Garry oak ecosystems recovery team

Annotated Bibliography on the Ecology and Management of Invasive Species:

Soft Brome (*Bromus hordeaceus*)

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For the Garry Oak Ecosystems Recovery Team

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Peer-Reviewed Journal Articles

Andersson, L., W. Milberg, and O. Steinmetz. 2002. Germination characteristics and emergence time of annual *Bromus* species of differing weediness in Sweden. European Weed Research Society Weed Research 42: 135-147.

Abstract: The germination ecology of four annual *Bromus* species, which differ in weediness on arable land in southern Sweden, was investigated. The most problematic species is *Bromus sterilis*, while *Bromus hordeaceus* frequently occurs on arable land. In contrast, *Bromus arvensis* is a rare weed, and *Bromus tectorum* is found infrequently in fields despite being a widespread ruderal species. Five experiments were conducted to identify germination characteristics that could explain differences in habitat and abundance: (i) intraspecific variation in dormancy level; (ii) germination response to different light conditions; (iii) light and temperature interactions at germination; (iv) timing of seedling emergence; and (v) seed persistence in soil. *Bromus sterilis* and *B. tectorum* behaved similarly in all tests. For both these species, there were large differences in dormancy level among populations and strong inhibition of germination by light. In addition, emergence from seeds sown on the soil surface was both delayed and reduced compared with buried seeds. In contrast, *B. hordeaceus* and *B. arvensis* showed generally weak dormancy, and germination was only slightly inhibited by light. It was concluded that germination characteristics alone do not explain the differences in weediness between these four species.

Clarke, J., S. Moss, and J. Orson. 2000. The future for grass weed management in the UK. The Royal Society of Chemistry Pesticide Outlook (April 2000): 59-63.

Abstract: This article reviews recent research on weeds and their management. It also highlights some issues for improvement in future weed management. Identified issues for consideration are the timing of treatment, competition between weeds and desired crops, weed resistance to herbicides, and mechanical removal of weeds.

DiTomasio, J. M., M. L. Brooks, E. B. Allen, R. Minnich, P. M. Rice, and G. B. Kyser. 2006. Control of invasive weeds with prescribed burning. Weed Technology 20: 535-548.

Abstract: Prescribed burning has primarily been used as a tool for the control of invasive late-season annual broadleaf and grass species, particularly yellow starthistle, medusahead, barb goatgrass, and several bromes. However, timely burning of a few invasive biennial broadleaves (e.g., sweetclover and garlic mustard), perennial grasses (e.g., bluegrasses and smooth brome), and woody species (e.g., brooms and Chinese tallow tree) also has been successful. In many cases, the effectiveness of prescribed burning can be enhanced when incorporated into an integrated vegetation management program. Although there are some excellent examples of successful use of prescribed burning for the control of invasive species, a limited number of species have been evaluated. In addition, few studies have measured the impact of prescribed burning on the long-term changes in plant communities, impacts to endangered plant species, effects on wildlife and insect populations, and alterations in soil biology, including nutrition, mycorrhizae, and hydrology. In this review, we evaluate the current state of knowledge on prescribed burning as a tool for invasive weed management.

Hamilton, J. G., C. Holzapfel, and B. E. Marshall. 1999. Coexistence and interference between a native perennial grass and non-native annual grasses in California. Oecologia 121: 518-526.

