WET PRAIRIE SWALES OF THE SOUTH PUGET SOUND, WASHINGTON

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INTRODUCTION

In a fire-maintained prairie landscape, ***wet prairies*** occur in areas with a seasonally high water table (Chappell, et al. 2004).[1] These wet prairies occupy sites midway along the continuum from dry, upland prairies to permanently saturated and unburned wetlands. In the South Puget Sound, wet prairies occur in low-lying sites that are in open topography with few or no firebreaks to isolate them from the historically frequent fires. In the typically permeable, glacial outwash substrates of the region, wet prairies are most likely limited to swales and along low-gradient riparian areas where the surface topography and groundwater table approach each other (Alverson, personal communication; personal observation) and where local aquitards[2] are present. These wet prairies of the South Puget Sound contrast with the wet prairies of the Willamette Valley, in that the latter generally occur on relatively impermeable, clay-rich soils with perched water and historically covered large areas. In this report, seasonal wet prairies of the South Puget Sound are referred to as ***wet prairie swales*** to indicate their position in the landscape and to distinguish the sites from the more extensive Willamette Valley wet prairies.

In the wet prairie swales of the South Puget Sound, relatively high site productivity resulted in their rapid conversion to agricultural use, intense grazing pressure from livestock, and/or rapid invasion of dense, woody vegetation in the absence of regular anthropogenic fires. In addition, the hydrology of many sites has been altered by draining, agriculture, roads, recession of the ground water table (due to wells), and lack of fire. As a result, native prairie vegetation in wet prairie swale habitat has been nearly extirpated in the South Puget Sound.

Because these areas presumably covered limited area and had been highly disturbed, most prior prairie conservation priorities in the South Puget Sound have been directed towards triage of dry upland prairie sites, which have dramatically declined from their historic area (Crawford and Hall 1997; Chappell et al., 2001). Thus, the extent, composition and function of wet prairie swales in the historic and current South Puget Sound prairie landscape have not been specifically addressed by conservationists.

However, functioning wet margins of upland prairies may enhance wildlife resources available on the landscape, and wet prairie management may be critical to the long-term conservation of some prairie species (see 'Ecological Processes and Functions of Wet Prairie Swales', below.)

This project was undertaken to provide some baseline information regarding the wet prairie habitat type in the South Puget Sound, including the following.

1. Investigate the location and extent of historic and existing wet prairies in the South Puget Sound region.

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[1] Other prairie-related habitats include the following (Chappell, et al. 2004). *Oak woodland and savanna*: habitats with oak as a dominant or co-dominant in the overstory and low shrubs and herbs in the understory. *Herbaceous balds and rock outcrops*: areas of bedrock exposure that are relatively open and herbaceous dominated, plus rock crevices and open talus slopes. *Upland prairies*: prairies on deep, well-drained soils, dominated by grasses and forbs. *Vernal Pools and vernal seepage*: localized depressions within a prairie landscape that are seasonally inundated, plus depressions or flats on bedrock outcrops that are seasonally inundated or constantly saturated.

[2] An aquitard is a confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer.

2. Research and describe ecological characteristics of existing and historic wet prairies in the South Puget Sound region, including ecological processes, ecological functions and conservation significance, and vegetation composition.
3. Map the riparian corridor of a portion of Muck Creek; use information gathered during the course of this project to make recommendations for restoring wet prairie swale habitat and function along this reach of the creek.

Historic Wet Prairie Swales of the South Puget Sound: Landscape Perspective

South Puget Sound prairies developed during the hot and dry Hypsithermal period, about 10-9,000 to 7,000 b.p. (Ames and Maschner 1999). Under the subsequent cooler and moister climates, the open structure and diversity of the vegetation was enhanced and maintained by regular fire, many of which were ignited by Native Peoples to maintain their food sources. The extent of the landscape maintained as open prairie for thousands of years likely fluctuated with varying climates and resources for Native Peoples, and varying population densities.

By the time European settlers arrived in the South Puget Sound and began providing written records of the landscape, populations of Native Peoples were reduced to a fraction of their former levels by devastating disease epidemics that swept through the region during the preceding century, or even earlier (Ames and Maschner 1999; White 1980). Correspondingly, the managed prairie landscape was undoubtedly already reduced from its former extent.

After frequent fires were stopped, the rate of woody vegetation encroachment probably varied dramatically between sites because of differences in edaphic and hydrologic conditions, and landscape configuration. During encroachment, moist sites within smaller prairies and savannahs would have been more rapidly converted than sites within large, droughty plains, where widespread fire would be easily carried and encroachment from peripheral wooded or wetland sites would take longer.

Qualitative information about the extent and composition of the prairie landscape in the Puget Sound in the mid-18th century was provided by early Europeans, some of whom were skilled observers and diarists. Another dataset providing information about the post-contact landscape was the General Land Office (GLO) surveys, done between 1853 and 1876 in the study area. For that project, surveyors traversed Washington's lowland landscape to establish a grid of Section corners.[3] Information recorded in the field notes included prairie and wetland margins.[4]

[3] At each corner, GLO surveyors measured the distance to and diameter of the nearest tree in each compass quadrant; midway between corners they measured the distance to and diameter of the nearest tree on either side of their line. In addition, they noted changes in vegetation along their compass lines (for example, the angle of prairie margins or wetlands) and characterized the overall vegetation along the transects at each section corner.

[4]Some potential problems with how the datasets were compiled thwart conventional statistical analysis (Peter, personal communication). The GLO surveyors usually did not distinguish between open woodland (maintained by fire) and forest (Peter, personal communication; personal observation). In addition, the surveys were conducted over more than two decades, and there were variations in their focus and methodology between the early and late surveys. Because of the long time over which the surveys were done, some township boundaries done in different decades show changes in vegetation types, indicating the rapid advance of woodlands into previously open prairie habitat. GLO maps made after 1860 include little of the prairie indicated on the adjacent, earlier maps. Tolmie (1852) generally confirms the extent of prairies depicted in earlier GLO maps.

General information recorded in the GLO surveys was later transcribed onto maps for each Township.

After Europeans arrived and displaced many of the remaining Native Americans from the more productive lowland sites (Meeker 1905), livestock and farming probably kept woody vegetation in check to a substantial degree. However, these activities disturbed the landscape and introduced exotic species that displaced native vegetation. Some of the first places to be converted were the most productive places, which included the wetter margins and river estuaries (Crooks 2001; Crooks, personal communication).

