aquatic invertebrate species abundance and richness are being measured in four different grazing removal treatments. These treatments are replicated six times across two soil types and a range of vernal pool sizes. After three years of treatment, ungrazed pools had significantly higher cover of exotic plants, particularly exotic annual grasses, than grazed pools. Grazing removal also contributed to significant changes in pool hydrology in the 2002-2003 field season. Ungrazed pools were inundated for a shorter period of time and were more likely to dry and refill multiple times throughout the season than grazed pools. Species richness of native plants and aquatic invertebrates was significantly higher in grazed versus ungrazed treatments. The preliminary results of this study suggest that the removal of cattle grazing from vernal pool grasslands negatively impacts not only native plant and aquatic invertebrate species diversity but also pool hydrology.

Mason, Liz and Susan Mazer, UC Santa Barbara. (lmason@co.santa-barbara.ca.us). **Effects of Cattle Grazing on Three Native California Perennial Grass Species: seedling growth, reproduction and suvivorship**

We monitored the responses of three native perennial bunchgrasses to cattle grazing in order to determine whether there are consistent effects of grazing on seedling performance that could help to inform a management strategy for grassland sustainability and restoration in serpentine-derived soils at Vandenberg Air Force Base (VAFB) in Santa Barbara County, California. We evaluated the effects of grazing on growth, reproduction, and survivorship of *Bromus carinatus*, *Hordeum brachyantherum*, and *Nassella pulchra* over two growing seasons, 2000-2001. Grazing promoted the highest mean seedling growth in all three species relative to complete protection from large herbivores. Increased competition and standing litter in ungrazed treatments suppressed seedling growth more than did the temporary reduction of biomass. There was, however, significant spatial variation in the magnitude and significance of grazing effects on seedling performance. Under some conditions (lighter grazing in richer soils), grazing appeared to promote reproduction by *B. carinatus* and *H. brachyantherum* seedlings. In contrast to the apparent positive effects of grazing on seedling growth and reproduction, grazing reduced seedling survivorship. Our results suggest that grazing combined with rest-rotation may be an effective tool to help maintain populations of native perennial bunchgrasses at Vandenberg Air Force Base. We recommend enforcing a grazing regime in which seedlings are protected during their early growth in winter and early spring, and in which seedlings are permitted to reach a threshold size before exposure to grazing.

McKay, John and Kevin Rice. UC Davis. (jkmckay@ucdavis.edu). **After the bottleneck: The role of quantitative trait mutation and maternal effects of the adaptive spread of the invasive barbed goatgrass, *Aegilops triuncialis***

Two major mechanisms have been proposed to explain the ability of introduced populations to colonize over large habitat gradients, despite significant population bottlenecks during introduction: 1) Broad Environmental Tolerance - successful invaders possess life history traits which confer superior colonizing ability and/or phenotypic plasticity, allowing acclimation to a wide range of habitats, and 2) Local Adaptation - successful invaders rapidly adapt to local selective pressures. However, many introduced grass species are cleistogamous, and therefore may have no genetic variation to allow the evolution of invasive traits and plasticity. Using genomic markers from wheat, we demonstrate that populations of barbed goatgrass are derived from a single founder. Despite this extreme bottleneck, our quantitative genetic experiments show variation in adaptive traits within and among populations invading serpentine soils. These results suggest a two-phase evolutionary process in barbed goatgrass invasions. First, plasticity (in the form of maternal effects) allowed populations to become initially established and naturalized. Then, once population sizes reach the thousands, novel mutations arise at a frequency high enough to provide the raw material for genetic differentiation and adaptation.

Mikkelsen, Thomas H., Ray Budzinski. East Bay Regional Park District. (Tomalyse@aol.com). **East Bay Regional Park District Grassland Management**