Abstract: Little is known about the potential for coexistence between native and non-native plants after large scale biological invasions. Using the example of native perennial bunchgrasses and non-native annual grasses in California grasslands, we sought to determine the effects of interference from non-native grasses on the different life stages of the native perennial bunchgrass *Nassella pulchra.* Further, we asked whether *N. pulchra* interferes with non-native annual grasses, and whether competition for water is an important component of these interspecific interactions in this water-limited system. In a series of field and greenhouse experiments employing neighbor removals and additions of water, we found that seedling recruitment of *N. pulchra* was strongly seed-limited. In both field and greenhouse, natural recruitment of *N. pulchra* seedlings from grassland soil was extremely low. In field plots where we added seeds, addition of water to field plots increased density of *N. pulchra* seedlings by 88% and increased total aboveground *N. pulchra* seedling biomass by almost 90%, suggesting that water was the primary limiting resource. In the greenhouse, simulated drought early in the growing season had a greater negative effect on the biomass of annual seedlings than on the seedlings of *N. pulchra*. In the field, presence of annuals reduced growth and seed production of all sizes of *N. pulchra,* and these effects did not decrease as *N. pulchra* individuals increased in size. These negative effects appeared to be due to competition for water, because *N. pulchra* plants showed less negative pre-dawn leaf water potentials when annual neighbors were removed. Also, simply adding water caused the same increases in aboveground biomass and seed production of *N. pulchra* plants as removing all annual neighbors. We found no evidence that established *N. pulchra* plants were able to suppress non-native annual grasses. Removing large *N. pulchra* individuals did not affect peak biomass per unit area of annuals. We conclude that effects of interference from non native annuals are important through all life stages of the native perennial *N. pulchra*. Our results suggest that persistence of native bunchgrasses may be enhanced by greater mortality of annual than perennial seedlings during drought, and possibly by reduced competition for water in wet years because of increased resource availability.

Harrison, S., B. D. Inoye, and H. D. Safford. 2003. Ecological heterogeneity in the effects of grazing and fire on grassland diversity. Conservation Biology 17 (3): 837-845.

Abstract: Grazing and fire and are major forces shaping patterns of native and exotic species diversity in many grasslands, yet both of these disturbances have notoriously variable effects. Few studies have examined how landscape-level heterogeneity in grassland characteristics, such as soil-based variation in biomass and species composition, may contribute to variation in the effects of fire or grazing. We studied the effects of livestock grazing and fire in a mosaic of serpentine and nonserpentine soils in California, where most grasslands are dominated by exotic annuals and serpentine soil is the major refuge for native grassland species. We predicted that the effects of disturbance would be proportional to productivity and therefore would be greater on nonserpentine than serpentine soils. We measured species composition at 80–100 grazed or ungrazed sites for 2 years before (1998–1999) and 2 years after (2000–2001) an autumn wildfire. Both disturbances increased total species richness on both soils. However, fire enhanced total and exotic species richness more on nonserpentine soils and enhanced native species richness more on serpentine soils. Grazing increased native species richness on serpentine soils but not on nonserpentine soils. These soil-disturbance interactions suggest that the use of fire and grazing to manage native species diversity in wildlands must be done with careful attention to background ecological heterogeneity.

Hawkes, C. V., J. Belnap, C. D'Antonio, and M. K. Firestone. 2006. Arbuscular mycorrhizal assemblages in native plant roots change in the presence of invasive exotic grasses. Plant and Soil 281: 369-380.

Abstract: Plant invasions have the potential to significantly alter soil microbial communities, given their often considerable aboveground effects. We examined how plant invasions altered the arbuscular mycorrhizal fungi of native plant roots in a grassland site in California and one in Utah. In the California site, we used experimentally created plant communities composed of exotic (*Avena barbata*, *Bromus hordeaceus*) and native (*Nassella* *pulchra*, *Lupinus bicolor*) monocultures and mixtures. In the Utah semi-arid grassland, we took advantage of invasion by *Bromus tectorum* into long-term plots dominated by either of two native grasses, *Hilaria jamesii* or *Stipa hymenoides*. Arbuscular mycorrhizal fungi colonizing roots were characterized with PCR amplification of the ITS region, cloning, and sequencing. We saw a significant effect of the presence of exotic grasses on the diversity of mycorrhizal fungi colonizing native plant roots. In the three native grasses, richness of mycorrhizal fungi decreased; in the native forb at the California site, the number of fungal RFLP patterns increased in the presence of exotics. The exotic grasses also caused the composition of the mycorrhizal community in native roots to shift dramatically both in California, with turnover of *Glomus* spp., and Utah, with replacement of *Glomus* spp. by apparently non-mycorrhizal fungi. Invading plants may be able to influence the network of mycorrhizal fungi in soil that is available to natives through either earlier root activity or differential carbon provision compared to natives. Alteration of the soil microbial community by plant invasion can provide a mechanism for both successful invasion and the resulting effects of invaders on the ecosystem.

