



# Davidsonia

A Journal of Botanical Garden Science



# Davidsonia

## Editor

Iain E.P. Taylor  
UBC Botanical Garden and Centre for Plant Research  
University of British Columbia  
6804 Southwest Marine Drive  
Vancouver, British Columbia, Canada, V6T 1Z4

## Editorial Advisory Board

Quentin Cronk  
Fred R. Ganders  
Daniel J. Hinkley  
Carolyn Jones  
Lyn Noble  
Murray Isman  
David Tarrant  
Roy L. Taylor  
Nancy J. Turner  
Barbara Wynn

## Associate Editors

Mary Berbee (Mycology/Bryology)  
Moya Drummond (Copy)  
Aleteia Greenwood (Art)  
Fran Hannabuss (Production)  
Michael Hawkes (Systematics)  
Richard Hebda (Systematics)  
Douglas Justice (Systematics and Horticulture)  
Eric La Fontaine (Publication)  
Jim Pojar (Systematics)  
Andrew Riseman (Horticulture)  
Charles Sale (Finance)  
Janet R. Stein Taylor (Phycology)  
Sylvia Taylor (Copy)  
Roy Turkington (Ecology)  
Jeannette Whitton (Systematics)

**Davidsonia** is published quarterly by the Botanical Garden of the University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z4. Annual subscription, CDN\$48.00. Single numbers, \$15.00. All information concerning subscriptions should be addressed to the editor. Potential contributors are invited to submit articles and/or illustrative material for review by the Editorial Board. Web site: <http://www.davidsonia.org/>

**ISSN 0045-09739**

Cover: *Quercus garryana* (Garry oak) standing in a meadow of flowering *Camassia* spp. (camas). Photo: Mark Vellend  
Back Cover: New leaves unfurl on the lichen covered branches of *Quercus garryana*. Photo: Mark Vellend

## Editorial

This issue contains the first two papers in what I hope will be a continuing project to highlight research on threatened ecosystems. The Garry oak ecosystem in British Columbia and the Pacific Northwest of the USA is thought to be a system that has failed to reach “climax” because of periodic burning by the First Nations communities who were cultivating the bulbs and other resources in the perennial flora.

Ted Lea’s paper provides mapping on Vancouver Island that has only recently become possible and Dunwiddie et al. have taken the opportunity to put on record their substantial work on the vascular flora of the ecosystem in Washington state. Other manuscripts are in preparation and we look forward to peer reviewing and publishing them in due course.

Several ecosystems that are under threat have fortunately attracted the attention of conservationists as well as taxonomic and ecological researchers who have undertaken rigorous fieldwork to document the current state of affairs and to provide records of change. The research responsibility seems to have fallen on government researchers and those working for non-government organizations. Many postgraduate degree dissertations surely must lie in the future. Unfortunately, the drive to let the latest technological advances dominate graduate education, too often at the expense of the underlying natural history, may put the drive for conservation on shaky foundations. The next issue will contain a paper by graduate students in the UBC Botany department, which suggest to me that there are still those whose concerns are for basic recording of flora.

The establishment of a model restoration of a Garry oak ecosystem at the UBC Botanical Garden, established in part through the tireless work of Tom Wheeler and his colleagues, will be one step towards providing a study area for research in a physically protected area.

Iain E.P. Taylor, Professor of Botany and Research Director,  
UBC Botanical Garden and Centre for Plant Research,  
6804 SW Marine Drive, Vancouver, BC, Canada, V6T 1Z4.  
iain.taylor@ubc.ca

# Historical Garry Oak Ecosystems of Vancouver Island, British Columbia, pre-European Contact to the Present

## Abstract

This paper summarizes the historical mapping of the major areas of *Quercus garryana* (Garry oak) ecosystems, from immediate pre-European settlement to present day. Less than 10 percent of the original Garry oak ecosystem remains on south-eastern Vancouver Island, British Columbia, Canada. Originally, there were two major ecosystem types, one on deep soils, known as Parkland Garry oak ecosystems, and the second on shallow soils, often referred to as scrub oak ecosystems because the oak trees are often of low stature. Little of the deep soil ecosystem remains, because these communities were the first areas cleared for agriculture and urban development. More of the shallow soil ecosystem remains, as many of these rocky areas were more difficult to develop in the early days of settlement and were not good for agriculture. However, many of these sites are presently being lost to development if they are not in protected areas. Much of the remaining area of these ecosystems is dominated by invasive alien plant species, so that less than 5 percent of the original area remains in natural condition.

## Introduction

The Garry oak ecosystem in Canada, also known as ‘Oregon white oak ecosystems’ in the United States, is restricted to the southeast coast of Vancouver Island, adjacent Gulf Islands and two locations on the mainland of southwestern BC (Figure 1). This ecosystem is a distinctive feature of the landscape particularly around Victoria, Duncan, Nanaimo, Comox and on most southern Gulf Islands. The maps portraying the

Ted Lea, Vegetation Ecologist  
Ecosystems Branch, British Columbia Ministry of Environment  
Victoria, BC Canada  
Ted.Lea@gov.bc.ca

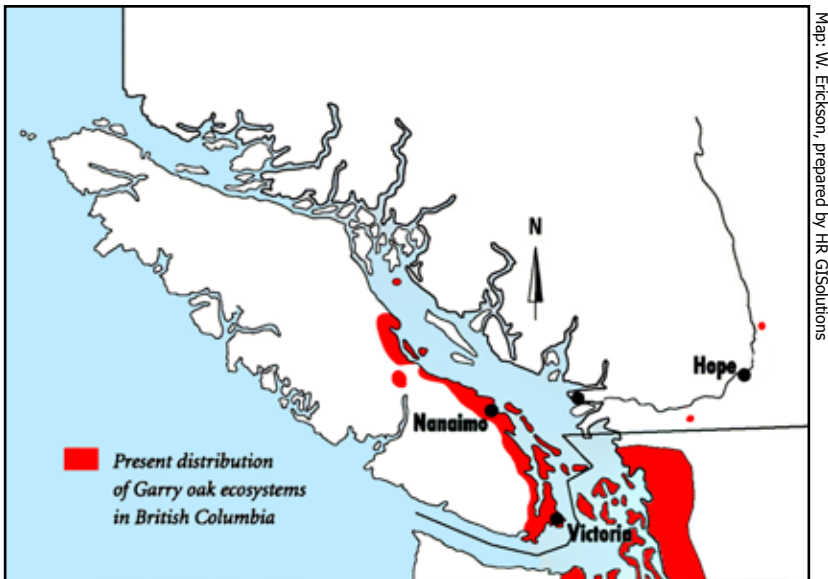


Figure 1. Distribution of Garry oak ecosystems in British Columbia (from Erickson, 1993).

Garry oak distribution in immediate pre-European settlement times (Figures 2, 4, 6 and 8) depict those areas where Garry oak was believed to be the dominant cover or co-dominant cover with *Pseudotsuga menziesii* (Douglas-fir) or *Arbutus menziesii* (arbutus or madrone) or, in the Comox area, *Pinus contorta* var. *contorta* (shore pine). Historical Garry oak ecosystem mapping for Vancouver Island, British Columbia allows comparisons between the likely pre-European settlement times and the present distributions. The study focused on 5 major areas known to support the Garry oak ecosystem in greater Victoria, Cowichan Valley, Nanaimo, Nanoose, and Comox areas, as well as where it is or was a major ecosystem on the southern Gulf Islands, including Saltspring Island and Hornby Island. Smaller areas of the Garry oak ecosystem occur on many other Gulf Islands, mainly along the shoreline and most of these remain intact, and are not the focus of this study. Other areas may have had or still have Garry oak as a minor component of the ecosystem; however, they were not considered for this mapping.

Garry oak ecosystems have been described in detail by Roemer (1972) and Erickson (1995). Originally, there were two major communities

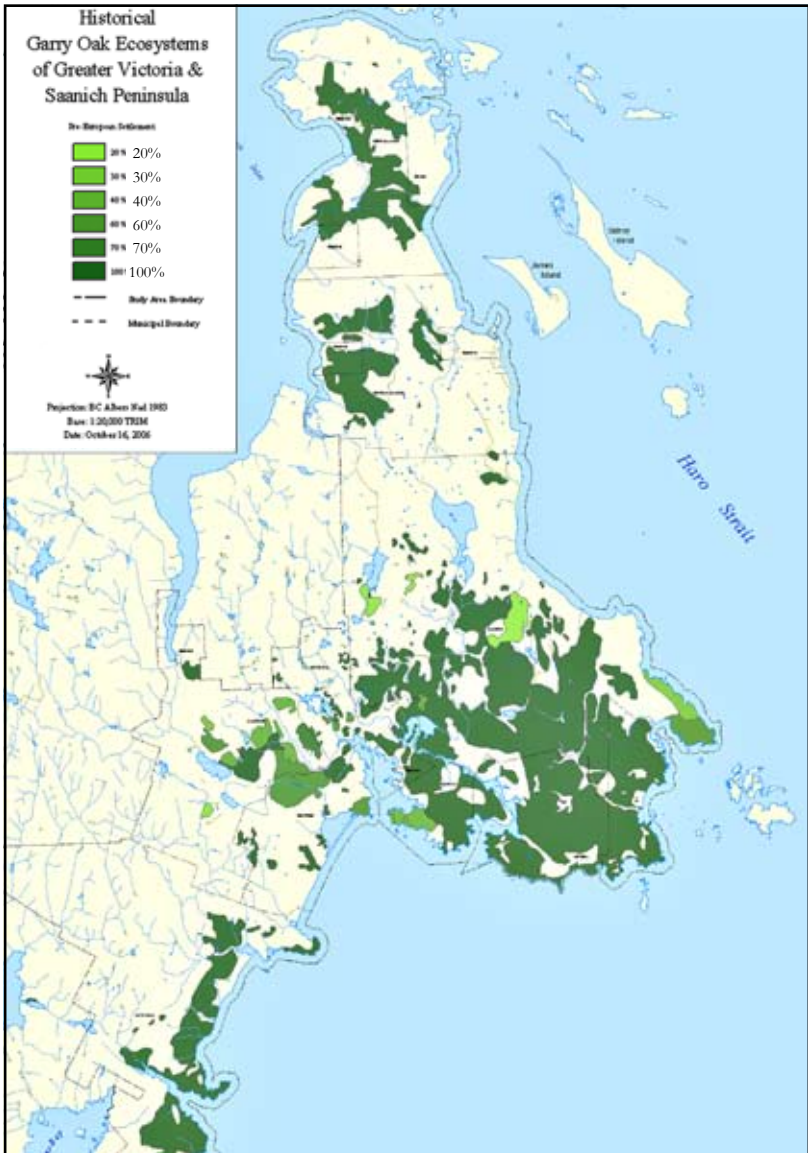


Figure 2. Garry oak ecosystems in the greater Victoria area for pre-European settlement.