What is the big fuss about grasslands in the East Bay anyway? Are they an integral component of the landscape mosaic of the East Bay to be preserved in perpetuity, a seedbed for anti-grazing activists to rail on and on about what should or shouldn't be, or are they just fodder for livestock? All of the above would seem to be the (partially) correct answer. The East Bay Regional Park District manages approximately 55,000 acres of grasslands in Alameda and Contra Costa Counties. In 2000, as a response to public concerns about cattle in the regional parks, the District commenced an evaluation of grassland management, specifically the practice of using cattle grazing as a primary management tool. The review process was conducted by a Task Force comprised of three members of the District's Board of Directors and five members of the Citizen based, Park Advisory Committee. Approximately 280 persons attended the Task Force meetings and another 90 individuals provided testimony during the 18 month course of background sessions, workshops and field trips. The Task Force visited nine Regional Parks and a major East Bay reservoir watershed to evaluate field conditions and to review specific grazing practices related to the management of natural resources. All meetings and field trips were all open to the public. Written summaries of each meeting and the reports presented by EBRPD staff were routinely posted on the District's website, www.ebparks.org. The review process took two years to complete and with surprisingly little fanfare, given all the fuss, the District immediately began a multi-year grassland monitoring program with the University of California at Berkeley and implemented adaptive management techniques in the routine stewardship of its grassland resources. The information gained from ongoing research and the day to day management of grazing tenants (cattle, sheep and goats) will continue to shape and refine the grassland management program for the next decade.

Parker, Sophie S. and Joshua P. Schimel. UC Santa Barbara. (parker@lifesci.ucsb.edu). **The distinct life history traits of grasses influence leaching and microbial immobilization of soil nitrogen**

To better understand the seasonal timing of nitrogen transformations in a California grassland ecosystem, we quantified leaching losses and rates of microbial N processing in both monocultures and mixed stands of native perennials (*Nassella pulchra*, *Bromus carinatus*, and *Elymus glaucus*) and nonnative annuals (*Bromus hordeaceus*, *Bromus madritensis*, and *Hordeum murinum*) seeded on homogeneous initial soils at Sedgwick Reserve. Just after the onset of the autumn rains in early November, microbial biomass N was greater in annual plots than in perennial plots, while microbial biomass C did not differ by plot type. Annual seedlings, which sprout from seed in the fall, may compete poorly with microbes for N in comparison to full-grown perennials. This could lead to a shift in N processing rates under annual grasses in the fall. However, the high clay content of soils at our site may postpone leaching losses of soil nitrate until late into the

rainy season, giving annual grasses more time to grow and eventually take up nitrate before it is leached below the rooting zone. Nearly ten times as much nitrate leached from perennial plots in comparison to annual plots, suggesting that once they are established, annual grasses may tightly cycle N in the upper 10cm of soil, leaving little to be lost through leaching.

Rassbach, Kate. UC Berkeley. (rassbach@nature.Berkeley.EDU). **Ecological Genetics of Nassella pulchra in Environmental Restoration**

My research addresses genetic implications of methods used in seed collection for environmental restoration. Seed collectors often focus on dense stands of target species while neglecting areas where target species grow at low relative densities. Restoration guidelines, however, recommend capturing the full range of genetic variation available on the seed-collection site by harvesting from many parents in all types of microsites. If biotic environment plays a selective role, plants growing in sparse patches may differ genetically from conspecifics growing in dense patches. If plants in sparse patches are bypassed by seed collectors, the genetic variation these plants may represent would be lost from restoration efforts. I examined *Nassella pulchra* (purple needlegrass) growing in dense versus sparse patches in three coastal-prairie sites, combining field and common-garden pot studies to examine potential differences in genetic characteristics among plants originating in different patch types. Differences in emergence, growth and reproduction may reflect variations in competitive regime experienced by parent plants, and may have implications for seed accession for purposes beyond restoration.

Reever Morghan, Kimberly J. and Kevin Rice. UC Davis. (kmorghan@ucdavis.edu). ***Centaurea solstitialis*** **invasion success is influenced by** ***Nassella pulchra*** **size**

Conversion of California's grasslands from a perennial to an annual system has increased soil moisture availability in deep soil layers. *Centaurea solstitialis*, a deep-rooted nonnative forb, can access this unused soil moisture and invade annual grasslands. Perennial grasses, especially established ones, also produce deep root systems and can compete for this soil moisture with *C. solstitialis*. For two years I studied how the size of established *N. pulchra* plants affected the success of *C. solstitialis* invasion into adjacent soil. *C. solstitialis* seed was allowed to fall naturally into plots containing *N. pulchra* plants. I measured the number of *C. solstitialis* seedlings and adult plants, total biomass, and total seedhead production for *C. solstitialis* growing in plots with *N. pulchra*. *C. solstitialis* number, biomass, and seedhead production was significantly negatively impacted by larger *N. pulchra* plants in both years of the study. However, *C. solstitialis* successfully produced some seed even around the largest *N. pulchra* plants, especially during a high rainfall year. I conclude that plantings with larger established *N. pulchra* plants will be more resistant to invasion by *C. solstitialis* than young *N. pulchra* plantings, but some management must continue as long as a *C. solstitialis* seed source is present.