Hutchings, M. J. and K. D. Booth. 1996. Studies on the feasibility or re-creating chalk grassland vegetation on ex-arable land. I. The potential roles of the seed bank and the seed rain. Journal of Applied Ecology 33 (5): 1171-1181.

Abstract: 1. This study is an investigation of the potential of the seed bank and the seed rain to promote the re-establishment of chalk grassland vegetation on an exarable site which had not been cultivated for 10 years. Comparisons are drawn with the composition of the seed bank as recorded in a study undertaken close to the current site 6 years after cultivation ceased. 2. The seed bank had the following composition: 46-6% grass seeds, 38-6% perennial forbs, 8.4% biennial forbs and 6.3% annual forbs. In comparison, annual forbs had accounted for 49.5% of the seed bank 6 years after cultivation ceased. The seed bank was concentrated near the top of the soil profile and grass seeds showed a more marked decline in abundance with depth than forb species. However, common annual forb species mostly germinated from the lower soil strata. The common grasses and perennial forbs were species with wide ecological amplitudes, characteristic of fertilized, neutral grassland. 3. Only 20 of the 68 forb species recorded in the seed bank were characteristic components of adjacent ancient chalk grassland. These species accounted for less than 20% of the total forb seed bank. Only two out of 11 recorded grass species were characteristic of the ancient chalk grassland, and these accounted for only 0.3% of all grass seedlings. The grass component of the seed bank was dominated by Agrostis stolonifera. 4. The species richness of the seed bank has increased in recent years due mainly to acquisition of seeds of non-annuals. However, species characteristic of the ancient chalk grassland have made little contribution either to the seed bank or to the vegetation growing on the site. Those chalk grassland species which were most abundant in the seed bank tended to be short- lived species and they occurred mainly at the margins of the ex-arable site, close to the adjacent chalk grassland. Even here they rarely accounted for more than 20% of the germinable seed bank. They were strongly concentrated at the soil surface, indicating their deposition since cultivation ceased. 5. Agrostis spp., Phleum pratense and Holcus lanatus accounted for over 50% of the recorded seed rain. Of the commonly trapped species, analyses of mean dispersal breadths indicated that forb species characteristic of the adjacent chalk grassland would be comparatively slow invaders of ex-arable habitats. 6. The vegetation on transects across the ex-arable site contained few of the species which occurred in the adjacent oldchalk grassland. Chalk grassland species were more abundant in vegetation at the margins of the ex-arable site, but even here similarity indices between the ex-arable vegetation and the chalk grassland vegetation were normally below 25%. 7. The slow invasion of species from the adjacent chalk grassland into this ex-arable site, which is ideally placed for their colonization, suggests that seeds of such species will often need to be artificially introduced to prevent ex-arable sites becoming dominated by fast-growing more weedy species. Further management would also be necessary to prevent more weedy species subsequently invading and eliminating the chalk grassland species.

Keeley, J. E., M. Baer-Keeley, and C. J. Fotheringham. 2005. Alien plant dynamics following fire in Mediterranean-climate California shrublands. Ecological Applications 15 (6): 2109-2125.

Abstract: Over 75 species of alien plants were recorded during the first five years after fire in southern California shrublands, most of which were European annuals. Both cover and richness of aliens varied between years and plant association. Alien cover was lowest in the first postfire year in all plant associations and remained low during succession in chaparral but increased in sage scrub. Alien cover and richness were significantly correlated with year (time since disturbance) and with precipitation in both coastal and interior sage scrub associations. Hypothesized factors determining alien dominance were tested with structural equation modeling. Models that included nitrogen deposition and distance from the coast were not significant, but with those variables removed we obtained a significant model that gave an R^2 = 0.60 for the response variable of fifth year alien dominance. Factors directly affecting alien dominance were (1) woody canopy closure and (2) alien seed banks. Significant indirect effects were (3) fire intensity, (4) fire history, (5) prefire stand structure, (6) aridity, and (7) community type. According to this model the most critical factor influencing aliens is the rapid return of the shrub and subshrub canopy. Thus, in these communities a single functional type (woody plants) appears to the most critical element controlling alien invasion and persistence. Fire history is an important indirect factor because it affects both prefire stand structure and postfire alien seed banks. Despite being fire-prone ecosystems, these shrublands are not adapted to fire per se, but rather to a particular fire regime. Alterations in the fire regime produce a very different selective environment, and high fire frequency changes the selective regime to favor aliens. This study does not support the widely held belief that prescription burning is a viable management practice for controlling alien species on semiarid landscapes.

