Garry oak ecosystems recovery team

Annotated Bibliography on the Ecology and Management of Invasive Species:

Barren Fescue (*Vulpia bromoides*) and Rattail Fescue (*Vulpia myuros*)

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For the Garry Oak Ecosystems Recovery Team

February 2009

Funding supplied by the Habitat Stewardship Program for Species at Risk of Environment Canada

Environment Canada Environnement Canada

Peer-Reviewed Journal Articles

An, M., J. E. Pratley, and T. Haig. 1997. Phytotoxicity of *Vulpia* residues: I. investigation of aqueous extracts. Journal of Chemical Ecology 23 (8): 1979-1995.

Abstract: Phytotoxic properties of vulpia *(V. myuros)* residue extracts on wheat *(Triticum aestivum* L. cv. Vulcan) were examined in the laboratory. Vulpia residues contained water-soluble materials that were toxic to germination and to coleoptile and root growth of wheat. There were strong correlations between extract concentration and toxicity, between extraction times and toxicity, and between extract pH and phytotoxicity. The phytotoxicity was residue rate dependent. There was no significant correlation between the phytotoxicity of residue extracts and the electrical conductivity of aqueous extracts. Milled residues were more toxic than chopped residues. The toxicity of vulpia residues increased as their decomposition proceeded, reaching a peak phytotoxicity after decomposition for 40 days and remaining potent for up to 60 days, gradually declining thereafter. Radicle elongation of wheat was the most sensitive indicator, germination was the least sensitive, and coleoptile growth was intermediate. The phytoxic effects of residue extracts on seed germination had two aspects: germination delay and inhibition. The relative magnitude of each aspect depended upon the potency of the extracts. With a strong phytotoxic potential, inhibition of germination was dominant over seed germination, whereas with a weak toxic level, delay was dominant over seed germination.

Ball, D. A., S. M. Frost, L. H. Bennett, D. C. Thill, T. Rauch, E. Jemmett, C. Mallory-Smith, C. Cole, J. P. Yenish, and R. Rood. 2007. Control of rattail fescue (*Vulpia myuros*) in winter wheat. Weed Technology 21: 583-590.

Abstract: Rattail fescue, a winter annual grass weed, has been increasing in Pacific Northwest (PNW) dryland cereal producing areas. Although rattail fescue is not a new weed species in the PNW, its incidence is expanding rapidly in circumstances where soil disturbances are minimized such as in direct seed systems. Options for effective rattail fescue control in winter wheat cropping systems have not been adequately investigated and need to be developed. Rattail fescue control with herbicide treatments was investigated in imidazolinone-resistant winter wheat using imazamox and other herbicides. Across multiple sites and two growing seasons, crop injury from herbicide treatments was minor to negligible with some exceptions. Treatments containing imazamox or mesosulfuron produced minor, transient winter wheat crop injury at some locations in some years. With the exception of flufenacet applied preemergence (PRE), control of rattail fescue in wheat was variable with single herbicide applications, but improved with sequential herbicide treatments. Rattail fescue biomass was greatly reduced by several treatments especially those containing flufenacet or from sequential herbicide application. Crop yield varied among sites due to growing season precipitation, and in some cases from rattail fescue control or herbicide related crop injury.

Ball, D. A., S. M. Frost, L. Frandrich, C. Tarasoff, and C. Mallory-Smith. 2008. Biological attributes of rattail fescue (*Vulpia myuros*) (abstract). Weed Science 56 (1): 26-31.

Abstract: Control of rattail fescue, a winter annual grass, can be difficult in spring or winter wheat. Although rattail fescue is not a new weed species in the Pacific Northwest, occurrences have been increasing in circumstances where soil disturbances are minimized, such as in direct-seed cropping systems. To develop integrated management strategies for rattail fescue, information is needed on the longevity of seed viability in the soil, the presence of seed dormancy, vernalization requirements, and optimal environmental conditions for seed germination and establishment under field conditions. Controlled experiments on the biology of rattail fescue indicated that newly mature seed required an afterripening period of 1 to 12 mo to obtain high

levels of seed germination, depending on germination temperature. Maximum seed germination was observed at constant day/night temperatures of approximately 20 C from thermogradient plate studies. Germination tests from seed burial studies indicated that a majority of buried seed was not viable after 2 to 3 yr. Field-grown rattail fescue plants required vernalization to produce panicles and germinable seed. A short afterripening period, cool germination temperature, and vernalization requirements support the classification of rattail fescue as a winter annual. This information will facilitate development of rattail fescue management systems, including crop rotations and various control tactics such as tillage or herbicide application timing during fallow periods.

