Historical Jigsaw Puzzles: Piecing Together the Understory of Garry Oak (*Quercus garryana*) Ecosystems and the Implications for Restoration[1]

Carrina Maslovat[2]

Abstract

Ecosystem restoration requires a set of reference vegetation conditions which are difficult to find for Garry oak *(Quercus garryana)* ecosystems in Canada because contemporary sites have been drastically altered. A survey of historical information provides only limited clues about the original understory vegetation. Although there is considerable variation in the soils, climate, and successional status of current ecosystems, an exploration of the ecology of contemporary, native grass species existing in association with Garry oaks can point to which species may have been adapted to the historical disturbance regimes of pre-European contact ecosystems. Both California oatgrass (*Danthonia californica*) and *Achnatherum* sp., such as Lemmon's needle grass (*Achnatherum lemmonii*), have ecological characteristics that suggest they are adapted to the disturbance regimes of fire and camas digging. These characteristics include dormancy, hygroscopic awns, and self-pollinated cleistogenes.

Introduction

Reference conditions are critical for defining restoration goals, determining the potential of restoration sites, and evaluating the success of restoration. This reference information is commonly derived from contemporary, undisturbed reference sites and/or historical data (White and Walker 1997). One of the challenges in deriving reference conditions for the Canadian range of Garry oak ecosystems is determining a target for herbaceous species composition, especially native grass species.

The Garry oak ecosystem is limited in Canada primarily to southeastern Vancouver Island as far north as Comox, BC and the southern Gulf Islands (Erickson 1993, GOERT 2001). Although Garry oak ecosystems stretch along the west coast of North America as far as southern California, the Canadian portion is geographically, genetically, and ecologically important because it occurs at the extreme northern limits of this distribution (GOERT 2001). It is also distinct because adjacent Garry oak ecosystems in Washington State tend to be located on glacial outwash soils (Dunn 1998, Dunn and Ewing 1997), whereas in British Columbia, oak ecosystems are primarily on rock balds or deeper soils (Roemer 2000).

Contemporary Garry oak ecosystems throughout their range are severely fragmented, have had drastic alterations to their ecological processes, and have been

[1] An abbreviated version of this paper was presented at the Fifth Symposium on Oak Woodlands: Oaks in California's Changing Landscape, October 22-25, 2001, San Diego, California.

[2] M.Sc. student, University of Victoria, Victoria, BC (e-mail: cmaslovat@pacificcoast.net)

heavily invaded by exotic species and woody native species (Fuchs 2000). This limits their ability to serve as reference sites. In Canada, the Garry oak ecosystem is one of the three most endangered ecosystems and has become so degraded that only one percent remains close to a natural state. The remaining patches are small and extremely fragmented (GOERT 2001, Hebda and Aikens 1993).

The Garry oak ecosystem has been invaded by exotic species to such a degree that 40-76 percent of the herbaceous species in meadows are exotic and exotic species dominate the herbaceous cover, ranging from 59-82 percent (Erickson 1996, Roemer 1995). The original species composition is difficult to determine given the high levels of invasion by exotic grass species and paucity of native perennial grasses remaining.

Large-scale processes have also been altered, most notably by fire suppression that began soon after European settlement. Regular fires kept meadows free from invasion by woody species and maintained rich food resources for Coast Salish First Nations (Lutz 1995). Native species that are dominant now may be favored by current regimes (e.g., fire suppression) which differ from the influences present in the original Garry oak ecosystems (Bartolome and Gemmill 1981, Dunwiddie 1997). In addition, contemporary camas harvest by First Nations is extremely limited.

Because of the degradation of existing remnants of Garry oak ecosystems and the fragmentation of patches, restoration is critical to improve functionality and connectivity of the ecosystem (GOERT 2001). However, restoration efforts have been seriously hindered by a lack of reference conditions.

The role of native grass species and their relative abundance compared to forbs before European contact is not known. If native grasses were prominent, identification of the former dominant species in the ecosystem is critical for defining reference conditions.