Lunt, I. D. 1990. Impact of an autumn fire on a long-grazed *Themeda triandra* (Kangaroo Grass) grassland: implications for management of invaded, remnant vegetations. Victoria Naturalist 107 (2): 45-51.

Abstract: The regeneration of vegetation after an intense autumn fire was studied in a longunburnt and long-grazed *Themeda triandra* Forssk. grassland at the Derrimut Grassland Reserve, Melbourne. Floristic composition and species richness did not change due to burning. The fire promoted abundant regeneration of exotics from seed, particularly *Vulpia bromoides, Romulea rosea, Briza minor* and *Aira cupaniana.* However, few native species regenerated from seed. Seedling regeneration reflected the composition of the soil seed bank after 80 years of grazing. In long-grazed grasslands (and presumably other communities) in which exotics are abundant, burning will continue to promote exotic species. If vegetation management aims to promote natives at the expense of exotics, fire cannot be used as the primary tool of management. Integrated techniques of vegetation manipulation must be developed.

MacDougall, A. S. and R. Turkington. 2007. Does the type of disturbance matter when restoring disturbance-dependent grasslands? Restoration Ecology 15 (2): 263-272.

Abstract: The reintroduction of burning is usually viewed as critical for grassland restoration; but its ecological necessity is often untested. On the one hand, fire may be irreplaceable because it suppresses dominant competitors, eliminates litter, and modifies resource availability. On the other hand, its impacts could be mimicked by other disturbances such as mowing or weeding that suppress dominants but without the risks sometimes associated with burning. Using a 5-year field experiment in a degraded oak savanna, we tested the impacts of fire, cutting and raking, and weeding on two factors critical for restoration: controlling dominant invasive grasses and increasing subordinate native flora. We manipulated the season of treatment application and used sites with different soil depths because both factors influence fire behavior. We found no significant difference among the treatments-all were similarly effective at suppressing exotics and increasing native plant growth. This occurred because light is the

primary limiting resource for many native species and each treatment increased its availability. The effectiveness of disturbance for restoration depended more on the timing of application and site factors than on the type of treatment used. Summer disturbances occurred near their reproductive peak of the exotics, so their mortality approached 100%. Positive responses by native species were significantly greater on shallow soils because these areas had higher native diversity prior to treatment. Although likely not applicable to all disturbance-dependent ecosystems, these results emphasize the importance of testing the effectiveness of alternative restoration treatments prior to their application.

Malmstrom, C. M., A. J. McCullough, H. A. Johnson, L. A. Newton, and E. T. Borer. 2005. Invasive annual grasses indirectly increase virus incidence in California native perennial bunchgrasses. Oecologia 145: 153-164.

Abstract: In California valley grasslands, *Avena fatua* L. and other exotic annual grasses have largely displaced native perennial bunchgrasses such as *Elymus glaucus* Buckley and *Nassella pulchra* (A. Hitchc.) Barkworth. The invasion success and continued dominance of the exotics has been generally attributed to changes in disturbance regimes and the outcome of direct competition between species. Here, we report that exotic grasses can also indirectly increase disease incidence in nearby native grasses. We found that the presence of *A. fatua* more than doubled incidence of infection by barley and cereal yellow dwarf viruses (B/CYDVs) in *E. glaucus*. Because B/CYDV infection can stunt *E. glaucus* and other native bunchgrasses, the indirect effects of *A. fatua* on virus incidence in natives suggests that apparent competition may be an additional mechanism influencing interactions among exotic and native grasses in California. *A. fatua*'s influence on virus incidence is likely mediated by its effects on populations of aphids that vector B/CYDVs. In our study, aphids consistently preferred exotic annuals as hosts and experienced higher fecundity on them, suggesting that the exotics can attract and amplify vector populations. To the best of our knowledge, these findings are the first demonstration that exotic plants can indirectly influence virus incidence in natives. We suggest that invasion success may be influenced by the capacity of exotic plant species to increase the pathogen loads of native species with which they compete.