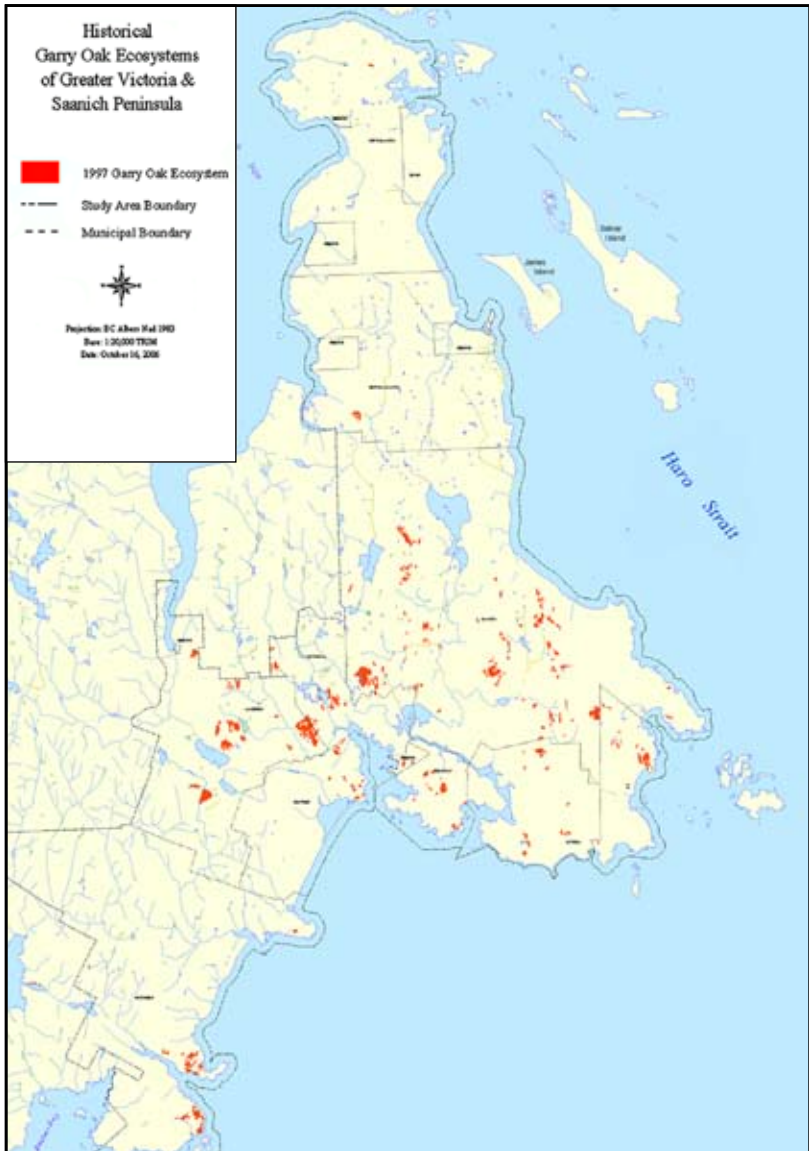


Figure 3. Garry oak ecosystems in the greater Victoria area in 1997.

recognized within the Garry oak ecosystem. Those on deep soils, known as the Parkland Garry oak ecosystem (Pojar, 1980a, 1980b), supported common understory plants including *Symphoricarpos albus* (snowberry), *Camassia leichtlinii* and *C. quamash* (camas), *Erythronium oregonum* (fawn lily), various graminoid species and *Pteridium aquilinum* (bracken fern). Almost all of this community type has gone, as it occupied areas that were most suitable for crops and were cleared for agriculture and urban development starting in the 1840s. While many large Garry oak trees remain, most have lawns, roads, agricultural fields or blacktop beneath them, rather than the original plant communities. The few examples of this ecosystem still remaining include the Nature Conservancy of Canada's Cowichan Garry oak preserve, a stand in Beacon Hill Park, Victoria and areas at the Department of National Defence lands at Rocky Point in Metchosin Municipality.

The second major Garry oak community type occurs on shallow soils and is often referred to as the scrub oak ecosystem. The oak trees are often of lower stature than those growing on deep soils. More of this ecosystem remains, probably because many of these rocky habitats were difficult to develop. Many are now in protected areas such as Mount Tzuhalem Ecological Reserve, Mount Tolmie Park and Mount Douglas Park. The understories of these rock outcrop communities were originally dominated by many spring flowering perennial forbs, grasses and mosses, but now often contain extensive cover of invasive alien species such as *Cytisus scoparius* (Scotch broom), agronomic grasses and other weeds.

The loss of much of these ecosystems and recent dominance of invasive alien species, has led to more than 100 Garry oak-associated plant and animal species being placed on the BC Species at Risk list. These include more than 75 plant taxa, 2 reptiles, 14 birds, 3 mammals, 13 butterflies and 10 other insect species (GOERT 2005). The plant species include the *Castilleja levisecta* (golden paintbrush), *Balsamorhiza deltoidea* (deltoid balsamroot), *Meconella oregana* (white meconella), and *Bartramia stricta* (rigid apple moss). Two notable animals are the butterfly, *Euchloe ausonides* (an undescribed subspecies of island marble), which is extirpated, and *Contia tenuis* (sharp-tailed snake). Unfortunately, species

at risk numbers are expected to increase as species assessments are completed and if the threats to Garry oak ecosystems continue.

Egan and Howell (2001) recognized a variety of information sources to determine historical ecology of an area, including cultural evidence—land surveys (both mapped and in journals), written records, and historical photographs—and biological evidence—forest stand history, observational field evidence, pollen records, geomorphology, hydrology and soil, and inferring vegetation history. Many of these methods were considered in the present study.

The objective of this mapping was to provide information on the loss of Garry oak ecosystems that could be used for a variety of purposes, including, understanding the value of the remaining pieces, understanding the cultural values associated with these ecosystems, determining which areas might be suitable for restoration or reconstruction of these ecosystems and to indicate areas that can be conserved to maintain species at risk.

## Methods

The mapping in this study was mainly based on (1) original land surveys done in the 1850s and 1860s, and (2) recent field observations of forest stand history. Maps were prepared at a 1:20,000 scale and included areas where Garry oak was a dominant or co-dominant component of the ecosystem. The land survey maps in the Victoria area often distinguished between coniferous forest and deciduous forest and prairies, as well as larger wetlands. Other data sources used included written records, maps, historical photographs, paintings and some soil, geomorphology and floodplain mapping. An ecosystem map for greater Victoria was created for the Canadian Forest Service by McMinn et al. (1976) that was used for comparison to known Garry oak occurrences.

Information on present day areas of Garry oak ecosystems was prepared using data from a variety of sources, including the Sensitive Ecosystem Inventory prepared by the BC Ministry of Environment, Lands and Parks (MELP), the BC Conservation Data Centre, MELP Nanaimo, and the Canadian Wildlife Service of Environment Canada.

Extensive field work undertaken between 2001 and 2004 established present distribution of oaks, and allowed estimation of the pre-European potential, assuming that the climate has not changed significantly over the last 200 years. Advice from local ecologists and naturalists who had considerable experience and expertise was used to determine areas that had the potential to support Garry oak ecosystems before urban, suburban and agricultural development took place in the greater Victoria area.

The study included a 'depth of soil' attribute allowing comparison of the remaining areas in the parkland and scrub oak ecosystems. Mapping was done on 1:20,000 Terrain Resource Information Mapping (TRIM) base map sheets by indicating the presence of existing trees and extrapolation using all sources of information and then drawing polygons depicting pre-European and present day extent of the ecosystems.

Some shortcomings of this mapping exercise exist. Data source information was inconsistent throughout the study area. The most detailed land survey maps, which show the differences in vegetative cover, are only available in parts of the greater Victoria area. However, there was no record of vegetation cover for either Colwood or Esquimalt. Similarly, survey information for areas farther north on Vancouver Island was restricted by property lot boundaries. Some areas had soils and floodplain mapping while other areas did not. In some historical oak areas, where Douglas fir has now replaced Garry oak, there may have been cover underestimations, especially where less detailed land survey information was available.

## Results

The maps (Figures 2 through 9) and Table 1 allow comparison of the Garry oak ecosystem distribution on Vancouver Island in immediate pre-European settlement times and now. Table 1 shows that approximately 10 percent of the area that was originally Garry oak ecosystem now remains as remnants. However, since much of this area is now dominated by invasive alien species, less than 5 percent of the

Table 1. Area coverage of the Vancouver Island Garry oak ecosystems for pre-European settlement and present day, broken into deep and shallow soil ecosystems.

|   | Deep<br>Pre-<br>European | Deep<br>Present<br>Day | Shallow<br>Pre-<br>European | Shallow<br>Present<br>Day | Overall<br>Pre-<br>European | Overall<br>Present<br>Day |
|---|--------------------------|------------------------|-----------------------------|---------------------------|-----------------------------|---------------------------|
| <b>Greater Victoria</b>                       | 9564 ha                  | 45 ha                  | 890 ha                      | 440 ha                    | 10454 ha                    | 485 ha                    |
| <b>Cowichan Valley/<br/>Saltspring Island</b> | 1824 ha                  | 83 ha                  | 1301 ha                     | 619 ha                    | 3125 ha                     | 702 ha                    |
| <b>Nanaimo/<br/>Nanoose</b>                   | 29 ha                    | 29 ha                  | 951 ha                      | 298 ha                    | 980 ha                      | 327 ha                    |
| <b>Comox</b>                                  | 527 ha                   | 7 ha                   | 0 ha                        | 0 ha                      | 527 ha                      | 7 ha                      |
| <b>Hornby/<br/>Denman Island</b>              | 65 ha                    | 11 ha                  | 98 ha                       | 57 ha                     | 163 ha                      | 68 ha                     |
| <b>Total</b>                                  | 12009 ha                 | 175 ha                 | 3240 ha                     | 1414 ha                   | 15249 ha                    | 1589 ha                   |
| <b>Percent of Original</b>                    |                          | 1.5%                   |                             | 44%                       |                             | 10%                       |

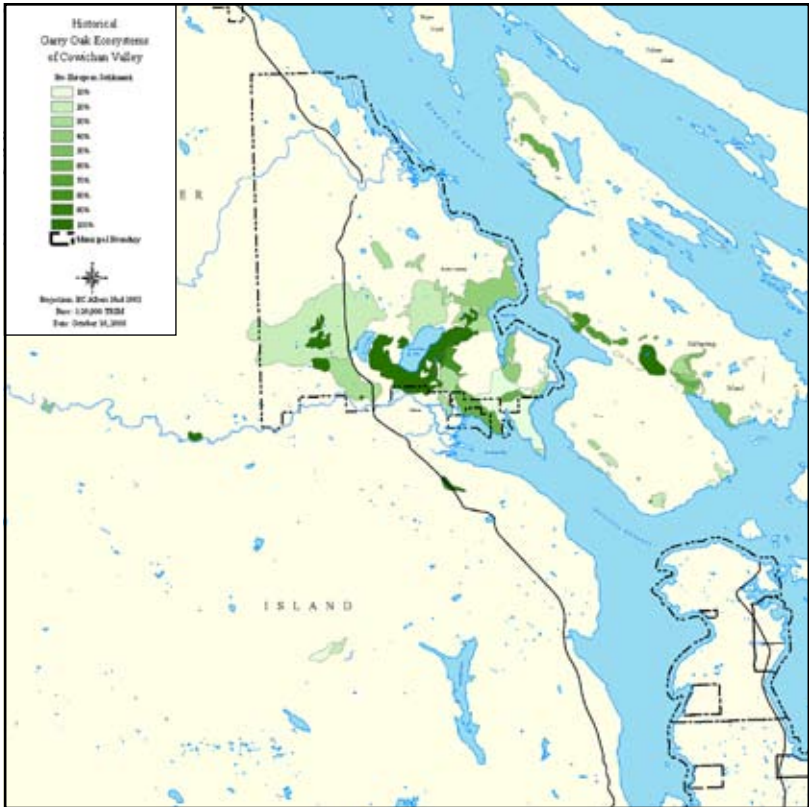


Figure 4. Garry oak ecosystems in the Cowichan Valley and Saltspring Island area for pre-European settlement.

original ecosystem remains in a near-natural condition, where native species dominate the understorey. Most of the remnants are in isolated, fragmented locations that have no connection to other Garry oak areas. The remaining remnant areas of Garry oak ecosystems are dominated by invasive alien plant species such as Scotch broom, agronomic grasses and weedy forbs.