Rice, Kevin, John McKay, and John Gerlach, UC Davis. (kjrice@ucdavis.edu). **Goatgrass and serpentine: A case of rapid adaptation?**

Barbed goatgrass, *Aegilops triuncialis* is a noxious annual grass that has been rapidly expanding its range in recent years. This species is capable of invading serpentine habitats generally thought to be invasion resistant. We sampled spreading populations of barbed goatgrass to investigate selection and evolutionary change during invasion into different habitat types. We collected seed from core microsites where goatgrass has become locally established as well as edge microsites where it is spreading as a front, to examine genetic variability and the potential for rapid adaptation. To examine rapid local adaptation along invasion fronts, reciprocal transplant experiments using bulked seed were initiated at each of the seed collection sites. Analyses of survival and reproduction suggested that genotypes from edge populations represent a subset of large seeded genotypes that perform well in both edge and core microsites. To control for maternal environment effects, we repeated the experiment for an additional year using seed produced in a common environment. Results from these experiments indicate that the edge genotypes perform better in edge sites but there were no differences among genotypes in core sites. Our results suggest that invasion of serpentine by goatgrass may be facilitated by highly localized and rapid evolutionary changes.

Robertson, Dina and James Bartolome. UC Berkeley. (plants@igc.org). **Influence of Historic Land Use and Environmental Factors on Grassland Species Composition in the Southern Diablo Foothills of California**

This study examined how historic dry-land farming and environmental factors affect grassland species composition in the southern Diablo Range in California. Dry-land farming, or farming without irrigation, was practiced in the Diablo Range from the 1800's until the 1990's. Aerial photographs, archival research and interviews with long time residents were used to locate and confirm areas where past cultivation occurred. Archival research required extensive consideration to determine the chain of title and land use practices of the numerous owners, tenant farmers and ranchers that have populated the area since European settlement. Plant species cover was estimated using point line transects, and environmental data collected included percent slope, aspect, soil texture and chemistry. Ordination analysis was used to identify the relative influence of environmental factors and historic land use on grassland plant composition. Ordination results suggested a trend in species distributions according to cultivation and soil texture, but not a significant one. Perhaps the more important finding in this study is the extent to which these grasslands have been manipulated by humans for hundreds of years. Findings suggest that ecological studies of this or similar sites would not be complete without a historical ecology component.

Seabloom, Eric W.[1] and O.J. Reichman[2]. [1]National Center for Ecological Analysis and Synthesis, Santa Barbara, CA. [2]Department UC Santa Barbara. (seabloom@nceas.ucsb.edu). **Community complementarity, disturbance, and the restoration of California grasslands**

Human endeavors have resulted in dramatic reductions in the dominance of native plant communities and corresponding changes in the abiotic environment. Furthermore, human impacts on the environment are expected to increase in the foreseeable future. Thus, to be successful, restored plant communities must maintain dominance in the face of changing disturbance regimes and abiotic conditions. Theory suggests that community complementarity in diverse communities should lead to increased resistance to disturbance. We examined the role of complementarity in a restored suite of California native perennial grasses by subjecting the community to a range of disturbances including fire, tilling, nitrogen addition, and mowing. Disturbance treatments had strong effects on relative abundances of the native grass species. While individual species of native perennial grasses were nearly extirpated in some treatments, their differing responses maintained dominance of native perennials over a wide range of conditions. Short-lived perennial grasses (e.g. Bromus carinatus and Elymus glaucus) were dominant in early successional communities and under conditions that increased system productivity (e.g., N addition). In contrast, longer-lived species (e.g., Nassella sp.) dominated in low nutrient and burned plots. These results demonstrate the importance of community-wide complementarity for successful restoration in the face of changing disturbance regimes.