Study Area

The study area for this project is the prairie landscape of the South Puget Sound (Dunn and Ewing, 1997; Figure 1), which is associated with the glacial plain and outwash deposits of the last Pleistocene glacial advance.

The most common substrates in this area are generally somewhat excessively drained (Pringle 1990; Zulauf 1979). However, variation exists due to processes that occurred during deglaciation, when massive amounts of outwash melt-water were channeled through the area. Thus, local aquitards may have formed within melt-water channels, by overflow deposition, or by temporary impoundment of melt-water. After glaciations, aquitards may have formed from lahars or volcanic ash and in some post-Pleistocene soils.

Landforms within the outwash prairie landscape include a retreating procession of large terraces, flat-bottomed channels carved in the glacial till, and locally closed drainages formed by stagnant ice. In some of the area, current drainages occupy oversized drainages that formed during melt-out (for example, Scatter Creek and Muck Creek).

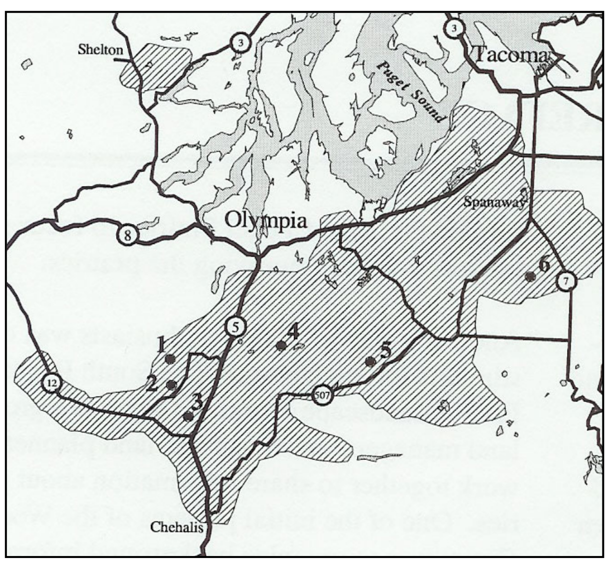

Figure 1. Study area within prairies of the South Puget Sound Prairie region. From Dunn and Ewing (1997).

METHODS

Historic Wet Prairie Swale Occurrences

Since wet prairie swales are a subset of the prairie landscape, we looked into the original extent of the prairies and then examined the potential for wet sites within that area.

Historical accounts and maps made by early chroniclers at the beginning of European settlement were researched to discern the extent of the prairie landscape in the mid-19th century. These included Cooper (1860), Tolmie (1847), Meeker (1905), in addition to research by Carpenter (1986) and Crooks (2001). Stories of native peoples were not accessed for this project.

Township maps made from the General Land Office surveys (1853-1876) were geo-rectified, clipped, and tiled together. Prairies depicted on those maps were then traced onto digital layers using ArcGIS.[5]

Within the areas identified as historic prairies, hydrology (USFWS 2005) and soils (Pringle 1990; Zulauf 1979) were examined to determine whether those datasets were useful in locating where significant wet prairie swales were likely to have occurred before Western settlement. Potential historic wet prairie swales were delineated on a TOPO! mapping program, which was later converted into a PDF file.

Existing Wet Prairie Swale Occurrences

Some sites identified in the analysis to have potential for historic wet prairie swales were sampled, focusing on sites most likely to have native plants, and which had public ownership that was accessible, and along roadsides on privately owned land. At site visits, species composition and cover, along with landscape position, were noted.

Herbarium Records

To assist in identifying existing or historic wet prairie swales, herbarium records from the Burke Museum, University of Washington (WTU), were searched for collection of species within the study area that might indicate wet prairie conditions.

Species that were searched for included those known to occur in wet prairies elsewhere, those listed by Christy (2004) as occurring in wet prairies of the Willamette Valley in northwest Oregon and southwest Washington, and those listed as having medium and high affinity to wet prairie swales in the Puget Trough by Chappell et al. (2004). We also examined Cooper's list of species collected in the South Puget Sound prairie region during the mid-1850s (Cooper 1860).

In addition, collection numbers of herbarium records for species on this list were noted, and specimens with adjacent collection numbers from the same sites were considered for addition to the list of species associated with wet prairies.

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[5] The year that each Township was surveyed can be accessed at the US BLM website or through the Public Land Survey Office at the Washington Department of Natural Resources, Olympia, since there were some differences in mapping and recording methodologies, and changes in prairie margins between the beginning and ending Township survey.

Comparison with Similar Habitats

Some representative sites in the Georgia Basin, Puget Trough and Willamette Valley were visited, and some regional experts were consulted, including Ed Alverson, Dave Peter, Jock Beall, Steve Smith, and John Christy. We also made several visits to wet prairies in Clark and Lewis counties, WA.

Muck Creek Vegetation Map

A map of vegetation types along approximately six miles of Muck Creek and its tributaries was created with particular attention given to mapping areas with wet prairie characteristics. To do this, initial site visits were made to become familiar with the vegetation patterns. Then, polygons were digitized directly onto digital orthoquads to depict woodland and grassland margins and changes in tree species and densities. The core 1.5 miles of the eastern portion of the creek was then revisited, and the cover and composition of vegetation at representative sites recorded. Vegetation was identified to the Alliance level in the International Vegetation Classification (http://www.natureserve.org/explorer/). Ground-truthing of the map was limited to the eastern portion of the area due to troop training activities; results were extrapolated into the western section from information gathered during initial visits and more-recent aerial photos.

RESULTS AND DISCUSSION

Potential Historic Wet Prairie Swales

The geo-rectified and tiled General Land Office maps with digitized prairie margins is presented in Figure 2, and ArcGIS files for the map are submitted with this report.

The later surveys (from about 1860 on) were generally more limited in their descriptions, and while surveys recorded vegetation changes directly along the Section lines, they apparently gave insufficient data for map-makers to infer prairie size. In any case, maps made from these notes did not interpolate between points to give a more detailed impressions of the size and extent of the prairies encountered when a vegetation boundary was crossed, as the earlier maps had done. In addition, by the 1860's accurate mapping of prairies would have been more difficult as landscape-sized prairies continued to be fragmented by encroaching trees and shrubs, and farms became established in former prairie sites. In these cases, polygons with jagged boundaries were drawn pointing in the direction in which prairie was indicated by the GLO map. Thus, the extent of prairie in those areas was underrepresented, as confirmed by an 1852 map of the Nisqually Plains (Puget Sound Agricultural Company, 1852; Figure 3).