Best, R. J. 2008. Exotic grasses and feces deposition by an exotic herbivore combine to reduce the relative abundance of native forbs. Oecologia 158 (2): 319-327.

Abstract: Increased resource availability can facilitate establishment of exotic plant species, especially when coincident with propagule supply. Following establishment, increased resource availability may also facilitate the spread of exotic plant species if it enhances their competitive abilities relative to native species. Exotic Canada geese (*Branta canadensis*) introduce both exotic grass seed and nutrients to an endangered plant community on the Gulf Islands of southwestern British Columbia, Canada. I used greenhouse experiments to assess the competitive advantage of the exotic grasses relative to native and exotic forbs in this community and to test the impacts of nutrient addition from goose feces on competitive outcomes. I grew experimental communities varying in their proportion of forbs versus exotic grasses, and added goose feces as a nutrient source. I found that both native and exotic forbs produced significantly more biomass in competition with conspecifics than in competition with the grasses, and that the proportional abundance of two out of three native forbs was lowest in the combined presence of exotic grasses and nutrient addition. In a second experiment, I found that in monoculture all species of forbs and grasses showed equal growth responses to nutrients. The exotic species did not convert additional nutrients into additional biomass at a higher rate, but did germinate earlier and grow larger than the native species regardless of nutrient availability. This suggests that the exotic species may have achieved their competitive advantage partly by pre-empting resources in community mixtures. Small and late-germinating native forbs may be particularly vulnerable to competitive suppression from exotic grasses and forbs and may be at an even greater disadvantage if their competitors are benefiting from early access to additional nutrients. In combination, the input of exotic propagules and additional nutrients by nesting geese may compromise efforts to maintain native community composition in this system.

Brown, C. S. and K. J. Rice. 2000. The mark of Zorro: effects of the exotic annual grass *Vulpia myuros* on California native perennial grasses. Restoration Ecology 8 (1): 10-17.

Abstract: Native perennial grasses were once common in California prairies that are now dominated by annual grasses introduced from Europe. Competition from exotics may be a principal impediment to reestablishment of native perennial grasses. Introduced annual grasses, such as *Vulpia myuros* (zorro fescue), are often included with native perennial species in revegetation seed mixtures used in California. To examine the potential suppressive effect of this graminoid, we evaluated the growth and performance of a mixture of California native perennial grasses and resident weeds when grown with varying densities of *V. myuros*. The annual fescue exhibited a strongly plastic growth response to plant density, producing similar amounts of above-ground biomass at all seeding densities. Perennial grass seedling survival and above- ground biomass decreased and individuals became thinner (i.e., reduced weight-to-height ratio) with increasing *V. myuros* seeding density. *V. myuros* also significantly suppressed above-ground biomass and densities of weeds and had a more negative effect on weed densities than on native perennial grass densities. Biomass of native grasses and weeds was not differentially affected by increasing densities of *V. myuros*. Overall, because *V. myuros* significantly reduced the survival and performance of the mixture of native perennial grasses and this effect increased with

increasing *V. myuros* density, we conclude that including this exotic annual in native seed mixtures is counterproductive to restoration efforts.

Didham, R. K., J. M. Tylianakis, M. A. Hutchison, R. M. Ewers, and N. J. Gemmell. 2005. Are invasive species the drivers of ecological change? Trends in ecology and evolution 20 (9): 470-474.

Abstract: Invasive species are widely accepted as one of the leading direct causes of biodiversity loss. However, much of the evidence for this contention is based on simple correlations between exotic dominance and native species decline in degraded systems. Although appealing, direct causality is not the only possible interpretation. A plausible alternative hypothesis is that exotic dominance could be the indirect consequence of habitat modification driving native species loss. In a new paper, MacDougall and Turkington now provide the first direct test of whether invasive species are the drivers of community change, or merely 'passengers' along for the environmental ride.