On the maps, the original pre-European distribution of Garry oak ecosystems is displayed in green, while the remaining present day areas are shown in red. For the mapping, shading is used to indicate the percentage of Garry oak ecosystems occurring in a particular polygon. The darkest shade means that one hundred percent of an area was Garry oak ecosystem, while the lightest shade indicates that ten percent

of the area would be Garry oak ecosystem, and the other ninety percent would be another type of ecosystem. This was determined using all available data sources

The Victoria area (Figures 2 and 3) had mainly deep soil Garry oak ecosystems (9564 ha). Very little of this ecosystem remains (45 ha). Less shallow soil ecosystem occurred originally (890 ha), and a greater percentage (440 ha) remains to date. In the Cowichan Valley and on Saltspring Island (Figures 4 and 5), deeper soil areas (1824 ha) were more common than shallow soil ecosystems (1301 ha), but as in Victoria, a greater percentage of shallow soils (619 ha) remains. For the Nanaimo and Nanoose areas (Figures 6 and 7), very little deep soil ecosystem (29 ha) occurred in the 1800s and all of it is still present.

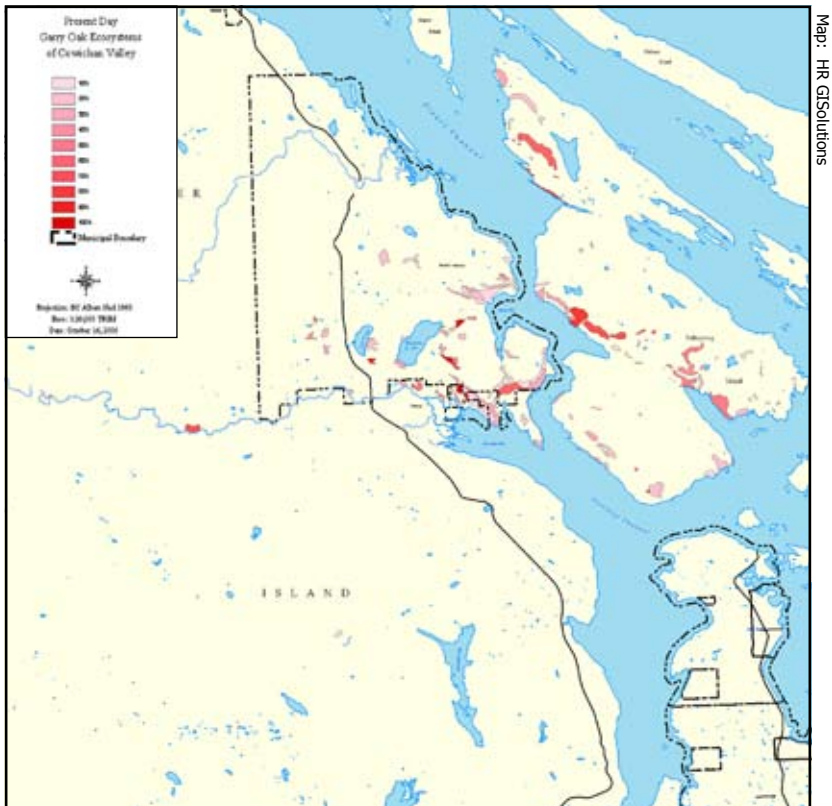


Figure 5. Garry oak ecosystems in the Cowichan Valley and Saltspring Island area for present day.

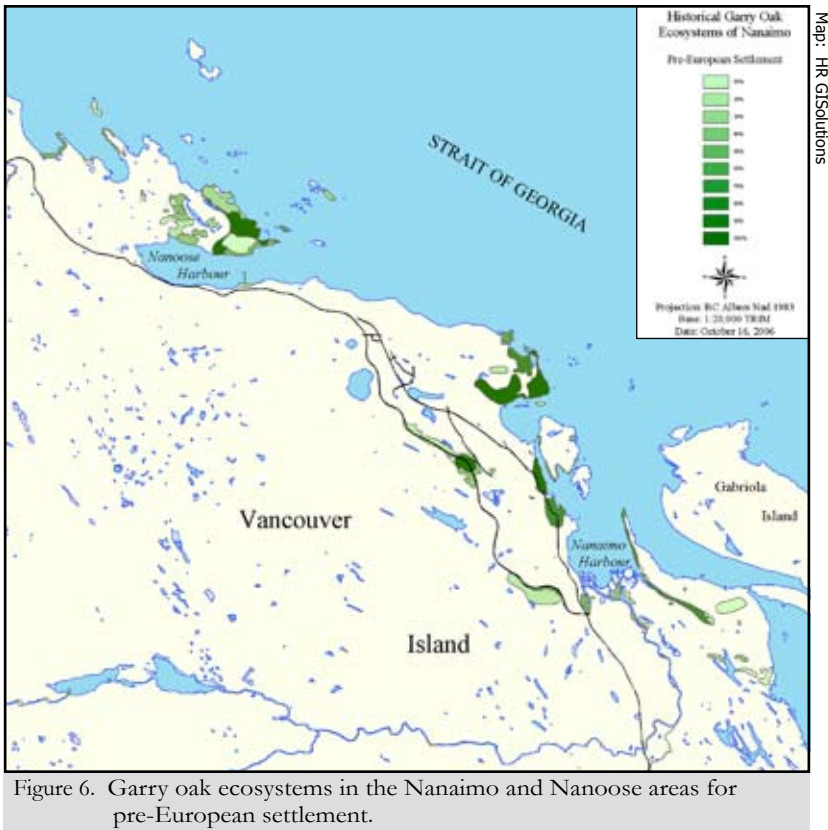


Figure 6. Garry oak ecosystems in the Nanaimo and Nanoose areas for pre-European settlement.

Approximately one third (298 ha) of the original (951 ha) shallow soil ecosystem still remains. In the Comox Valley and Hornby/Denman Island areas (Figures 8 and 9) areas, deep soils ecosystems were originally fairly limited (592 ha) and little remains (18 ha). No measurable shallow soil ecosystem occurred in the Comox Valley, but on Hornby Island 98 ha originally occurred and over one half of this (57 ha) still remains. Overall, for Vancouver Island, only 1.5 percent of the original deep soil Garry oak ecosystem remains, while approximately 44 percent of shallow soil Garry oak ecosystem remains.

## Discussion

Mapping ecosystems over time allows us to record the historical ecosystem loss and to identify areas with potential for restoration. It also allows landscape managers to understand regional heritage, how humans have affected ecosystems, the importance of the remaining areas of an ecosystem, and to make general predictions about future vegetation that may result from climate change. Measurement of ecosystem loss allows us to assess the importance of the remaining areas, especially in the Garry oak ecosystems, which contain large numbers of species at risk (Fuchs 2000). Many species at risk are not adequately supported if the ecosystem is reduced in size or otherwise degraded. Preservation and stewardship of the remaining areas will

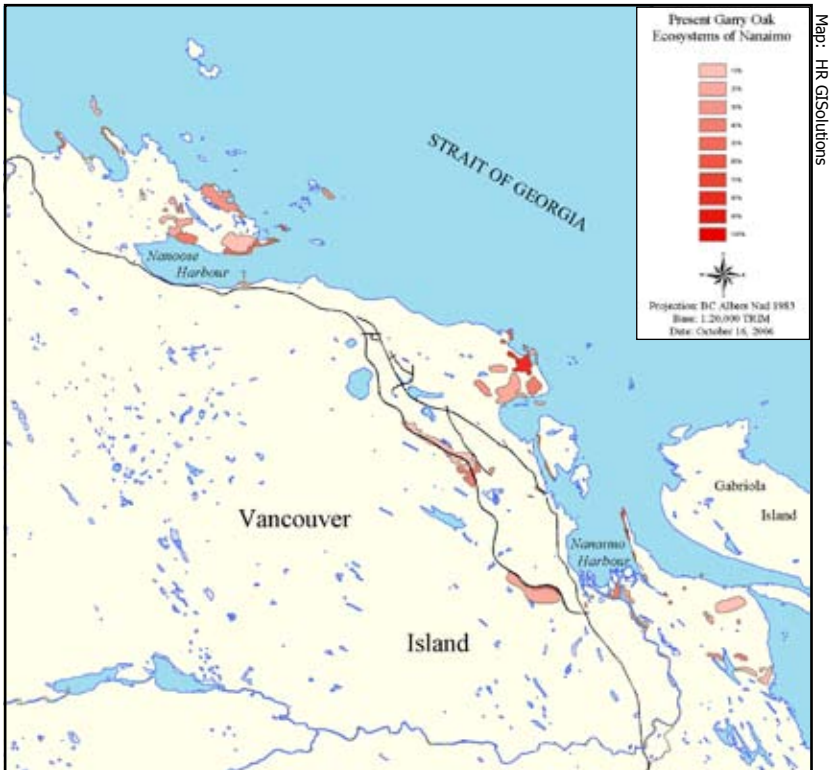


Figure 7. Garry oak ecosystems in the Nanaimo and Nanoose areas for present day.

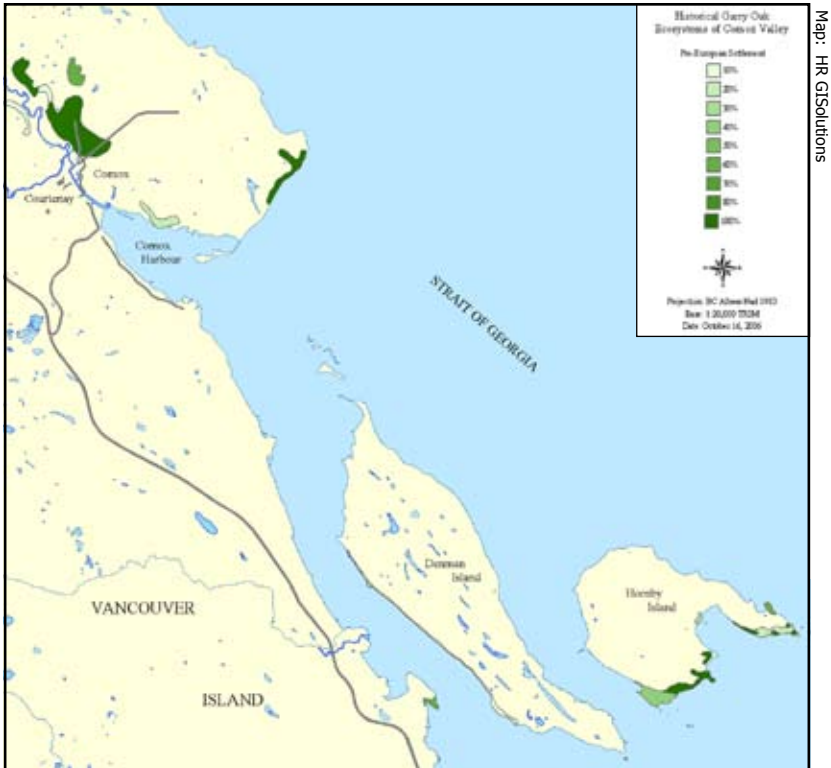


Figure 8. Garry oak ecosystems in the Comox, and Hornby Island areas for pre-European settlement.

be essential.