Potential wet prairies in the study area usually occurred at a scale finer than what appeared on wetland and soils maps. Therefore, those layers were not generally useful in identifying potential wet prairie swales, although soils capable of supporting wet prairie swales were sometimes listed as inclusions within the mapping units of other soils. In addition, wet prairie types may have less fidelity to soil type than drier vegetation associations, as Campbell (2004) found with the wetter vegetation associations in the Willamette Valley.

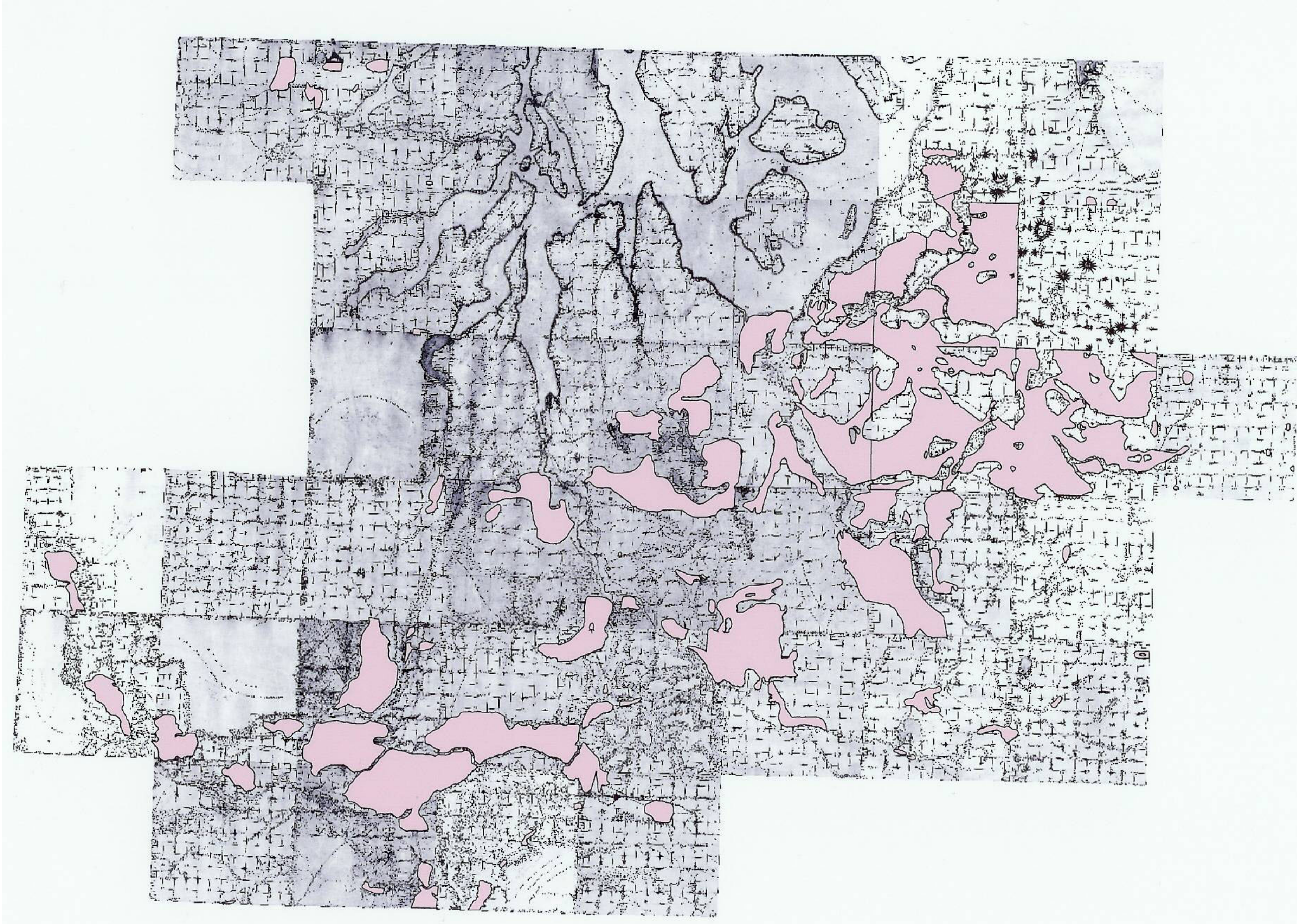

Figure 2. General Land Office survey maps (1853-1876) with mapped prairies outlined