Flood, R. G. and G. M. Halloran. 1982. Flowering behaviour of four annual grass species in relation to temperature and photoperiod. Annals of Botany 49: 469-475.

Abstract: Populations of four co-habiting annual grass species *Bromus mollis* L. (Soft brome), *Hordeum hystrix* Roth (Mediterranean barley grass), *Lolium rigidum* Gaud. (Wimmera ryegrass) and *Vulpia bromoides* (L.) S. F. Gray (Squirrel-tail fescue) were examined for the presence and comparative levels of vernalization and photoperiod response. This was evaluated as the number of days from sowing to heading in both long (16 h) and short (normal, over-winter) photoperiods at two levels of temperature. Wide variation among the species in both vernalization and photoperiodic response was detected. *L. rigidum* possessed a high level of vernalization response and was comparatively sensitive to photoperiod while *V. bromoides* possessed little or no vernalization response and was comparatively insensitive to photoperiod. *B. mollis* and *H. hystrix* appeared to be intermediate between these two species for both responses. There were wide differences in time to heading under long photoperiod (16 h) and high temperature (20 °C) of plants derived from seed of three of the species ripened under non-vernalizing temperatures. This variation indicates the likely existence of genetic differences in vernalization response between plants of these populations. The implications of these findings to the adaptability of these species to the Australian environment have been outlined.

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 $R2 5 0.60$ 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.

Jemmett, E. D., D. C. Thill, T. A. Rauch, D. A. Ball, S. M. Frost, L. H. Bennett, J. P. Yenish, and R. J. Rood. 2008. Rattail fescue (*Vulpia myuros*) control in chemical-fallow cropping systems (abstract). Weed Technology 22 (3): 435-441.

Abstract: Rattail fescue infestations are increasing in dryland conservation-tillage winter wheat cropping systems in the inland Pacific Northwest (PNW) region of Idaho, Oregon, and Washington. Rattail fescue typically is controlled with cultivation in conventional tillage farming systems. However, reduced soil disturbance has allowed infestations to increase significantly. The objectives of this research were to determine the effectiveness of glyphosate rates and application timings on control of rattail fescue during a chemical-fallow period in winter wheat cropping systems. Chemical-fallow field studies were conducted during two growing seasons at nine sites throughout the PNW. Glyphosate was applied early POST, late POST, or sequentially in early plus late POST timings. Additionally, paraquat + diuron was applied early and late POST alone or sequentially with glyphosate. Sequential application treatments (glyphosate followed by [fb] glyphosate, paraquat + diuron fb glyphosate, and glyphosate fb paraquat + diuron) controlled rattail fescue (94% in Idaho and Washington, 74% in Oregon) and reduced panicle number (85% in Idaho, 30% in Oregon and Washington) equivalent to or greater than one-time treatments. Rattail fescue control and panicle reduction generally increased with increasing rates of glyphosate within application timings. Paraquat + diuron usually provided similar control and reduced rattail fescue panicle number compared to glyphosate treatments applied at the same application timing. Although not completely effective, sequential applications of either glyphosate or paraquat + diuron, fb glyphosate will provide effective control during chemical fallow.

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.

Maron, J. L. and R. L. Jefferies. 2001. Restoring enriched grasslands: effects of mowing on species richness, productivity, and nitrogen retention. Ecological Applications 11 (4): 1088-1100.