In order to complement the information from existing sites, I reviewed historical literature from explorers, land surveyors, and early settlers for clues to herbaceous species composition and disturbance regimes. To augment this limited information, I surveyed contemporary literature on the ecology of native grass species currently found in Garry oak ecosystems to pinpoint candidate species that might have been abundant in the putative original ecosystem. The species researched were blue wild-rye (*Elymus glaucus* ssp. *glaucus*), California oatgrass (*Danthonia californica*), California brome (*Bromus carinatus*), June grass (*Koeleria macrantha*), Alaska oniongrass (*Melica subulata*), Lemmon's needlegrass (*Achnatherum lemmonii*) and Roemer's fescue (*Festuca idahoensis* var. *roemeri*). Although the composition of Garry oak ecosystems is highly variable, the ecology of the species and their adaptive strategies can offer suggestions as to which species would have been favored under former disturbance regimes. This paper does not address experimental data but instead reviews historical and contemporary literature in order to highlight the possible original species composition and indicate where future research should be focused.

Methods and Materials

I examined historical writings from settlers, land surveyors and explorers for descriptions of Garry oak ecosystems, with particular focus on the herbaceous community. These documents were obtained from the British Columbia Archives, libraries at the University of British Columbia and the University of Victoria, the Cowichan Valley Archives, and the Royal British Columbia Museum.

I also reviewed current literature on native grass species now found in Garry oak ecosystems to determine the ecological characteristics of individual species, including their response to disturbance, production of cleistogamous seed, dormancy and hygroscopic awns. I used this information to deduce which species would have been most likely to be common under former conditions and disturbance regimes.

Results

Historical Information

The historical literature that mentions the herbaceous layer of Garry oak ecosystems tends to be descriptive but not specific. There are species lists of showy forbs, but there are no descriptions or names recorded for grass species.

Judging from the descriptions "park-like" and "work of art," the historical herbaceous layer must have contained many flowering species. Mayne (1862) writes: "I have never seen wildflowers elsewhere grow with the beauty and luxuriance they possess here."

Historical descriptions of the grass component of the ecosystem require greater interpretation than that of forbs. Given the focus on self-sufficiency of the new Hudson's Bay Company colony, grass for forage would have been of considerable interest to settlers. The first governor of Victoria, Sir James Douglas, described in 1842 the rich, moist bottoms around future Fort Victoria as having an "abundance of grass and several varieties of red clover" (Bowsfield 1979). Other early reports of grasses associated with oaks seem to confirm that grass and grass/forb complexes were common occurrences in historical oak ecosystems (Fitzgerald 1848, Anonymous 1849).

Fire was a common feature of the pre-European contact ecosystem. In places with regular burns, the "fire runs along the grass at a great pace and it is the custom here if you are caught to gallop right through it: the grass being short, the flames being little and you are through it in a second" (Anonymous 1849).

Another report describes "[an area] which had not a blade of grass growing, owing to it having lately been burnt by the Indians, and that a few months afterwards, on going over the same spot, …the grass up to his middle in height" (Fitzgerald 1848).

Although by the 1860s there are numerous references to "fertile, grassy pastures," it cannot be determined if these are composed of native or exotic species. Extensive early grazing was highly destructive but relatively short in duration (Lutz 1995). Overgrazing led to a scarcity of "natural grasses" which caused the importation and sowing of exotic range species as early as 1851 (Bowsfield 1979; Grant 1857). By 1859 "varieties of every grass species which grows in Europe, and many which do not, are found" (Mayne 1862). Although it seems clear that grasses were common in the putative original Garry oak ecosystem, there are no early descriptions of the grass species present.

Before European settlement, specific areas of Garry oak ecosystems were intensively managed by the Coast Salish people for food production. This subjected the soil to frequent mechanical disturbance. The camas beds were managed as follows: "where the camas grew thick, the women had their own plots marked off with stakes…. Women dug the bulbs in the spring… When they had finished they leveled the ground and covered it with seaweed. Later when it was dry, they burned it over" (Suttles 1987).

Contemporary Ecological Information

In the absence of concrete details on historical understories, contemporary ecological characteristics of native grasses can be used to infer which species would have been adapted to the historical disturbances of fire and digging. Species differ in response to these environmental conditions both in vegetative growth and in germination characteristics *(table 1)*.

Table 1—*Adaptations to disturbance regimes of grass species associated with Garry oak ecosystems.*

	Vegetative response to fire	Dormancy	Cleistogenes	Hygroscopic awns
Blue wild-rye	High tolerance	No	No	No
California oatgrass	High tolerance	Yes	Yes	Yes
California brome	No data	No	Yes	No
June grass	High tolerance	No data	No	No
Alaska oniongrass	High tolerance	No	No	No
Lemmon's needlegrass	No data	Yes	Yes (*Achnatherum* sp.)	Yes (*Achnatherum* sp.)
Roemer's fescue	Decreases in cover	No	No	No

Vegetative Response to Disturbance

Native grass species differ in their response to fire. Blue wild-rye, Alaska oniongrass, June grass and California oatgrass have a high fire tolerance and do not decrease in cover with burns (FEIS 1999, Hatch and others 1999, USDA 1999). Idaho fescue (*Festuca idahoensis*) decreases in cover after burns, especially severe burns that damage the basal buds just below the soil surface (Dunwiddie 1997, FEIS 1999, Wikeem and Strang 1983). Few researchers have measured the response of these species to successive fires.