Pickart, A. J., L. M. Miller, and T. E. Duebendorfer. 1998. Yellow bush lupine invasion in Northern California coastal dunes I. Ecological impacts and manual restoration techniques. Restoration Ecology 6 (1): 59-68.

Abstract: We studied the ecological effects of the invasion of coastal dunes by Lupinus arboreus (yellow bush lupine), an introduced species, and used the results to develop manual restoration techniques on the North Spit of Humboldt Bay. Vegetation and soil data were collected in five vegetation types representing points along a continuum of bush lupine's invasive influence. We collected data on the number and size of shrubs, vegetation cover, and soil nutrients. One set of plots was subjected to two restoration treatments: removal of lupine shrubs only, or removal of all nonnative vegetation and removal of litter and duff. Treatments were repeated annually for four years, and emerging lupine seedlings were monitored for three years. Prior to treatment, ammonium and nitrate were found to increase along the lupine continuum, but organic matter decreased at the extreme lupine end. Yellow bush lupine was not the most significant variable affecting variation in soil nutrients. After four years, nonnative grasses, including Vulpia bromoides, Holcus lanatus (velvet grass), Bromus spp. (brome), and Aira spp. (European hairgrass), were significantly reduced in those restoration plots from which litter and duff was removed. Native species increased significantly in vegetation types that were less influenced by lupine. By the third year, soil variables differed among vegetation types but not by treatment. Bush lupine seedling emergence was higher, however, in plots receiving the litter and duff removal treatment. Based on these results, we conclude that bush lupine invasion results in both direct soil enrichment and indirect enrichment as a result of the associated encroachment of other nonnative species, particularly grasses. Although treatment did not affect soil nutrients

during the period of this study, it did reduce establishment of nonnative grasses and recruitment of new bush lupine seedlings. Restoration should therefore include litter and duff removal. In areas that are heavily influenced by lupine and contain few native propagules, revegetation is also required.

Pollak, O. and T. Kan. 1998. The Use of Prescribed Fire to Control Invasive Exotic Weeds at Jepson Prairie Preserve. In Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference. Witham, C. W., E. T. Bauder, D. Belk, W. R. Ferren, Jr., and R. Ornduff (eds.). California Native Plant Society. Sacramento, California. pp. 241-249.

Abstract: Jepson Prairie in Solano County, an outstanding example of remnant California Central Valley vernal pool and grassland habitats, is threatened by invasive exotic species. This paper describes the results of a 200-acre late-spring prescribed fire conducted at Jepson Prairie in June of 1995 and aimed at reducing the cover of an extensive infestation of Medusahead (*Taeniatherum caput-medusae*). Burned and unburned control plots are compared with respect to changes in community composition within three habitat types. The habitat types - mound, intermound, and swale - correspond to three topographic/hydrologic regimes within vernal pool complexes. Ocular estimates of percent cover (using Daubenmire cover classes) were recorded for six species guilds: native grasses, exotic grasses, native early forbs, exotic early forbs, native late forbs, and exotic late forbs. Cover of thatch, bare ground and residual dry matter was also measured. Results show significant decreases in the cover of exotic annual grasses (including Medusahead) and thatch in burned mound and intermound habitats. Cover of native grasses and native early forbs increased on burned mound and intermound habitats. However, exotic early forbs also increased on burned mounds and intermounds, due mainly to an increase in cover of *Erodium* spp. The results provide strong evidence that late-spring burning reduces the cover of non-native annual grasses, such as Medusahead, while increasing the dominance of native species and the cover of native grasses and forbs. Prescriptions for management of vernal pool and grassland habitats in California should include late-spring prescribed fire in areas that have heavy infestations of Medusahead or an accumulated thatch layer.