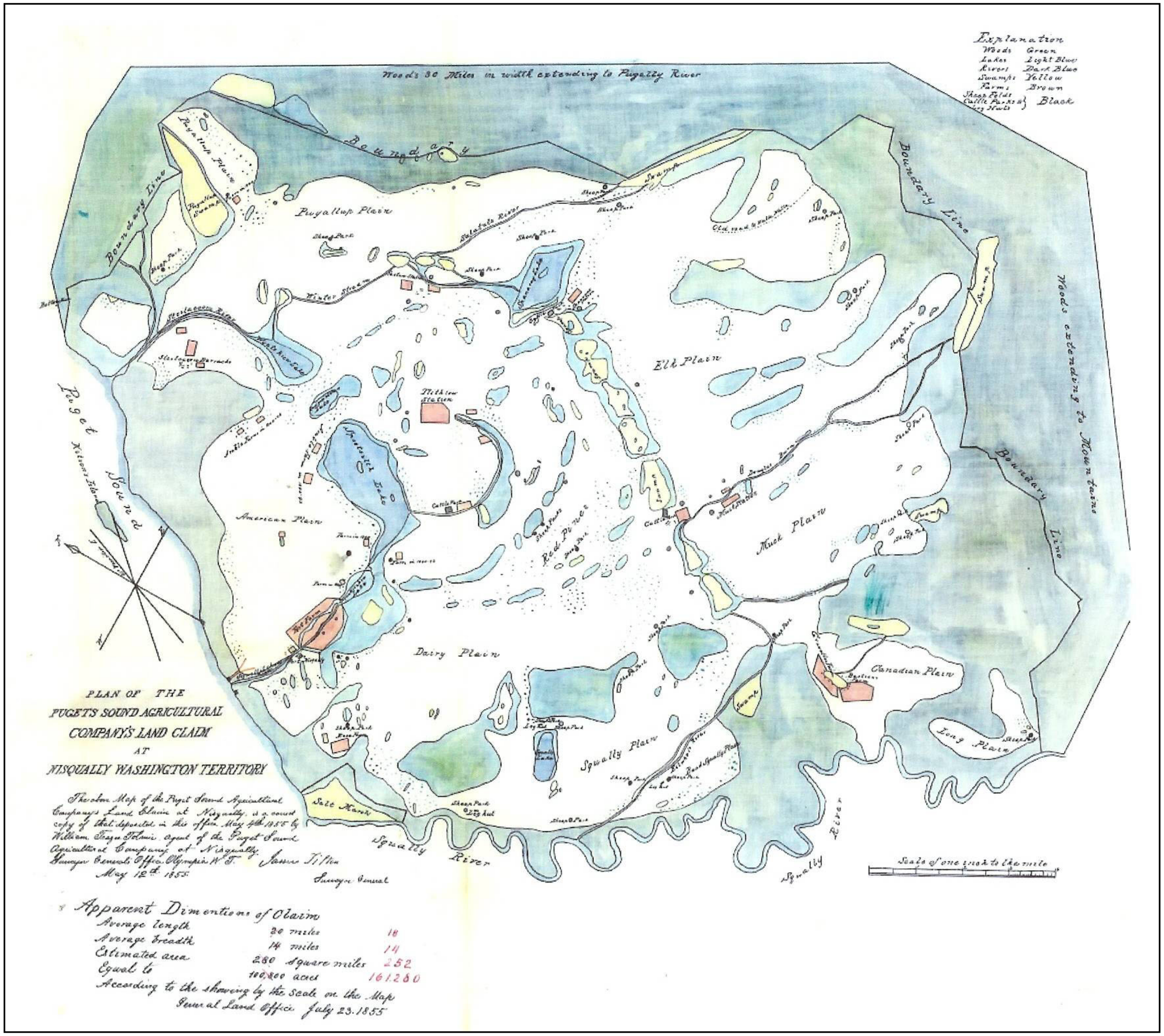

Figure 3. 1852 map of the Nisqually Plain (Puget Sound Agricultural Company, 1852).

Herbarium collection records from WTU for wet prairie species, although informative, were not useful in building the map of potential wet prairie swale locations because of the scarcity of collections and/or lack of specific collection location information. However, these herbarium collections and associated information were extremely useful in compiling lists of prairie-associated species (Alverson, personal communication; see 'Original Composition of South Puget Sound Wet Prairies, below).

Thus, the map of possible wet prairies within a matrix of fire-maintained prairies in the South Puget Sound was created primarily by using a combination of historical records (prairies depicted on the GLO maps and referred to in other historical accounts), topography, and the presence of water features (that is, creeks, lakes, wetlands, etc.). Areas identified as possible historic wet prairie sites are depicted on a map attached as Appendix 1.

Current Wet Prairie Swales

Many sites identified as potential wet prairie swales were located in areas almost completely developed or converted, were located on private property, or were otherwise inaccessible (i.e., some areas within Fort Lewis), and thus were not surveyed for this project. Remote inspection of some of those areas usually indicated heavy cover of rhizomatous grasses such as *Phalaris arundinacea* and/or *Agropyron repens,* and significant cover by native species was unlikely.

Elsewhere, woody vegetation with associated herbaceous understory dominated the sites, presumably a result of succession in a post-fire environment. These sites typically had cover contributed by an array of shrubs and trees, including *Fraxinus latifolia, Quercus garryana, Populus balsamifera* ssp. *trichocarpa, Symphoricarpos albus, Rosa nutkana, Crataegus douglasii, Cornus serecea, Salix* spp., *Rubus discolor,* etc. Vegetation composition and cover at representative sites are presented in Appendix 2.

Thus, within the South Puget Sound region, native vegetation in seasonal wet prairie swales appears to be nearly extirpated. The best of what is known to occur is represented by one remnant site: an unplowed portion of a swale complex at the Scatter Creek Wildlife Area, Thurston County. This site was previously known; a brief description of the Scatter Creek site is provided below. In addition, the portion Muck Creek within the 13th Division Prairie (Fort Lewis) that historically supported wet prairie swales is also described below.

In addition, a portion of the remnant Bush Prairie at the Olympia Airport, located on the sand-dominated Nisqually soil type, had significant cover of *Equisetum hyemale.* This species may be an indicator of moist conditions at depth, possibly an aquitard or access to the water table of the nearby Deschutes River (Easterly and Salstrom 2004).

Scatter Creek

In addition to numerous species that occur in both upland and seasonal wet prairie swales, several species occur in a small portion of an open swale of the North Unit, Scatter Creek Wildlife area, that indicate seasonally wet prairies. These include *Polygonum bistortoides, Plagiobothrys figuratus, Carex arcta, C. arthrostachya, C. unilateralis, Deschampsia caespitosa, Hordeum brachyantherum* and *Ranunculus orthorhynchus* (Chappell, et al. 2004). In addition, *Equisetum hyemale* occurs with *Deschampsia caespitosa* at one end of the swale, which may indicate a perched water table or increased effective soil moisture storage from the sandy substrate at that site.

Elsewhere, openings in the native-dominated woodland along the riparian corridor are dominated by *Phalaris arundinacea, Agropyron repens, Alopecurus pratensis* and *Phleum pratensis***,** with few native species, although *Camassia leichtlinii* is locally abundant. One meadow otherwise dominated by *Phalaris arundinacea* has patches of *Lupinus polyphyllus* and *Veratrum californicum,* whose affinity for prairies are medium and low, respectively (Chappell, et al. 2004).

Muck Creek

Although Muck Creek has had few physical impacts in recent decades, it was heavily used historically. For example, Tolmie (1847) made a map of Muck Station, an important out-station for the Hudson Bay Company, which included buildings, corrals, numerous 'Indian Potato Patches,' good soil, gravelly prairies, and oak and pine (savannas) (Figure 4).