Solomeshch, Ayzik I. and Michael G. Barbour. UC Davis. (aizsolomeshch@ucdavis.edu). **Could California grasslands all have been derived from bunchgrass prairie?**

California grasslands dominated by exotic annuals represent one of the most dramatic examples of ecological invasions. The widely accepted view is that they were originally dominated by perennial bunchgrasses (Clements 1920). However, this view is based on limited evidence (Hamilton 1997). We analyzed 55 plots (100m^2 each) trying to understand whether or not all of them could have been derived from bunchgrass prairie. Grasslands were sampled on hillocks near vernal pool complexes in Solano and Sacramento counties, all located within vegetation type 36, "California prairie (Stipa spp.)," on the map of Natural Vegetation of California (Kuchler 1977). Despite the low abundance of native species, their contribution to α-diversity is much greater than the contribution of exotics. Of the 175 taxa of vascular plants we encountered, 122 were native. Five community types were recognized based on differences in their native species assemblages. Their life form spectra and ratio between native and exotic species were analyzed. We show that some modern grasslands could not have been derived from bunchgrass vegetation, and that the diversity of pre-contact communities was not restricted to bunchgrass prairie, but also included annual-dominated vegetation.

Strathmann, Katrina[1], Julie Nygard[2], and Lisa Dillon[1]. [1]Golden Gate National Recreation Area (NPS), [2]San Francisco State University. (katrina_strathmann@nps.gov). **Case Example: Preliminary Results of Serpentine Grassland Restoration Following Tree Removal, Presidio of San Francisco**

In 2001, exotic trees were removed from two acres of serpentine grassland in the Presidio of San Francisco. In winter 2001-02, the National Park Service, Presidio Trust, Golden Gate National Parks Conservancy and community volunteers collaborated on restoration of the site. Restoration, if successful, will increase serpentine grassland habitat by 30% within a fragment that supports two federally protected serpentine endemics. In revegetation trials, we evaluated early survival of transplanted container plants and of seeded annual species. Average survival 16 months following installation was 78%, with highest survival for grasses (94%). Four months after seeding, survival of annuals varied among species from less than 1% to over 50%, suggesting that some annual species may require seed stratification or specific environmental conditions. Composition of the grassland changed dramatically from 2001 to 2003 due to removal and revegetation, with native grasses and annuals each increasing by 14%; exotic grasses and annuals increased by 14% and 22% over the same period. To characterize soils prior to restoration, and to compare soil properties to two adjacent formerly forested sites, soils were analyzed for chemical and physical composition. We plan to resample vegetation and soil nutrients after revegetation is complete.

Sweet, Sara and DiTomaso, Joseph. UC Davis. (sbsweet@ucdavis.edu). **Refining a restoration tool: minimum requirements of fire to control two invasive exotic annual grasses.**

Prescribed burning has had mixed success in controlling invasive exotic annual grasses. However, burning deserves further research because it is inexpensive and can remove thatch, which inhibits revegetation efforts. In order to use burning effectively, managers must know the minimum temperature and duration of exposure necessary to kill weed seeds, and whether these minimum requirements vary over the period of seed development. We determined these requirements for two invasive exotic annual grasses, medusahead (Taeniatherum caput-medusae (L.) Nevski) and barbed goatgrass (Aegilops triuncialis (L.)), at four times during seed development. To simulate conditions on the soil surface, we used a brick-lined furnace to expose seeds to heat for 25 temperature-duration combinations. To simulate conditions in the flame, we used a Bunsen burner (flame temperature 375 ¡À 25 C) to expose seeds for 5 durations. Germination tests measured the success of each treatment. Seeds of both species grew more resistant to heat and flame as they matured. The soil surface conditions generated by grassland fires will not kill most seeds of either species, regardless of seed maturity. Immature medusahead and goatgrass seeds (>30% moisture) require 6-8 s exposure to flame of 375 C to achieve >95% control, while mature seeds (¡Ü10% moisture) require over 10 s. According to these results, prescribed burns have the highest chance of controlling these two species if conducted as soon as the fuel will carry a flame.