While the maps provide substantial information about the changes and current existence of major fragments of the Garry oak ecosystem, they give less detailed insight to the original conditions which we must understand more fully before restoration is attempted (MacDougall et al., 2004). Historical mapping generally only gives one point in time and usually does not describe the detailed plant composition of communities that existed 150 to 200 years ago. Often restoration workers seem to have selected a particular successional community and tried to manage their area to that “ideal state.” In the case of Garry oak stands, this is often an oak savanna or oak woodland with a meadow-like understorey of camas, fawn lily and other attractive flowers, but many other stages could also be appropriate (see Peter and Harrington 2004). As with

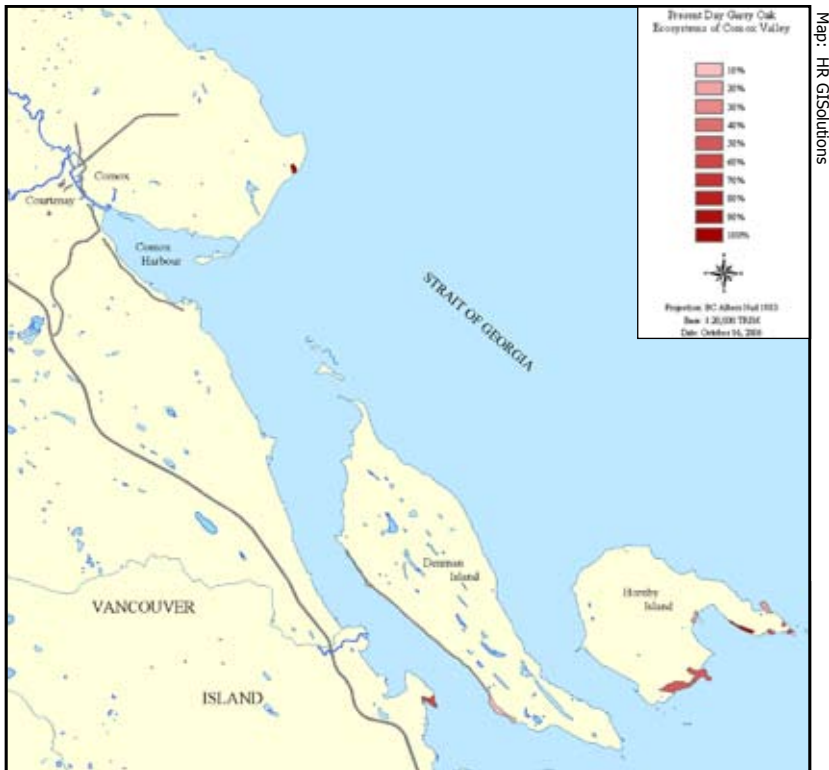


Figure 9. Garry oak ecosystems in the Comox, and Hornby Island areas for present day.

many natural ecosystems, successional stages often existed in mosaics in the landscape, depending on disturbance history. A very important part of the Garry oak landscape for thousands of years was the influence of First Nations people who burned many areas for maintenance of plant resources such as camas, and other root crops, such as bracken fern (Turner 1999).

According to this study, only 10 percent of the Garry oak ecosystem that existed in immediate pre-European settlement times, remains now. These ecosystems are now critically imperilled, due to their rapid loss since the European migration to Vancouver Island beginning in the 1800s. Losses of these ecosystems continue even today, except for the small remnants that occur on some hilltops protected in parks and Ecological Reserves. Invasive alien species dominate most of these

fragmented areas. The future for Garry oak ecosystems is not bright. Some individuals have suggested that with climate change, the range of Garry oak ecosystems could expand (Hebda, 2004). I believe that *Q. garryana* may have the potential to expand its range as an individual species, but natural understorey components may not be able to expand and compete with the many alien species that now occur. The only way to maintain this ecosystem will be with extensive human intervention, at a significant cost of both money and human effort. The main lessons to be learned from this study are (1) that slow, but continued human land use can largely eliminate ecosystems over time, and (2) a fact overlooked as coming generations only know what they see is that historical mapping shows us what we have lost and what we have forgotten. Unless humans find a way to protect rare ecosystems, through a variety of mechanisms, including legislation (similar to present laws covering species at risk), as well as stewardship and restoration activities, many more ecosystems at risk may be lost.

The following activities must be considered to improve the survival possibilities for Garry oak ecosystems: protect the remnants; deal with invasive species; restore suitable areas; purchase lands for conservation; promote stewardship on private lands; assess the potential to introduce appropriate species at risk; prevent other ecosystems from becoming threatened; and plan for climate change.

## Acknowledgements

Special thanks go to Jan Kirkby and Carmen Cadrin for encouragement throughout the mapping project. I thank Kate Miller for her assistance in mapping the Cowichan Valley, Saltspring Island, Nanaimo and Nanoose areas. Thanks to Lora Lea, Griffin Lea, Janna Lea, Bob Maxwell, Carmen Cadrin, Andy MacKinnon, Moralea Milne, Kate Miller, Alex Miller, Miles Miller, Brent Ingram, and Carolyn MacDonald for their field assistance checking the present locations of Garry oak trees, and ecosystems. The map of Garry oak distribution in British Columbia is from Erickson (1993). Funding was provided by the BC Ministry of Sustainable Resource Management, Ministry of

Water, Land and Air Protection, BC Ministry of Environment, Parks Canada and Forest Renewal British Columbia. Digital Products are by Duncan Richards and Dan Horth of HR GISolutions. Thanks to Gary Bradfield, Brenda Costanzo, Lora Lea and an anonymous individual for reviewing drafts of this paper.

## References

- British Columbia Land Surveys. 1858, 1859, 1860. Land surveys of the Victoria, Central Saanich, North Saanich, Lakes and Metchosin Districts. Victoria: BC Crown Land Registry Office, BC.
- BC Ministry of Environment, Lands and Parks and Environment Canada. 1997. Sensitive Ecosystem Inventory of Eastern Vancouver Island and the Gulf Islands. 1:20,000 maps.
- Egan, D. and Howell, E.A. (editors). 2001. The Historical Ecology Handbook: A Restorationist's Guide to Reference Ecosystems. Washington, DC: Island Press. 457 pp.
- Erickson, W. 1993. Garry oak Ecosystems. Ecosystems in British Columbia at Risk Series. Conservation Data Centre, Wildlife Branch. Victoria: BC Ministry of Environment, Lands and Parks. 6pp.
- Erickson, W. 1995. Classification and interpretation of Garry oak (*Quercus garryana*) plant communities and ecosystems in southwestern British Columbia. MSc. Thesis. Department of Geography, University of Victoria, Victoria, BC. 307 pp.
- Fuchs, M. 2000. Towards a recovery strategy for Garry oaks and associated ecosystems in Canada: Ecological Assessment and Literature Review. Environment Canada, Canadian Wildlife Service. 106 pp.
- GOERT. 2005. Garry Oak Ecosystems Recovery Team website. [www.goert.ca](http://www.goert.ca) Accessed October 1, 2006.
- Hebda, R.J. 2004. Paleocology, climate change and forecasting the future of species at risk. In Lofroth, E.C. and T.D. Hooper (editors). Proceedings of the Species at Risk 2004. Pathways to Recovery, Victoria, BC

- MacDougall, A.S., Beckwith, B.R. and Maslovat, C.Y. 2004. Defining conservation strategies with historical perspectives: a case study from a degraded oak grassland ecosystem. *Conservation Biology* 18: 455-465.
- McMinn, R.G., Eis, S., Hirvonen, H. E. Oswald E.T. and Senyk, J.P. 1976. Native Vegetation in British Columbia's Capital Region. Forest Service, Environment Canada.
- Penn, B. 1992. The last of the Garry oaks. *Monday Magazine*, February 27 - March 4., Monday Publications, Victoria, BC. pp.6-8.
- Peter, D. and Harrington, C. 2004. *Quercus garryana* Acorn Production Study [Online.] 6 p. Available at: [http://www.fs.fed.us/pnw/olympia/silv/oak-studies/acorn\\_survey/survey-background.shtml](http://www.fs.fed.us/pnw/olympia/silv/oak-studies/acorn_survey/survey-background.shtml) (accessed 08 May 2004; verified 18 October 2006). Olympia, WA: USDA Forest Service, PNW Research Station,
- Pojar, J. 1980a. Threatened Forest Ecosystems of British Columbia. In *Proceedings of the Symposium: Threatened and Endangered Species and Habitats in British Columbia and the Yukon*. Edited by R. Stace-Smith, L. Johns and P. Joslin. Federation of BC Naturalists, Douglas College and BC Ministry of Environment. pp 28-39.
- Pojar, J. 1980b. Threatened Habitats of Rare Vascular Plants in British Columbia. In *Proceedings of the Symposium: Threatened and Endangered Species and Habitats in British Columbia and the Yukon*. Edited by R. Stace-Smith, L. Johns and P. Joslin. Federation of BC Naturalists, Douglas College and BC Ministry of Environment. pp 40-48.
- Roemer, H. 1962. Forest vegetation and environments on the Saanich Peninsula, Vancouver Island. PhD. Thesis, Department of Biology. University of Victoria, Victoria, BC 292pp.
- Turner, N.J. 1999. Time to Burn: Traditional use of fire to enhance resource production by Aboriginal peoples in British Columbia. In *Indians, fire and the land in the Pacific Northwest*. Edited by R. Boyd. Corvallis OR: Oregon State University Press. pp 194 – 211.

# The Vascular Plant Flora of the South Puget Sound Prairies, Washington, USA

## Abstract

Vascular plant species lists were compiled for all the major prairies that remain in south Puget Sound, Washington State, USA. Overall, 278 species were recorded in 15 prairies that ranged in area from 12-3,000 ha. Fifty-nine percent of these were native taxa, with forbs the most frequently represented life form (74%). Seventy percent of the species were perennials. Annuals were most common in Ft. Lewis prairies, which may reflect higher levels of disturbance. On average, introduced annuals outnumbered the native annuals 2:1. Twenty-three native species were widespread, occurring in >80% of the prairies; all but one of these were perennial. In contrast, 5 of the 18 most widespread non-natives were annuals. Forty percent (64) of the native species were found in only 1 or 2 prairies, and another 61 prairie species were documented from a variety of sources as formerly or currently growing in the south Puget Sound region, but not currently known from the 15 prairies we studied. Our results provide a basis for identifying species potentially appropriate for including in prairie restoration efforts in this region. Our findings also suggest taxa that are uncommon, rare, or locally extirpated, and which may only persist in this region if active efforts are made to establish them in extant sites.