Abstract: Species-rich grasslands that become enriched with nitrogen often suffer decreases in species richness, increases in plant biomass, and invasion by weedy exotic species. Suitable techniques to restore enriched grasslands and reestablish native communities are increasingly needed. Here we report results of a 5-yr experiment in enriched coastal prairie grasslands (Bodega Marine Reserve, Bodega Bay, California, USA), to determine the combined effects of mowing and biomass removal on total soil nitrogen, net rates of mineralization, nitrogen retention, and species richness and biomass. We mowed and removed plant biomass from plots in areas where the N-fixing shrub, bush lupine (*Lupinus arboreus*), had greatly enriched the soil, and where the community was composed of weedy introduced plants. Our goal was to facilitate the establishment of the native grassland assemblage such as was found at nearby low soil nitrogen sites. Mowing and biomass removal resulted in a dramatic change in the species assemblage, from exotic annual grasses to a mixed exotic/native forb community composed primarily of perennials. Species richness was significantly greater in treated plots than in control plots; weedy exotic grasses diminished in abundance, and both native and exotic forb species increased. In mowed vs. control plots, there was significantly less mean aboveground biomass, but significantly greater belowground biomass. This shift in species composition had significant impacts on nitrogen retention. In late fall and winter when plant-available N was highest, much nitrogen leached from the effectively fallow control plots where germination of annual grasses did not peak until midwinter. In contrast, mowed plots retained substantially greater amounts of nitrogen, due to the presence of perennial plants possessing large amounts of belowground biomass early in the season. Despite the cumulative removal of 22 g N/m^2 in biomass over 5 yr, there was no difference between mowed and control plots in total soil N, pool sizes of inorganic N, or net rates of N mineralization. The results indicate that removal of plant biomass by mowing shifted this plant community from an annual grass to a perennial forb assemblage. However, in doing so, N retention by vegetation was increased, making it more difficult to reduce soil N.

Perchemlides, K. A., P. S. Muir, and P. E. Hosten. 2008. Responses of chaparral and oak woodland plant communities to fuel-reduction thinning in Southwestern Oregon. Rangeland Ecology and Management 61 (1): 98-109.

Abstract: Fire suppression has led to large fuel accumulations in many regions of the United States. In response to concerns about associated wildfire hazards, land managers in the western United States are carrying out extensive fuel-reduction thinning programs. Although reductions in cover by woody vegetation seem likely to cause changes in herbaceous communities, few published studies have reported on consequences of such treatments for native or exotic plant species. We compared vegetation and abiotic characteristics between paired thinned and unthinned chaparral and oak woodland communities of southwestern Oregon 4-7 yr posttreatment and contrasted impacts of manual vs. mechanical treatments. Herbaceous cover increased on thinned sites, but species richness did not change. Herbaceous communities at thinned sites had an early postdisturbance type of composition dominated by native annual forbs and exotic annual grasses; cover by annuals was nearly twice as high on treated as on untreated sites. Absolute and proportional cover of native annual forbs increased more than any other trait group, whereas exotic annual forbs and native perennial forbs declined. Exotic annual grass cover (absolute and proportional) increased, whereas cover by native perennial grasses did not. Shrub reestablishment was sparse after thinning, probably because of a lack of fire-stimulated germination. Manual and mechanical treatment impacts on abiotic site conditions differed, but differences in vegetation impacts were not statistically significant. Fuel-reduction thinning may have some unintended negative impacts, including expansion of exotic grasses, reductions in native perennial species cover, persistent domination by annuals, and increased surface fuels. Coupled with sparse tree or shrub regeneration, these alterations suggest that ecological-state changes may occur in treated communities. Such changes might be mitigated by retaining more

woody cover than is currently retained, seeding with native perennials after treatment, or other practices; further research is needed to inform management in these ecosystems.

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.

Scott, J. M. and G. J. Blair. 1987. Competition from *Vulpia myuros* (L.) C.C. Gmelin in pastures, and its control by coating seeds with herbicides (abstract). Australian Journal of Experimental Agriculture 27 (3): 367-375.

Abstract: Competition from the annual grass weed rat's tail fescue (*Vulpia myuros* [L.] C. C. Gmelin) seriously reduces the establishment of autumn sown, direct-drilled pastures on the Northern Tablelands of New South Wales. Field populations of rat's tail fescue of 43 000 seedlings m^{-2} have been observed. The effect of a range of rat's tail fescue populations (0, 5, 10, 20, 40 and 80x 103 seeds m^{-2}) on the early growth of lucerne and phalaris was measured in a glasshouse experiment in soil amended with either high or low levels of nitrogen and phosphorus. Under both fertility regimes, competition from rat's tail fescue was severe at densities of 5x 103 seeds m^{-2} and above with leaf number, plant height and DM yield of the sown species being markedly reduced in the presence of rat's tail fescue. In 2 further glasshouse experiments with lucerne, a wide range of seed-applied herbicides (EPTC, benfluralin, napropamide, chlorthal-dimethyl, trifluralin, oryzalin, alachlor, diclofop-methyl and 2,2-DPA) were evaluated at several rates to control germinating rat's tail fescue. EPTC significantly reduced weed density at rates as low as 0.35 kg ha^{-1} and was the only herbicide to significantly reduce the yield of rat's tail fescue (at rates as low as 0.1 kg ha^{-1}) and to allow an increase in the yield of the sown lucerne. Confirmation of the effectiveness of seed-applied EPTC under direct-drill conditions is still needed.