Thomsen, Meredith. UC Berkeley. (mthomsen@socrates.berkeley.edu). **Interactions among elements of resistance to invasion in a California coastal prairie.**

Understanding the mechanisms of resistance in a community is a first step towards using resistance as a management tool. I conducted an experiment in a California coastal prairie to evaluate how competition from residents and water availability contribute to resistance to the invasion of the exotic perennial grass *Holcus lanatus* L. (velvet grass). I planted monocultures of three native perennial grass species, which I subsequently invaded by adding *Holcus* seeds. I watered half these plots to extend the period of high soil moisture availability by three months. These plots were randomly distributed across a single hillside; because a number of factors vary along this slope, I examined elevation in several analyses. Resident species identity had a strong effect on *Holcus* seedling establishment; the plots of one species were as highly invaded as bare plots, while the other two were much less invaded. The less-invaded plots had higher percent cover and lower light levels at the soil surface, suggesting that light limitation is an important element of resistance in this system. Evaluated alone, watering had no effect on *Holcus* establishment; however, in a model with watering treatment, elevation, and their interaction, all three factors were significant. Watered plots were less invaded at lower elevation, and the invasion of control plots did not change along the slope. Seedling numbers from a second year of seed additions follow the same patterns for resident identity and the significant interaction of watering and elevation. In contrast, however, watered plots had significantly fewer new *Holcus* seedlings in the second year. From these results, it appears that disturbances that open the canopy of established native grasses may decrease resistance to invasion. Furthermore, managers should be on guard for *Holcus* expansion into drier habitats in wet years, since resident resistance could be lower in these areas, and even short-term increased water availability may benefit *Holcus*.

Twedt, Brain, Paul Reeberg, and Robin Wills. National Park Service, Point Reyes National Seashore. **Effects of prescribed fire and mechanical shrub removal on coastal grasslands of Point Reyes National Seashore, Marin County, CA**

Point Reyes National Seashore has supported an active prescribed fire program for the past fifteen years. The park's boundaries encompass a diverse array of plant communities, including some excellent examples of remnant grasslands. A long history of varied land use has degraded many of these communities. Since 1990 a combination of prescribed fire and mechanical treatments have been implemented in an effort to control selected weed species and increase the cover of native grasses. Management treatments have demonstrated a significant reduction in the frequency of Scotch broom (*Cytisus scoparius*). The frequency of occurrence of this shrub has been reduced, on average, by 84% within sampled plots. Encouraging reductions of French broom (*Genista monspessulanus*) have also been seen following multiple treatments. Results suggest that mechanical treatment (i.e., cutting/mowing) followed by multiple burns (3 to 5) over the course of 10 to 12 years can be an effective means of managing these introduced species. Still monitoring also

indicates a sharp decline in relative % native cover in at least three of the vegetation types where prescribed burning is being conducted. Common velvet grass (*Holcus lanatus*), a non-native perennial, may be increasing in response to the current prescription. It would appear that conservation of native plant species and reduction of non-native plant species may be difficult to achieve under the current management regimes. Trends in community structure have been analyzed and an adaptive refinement of burn prescriptions is suggested.

Young, Steve L., Joseph M. DiTomaso and Guy B. Kyser. UC Davis. (slyoung@ucdavis.edu). **The ability of native plants to prevent weed establishment**

Native species have declined on non-agricultural land due to aggressive non-native species, especially annual grasses. A combination of overgrazing, periods of drought, fire suppression and introduction of non-native seed have led to the large-scale replacement of natives by exotics. Deep-rooted weeds, like yellow starthistle, have the potential to invade annual grasslands where deep soil moisture is underutilized by exotic annual grasses. A study has been initiated to 1) assess whether a restored native perennial community can suppress yellow starthistle invasion to a greater extent than a non-native annual grass ecosystem and 2) determine whether adding annual native forbs in the first year to increase functional diversity of a community can suppress subsequent invasion by yellow starthistle. Native species were chosen that had good potential for establishment in Yolo County soil conditions and climate and could take up water primarily either early or late in the growing season. Seeds of the different species were mixed together and broadcast by hand in December 2000. Yellow starthistle was added to the plots by broadcast application in early fall 2001. Cover, density and number of flowering culms (grasses) or stems (broadleaves) of each species was measured at the end of spring and summer. Soil moisture measurements were taken with a neutron probe at 30, 60, 90, 120, 150 and 180 cm approximately every three weeks from April through October. After two years of research, some midpoint observations can be made about plant community resistance to yellow starthistle or annual grasses. For soil moisture: use was less in the early season plant community after two years and an early/late season community had a similar water use pattern to yellow starthistle. Soil moisture depletion was greatest for the late season plant community and the addition of yellow starthistle to an early season plant community caused an increase in water use, indicating that such communities are vulnerable to yellow starthistle invasion. For competition: late season plant communities were most effective in suppressing yellow starthistle. More diverse perennial communities appear to not only compete with yellow starthistle for soil moisture, but also for available light during the growing season.