I could find no published information on the response of native grasses to indigenous harvesting regimes.The native species associated with Garry oak ecosystems are primarily bunchgrasses which do not spread extensively by rhizomes (Hitchcock 1969). With the combination of mechanical soil disturbance from camas harvesting and regular fires, recruitment from seed would have played an important role in determining species composition since patterns in plant succession are closely related to germination requirements and seedling establishment (Bartolome 1979).

Dormancy

One strategy that species use to adapt to disturbances is the formation of seedbanks by dormant seeds that require specific environmental cues to germinate.

Species that are adapted to establishing after a disturbance or in gaps generally make up the largest component of grassland seed banks (Rice 1989).

Many native species present in Garry oak ecosystems do not form seedbanks but germinate in the fall once rains begin. Idaho fescue (FEIS 1999, Young 1982), blue wild-rye (Archibald and others, 2000, Knapp and Rice 1994, Link 1993, Rose and others 1998), California brome (FEIS 1999, Link 1993, Rose and others 1998), and Alaska oniongrass (Rose and others 1998) germinate readily without the need for stratification.

Other species, including California oatgrass (Knapp and Rice 1994, Laude 1949, Trask and Pyke 1998), Lemmon's needle grass (Trask and Pyke 1998) and other *Achnatherum* sp. (Rose and others 1998), do not germinate in the fall and require specific treatments to overcome dormancy.

Cleistogenes

Cleistogenes are self-pollinated seeds that are produced from flowers that do not open. About 60 percent of species that produce cleistogenes are colonizers of disturbed or early successional habitats. Most of the non-ruderal species are "stress-tolerators," often found in sites with low moisture (Campbell and others 1983). Cleistogenes are often produced during stressful conditions, such as overgrazing or repeated mowing, and found in areas susceptible to fire (Campbell and others 1983, Clay 1983, Dobrenz and Beetle 1966).

California oat-grass can produce up to eight cleistogamous seeds per node in the leaf sheaths (25-36 per plant), often more seeds than are produced from cross fertilization (21-33) (Dobrenz and Beetle 1966, Hitchcock 1969). Some *Achnatherum* sp. also produce this type of cleistogene, although Lemmon's needlegrass is not specifically mentioned in the literature (Campbell and others 1983). Under light and moisture conditions adverse for flowering, California brome produces cleistogenes in the same panicle as cross-pollinated, chasmogenes, but the florets do not open due to lodicule failure (Campbell and others 1983).

Although other species in the same genera of those studied are known to produce cleistogamous seed (Campbell and others 1983), I could find no reference to cleistogenes for the species associated with Garry oak ecosystems.

Hygroscopic Awns

Hygroscopic awns cause seeds of some grass species in the genus *Danthonia* and *Achnatherum* to move along the soil surface until they lodge in a microsite and become buried in the soil (Peart 1979). Burial is especially important for the survival of grass seeds in fire-prone habitats. There are no references in the literature to hygroscopic awns of the other grass genera native to Garry oak ecosystems and examination of seed indicates they do not have them.

Discussion and Conclusion

The historical data concerning the understory composition of Garry oak ecosystems is sketchy at best. There is no detailed information regarding species composition and no descriptions of which grass species were present. The few descriptions of the grasses refer to waist-high grasses, although shorter grasses are also mentioned in connection with fire. However, from the historical writings it seems clear that grasses and grass/forb complexes were an important component of historical ecosystems. The historical literature clearly indicates that fire and soil disturbance from camas harvesting were common, at least in some areas.

The current Garry oak landscape is highly variable as a result of variation in many factors including soil depth and type, topography, disturbance history, slope, aspect and woody species cover. These factors must be incorporated into the establishment of reference conditions for restoration. Given the complexity of a landscape managed by fires and its mosaic affect, it is highly likely the ecosystem was variable before European contact. No single dominant species would have been consistent on the landscape scale. However, in sites that were more intensively managed by First Nations, the ecological adaptive strategies of some grass species indicate that they would have been more likely to occur than other species.