Tozer, K. M., D. F. Chapman, P. E. Quigley, P. M. Dowling, R. D. Cousens, G. A. Kearney, and J. R. Sedcole. 2008. Controlling invasive annual grasses in grazed pastures: population dynamics and critical gap sizes. Journal of Applied Ecology 45: 1152-1159.

Abstract: 1. Vulpia (*Vulpia bromoides* and *V. myuros*) and barley grass (*Hordeum murinum)* are prevalent annual grass weeds of native grasslands and grazed pastures in temperate climates, for which more effective control strategies are needed. Annual grass weeds can negatively impact natural grassland ecosystem function, in addition to causing productivity loss in agricultural systems. 2. We investigated the effects of gap size, time of sowing, grazing method (continuous or rotational grazing) and species sown in the gap (vulpia and/or barley grass) on vulpia and barley grass panicle production and intrinsic rate of population growth in southern Australian pastures. From these data, we estimated the critical gap size below which vulpia and barley grass populations would decline. 3. Panicle production declined rapidly with decreasing gap size, particularly in rotationally grazed pastures. Barley grass produced more panicles than vulpia in some treatments, while time of sowing, and sowing these annual species in mixture had little effect on panicle production. 4. The rate of population growth increased with gap size, but at the same rate in rotationally and continuously grazed pastures. There was no effect of annual species treatment (vulpia or barley grass) or time of sowing on the rate of population growth. The critical gap diameter was 0.04 cm and 2.31 cm for continuously and rotationally grazed pastures, respectively. 5. A sensitivity analysis showed that reducing plant fecundity (seeds plant -1) and propagule survival prior to seedling establishment by 60% could increase the critical gap diameter by 1.8 cm. 6. The results of this study highlight the importance of minimizing bare ground throughout autumn and winter to suppress annual grass weed population growth, as was unaffected by time of sowing. Estimates of and the critical gap diameter show that rotational grazing will better control weedy annual grasses than continuous grazing. Further, similar sensitivities of the critical gap diameter to fecundity and propagule survival prior to establishment lend support to weed management strategies that focus on reducing both fecundity and propagule survival.

Other Published Sources

Ball, D., C. Mallory-Smith, D. C. Thill, and J. P. Yenish. 2006. Biology and management of rattail fescue in direct-seed systems. In Proceedings of the 9th Annual PNW Direct Seed Cropping Systems Conference. Pacific Northwest Direct Seed Association. pp. 9-17.

Abstract: In chemical fallow, across four sites, glyphosate was more effective at controlling rattail fescue than paraquat + diuron. Split applications of glyphosate provided the most consistent control across locations and provided the greatest overall reduction in late-season rattail fescue panicle density and subsequent seed production. Stage of rattail fescue growth may be important in obtaining optimum control with glyphosate in fallow. In investigations of rattail fescue control in ClearfieldTM winter wheat across five locations each for two years, crop injury due to herbicide treatments was negligible to slight. Control of rattail fescue in wheat was generally marginal from single applications with the exception of flufenacet applied as a preemergence treatment. Sequential herbicide treatments provided excellent rattail fescue control. Rattail fescue biomass was greatly reduced from 10 flufenacet and sequential herbicide applications. Crop yield varied among sites and was, in general not related to level of rattail fescue control or crop injury. Laboratory studies on the biology of rattail fescue indicated that newly mature seed, depending on germination temperature, required from 1 to 6 months break a primary dormancy (afterripening) and obtain high levels of seed germination,. Optimal seed germination was observed at day/night temperatures of approximately 20 C from thermogradient plate studies. Seed burial studies at three locations indicated that a majority of buried rattail fescue seed decomposed after 3 years. Rattail fescue plants grown in a field study required vernalization to produce panicles and germinable seed. The presence of a short afterripening

requirement, cool seed germination temperature optima, and a vernalization requirement supports the classification of rattail fescue as a winter annual. Knowledge of seed dormancy, germination temperature optima, and longevity of seed in soil are useful information for developing rattail fescue management programs in dryland cropping systems.