Peter Dunwiddie<sup>1</sup>, Ed Alverson<sup>2</sup>, Amanda Stanley<sup>3</sup>,  
Rod Gilbert<sup>4</sup>, Scott Pearson<sup>5</sup>, Dave Hays<sup>5</sup>, Joe Arnett<sup>6</sup>,  
Eric Delvin<sup>1</sup>, Dan Grosboll<sup>1</sup>, Caroline Marschner<sup>1</sup>

1. The Nature Conservancy, 1917 1<sup>st</sup> Ave., Seattle, WA 98101
2. The Nature Conservancy, 87200 Rathbone Rd., Eugene, OR 97402
3. Institute for Applied Ecology, 563 SW Jefferson, Corvallis, OR 97333
4. Public Works-ENRD Att: IMNW-LEW-PWE, MS 17 (Rod Gilbert, Fish and Wildlife Program) Box 339500, Fort Lewis, WA 98433-9500
5. Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia, WA 98501
6. Washington Natural Heritage Program, P.O. Box 47014, Olympia,

## Introduction

The prairies of the south Puget Sound region are part of an array of grassland, savanna, and woodland habitats that extend intermittently from Oregon's Willamette Valley, north through western Washington, to the Georgia Basin in southwest British Columbia. These habitats share numerous floristic and faunal affinities, and comprise a remarkable and somewhat unexpected collection of seasonally xeric communities within a larger, more mesic landscape dominated by coniferous forests. They owe their existence to a variety of edaphic, climatic, and historic factors that have helped to keep dense forest vegetation from overtaking these sites (Alverson 2005). These habitats in the south Puget Sound area occur on soils that tend to be shallower, coarser, and more xeric than elsewhere in the ecoregion.

The northernmost expression of these assemblages occurs in southwestern British Columbia, where they are best developed on Vancouver Island and the Gulf Islands. Here they are frequently dominated by *Quercus garryana* (Garry oak or Oregon white oak), and the associated communities are often collectively referred to as the Garry oak ecosystem (Plants at Risk Recovery Implementation Group 2005). In the northern Puget Trough, including the San Juan Islands, Olympic Peninsula, and Whidbey Island, xeric grass and oak-dominated communities frequently occur on coastal bluffs and rocky balds, although historically, some well-developed prairies occurred near Sequim and on central Whidbey Island (Chappell 2006). Prairies also occurred historically in Lewis, Cowlitz, and Clark Counties in southwest Washington, but little remains. Today, the largest and most intact prairies and oak woodlands in western Washington are centered around Olympia (Figure 1). Over 90% of the historic prairies and savannas in this region have been destroyed through a combination of agricultural conversion, urban development, and encroachment by coniferous forest (Crawford and Hall 1997). Most of the remaining sites are the focus of considerable protection and restoration efforts.

Restoration of degraded or destroyed habitats requires a clear understanding of the species, structure, and ecological processes that

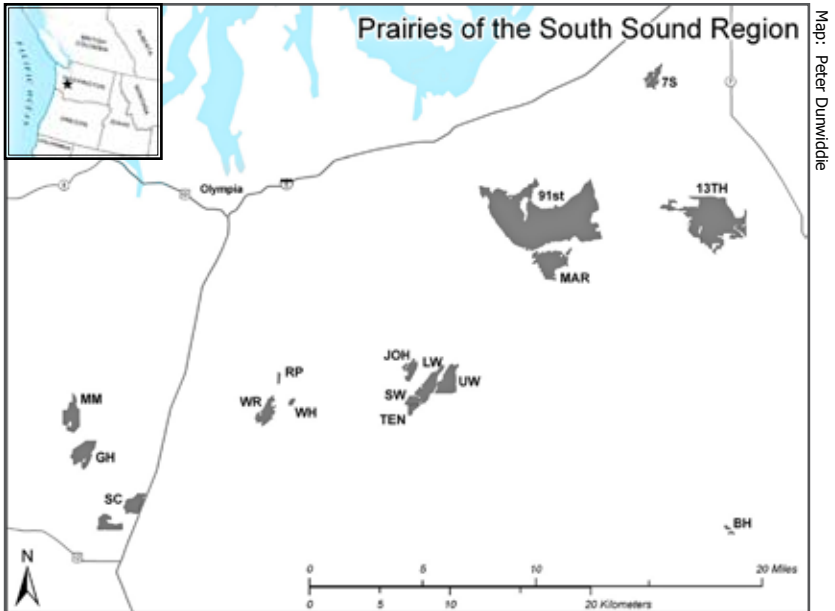


Figure 1. Locations of major prairies in the south Puget Sound region. Sites included in this study indicated as follows: GH=Glacial Heritage, Joh=Johnson, W=Lower Weir, Mar=Marion, MM=Mima Mounds, 91<sup>st</sup>=Ninety-first Division, RP=Rocky Prairie, SC=Scatter Creek, 7S= 7S Prairie, SW=South Weir, Ten=Tenalquot, 13<sup>th</sup>=Thirteenth Division, UW=Upper Weir, WR= West Rocky, WH=Wolf Haven. Bald Hill (BH) is a rocky bald community also noted in the text.

comprised and shaped the communities being restored. Unfortunately, all remaining fragments of these communities are significantly degraded. Most are a small fraction of their historic extent, with houses, cropland, tree farms, pastures, and surrounding forest now occupying the former prairies and oak woodlands. Numerous non-native species have invaded the remnants, in some cases entirely converting open grasslands into thickets of *Cytisus scoparius* (Scotch broom), *Rubus armeniacus* (blackberry), and other shrubs. Many native species have no doubt been lost from sites when the encroachment of exotic taxa is so extensive. But even where the historic grassland or woodland structure remains, past livestock grazing, fire suppression, and other land uses are likely to have resulted in the disappearance of many native species from these communities.

Understanding the current composition of native prairie remnants

provides a starting point for restoring these communities. With this information, a clearer picture can be developed of the nature and extent of degradation—what species are restricted to only a few sites? What sites appear to be particularly species depauperate? And what levels of native species diversity typify the most intact sites? We explore these questions for the prairies of south Puget Sound by compiling, in a single document, the most complete vascular plant species lists available for most of the major prairie fragments remaining in this region.

## Study Area

The largest remnants of upland prairie in western Washington are found in the southern Puget Sound region, where conservation efforts have been underway for over 30 years. Most of these sites are now protected, and many are under active management to control invasive species and restore degraded areas. We identified 15 sites with reasonably complete lists of vascular plant species, such that meaningful comparisons could be made with one another (Figure 1). These included all of the major remaining prairies, as well as several smaller fragments that still retain many of their native species. All probably were regularly burned by Native Americans prior to the mid-1800s, and likely received some level of livestock grazing in the 19<sup>th</sup> and 20<sup>th</sup> centuries, although these histories are difficult to reconstruct in any detail.

Half of the study sites, including Johnson, Marion, 13<sup>th</sup> Division, 91<sup>st</sup> Division, 7S, Upper Weir, Lower Weir, and South Weir, are prairies on the Fort Lewis Military Reservation, established in 1917. Although neglected after World War I, Fort Lewis has been an active installation administered by the U.S. Department of Defense since the late 1930s. Military training occurs on most of the prairies, with the exception of South Weir. Fires are frequently ignited as a result of training exercises, particularly in the 91<sup>st</sup> Division prairie. The remaining study sites occur on non-military lands. Rocky Prairie and Mima Mounds are Natural Area Preserves managed by the Washington Department of Natural Resources. Rocky Prairie probably has been little disturbed in many decades; Mima Mounds was grazed by livestock until the 1960s, but has

been largely undisturbed since then except for restoration activities to control invasive grasses, shrubs, and trees. Scatter Creek and the recently acquired West Rocky Prairie are managed by the Washington Department of Fish and Wildlife for a variety of resource interests; neither has been grazed or burned in at least several decades. Glacial Heritage (officially the Black River-Mima Mounds Glacial Heritage Preserve) is owned by Thurston County, with restoration actions cooperatively managed with The Nature Conservancy. Fire management has been returned to portions of Glacial Heritage during the last 5 years, but this site has received little other use in several decades. Tenalquot Prairie is immediately adjacent to South Weir on Fort Lewis, but is private land outside the military reservation. It was very lightly grazed until 2005, when it was acquired by The Nature Conservancy. Finally, Wolf Haven is a privately owned wildlife rehabilitation centre that includes a small, lightly-used area of native prairie habitat.

## Methods

Scientists have been documenting the flora of these prairies for over a century (Piper 1906, Rigg 1918, Lang 1961, Del Moral and Dearnorff 1976). The famed west-coast botanist David Douglas may have botanized in the region in the mid 1800s but regrettably his journals and specimens were destroyed in a canoeing accident. Some early studies were documented with vouchered specimens, but often the labels do not clearly identify the prairie from which the specimens were collected. Over the last 25 years, researchers and site managers have begun compiling species lists for individual prairie sites, and it is this information, which exists primarily in unpublished reports and species lists, that we used as a starting point for this analysis (Evans et al. 1984, [http://www.wnps.org/plant\\_lists/](http://www.wnps.org/plant_lists/)). We augmented these lists with additional species occurrence data from plot-based studies that are underway in several sites (Dunwiddie, Stanley, Delvin, Pearson, unpublished studies). Finally, we added species occurrences based on our personal records and from searches of the University of Washington and Washington State University herbarium collection databases. We did

not include species found in nearby forests, woodlands, and wet prairies, based on our knowledge of the particular sites and the occurrences of the taxa in question. In some sites, these distinctions were difficult to draw, and inconsistencies may exist among the lists from different prairies as a result.

We used the USDA PLANTS database (USDA 2006) as a basis for our nomenclature. Uncertainties inevitably arose regarding taxonomic identifications, particularly for taxa difficult to identify in the field, and for some identifications of species drawn from older lists. Given the general level at which the data are summarized in this paper, we feel that these issues would not significantly alter the main conclusions. However, we note in the Discussion where some questions remain to be resolved. In addition, some sites have been less well-studied than others. In particular, the lists from 7S, South Weir, Tenalquot, West Rocky, and Wolf Haven are probably missing some of the less-common taxa.

The area of the prairie and savanna habitat on each site was calculated by identifying these vegetation types on aerial imagery, delineating the perimeter in a GIS, and calculating the area of the polygons. Sites ranged from 12 to 3000 ha (Table 1).

## Results and Discussion

A total of 278 taxa was recorded from the fifteen prairies, which individually contained from 40 to 195 taxa (Table 1). The total number of species was positively correlated with prairie area ( $R^2=0.34$ ,  $P=0.02$ ). This relationship was virtually unchanged when only native species were included. The most species rich prairies, both for native species richness and total species richness, were 13<sup>th</sup> Division Prairie with 199 species and 106 native prairie taxa; and 91<sup>st</sup> Division Prairie, with 170 species total and 105 native prairie taxa. Both prairies are located in Pierce County on Fort Lewis and are also the largest in extent.