Along Muck Creek in the 13th Division Prairie, the transition between woody, riparian vegetation and upland prairies was generally a relatively narrow band, with inter-fingering and integration of habitat types in the floodplain of the creek. The upper portion of the strip, transitional between upland and wet prairies, was almost completely dominated by the exotic rhizomatous grasses *Agropyron repens* and *Poa pratensis.* This zone was described by Dorner (1999) as the *Poa pratensis - Agropyron repens* community type, and corresponds to the *Poa pratensis* Alliance of the International Vegetation Classification (NatureServe 2005). The presence of this community type may reflect the moisture gradient of the site, as suggested by Pabst (1995) and its location in the creek profile. Alternatively, it may reflect deposition of nutrient-rich sediments from upstream agricultural activities (Dorner 1999) and historic nutrient loading of the ecosystem by salmon. In Washington, *Agropyron repens* is considered a facultative upland species, although in some other states it is considered a facultative wetland species (NRCS Plants Database 2005).[6] Other species present include *Agrostis capillaris, Phleum pratensis, Geranium* spp.*, Galium triflorum, Cirsium arvense, Vicia hirsuta, Marah oreganus* and occasionally *Vicia sativa.*

A few pockets of open native vegetation remain in the wet zone near the confluence of Muck and South creeks, which was the best site located along Muck Creek. This area may have escaped cultivation by its marginal setting. Species found in that area include *Montia linearis* and *Plagiobothrys scouleri* and a wetland complex dominated by *Eleocharis palustris. Plagiobothrys figuratus* also occurs in a small dip along a secondary road east of where Muck Creek runs parallel to 8th Ave S (Gilbert, personal communication; personal observation).

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[6] A facultative upland species usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%).

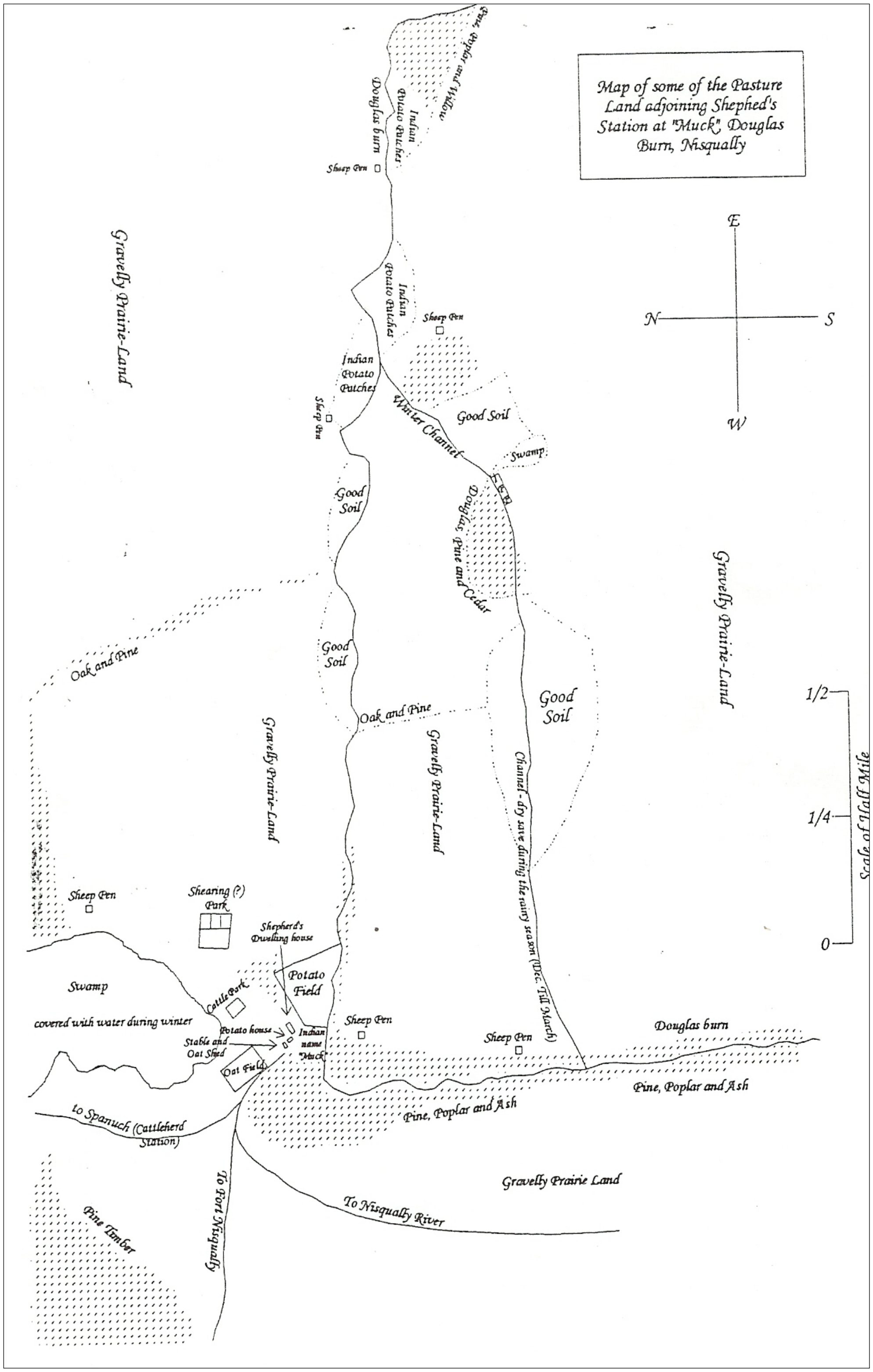

Figure 4. Redrafted Hudson's Bay Company map of Old Muck Station c. 1847 (Tolmie c. 1847 from Larson and Lewarch, 1993).

Adjacent sites lower in the elevation profile had patches of *Symphoricarpos albus, Urtica dioica* and *Rosa nutkana.* Frequently, *Crataegus douglasii* provided intermittent cover. Adjacent, lower in the riparian area, the *Fraxinus latifolia* Seasonally/Temporarily Flooded Alliance (NatureServe 2005)[7] occurs, with cover by *Physocarpus capitatus, Cornus sericea,* and occasionally *Quercus garryana, Acer macrophyllum,* and *Populus balsamifera* ssp. *trichocarpa*. Openings were occupied by the invasive rhizomatous grass *Phalaris arundinacea,* with *Solanum dulcamara* and occasionally *Festuca arundinacea, Oemleria cerasiformis,* and *Symphoricarpos albus.*

Comparison of South Sound Wet Swales and Willamette Wet Prairies

The Willamette Valley is a large, generally low gradient basin that has old, clay-rich soils;[8] prairies in the southern Puget Trough, south of Pleistocene glaciations, have physical and floristic affinities with the Willamette Valley. Aquitards caused by the clay-rich soil created perched water tables on which wet prairies developed. Historically, the Willamette Valley wet prairie system

> '… is largely restricted to the Willamette Valley of Oregon and adjacent Washington. It is nearly extirpated from the Puget Trough of Washington. These are high-nutrient wetlands that are temporarily to seasonally flooded. They are dominated primarily by graminoids, especially *Deschampsia caespitosa, Camassia quamash, Carex densa*, and *Carex unilateralis*, and to a lesser degree by forbs (e.g., *Isoetes nuttallii*) or shrubs (e.g., *Rosa nutkana*). Wet prairies historically covered large areas of the Willamette Valley where they were maintained by a combination of wetland soil hydrology and frequent burning. They have been reduced to tiny fragments of their former extent.' (NatureServe 2005).