COSEWIC. 2004. COSEWIC assessment and status report on the Rosy Owl-clover *Orthocarpus bracteosus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

Abstract: Species Information Rosy owl-clover (*Orthocarpus bracteosus*) is a small, annual herb. Its leaves are alternate and unstalked. The tube-shaped rose-purple flowers are grouped in a dense terminal spike among prominent bracts. A white-flowered form is occasionally encountered, usually among purple-flowered plants. Distribution Rosy owl-clover occurs in western North America, mainly from Vancouver Island south to Oregon west of the Cascades, and southward east of the Cascades to northern California. In Canada, it has been found in the vicinity of Victoria, British Columbia. Populations in the adjacent islands of Washington State have disappeared. Habitat Rosy owl-clover favours moist vernal pools and depressions that are moist in the winter and dry out in the summer. It is found with a variety of small herbs, in the absence of robust herbs, shrubs or trees. Biology Rosy owl-clover is an annual plant that germinates, grows, flowers and produces seed in the spring/early summer, and then withers and dies. Most seeds are probably dispersed in the vicinity of the parent plant, as the seeds lack adaptations for long-distance dispersal. It forms root-connections with a number of other species of plants, from which it obtains water and nutrients but it also contains chlorophyll and is autotrophic. Population Sizes and Trends A maximum of nine historic records are known. Eight of these presumably different populations dating from 1887 to 1954 are now extirpated. A single population remains on Trial Island, near Victoria, B.C. This population has fluctuated from 40 to about 940 individuals between 1998 and 2002 but the plants have not spread to occupy new habitat, even in favourable years. Limiting Factors and Threats Urbanization in the vicinity of Victoria, B.C. has eliminated many former populations and continues to pose a threat to suitable, unoccupied habitat. Invasions by aggressive, alien weeds have reduced the capability of habitats to support rosy owl-clover and threaten the remaining population on Trial Island. Foot traffic associated with the Canada Coast Guard lighthouse on Trial Island and incidental use by boaters also threaten the current population. Marine pollution presents a constant threat as this species occurs near sea level along a busy oil tanker route. Special Significance of the Species The British Columbia population of *O. bracteosus* is about 300 km disjunct from the northern extent of their main range in California, Oregon and southern Washington State. Existing Protection or Other Status Designations The Trial Island population occurs in Trial Island Ecological Reserve within metres of its boundary with a commercial communications lease. The plants, like all species within an ecological reserve, are legally protected under the Protected Areas of British Columbia Act. The ecological reserve lacks a management plan to address management of the species and employees rarely visit the site. Rosy owl-clover is red-listed in British Columbia and has a provincial status of S1 (critically imperiled).

Loo, Christopher. 2005. The ecology of naturalized silvergrass (*Vulpia*) populations in south-west Australia. Doctor of Philosophy in Biological Science. The University of Western Australia.

Abstract: Annual grasses have colonized a diverse range of environments in southern Australia. The “Silvergrasses” of the genus *Vulpia* are excellent examples being widely distributed, are prevalent weeds of agriculture and have had a long history to naturalise on the continent. Research was undertaken on *Vulpia* populations to identify if naturalizing species have reproductive traits that provide propagules with the best chances of success. Furthermore, research aimed at investigating if these traits vary between species and their populations and how this variability related to the environment.

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.

E-Flora. 2008. E-Flora BC: Electronic Atlas of the Plants of British Columbia. http://www.eflora.bc.ca/. Klinkenberg, Brian. (ed.) Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia. University of British Columbia, Vancouver, BC.

Howard, J. L. 2006. *Vulpia myuros*. In: Fire Effects Information System. http://www.fs.fed.us/database/feis/. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory.

The State of Victoria Department of Primary Industries. 2008. Victorian Resources Online. http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/vrohome.

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