When the species list for all prairies is considered collectively, 59% were native, and 40% were introduced, with 1% of uncertain origin, including *Aphanes arvensis*, *Draba verna*, *Festuca rubra*, and *Vulpia myuros*.

Most abundant were forbs, which comprise 74% of the taxa; graminoids (17%), shrubs (8%), and trees (2%) contribute relatively less. The majority of native forbs in these prairies were perennials (70%), but among the introduced forbs, annuals and biennials were more common, with perennials comprising only 39% of the exotic taxa. Among the graminoids, the majority of species were perennials, both among the natives (94%) and non-natives (67%).

These proportions did not vary greatly among the different prairies we examined, despite differences in historic and current land uses (Table 1). Although the abundance and dominance of introduced species probably would be found to vary considerably among the prairies, based on quantitative measures of cover or frequency, the percentage of introduced species as a proportion of the total flora for each site only varied from 33-48% among the 15 sites.

Perennial species dominated all the prairies, but the proportion of annuals varied among sites (Table 1). In general, annuals appeared to be more abundant in the prairies that receive regular disturbance, particularly the Ft. Lewis prairies, where they comprise up to 30% of the species. Tracked military vehicles created areas of bare soil and dispersed seeds, aiding in the spread and establishment of annuals. Frequent fires reduced thick mats of moss, lichens, and accumulated litter, and set back the growth of *Festuca roemerii*, a dominant native bunchgrass. Together, these processes would tend to encourage a greater diversity of annual species. Although introduced taxa now make up the majority of annual species, we surmise that historically, native annuals may have represented a significant portion of the floristic diversity of many of these prairies when they were being regularly burned by Native Americans. We recorded 32 native annuals in the 15 prairies. *Lotus micranthus* was particularly widespread, but several species of *Lupinus* and *Trifolium*, caryophs such as *Silene antirrhina* and *Microsteris gracilis*, and an assortment of taxa from other families, may once have been more abundant.

Nine native species were recorded in every prairie, and another nine occurred in all but one (Table 2). Widespread graminoids included *Festuca roemerii*, *Carex inops* ssp. *inops*, and *Danthonia californica*. Species of

*Luzula* also were common, but this genus includes both native and non-native species, which were not reliably distinguished in our data. *Koeleria macrantha* was also nearly as common, reported from 14 of the 15 sites. Native forbs that occurred in virtually every site included *Achillea millefolium*, *Apocynum androsaemifolium*, *Camassia quamash* ssp. *azurea* or ssp. *maxima*, *Eriophyllum lanatum* var. *leucophyllum*, *Fragaria virginiana*, *Fritillaria affinis* var. *affinis*, *Lomatium utriculatum*, *Lotus micranthus*, *Microseris laciniata*, *Ranunculus occidentalis* var. *occidentalis*, *Sericocarpus rigidus*, *Viola adunca*, and *Zigadenus venenosus* var. *venenosus*. Other forbs that occurred on 12-13 of the 15 prairies included *Brodiaea coronaria* ssp. *coronaria*, *Campanula rotundifolia*, *Hieracium cynoglossoides*, and *Prunella vulgaris* ssp. *lanceolata*. This list of taxa largely coincides with those species included in the *Festuca roemerii*–*Sericocarpus rigidus* plant association described by the Washington Natural Heritage Program as characteristic of prairies in this region (<http://www.dnr.wa.gov/nhp/refdesk/communities/pdf/fero-seri.pdf>). Finally, the low shrub *Arctostaphylos uva-ursi* was found in most prairies.

While there was significant overlap between the species found in the south Puget prairies and those reported from similar habitats farther north, it is noteworthy that several of the widespread taxa appeared to be considerably less frequent in the San Juan Islands (Chappell 2006), and were entirely absent from species lists from Garry oak ecosystems in British Columbia (W. Erickson, personal communication). These include *Campanula rotundifolia*, *Delphinium nuttallii*, *Erigeron speciosus*, *Hieracium cynoglossoides*, *Lupinus albicaulis*, *Microseris laciniata*, and *Potentilla gracilis*. Most of these species occur in the Willamette Valley, however, suggesting that their absence in British Columbia is due either to limitations in species geographic range, or reduced species richness due to the smaller extent of prairies in British Columbia even in pre-EuroAmerican settlement times.

A suite of introduced species was also similarly widespread in the south Puget Sound area prairies (Table 3). Among the grasses, the most ubiquitous included *Aira caryophyllea*, *Aira praecox*, *Agrostis capillaris*, *Anthoxanthum odoratum*, and *Poa pratensis*. *Arrhenatherum elatius*, *Dactylis glomerata*, and *Holcus lanatus* were nearly as widespread. Introduced forbs that occurred in virtually all the prairies included *Hypericum perforatum*,

*Hypochaeris radicata*, *Leucanthemum vulgare*, *Plantago lanceolata*, *Rumex acetosella*, *Taraxacum officinale*, *Teesdalia nudicanlis*, *Trifolium dubium* and *Vicia sativa*. In addition, one shrub—*Cytisus scoparius*—also occurred in nearly every site. As with the widespread native species, most of these taxa were identified by the Washington Natural Heritage Program as frequent occurrences in the *Festuca roemerii*–*Sericocarpus rigidus* plant association.

In the absence of relatively pristine remnants of native prairie communities, it is difficult to determine which species are appropriate to include in restoration projects. It is likely that even sites that are still dominated by native species have lost some of their original flora. Developing comprehensive quantitative restoration goals thus can be problematic. For example, only occasionally do we have specific information that documents particular species as having been extirpated from a site (Table 4). The data compiled in this paper begin to provide a more complete picture of prairie floristic composition that will assist in developing restoration goals. The species documented here as being most frequent in the prairies of southern Puget Sound describe a basic suite of taxa that restorationists can be reasonably confident should be represented in significant numbers in a reconstructed prairie in this region. Furthermore, the list of common non-native taxa provide a warning of what species are almost certain to succeed in a site, and towards which appropriate control measures should be taken early on in the restoration process.

Many species were documented from only a few of the prairies, for complete list see Appendix A. (<http://www.davidsonia.org/>). Nearly 40% of the 163 native species occurred in only 1 or 2 prairies. We also compiled a list of species that, although they were not recorded in our dataset for the 15 focal prairies, warrant further efforts to determine their current distribution (Table 4). This list includes prairie species previously recorded in the sites we inventoried (based on herbarium records), species known from other south Puget Sound prairie sites not included in this study, and species which historically occurred in prairies in the south Puget Sound, but now are only found in the Bald Hill area. Bald Hill includes several rocky bald habitats which share many affinities with the south Puget

Sound prairies. However, these unique higher elevation habitats appear to have sustained remnant populations of several taxa that are no longer found in the nearby lowland prairies.

The species noted in [Table 4](#), together with a longer list of species we recorded from only one or two prairies, present several issues worthy of consideration. First, greater efforts are warranted at most of the sites to thoroughly document their floras, and these less widespread species in particular ought to be the focus of directed searches in sites where they have not yet been recorded. Closer scrutiny of the distributions of these less-common species may reveal patterns that would be helpful in understanding where they might be expected to occur. Second, some of these taxa may be more limited in their distributions because they have more specialized habitat requirements or are at the edge of their range, and attempting to establish them at more sites may not be successful unless conditions are appropriate. More research is needed to clarify the ecological requirements of these taxa. For example, the documented northern-most limit of several native prairie species, including *Sidalcea malviflora* ssp. *virgata* and *Wyethia angustifolia*, is Scatter Creek, the southern-most prairie in this study. The other prairies may thus be outside of the potential geographic range of these species. Third, even though the prairies included in this study occur in a relatively small geographic region, differences in soils and precipitation may impose environmental patterns on the landscape that are important determinants in plant distributions. Fourth, of particular concern are species that are now limited to a handful of sites due to the extensive loss of their former habitat, like the federally threatened *Castilleja levisecta*.

The absence of these taxa from many sites may also help identify where conditions have been significantly altered by past land use, or where key ecological processes have been significantly altered. Conservation biologists have suggested that species losses may be greater in highly fragmented habitats. Species richness varies widely among the smallest prairies documented in this compilation—Wolf Haven, Tenalquot, South Weir, 7S, West Rocky, Rocky Prairie, and Marion. As noted previously, the first five need to be more thoroughly inventoried, but they also may have witnessed the disappearance of a part of their

floras due to a variety of factors. Stochastic events, loss or alteration of ecologically important processes (e.g., digging and harvesting by Native Americans, fire, fossorial animals, large grazing ungulates, pollinators, seed dispersers), introduction of novel processes (non-native plant and animal species, grazing livestock, fire at different times of the year, atmospheric nitrogen deposition), and interactions among these various factors, all may have particularly affected these smaller prairie remnants. These sites should be examined closely to determine whether their floras are, indeed, depauperate, and which species are likely to have been lost.

Site-specific data from a large number of prairies and savannas across the ecoregion would be helpful in understanding these distributional questions. While presence/absence data may clarify biogeographical questions, quantitative, plot-based abundance information (e.g., cover or frequency) would be especially helpful. An ecoregional conservation assessment has recently been completed by The Nature Conservancy and The Nature Conservancy of Canada, together with numerous experts from many agencies, which begins to gather some of this distributional data for many of the less common species (Floberg et al., 2004). Extensive site-specific work has been done in some regions for these habitats, including studies in Canada by Wayne Erickson (1996), in Oregon by Ed Alverson, and in Washington in this paper, and by Chris Chappell and others (Chappell 2006, Chappell et al. 2004, <http://www.dnr.wa.gov/nhp/refdesk/communities/pdf/intro.pdf>). Future work should be directed towards bringing this information into a comprehensive, regional synthesis.

## Acknowledgements

We are grateful to the many people who have contributed to our understanding of the flora of these prairies. In addition to those cited in the references, we would like to thank Andrew MacDougall, Wayne Erickson, Doug Swanson, and Elizabeth Roderick for providing information and suggestions. Jesse Langdon provided invaluable assistance in calculating acreages and preparing the map.

## References

- Alverson, E. 2005. Preserving prairies and savannas in a sea of forest. Plant Talk 40:23-27.
- Chappell, C. 2006. Plant associations of balds and bluffs of western Washington. Natural Heritage Report 2006-02. 70p.
- Chappell, C., Alverson, E., and Erickson, W., 2004. Ecologic and geographic variation in species composition of prairies, herbaceous balds, and oak woodlands of the Willamette Valley–Puget Trough–Georgia Basin Ecoregion. Presentation at Ecological Society of America, 2004 Annual Meeting, Portland, OR, Aug. 2-6, 2004.
- Crawford, R. and Hall, H., 1997. Changes in the south Puget prairie landscape. *in* Ecology and Conservation of the South Puget Sound Prairie Landscape, *edited by* P. Dunn and K. Ewing. The Nature Conservancy, Seattle. pp. 11-15
- Del Moral, R. and Deardorff, D.C., 1976. Vegetation of the Mima Mounds, Washington State. Ecology 57:520-530.
- Erickson, W.R., 1996. Classification and Interpretation of Garry oak (*Quercus garryana*) Plant Communities and Ecosystems in Southwestern British Columbia. M.Sc. thesis. Dept. of Geography, University of Victoria.
- Evans, S., Schuller, R., and Augenstein, E. 1984. A report on *Castilleja levisecta* Greenm. at Rocky Prairie, Thurston County, Washington. Unpublished report to The Nature Conservancy, Seattle, WA. 56p.