The Willamette Valley prairie vegetation is diverse, with phases running from wet to dry upland prairies. Although only fragments of the original vegetation of the Willamette Valley still exist and much of the variation in the remaining vegetation has not been identified, ten Willamette Valley wet prairie plant communities have been described (Christy 2004; Table 1). The extant Willamette Valley wet prairies we visited during this contract were never plowed because of their marginal agricultural potential. Several species are endemic to these Willamette Valley wet prairies.

Differences in geomorphology and soils between the wet prairies of the South Puget Sound and the Willamette Valley indicate that they were of a different character. Wet prairies were never as extensive in the South Puget Sound, where they were probably mostly restricted to sites around lakes and riparian zones. The plant communities described from the Willamette Valley wet prairies do not appear to have clear analogs to the South Puget Sound wet prairie swales.

In the absence of fire, succession occurred in many undisturbed sites in the Willamette Prairies. In at least some areas, the endpoint of wet prairies succession is *Fraxinus latifolia* with *Symphoricarpos albus* (Frenkel and Heinitz, 1987), the same as in the South Puget Sound (Peter, personal communication; personal observation).

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[7] The distinction between 'seasonal' and 'temporary' flooding at this site is not clear.

[8] Volcanic ash from Mt. Mazama may be important in some areas (Alverson, personal communication), and the Willamette Valley is also overlain by slackwater fine deposits deposited during glacial outwash events (Missoula Floods).

Table 1. Wet prairie associations described from the Willamette Valley (NatureServe 2005).

Willamette Valley Wet Prairie Associations
Deschampsia caespitosa - Danthonia californica Herbaceous Vegetation
Carex aperta Herbaceous Vegetation
Eleocharis palustris Herbaceous Vegetation
Camassia quamash Wet Prairie Herbaceous Vegetation
Isoetes nuttallii Herbaceous Vegetation
Rosa nutkana / Deschampsia caespitosa Shrubland [Provisional]
Eleocharis palustris – Carex unilateralis Herbaceous Vegetation
Carex densa – Deschampsia caespitosa Herbaceous Vegetation
Carex densa – Eleocharis palustris Herbaceous Vegetation
Rosa nutkana / Oenanthe sarmentosa Shrubland [Provisional]

Original Composition and Structure of South Puget Sound Wet Prairie Swales

Because wet prairie swale habitat in the South Puget Sound is so disturbed and only a few known fragments are extant, the original composition, diversity and structure of the vegetation are largely unknown. However, while some components of the original vegetation may have become extirpated, species in the same or similar habitats elsewhere in the Willamette Valley/Puget Trough/Georgia Basin ecoregion provide the best model for reconstructing elements of the original vegetation. The historic flora of wet prairie swales in the South Puget Sound would likely have consisted of species currently known from that habitat type in the South Puget Sound. In addition, the flora may have included species known from the Puget Sound in habitats other than wet prairie swales, but that occur in wet prairies or vernal pools elsewhere in the ecoregion.

Chappell et al. (2004) compiled a list of species known from prairies in the Willamette Valley, Puget Trough and Georgia Basin ecoregion. This list indicated which prairie-associated habitat type each species occurred in, including oak woodland and savanna, herbaceous balds and rock outcrops, upland prairies, seasonal wet prairies, and vernal pools and seepages. A subset of this list that includes species that potentially occur in South Puget Sound wet prairie swales, which Alverson (personal communication) sorted from the original, is attached to this report as Appendix 3. This list may be used as a starting point to develop more refined species lists that factor in more site-specific criteria such as hydrology, soil moisture and texture, disturbance regimes, etc. (Alverson, personal communication).

The wet prairie swales were productive and were likely dynamic, probably changing rapidly between fires. In many settings, wetland and riparian edges may not have burned during every fire, and fire-tolerant woody species were probably common in those areas (Peter, personal communication). Thus, narrow wet prairie swales along riparian corridors would probably have required frequent management by fire to keep woody species from encroaching and becoming dominant. Sites with broader wet prairie swales, such as in outwash channels and depressions, would have been more isolated from woody encroachment and would likely have persisted longer than narrow strips along wooded riparian areas.
Thus, in marginal sites, species that were able to persist under some woody cover, if only in the seed bank, were more likely to have been components of wet prairie swales. Sites that were more easily maintained as prairie by fire may have included species less tolerant of shade. Thus, topography, especially in relation to water features, and relative importance of the site to Native

Peoples would have played roles in the composition and dynamic of the ecotones between upland prairies and wet prairie swales, wetlands and riparian areas.

The composition of the woody portion of the flora would likely have included many that are present in the area today, but probably in different proportions. For example, fire-tolerant trees like *Quercus garryana, Populus tremuloides* and probably *P. balsamifera* ssp. *trichocarpa,* most likely would have been more abundant than the intolerant *Fraxinus latifolia,* the latter of which has presumably increased in post-fire ecology (Peter, personal communication). Shrubby species likely included *Symphoricarpos albus, Crataegus douglasii, Rosa nootkana, R. pisocarpa, Oemleria cerasiformis, Amalanchier alnifolia, Spiraea douglasii* and *Salix* spp. In addition, until recently *Alnus sinuata* was apparently common around wetland edges in the Tacoma area, and may have been a component of these systems (Fries, personal communication to Peter). *Pteridium aquilinum* may have been aggressive and had significant cover in some sites (Peter, personal communication).