Rice, K. J. and E. S. Nagy. 2000. Oak canopy effect on the distribution patterns of two annual grasses: the role of competition and soil nutrients. American Journal of Botany 87 (11): 1699-1706.

Abstract: Within the oak woodlands of California there is often a distinct shift in the botanical composition between the open grassland and the herbaceous understory beneath oak canopy. Botanical sampling at two woodland sites indicated that the annual grass *Bromus diandrus* was dominant under deciduous blue oak canopy, while a congener, *Bromus hordeaceus*, was dominant in open grassland. We examined the relative importance of congeneric competition and edaphic factors in creating these differences in species distribution in two separate field experiments that manipulated both congeneric and intraspecific competition, as well as soil type. We used the demographic measure of relative reproductive rate as an index of population growth. In general, demographic performance correctly predicted the distribution of the two annual grasses in the field. Our results indicate that reduced abundance of *B. hordeaceus* under canopy reflects the negative effects of competition with *B. diandrus.* In contrast, *B. diandrus* is little affected by competition from *B. hordeaceus.* The reduced abundance of *B. diandrus* in open grassland may result, in part, from its inability to adapt as well as *B. hordeaceus* to lower nutrient availability in soils of the open grassland.

Roberts, H. A. 1986. Persistence of seeds of some grass species in cultivated soil. Grass and Forage Science 41: 273-276.

Abstract: Freshly collected ripe caryopses of twenty-five indigenous grasses were mixed

with the top 7-5 cm of sterilized soil confined in cylinders sunk in the ground and cultivated three times yearly. There was a flush of seedlings of most species shortly after sowing, but species differed in the persistence of viable seeds. About one third, including *Bromus sterilis, B. hordeaceus, Lolium perenne ssp. perenne, Arrhenatherum elatius a.nd Alopecurus pratensis,* produced few seedlings after the initial flush. Others such as *Deschampsia cespitosa, Holcus lanatus* and *Poa trivialis,* recognized as forming persistent seed banks in grassland soils, produced appreciable numbers of seedlings in the second year after sowing. Most persistent were species that occur as arable weeds *(Avena fatua, Poa annua)* or in wetlands *(Glyceria plicata, G. maxima, Alopecurus geniculatus).* Emergence from the seed bank generally followed soil disturbance but some species *(Aira praecox, Avena fatua, A. sterilis* ssp. *ludoviciana, Danthonia decumbens)* exhibited consistent seasonal patterns which may be associated with cyclic changes in germination requirements of the buried seeds.

Wu, K. K. and S. K. Jain. 1979. Population regulation in *Bromus rubens* and *B. mollis*: Life cycle components and competition. Oecologia 39 (3): 1432-1439.

Abstract: A series of *Bromus rubens* and *B. mollis* populations were sampled in the coastal range and northern part of the Central Valley of California in order to study their population ecology in demographic terms. Quantitative estimates were obtained on plants collected directly in nature, and their progenies in controlled environments with randomized block design in the greenhouse. Two parameters of population growth - the intrinsic rate of increase, *r*, and the carrying capacity, *K*-were estimated by using the logistic model (*r*=ln *R* and *K*=equilibrium population size). It was found that *B. mollis* is a relatively *K*-type species, while *B. rubens* is a relatively *r*-type species. The effects of density on competition between individuals in pure and mixed populations of *B. mollis* and *B. rubens* were studied. In both species, increasing density induced greater mortality and a striking plastic reduction in the size and reproductive potential of the individuals. Further, *B. rubens* showed a relatively greater mortality and less plastic response to densities than *B. mollis* in both pure and mixed stands. Two different types of plasticity were considered: one in response to changing density (d-plasticity); and the other in response to changing enironmental conditions (e-plasticity). High plasticity in one of them need not imply that the other one is high too. *B. rubens* showed higher e-plasticity, but lower d-plasticity than *B. mollis*. The relationships between *r, K* and competitive ability were discussed. Two types of *K*-strategy were distinguished: one involving greater nonreproductive effort with longer life span, or lowered mortality (Type-I) and the other with density-induced adjustments in body size along with survival in higher numbers (Type-II). Different populations of these two *Bromus* species showed different values of *r* and *K* (Type-II) and different competitive abilities. It was found that higher *r* was usually accompanied by lower *K* (Type-II), while higher *K* (Type-II) was accompanied by lower competitive ability, which in turn is correlated with higher d-plasticity. In general, coexistence was predicted on the basis of estimates derived from the interspecific competition experiments.