Floberg, J., Goering, M., Wilhere, G., MacDonald, C., Chappell, C., Rumsey, C., Ferdana, Z., Holt, A., Skidmore, P., Horsman, T., Alverson, E., Tanner, C., Bryer, M., Iachetti, P., Harcombe, A., McDonald, B., Cook, T., Summers, M., and Rolph, D. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report. *Prepared by* The Nature Conservancy *with support from* the Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.

<http://www.dnr.wa.gov/nhp/refdesk/communities/pdf/fero-seri.pdf>. (last consulted 31 Oct 2006)

<http://www.dnr.wa.gov/nhp/refdesk/communities/pdf/intro.pdf>. (last consulted 31 Oct 2006)

[http://www.wnps.org/plant\\_lists/counties/thurston/mima\\_mounds.doc](http://www.wnps.org/plant_lists/counties/thurston/mima_mounds.doc). (last consulted 31 Oct 2006)

[http://www.wnps.org/plant\\_lists/counties/thurston/scatter\\_creek.doc](http://www.wnps.org/plant_lists/counties/thurston/scatter_creek.doc). (last consulted 31 Oct 2006)

Lang, F.A. 1961. A Study of Vegetation Change on the Gravelly Prairies of Pierce and Thurston Counties, Western Washington. M.S. Thesis, University of Washington, Seattle.

Piper, C.V. 1906. Flora of the State of Washington. Contributions to the US National Herbarium 11:1-637.

Plants at Risk Recovery Implementation Group. 2005. National multi-species recovery strategy for species at risk in Garry oak woodlands. Draft report to the Rare Plants Recovery Implementation Group (RIG) of the Garry Oak Ecosystems Recovery Team.

Rigg, G.B. 1918. Notes on plants found in the vicinity of Camp Lewis. Washington Geological Survey Bulletin 18:74-90.

USDA, NRCS. 2006. The PLANTS Database (<http://plants.usda.gov>, consulted 15 July 2006). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Table 1. Area of upland prairie at each site, total number of species, and frequency of species according to origin, life history, life form, and combinations of these categories at each prairie. Prairie name abbreviations as follows: GH=Glacial Heritage, Joh=Johnson, LW=Lower Weir, Mar=Marion, MM=

| Prairie Site             | GH   | Joh  | LW   | Mar  | MM   | 91st | RP   | SC   |
|--------------------------|------|------|------|------|------|------|------|------|
| Area (ha)                | 235  | 94   | 200  | 62   | 150  | 3000 | 12   | 223  |
| No. Species              | 94   | 136  | 111  | 140  | 100  | 168  | 115  | 119  |
| <b>Origin</b>            |      |      |      |      |      |      |      |      |
| Intro. Species           | 0.36 | 0.40 | 0.41 | 0.45 | 0.40 | 0.39 | 0.36 | 0.34 |
| Native Species           | 0.64 | 0.60 | 0.59 | 0.55 | 0.60 | 0.61 | 0.64 | 0.66 |
| <b>Life History</b>      |      |      |      |      |      |      |      |      |
| Annual Species           | 0.15 | 0.24 | 0.24 | 0.28 | 0.14 | 0.30 | 0.17 | 0.20 |
| Bien. & Peren. Spp.      | 0.86 | 0.77 | 0.77 | 0.74 | 0.87 | 0.71 | 0.86 | 0.82 |
| <b>Origin x Ann.</b>     |      |      |      |      |      |      |      |      |
| Native Annuals           | 0.29 | 0.39 | 0.33 | 0.33 | 0.07 | 0.46 | 0.26 | 0.38 |
| Intro. Annuals           | 0.71 | 0.58 | 0.63 | 0.64 | 0.93 | 0.52 | 0.63 | 0.58 |
| <b>Life Form</b>         |      |      |      |      |      |      |      |      |
| Forbs                    | 0.62 | 0.74 | 0.71 | 0.73 | 0.61 | 0.80 | 0.67 | 0.69 |
| Graminoids               | 0.26 | 0.18 | 0.22 | 0.19 | 0.23 | 0.15 | 0.20 | 0.19 |
| Shrubs                   | 0.11 | 0.07 | 0.05 | 0.06 | 0.14 | 0.03 | 0.12 | 0.09 |
| Trees                    | 0.02 | 0.01 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.03 |
| <b>Orig. x Life Form</b> |      |      |      |      |      |      |      |      |
| Native Forbs             | 0.41 | 0.45 | 0.43 | 0.39 | 0.36 | 0.49 | 0.44 | 0.48 |
| Nat. Gram.               | 0.13 | 0.08 | 0.09 | 0.10 | 0.10 | 0.07 | 0.10 | 0.08 |
| Native Shrubs            | 0.07 | 0.06 | 0.04 | 0.04 | 0.12 | 0.02 | 0.10 | 0.08 |
| Native Trees             | 0.02 | 0.01 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.03 |
| Intro. Forbs             | 0.20 | 0.29 | 0.28 | 0.34 | 0.25 | 0.30 | 0.23 | 0.21 |
| Intro. Gram.             | 0.13 | 0.10 | 0.13 | 0.09 | 0.13 | 0.08 | 0.10 | 0.12 |
| Intro. Shrubs            | 0.03 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.03 | 0.02 |

Mima Mound, 91<sup>st</sup>=Ninety-first Division, RP=Rocky Prairie, SC=Scatter Creek, 7S= 7S Prairie, SW=South Weir, Ten=Tenalquot, 13<sup>th</sup>=Thirteenth Division, UW=Upper Weir, WR=West Rocky, WH=Wolf Haven.

| <b>Prairie Site</b>      | <b>7S</b> | <b>SW</b> | <b>Ten</b> | <b>13th</b> | <b>UW</b> | <b>WR</b> | <b>WH</b> | <b>Ave.</b> |
|--------------------------|-----------|-----------|------------|-------------|-----------|-----------|-----------|-------------|
| Area (ha)                | 77        | 55        | 38         | 1114        | 219       | 70        | 13        |             |
| No. Species              | 53        | 60        | 40         | 195         | 116       | 57        | 40        |             |
| <b>Origin</b>            |           |           |            |             |           |           |           |             |
| Intro. Species           | 0.45      | 0.47      | 0.38       | 0.48        | 0.35      | 0.35      | 0.33      | 0.39        |
| Native Species           | 0.55      | 0.53      | 0.63       | 0.52        | 0.65      | 0.65      | 0.68      | 0.61        |
| <b>Life History</b>      |           |           |            |             |           |           |           |             |
| Annual Species           | 0.23      | 0.20      | 0.15       | 0.29        | 0.23      | 0.11      | 0.13      | 0.20        |
| Bien. & Peren. Spp.      | 0.79      | 0.80      | 0.85       | 0.73        | 0.78      | 0.89      | 0.88      | 0.81        |
| <b>Origin x Ann.</b>     |           |           |            |             |           |           |           |             |
| Native Annuals           | 0.25      | 0.17      | 0.17       | 0.38        | 0.44      | 0.67      | 0.40      | 0.33        |
| Intro. Annuals           | 0.75      | 0.83      | 0.83       | 0.57        | 0.56      | 0.33      | 0.60      | 0.65        |
| <b>Life Form</b>         |           |           |            |             |           |           |           |             |
| Forbs                    | 0.68      | 0.68      | 0.65       | 0.70        | 0.71      | 0.67      | 0.70      | 0.69        |
| Graminoids               | 0.25      | 0.23      | 0.30       | 0.20        | 0.22      | 0.18      | 0.18      | 0.21        |
| Shrubs                   | 0.06      | 0.08      | 0.00       | 0.09        | 0.05      | 0.12      | 0.10      | 0.08        |
| Trees                    | 0.02      | 0.00      | 0.03       | 0.02        | 0.02      | 0.04      | 0.03      | 0.02        |
| <b>Orig. x Life Form</b> |           |           |            |             |           |           |           |             |
| Native Forbs             | 0.42      | 0.40      | 0.40       | 0.38        | 0.48      | 0.47      | 0.48      | 0.43        |
| Nat. Gram.               | 0.08      | 0.08      | 0.18       | 0.07        | 0.10      | 0.05      | 0.10      | 0.09        |
| Native Shrubs            | 0.04      | 0.05      | 0.03       | 0.06        | 0.04      | 0.09      | 0.08      | 0.06        |
| Native Trees             | 0.02      | 0.00      | 0.03       | 0.02        | 0.02      | 0.04      | 0.03      | 0.02        |
| Intro. Forbs             | 0.26      | 0.28      | 0.25       | 0.32        | 0.22      | 0.19      | 0.23      | 0.26        |
| Intro. Gram.             | 0.17      | 0.15      | 0.13       | 0.13        | 0.12      | 0.12      | 0.08      | 0.12        |
| Intro. Shrubs            | 0.02      | 0.03      | 0.00       | 0.03        | 0.01      | 0.04      | 0.03      | 0.02        |

Table 2. Frequency of common native species in fifteen prairies in south Puget Sound. (Note: *Luzula* spp. may include both native and introduced species.)

| Plant Name  | Growth Habit | Duration  | % Freq. |
|---|--------------|-----------|---------|
| <i>Achillea millefolium</i>                             | Forb         | Perennial | 100     |
| <i>Camassia quamash</i>                                 | Forb         | Perennial | 100     |
| <i>Carex inops</i> ssp. <i>inops</i>                    | Graminoid    | Perennial | 100     |
| <i>Eriophyllum lanatum</i> var. <i>leucophyllum</i>     | Forb         | Perennial | 100     |
| <i>Festuca roemerii</i>                                 | Graminoid    | Perennial | 100     |
| <i>Microseris laciniata</i>                             | Forb         | Perennial | 100     |
| <i>Sericocarpus rigidus</i>                             | Forb         | Perennial | 100     |
| <i>Arctostaphylos uva-ursi</i>                          | Shrub        | Perennial | 93      |
| <i>Danthonia californica</i>                            | Graminoid    | Perennial | 93      |
| <i>Fragaria virginiana</i> ssp. <i>platypetala</i>      | Forb         | Perennial | 93      |
| <i>Fritillaria affinis</i> var. <i>affinis</i>          | Forb         | Perennial | 93      |
| <i>Lomatium utriculatum</i>                             | Forb         | Perennial | 93      |
| <i>Ranunculus occidentalis</i> var. <i>occidentalis</i> | Forb         | Perennial | 93      |
| <i>Viola adunca</i>                                     | Forb         | Perennial | 93      |
| <i>Zigadenus venenosus</i> var. <i>venenosus</i>        | Forb         | Perennial | 93      |
| <i>Apocynum androsaemifolium</i>                        | Forb         | Perennial | 87      |
| <i>Hieracium cynoglossoides</i>                         | Forb         | Perennial | 87      |
| <i>Koeleria macrantha</i>                               | Graminoid    | Perennial | 87      |
| <i>Lotus micranthus</i>                                 | Forb         | Annual    | 87      |
| <i>Luzula</i> spp.                                      | Graminoid    | Perennial | 87      |
| <i>Prunella vulgaris</i> ssp. <i>lanceolata</i>         | Forb         | Perennial | 87      |
| <i>Brodiaea coronaria</i> ssp. <i>coronaria</i>         | Forb         | Perennial | 80      |
| <i>Campanula rotundifolia</i>                           | Forb         | Perennial | 80      |