Ecological Processes and Functions of Wet Prairie Swales

Historically, prairies in the South Puget Sound were maintained by frequent fire (see 'Historic Wet Prairies: Landscape Perspective', above), which no longer occur. In addition, the hydrologic regime of many wet prairie sites has likely been altered by draining and/or recession of the water table. The lack of fire and change of hydrology in the current landscape has likely had a profound influence on the ecological processes and dynamics of the sites, including nutrient cycling and successional status. For sites near salmon-bearing streams, attenuation of salmon runs also likely has affected nutrient cycling in surrounding areas, as has upstream agricultural activities. The specific effects of these changes in ecological processes are not known.

Since biological diversity is enhanced by ecotones (Thomas et al. 1979), mosaics of wet prairie swales with upland and riparian habitat may have been important in the historic prairie landscape. These productive sites probably contributed more resources per area, and for longer times, than adjacent dry, less productive upland sites. As such, functioning wet prairie swales in complexes with upland prairies, woodlands and wetlands may enhance wildlife resources available on the landscape, and their management may be important to the long-term conservation of some prairie species.

For example, butterflies would benefit from a functional wet prairie that would extend the season that flower nectar and host plant resources are available. This could increase resource availability at critical times and possibly help stabilize butterfly populations by buffering them against environmental stochasticity (Fimbel 2004). For example, Mardon Skippers in the south Cascades use both upland and wet areas, and Valley Silverspots use nectar sources provided in wetter sites (Grosboll, personal communication). In addition, seasonal wet prairie swales likely provided open wetland habitat suitable to support Oregon spotted frogs and western pond turtles (Grossboll, personal communication).

Muck Creek Vegetation Map
A vegetation map of the Muck Creek riparian corridor is submitted with this report as an ArcGIS file.

Below the upland prairie vegetation is a discontinuous strip completely dominated by rhizomatous, non-native grasses of the *Poa pratensis* Semi-Natural Seasonally Flooded Alliance (NatureServe 2005), although the fit is not particularly good (see 'Muck Creek', above). Woody species are occasionally encroaching into these areas, including *Fraxinus latifolia, Crataegus douglasii,* and *Symphoricarpos albus,* along with *Rubus discolor.* This strip frequently abuts or intergrades with the *Phalaris arundinacea* Seasonally Flooded Alliance, which is dominated almost completely by that species, with *Solanum dulcamara* and sometimes with patches of *Symphoricarpos albus, Rosa* spp., *Urtica dioica,* and smaller *F. latifolia* trees. The *Phalaris arundinacea* Alliance most often was found within and along the creek, frequently with *Myosotis laxa.*

Most forested and woodland types fall within the *Quercus garryana* Woodland Alliance and the *Fraxinus latifolia* Seasonally/Temporarily Flooded Forest Alliance (NatureServe 2005) and many sites correspond to the *Quercus garryana (Fraxinus latifolia)/Symphoricarpos albus* association (Chappell and Crawford 1997; Chappell 2004). In the latter, the tree layer is commonly dominated by *Quercus garryana* higher in the profile, with intermittent cover from *Fraxinus latifolia,* which comes in under the *Q. garryana* canopy. Lower in the profile, *F. latifolia* becomes dominant, and *Populus balsamifera* ssp. *trichocarpa* is sometimes mixed in. In these settings, *F. latifolia* may have greatly increased density in the post-fire prairie/savanna woodland.

In a portion of this zone, *F. latifolia* dominance is represented by a taller, older cohort, while lower in the profile *F. latifolia* trees are often smaller, with discontinuous or mixed cover with other species, especially shrubs.

The boundaries between the trees and wet prairie swale and within the Flooded Forest Alliances have cover by *Symphoricarpos albus, Rubus discolor, Crataegus douglasii, Rosa nutkana,* and *R. eglantera* frequently provide dense cover. In addition, *Physocarpus capitatus and Cornus sericea* often provide dense cover in the wetter sites, especially near the creek. *Phalaris arundinacea* occurs in patches throughout most of the zones.

Restoration Recommendations for Muck Creek
Areas dominated by rhizomatous grasses represent altered systems. Because they are altered systems, they presumably have low habitat function, at least for priority species. However, some areas within the *Poa pratensis - Agropyron repens* zone appeared to have relatively large rodent populations. Before their habitat is altered, these animals should be identified, and a wildlife biologist consulted regarding their importance in shaping the landscape structure. In addition, current habitat resources in many wet prairie swales include thistles, which are late-season nectar sources for butterflies (Hayes, et al. 2000).

If it is determined that the wet prairie swale should be restored and native plants reestablished in the areas dominated by rhizomatous grasses, aggressive control will be necessary before restoration to native plant species can succeed. Procedures used for control or elimination of *Agropyron repens* and *Phalaris arundinacea,* the dominant invaders, are outlined in Boxes 1 and 2. In addition, management recommendations by Boyer (2005) should be considered.

Once control is achieved, native grasses should be densely planted to stabilize the site and preclude reinvasion, and to facilitate the development of structure into which forbs can be later introduced. In the zone dominated by *P. arundinacea, Deschampsia caespitosa* should be seeded.

This methodology is being employed in restoration of areas dominated by *Phalaris arundinacea* in the Willamette Valley (Beall and Smith, personal communication), where *Deschampsia caespitosa* seeded onto treated sites has resulted in dense cover of that species.[9] The Willamette scientists use a mulch of *Hordeum* brachyantherum hay on drill-seeded *D. cespitosa* sites. *H. brachyantherum* becomes established at the site during the early years, providing cover which prevented reestablishment of the problematic rhizomatous grasses. After a couple years, *H. brachyantherum* then tended to decrease in cover as the *D. cespitosa* plants became established, the latter of which took three years to establish good cover (Beall and Smith, personal communication).

In Willamette Valley wet prairie restoration, riparian shrubs such as *Spiraea douglasii, Symphoricarpos albus* and/or *Salix* spp. were established or maintained along the riparian corridor. The dense stem count of the shrubs strains the water flow, trapping seeds and rhizome fragments, slowing dispersal of *P. arundinacea,* and checking reinfestation of the treated sites (Beall and Smith, personal communication). Likewise, all things equal, upstream sites should be restored before downstream sites because of reinfestation concerns.