Other Published Sources

Frost, W. E., J. W. Bartolome, and J. M. Connor. 1997. Understory-canopy relationships in oak woodlands and savannas. In Proceedings of a Symposium on Oak Woodlands: Ecology, management, and urban interface issues. Gen. Tech. Rep. PSW-GTR-160. Pillsbury, N. H., J. Verner, and W. D. Tietje (eds.). U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Albany, CA. pp. 183-190.

Abstract: STUDY OBJECTIVE: to summarize available information about the relationships between oak overstory and understory plants for major California rangeland types. Although Quercus garryana is mentioned as a component of the montane hardwood forests, one

of the five major hardwood rangeland habitat types in California, there is no specific mention of the species in the literature review. RESULTS: Deciduous oak canopies in areas with less than 50cm annual precipitation generally have either no effect or enhance understory productivity compared to adjacent grassland. Dense canopies in areas with more than 50cm annual precipitation generally suppress understory productivity. Forage management implications are summarized for different woodland types around the State (Table 1 - live oaks vs. deciduous oaks - not species specific)

Parminter, J. and D. Bedford. 2006. Fire effects on selected bryophytes, lichens and herbs in Garry oak and associated ecosystems. The Garry Oak Ecosystems Recovery Team and the Nature Conservancy of Canada. Victoria, BC.

Abstract: This paper summarizes the effects of fire on plant species in the Garry oak and associated ecosystems. Discusses the fire ecology of each species, the effects of fire on the plant, the response of the plant to fire and considerations for fire management.

Rice, P. M. 2005. Fire as a tool for controlling nonnative invasive plants. Centre for Invasive Plant Management. Bozeman, Montana.

Abstract: This paper is a review of 235 available published papers about controlling invasive species with intentional burning. It is specified that knowledge of a plant's life history, plant morphology, and phenology is required to effectively prescribe management by burning, as is the promoting of desirable species in conjuction with burning. *Bromus hordeaceus* was found to increase after burning aimed at controlling medusahead, as it seeds much earlier. However, the removal of the mulch layer by burning or other method, reduced seed germination of *B. hordeaceus* and other exotic grass species.

Online Resources

Calflora. 2008. Calflora: Information on California plants for education, research and conservation. http://www.calflora.org/. The Calflora Database [a non-profit organization]. Berkeley, CA.

Clayton, W. D., K. T. Harman, and H. Williamson. 2008. GrassBase - The Online World Grass Flora. http://www.kew.org/data/grasses-db.html. The Board of Trustees, Royal Botanic Gardens, Kew.

Dyer, D. and R. O'Beck. 2008. Plant Guide. plants.usda.gov/plantguide/doc/pg_brhoh .doc. USDA NRCS Plant Materials Center. Lockeford, California.

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Peeters, A. 2008. Grassland Species Profiles. http://www.fao.org/ag/AGP/AGPC/doc/ GBASE/Default.htm. Food and Agriculture Organization.

Stewart, H. and R. Hebda. 2002. Grasses of the Columbia Basin of British Columbia: Major groups of grasses and their characteristics. http://www.livinglandscapes.bc.ca/cbasin/cb_grasses

/groups.html. Living Landscapes program of the Royal British Columbia Museum. 675 Belleville Street, Victoria, British Columbia, Canada V8W 9W2.

UC IPM Online Statewide Integrated Pest Management Program . 2008. Pests in Gardens and Landscapes—Weeds. http://www.ipm.ucdavis.edu/PMG/menu.weeds.html. University of California Agriculture and Natural Resources.

United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). 2008. Plants Database. http://plants.usda.gov/.