California oatgrass and Lemmon's needlegrass are both candidate species for regularly disturbed ecosystems. Both have innate dormancy that may cause them to form persistent seedbanks. Both species produce cleistogenes and have hygroscopic awns that are known to be associated with disturbance-prone habitats. The lack of response of California oatgrass to fire reinforces the potential for it to have been a component of the original ecosystem. Fire response information for Lemmon's needlegrass was not found. The potential for California oatgrass to be a dominant bunchgrass of the original Canadian Garry oak ecosystem is also reinforced by the likelihood that it was historically an important dominant in Californian coastal prairies (Hatch and others 1999), especially in drier areas (Hecktner and Foin 1977). California oatgrass, however, is considerably shorter (<0.5 m) than the historical references suggest with their descriptions of waist high grasses (Hitchcock 1969).

Native grasses will be foundation species for restoration efforts in Garry oak ecosystems (GOERT 2001). Native bunchgrasses create favorable sites for the establishment of other native species by reducing soil-surface temperatures and increasing nutrient availability. In grasslands, bunchgrasses may control the spatial distribution of species and their presence has been linked to increased species diversity (Hatch and others 1999). Native grasses play an important role in preventing invasion by exotic species because they provide soil cover during the winter months when many of the forb species are dormant. Although very little is known about the successional progression of herbaceous species in Garry oak ecosystems, it seems likely that native grasses and legumes would be the first to colonize open ground since many of the forbs take years to mature. Restoring native grass species is therefore critical for restoring the complexity and diversity of understory species.

Determining which species may have been present with pre-contact disturbance regimes is only the first step towards defining reference conditions for the herbaceous layer of these ecosystems. The long-term stability of reintroducing these species without re-establishing the disturbance regimes that helped foster them is questionable. This is further complicated by the presence of exotic species whose response to fire and other original disturbance regimes may impact restoration goals.

References

Anonymous. 1849. **Report in the Times newspaper.** In: Coughman ,L.,ed. Colonization of Vancouver Island. Vancouver BC: Burrup and Son, London; University of British Columbia Archives.

Archibald, C.; Feigner, S.; Visser, J. 2000. **Seed and seedling production of blue wild-rye.** Native Plants Journal 1: 32–34.

Bartolome, J. W. 1979. **Germination and seedling establishment in California annual grassland.** Journal of Ecology 67: 273–281.

Bartolome, J. W.; Gemmill, B. 1981. **The ecological status of *Stipa pulchra* (Poaceae) in California.** Madrono 28 (3): 172–184.

Bowsfield, H. 1979. **Fort Victoria letters.** 1846–1851. Hudson's Bay Record Society; Winnipeg, MN.

Campbell, C. S.; Quinn, J. A.; Cheplick, G. P.; Bell, T. J. 1983. **Cleistogamy in grasses.** Annual Review of Ecological Systematics 14: 411–441.

Clay, K. 1983. **The differential establishment of seedlings from chasmogamous and cleistogamous flowers in natural populations of the grass *Danthonia spicata* (L.) Beauv.** Oecologia 57: 183–188.

Dobrenz, A. K.; Beetle, A. A. 1966. **Cleistogenes in *Danthonia*.** Journal of Range Management 19: 292–296.

Dunn, P. 1998. **Prairie habitat restoration and maintenance on Fort Lewis and within the South Puget Sound prairie landscape: final report and summary of findings.** Fort Lewis, WA: United States Army; Nature Conservancy of Washington.

Dunn, P.; Ewing, K., eds. 1997**. Ecology and conservation of the South Puget Sound Prairie landscape.** Nature Conservancy of Washington. Seattle, WA.

Dunwiddie, P. W. 1997. **Yellow Island vegetation studies: 1997 data and analysis.** Unpublished report. Seattle, WA: The Nature Conservancy of Washington.

Erickson, W. 1993. **Garry oak ecosystems. ecosystems at risk brochure.** Victoria, BC: BC Ministry of Environment, Lands and Parks,

———. 1996. **Classification and Interpretation of Garry oak (*Quercus garryana*) plant communities and ecosystems in southwestern British Columbia.** Victoria: University of Victoria,; M.Sc. Thesis.