Table 3. Frequency of common introduced species in south Puget Sound prairies.

| Plant Name                   | Growth Habit | Duration  | % Freq. |
|------------------------------|--------------|-----------|---------|
| <i>Hypericum perforatum</i>  | Forb         | Perennial | 100     |
| <i>Hypochaeris radicata</i>  | Forb         | Perennial | 100     |
| <i>Leucanthemum vulgare</i>  | Forb         | Perennial | 100     |
| <i>Plantago lanceolata</i>   | Forb         | Perennial | 100     |
| <i>Rumex acetosella</i>      | Forb         | Perennial | 100     |
| <i>Teesdalia nudicaulis</i>  | Forb         | Annual    | 100     |
| <i>Agrostis capillaris</i>   | Graminoid    | Perennial | 93      |
| <i>Anthoxanthum odoratum</i> | Graminoid    | Perennial | 93      |
| <i>Cytisus scoparius</i>     | Shrub        | Perennial | 93      |
| <i>Poa pratensis</i>         | Graminoid    | Perennial | 93      |
| <i>Trifolium dubium</i>      | Forb         | Annual    | 93      |
| <i>Aira caryophylllea</i>    | Graminoid    | Annual    | 87      |
| <i>Aira praecox</i>          | Graminoid    | Annual    | 87      |
| <i>Arrhenatherum elatius</i> | Graminoid    | Perennial | 87      |
| <i>Holcus lanatus</i>        | Graminoid    | Perennial | 87      |
| <i>Vicia sativa</i>          | Forb         | Annual    | 87      |
| <i>Dactylis glomerata</i>    | Graminoid    | Perennial | 80      |
| <i>Taraxacum officinale</i>  | Forb         | Perennial | 80      |

Table 4. Prairie species not recorded in the 15 prairies. X= prairie plants documented for south Puget Sound counties only from historic records, possibly extirpated, O= plants documented from other south Puget Sound prairies but not those in this study, BH= plants with historic records from south Puget Sound prairies but now only known from grassy balds in the Bald Hills area, Thurston County.

|   | Status |
|---|--------|
| <i>Agoseris elata</i>                                 | X      |
| <i>Agoseris heterophylla</i> ssp. <i>heterophylla</i> | X      |
| <i>Amsinckia intermedia</i>                           | X      |
| <i>Apocynum cannabinum</i> var. <i>glaberrimum</i>    | O      |
| <i>Athysanus pusillus</i>                             | BH     |
| <i>Bromus marginatus</i>                              | O      |
| <i>Carex tumulicola</i>                               | O      |
| <i>Castilleja attenuata</i>                           | BH     |
| <i>Chamaesyce serpyllifolia</i>                       | X      |
| <i>Cirsium edule</i>                                  | X      |
| <i>Cirsium remotifolium</i>                           | O      |
| <i>Clarkia gracilis</i>                               | X      |
| <i>Clarkia purpurea</i> ssp. <i>quadrivulnera</i>     | BH     |
| <i>Claytonia exigua</i> var. <i>exigua</i>            | X      |
| <i>Claytonia perfoliata</i> ssp. <i>perfoliata</i>    | O      |
| <i>Claytonia rubra</i> ssp. <i>depressa</i>           | BH     |
| <i>Claytonia rubra</i> ssp. <i>rubra</i>              | X      |
| <i>Collomia linearis</i>                              | O      |
| <i>Crataegus castlegarensis</i>                       | O      |
| <i>Crocidium multicaule</i>                           | BH     |
| <i>Cryptantha intermedia</i>                          | O      |
| <i>Daucus pusillus</i>                                | BH     |
| <i>Epilobium brachycarpum</i>                         | O      |
| <i>Fragaria vesca</i> ssp. <i>bracteata</i>           | O      |
| <i>Galium boreale</i>                                 | O      |
| <i>Gilia capitata</i>                                 | O      |
| <i>Githopsis specularioides</i>                       | BH     |

Table 4 continued.

|   |    |
|---|----|
| <i>Gnaphalium stramineum</i>                        | O  |
| <i>Heterocodon variflorum</i>                       | BH |
| <i>Hieracium scouleri</i> var. <i>scouleri</i>      | O  |
| <i>Iris tenax</i> var. <i>tenax</i>                 | O  |
| <i>Lactuca biennis</i>                              | O  |
| <i>Ligusticum apiifolium</i>                        | O  |
| <i>Madia exigua</i>                                 | X  |
| <i>Madia glomerata</i>                              | O  |
| <i>Madia gracilis</i>                               | BH |
| <i>Madia minima</i>                                 | X  |
| <i>Madia sativa</i>                                 | O  |
| <i>Meconella oregano</i>                            | X  |
| <i>Minuartia rubella</i>                            | X  |
| <i>Orobanche fasciculata</i>                        | O  |
| <i>Plantago aristata</i>                            | X  |
| <i>Plantago patagonica</i>                          | X  |
| <i>Poa bowellii</i>                                 | BH |
| <i>Poa scabrella</i>                                | O  |
| <i>Sagina decumbens</i> ssp. <i>occidentalis</i>    | X  |
| <i>Sambucus cerulea</i> var. <i>cerulea</i>         | O  |
| <i>Sanicula crassicaulis</i> var. <i>tripartita</i> | O  |
| <i>Synthyris reniformis</i>                         | O  |
| <i>Thysanocarpus curvipes</i>                       | X  |
| <i>Tonella tenella</i>                              | X  |
| <i>Toxicodendron diversilobum</i>                   | O  |
| <i>Trifolium microdon</i>                           | BH |
| <i>Trifolium oliganthum</i>                         | BH |
| <i>Trifolium variegatum</i>                         | X  |
| <i>Trifolium wormskioldii</i>                       | X  |
| <i>Vaccinium caespitosum</i>                        | O  |
| <i>Vicia gigantea</i>                               | O  |
| <i>Viola bowellii</i>                               | O  |
| <i>Vulpia megalura</i>                              | O  |
| <i>Vulpia microstachys</i>                          | O  |

# Book Review

**Breeding Field Crops 5<sup>th</sup> Ed.**  
**Sleper, D.A. and Poehlman, J.M. 2006.**  
**Oxford: Blackwell Publishing. 424 pp.**

This book is the 5<sup>th</sup> edition of a popular plant breeding textbook used worldwide. The 1<sup>st</sup> edition was published in 1959 with subsequent editions produced approximately every ten years. The current edition is an up-dated and revised version of the earlier work. It is intended for both beginning plant breeding students as well as post-graduate students and professionals. As an undergraduate text, it provides all the fundamental information required as well as study questions and suggestions for further readings. In addition to its ability to serve an undergraduate course, I feel it would be equally useful to a graduate level course or as a reference for anyone interested in agronomic plant breeding. The focus of this book is breeding of field crops, as one would expect, but wider aspects of plant breeding applicable to non-field crops are also covered, including a basic review of reproduction and variation, classical and modern tools available, and specific methods used in crop improvement. In addition, the book integrates recent literature when appropriate while also providing historical context in a comprehensive review of individual crops. I found the overall organization of the book and writing to be clear and logical with the text well supported by relevant photographs and illustrations. Care is taken to define and make clear the technical aspects of plant breeding with an excellent glossary and index to support this objective.

The first half of the book is devoted to fundamental information including the genetic basis for plant breeding (i.e., reproduction, qualitative/quantitative inheritance), tools of the plant breeder (i.e., ploidy level, mutation, fertility-regulating mechanisms, and biotechnology), ending with methods used by the plant breeder (i.e., breeding self- or cross-pollinated species, hybrid cultivars, and development of breeding objectives and techniques). The second half of the book concentrates on the application of this information in the breeding of specific crops

grouped into self-pollinated crops (e.g., wheat, rice), hybrid crops (e.g., corn, sorghum), vegetatively propagated crops (e.g., potato, sugarcane), and ending with a section on maintenance and seed production of improved cultivars.

In conclusion, this book is an excellent reference on the breeding and improvement of crop plants set against a comprehensive historical background. It is an excellent course book for advanced students and a unique introduction to the literature for research scientists new to plant breeding.

**Andrew Riseman, Ph.D, Assistant Professor in Agroecology,  
Plant Breeder, UBC Botanical Garden and Centre for Plant Research**

## **Gleanings**

**Notes on papers (some technical and others less so)  
that may be of interest**

### **Journal articles**

**Invasive plant species: results of a consumer awareness,  
knowledge, and expectations survey conducted in Pennsylvania.  
Kelley, K.M., Conklin, J.R., Sellmer, J.C., and Bates, R.M.  
March 2006.**

**Journal of Environmental Horticulture 24 (1): 53-58.**

A survey at the 2004 Philadelphia Flower Show discovered that while 81.5% of participants knew about invasives, only 40.1% acknowledged owning such plants and fewer (33.5%) did not know if they were growing in their landscapes. The authors call for greater use of the television and print media to educate consumers about potential problems associated with invasives.

**Contrasting terrestrial lichen, liverwort and moss diversity  
between old growth and young second-growth forest on two soil  
textures in central British Columbia**

**Botting, R.S. and Fredeen, A.L. January 2006.  
Canadian Journal of Botany 84: 120-132**

The title is largely self-explanatory, but it is gratifying to see a major journal publishing a high quality inventory study. The context is of sub-boreal spruce forests and shows that 30% of species were found only in old-growth and 21% were only in the young stands. The statistical analysis separated plots by forest age and showed that soil texture was a defining variable.

**A new invasive hawkweed, *Hieracium glomeratum*  
(Lactuceae, Asteraceae), in the Pacific Northwest  
Wilson, L.M., Fehrer, J., Bräutigam, S. and Grosskopf, G.  
January 2006.**

**Canadian Journal of Botany 84: 133-142.**

The authors conclude that this introduction, present in SE British Columbia, NE Washington and northern Idaho, probably originated from a single introduction from Europe. There are now 15 adventive, exotic *Hieracium* species in USA and Canada.

**Impacts of *Lythrum salicaria* invasion on plant community and  
soil properties in two wetlands in central New York, USA  
Mahaney, W.M., Smemo, K.A. and Yavitt, J.B. March 2006.  
Canadian Journal of Botany 83: 477-484.**

The authors have tried to establish some reliable information about the impacts of *L. salicaria* on pristine wetland plant diversity. They reach a somewhat controversial conclusion that the impact is not as severe as previously understood.

# Table of Contents

|  |    |
|--|----|
| Editorial  | 33 |
| <i>Taylor</i>  |    |
| Historical Garry Oak Ecosystems of<br>Vancouver Island, British Columbia,<br>pre-European Contact to the Present | 34 |
| <i>Lea</i>   |    |
| The Vascular Plant Flora of the<br>South Puget Sound Prairies, shington, USA                                     | 51 |
| <i>Dunmiddie et al.</i>  |    |
| Book Review  | 70 |
| Gleanings  | 71 |



THE UNIVERSITY OF  
BRITISH COLUMBIA



ubcbotanicalgarden  
& centre for plant research