FEIS (Fire Effects Information System). 1999. **Botanical and ecological characteristics.** Website: http://www.fs.fed.us.database/feis/plants

Fitzgerald, J. E. 1848. **Vancouver's Island: the new colony.** UBC Special Collections

Fuchs, M. 2000. **Towards a recovery strategy for Garry oak and associated ecosystems in Canada: ecological assessment and literature review.** Prepared for: Environment Canada, Canadian Wildlife Service with support from Georgia Basin Ecosystem Initiative.

GOERT (Garry Oak Ecosystem Recovery Team). 2001. **Recovery strategy for Garry oak and associated species at risk in Canada: 2001 – 2006**. Prepared by Marilyn Fuchs, Foxtree Ecological Consulting. Draft May 29. Victoria, BC.

Grant, W. C. 1857. **Description of Vancouver Island. By its first colonist, W. Colquhoun Grant, Esq., F.R.G.S. of the 2nd Dragoon Guards, and the late Lieut.-Col. of the Calvalry of the Turkish contingent.** Journal of the Royal Geographic Society. 27: 268–320 BC Archives # NW 910.6/R888/V27.

Hatch, D. A.; Bartolome, J. W.; Fehmi, J. S.; Hillyard, D. S. 1999**. Effects of burning and grazing on a coastal California Grassland.** Restoration Ecology 7: 376–381.

Hebda, R J.; Aikens, F., eds. 1993. **Garry-oak meadow colloquium proceedings.** Garry oak meadow preservation society; Victoria, BC.

Hektner, M. M.; Foin, T. C. 1977. **Vegetation analysis of a northern California coastal prairie: Sea Ranch, Sonoma County, California.** Madrono 24: 83–103.

Hitchcock, C. L. 1969. **Vascular plants of the Pacific Northwest.** University of Washington Press; Seattle, WA.

Knapp, E. E.; Rice, K. J. 1994. **Isozyme tests of *Elymus glaucus* and *Danthonia californica*.** Report of work in progress to the USDA Forest Service-Rogue River National Forest, The Nature Conservancy, and the Bureau of Land Management.

Laude, H. M. 1949**. Delayed germination of California Oatgrass.** Agronomy Journal 41: 404–408.

Link, E. 1993. **Native plant propagation techniques for national parks: interim guide.** U.S. Department of Agriculture Soil Conservation Service; U.S. Department of Interior National Park Service. Compiled by: Roes Lake Plant Materials Centre. East Lansing, Michigan.

Lutz, J. 1995**. Preparing Eden: Aboriginal land use and European settlement.** Paper presented to the 1995 meeting of the Canadian Historical Association. August 1995, Montreal, PQ.

Mayne, R. C. 1862. **Four years in British Columbia and Vancouver Island: An account of their forests, rivers, coasts, gold fields and resources for colonization.** Reprinted by Johnson Reprint Corp., New York.

Peart, M. H. 1979. **Experiments on the biological significance of the morphology of seed-dispersal units in grasses.** Journal of Ecology 67: 843–868.

Rice, K. J. 1989. **Competitive interactions in California annual grasslands.** In: Huenneke, L. F.; Mooney, H., ed. Grassland structure and function: California annual grassland. Dordrecht, Netherlands: Kluwer Academic Publishers; 59–71.

Roemer, H. 1995. **Identity crisis: do we really know what we want to rehabilitate?** Botanical Electronic News 105.

———. 2000. Ecological reserves specialist, BC Parks, Victoria, BC. Personal communication. 12 October 2000.

Rose, R.; Chachulski, C. E. C.; Haase, D. L. 1998**. Propagation of Pacific Northwest native plants.** Corvallis OR: Oregon State University Press.

Suttles, W. 1987. **Coast Salish essays.** Seattle, WA: University of Washington Press.

Trask, M. M.; Pyke, D. A. 1998**. Variability in seed dormancy of three Pacific Northwestern grasses.** Seed Science and Technology 26: 179–191

USDA. 1999. **Natural Resources Conservation Service: plant characteristics.** Website: http:// plants. usda. gov/plants/cgi_bin/

White, P. S.; Walker, J. L. 1997. **Approximating nature's variation: selecting and using reference information in restoration ecology.** Restoration Ecology 5: 338–349

Wikeem, B. M.; Strang, R. M. 1983**. Prescribed burning on BC rangelands: the state of the art.** Journal of Range Management 36 (1): 3–8

Young, J. A. 1982. **Temperature profiles for germination of cool season range grasses.** Agricultural Research Service (Western Region). U.S. Department of Agriculture