A. repens is not an aggressive invader in the Willamette Valley prairies, which probably reflects the differing hydrology and physical conditions between the two areas, and the transitional qualities of the South Puget Sound's habitat between upland and wetland habitat. Species that could be initially introduced into that zone include *Danthonia californica, Festuca roemeri,* and *Hordeum brachyantherum.*

Once native grass is well established, the restoration site may be treated with a broadleaf control, if necessary, and then burned. Selected plants are then removed with herbicide to provide room for other species, if necessary, and a seed mix with a diversity of graminoids and forbs are reintroduced onto the site. Species should come from the list compiled by Chappell et al. (2004) and sorted by Alverson (Appendix 3), using local seeds gathered from similar habitat, if possible. Their stages of establishing enough native seed for no-till drill planting were to collect the seed, grow them in a garden plot to increase seed volume, and then go into high-volume production.

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[9] Seeding levels are being adjusted downward as success is monitored. They started at two pounds of *Deschampsia caespitosa* seeds per acre; current maximum drill seed levels are not more than two ounces per acre (Beall and Smith, personal communication).

Box 1. Control & Elimination of Reed Canarygrass From Campbell (2004)

Reed canarygrass can be eliminated by tillage. Most rhizomes are in the upper 6-8 inches of soil. Tillage kills top growth and eventually exhausts below-ground energy reserves. To maximize removal of energy reserves, disking or plowing should occur as the plants are beginning to flower. In the Willamette Valley this is usually May-June. Several tillage operations at about two week intervals are required.

Tillage is relatively inexpensive, the results are evident within a few days, and it creates a seedbed for reseeding. It does, however, require equipment access to the site, which may be limited by flooding or wet soils, and soil left unprotected is susceptible to erosion and weed invasion.

Chemical control is an effective means of removing reed canarygrass. Currently, only glyphosate (Rodeo®) is approved for application for emergent and marginal vegetation. Other chemicals may be appropriate, depending on the site, and are identified in the current *Pacific Northwest Weed Control Handbook*[62] available from the Oregon State University Cooperative Extension Service. Application to foliage should be uniform. To facilitate even coverage by spray equipment, application around boot (leaves fully emerged) or late-boot stage is most practical, generally late April-May. Follow-up treatments in late summer (September) are usually necessary and effective.

Herbicide application is relatively inexpensive, revegetation is more successful because competition is reduced, and properly applied chemicals are very effective in eliminating reed canarygrass. The biggest disadvantages are that herbicides effective on canarygrass are nonselective and spring applications can aggravate other weed problems such as establishment of Canada thistle. In addition, many landowners prefer not to use chemicals.

Mowing depletes much of the carbohydrate root reserve. Grass should be mowed when large amounts of foliage are produced but before energy is transferred from the leaves to the rhizomes. This is usually at or near flowering. Plants will respond by producing more shoots, which should be mowed again when they are approximately 4 inches tall. This forces the plants to again develop new shoots, depleting energy reserves. Several mowings will be necessary.

Advantages to mowing include ease at which defoliation can be gauged and ability to alter mowing frequency and severity as needed. Also, desirable plants may be released from the shade of the canarygrass. The primary disadvantage is accessibility; many areas where canarygrass is a problem are not suitable for mowing.

Burning can remove vegetative growth before spraying but, by itself, will not eliminate reed canarygrass. Burning should be done in the early spring when fire danger is low. Costs are low and fire may open up the canopy and release suppressed native plants such as sedges and grasses. Disadvantages are the requirement for a permit, fire does not by itself eliminate canarygrass, and canarygrass in wet meadows may actually be stimulated by burning.

Flooding has limited application. Reed canarygrass can tolerate periodic flooding, especially flowing water. It does not tolerate continual deep ponding, especially during warm weather. However, there are cases where canarygrass has tolerated inundation by at least one foot of water for two years before succumbing. Advantages of flooding are its effectiveness in improving wetland habitats and the potential for remnant wetland plants to respond and colonize the site. The major disadvantage is the need for water control structures to hold water during dry seasons. Many small wetlands and wet prairies do not have such structures.

Competition and shading have been effective in controlling reed canarygrass. Canarygrass will not tolerate shading greater than 40%. Shade may be provided by natural or artificial means. Artificial methods include mulching with bark, weed barriers, and black plastic. Grass is typically cut to within a couple inches of the ground before mulching. Advantages of mulching include availability of materials, ease of installation, and suitability for small areas. Disadvantages include limited effectiveness of bark mulching to keep rhizomes from increasing and penetrating the surface, sensitivity of black plastic to UV breakdown, limitation to small areas, and the refugia barriers can provide for rodents.

Shading by trees, shrubs or rapidly growing grasses, possibly in conjunction with mulching, can control reed canarygrass. Species that develop foliage early in the spring or that will out-compete canarygrass work best. In areas where reed canarygrass has been removed by spraying or tilling, consider seeding species that will present a significant obstacle to canarygrass establishment. These include tufted hairgrass, slough grass, spike bentgrass, bluejoint or Canadian reed-grass, turf-forming varieties of red fescue, meadow barley, or sedges such as bigleaf sedge. Seedings should be heavy (25-50+lbs./acre).

A recent publication (Antieau 2003) suggested a method of using pole plantings to out-compete and shade out canarygrass. Large poles (2-4 inches diameter at butt, 1-3 inches diameter at top, and 6-8 feet long) of black cottonwood and willow are collected during the dormant season (November-February). Lateral branches are removed and poles are planted with half to two-thirds of the bottom end in the ground. Make sure that the bottom of the pole is planted and not the top. Holes for planting can be dug with a post hole digger or auger; do not drive posts into the ground. Protection from rodent and deer damage will likely be needed.

Box 2. Poa pratensis zone, dominated by *Agropyron repens* at Muck Creek. Successful control measures currently include applying herbicides, burning, tilling, and combinations of these three methods (Batcher 2002).

In a European study, ninety percent control of *Agropyron repens* was achieved by repeated cultivation in midsummer to fragment, weaken and desiccate the rhizomes, then planting with a catch crop to suppress shoot growth from the rhizome fragments (Melander et al. 2005). Alternatively or in addition, the species can be controlled with chemicals such as glyphosate, dichlobenil, and fauzifop (Woehler, et al. 1978). Sometimes, however, chemicals are not effective and can cause a slight increase in quackgrass cover and no effect on stem density (Halvorsen and Anderson, 1983). A minimum of two years total control for is necessary for eradication, since the rhizome remains viable for two years (Lemiux et al. 1991).

In some areas, density of *Fraxinus latifolia* and *Quercus garryana* trees has increased, and the canopy closure has precluded habitat for native wet prairie species. Selective thinning should be done in some areas, and the site interplanted with forbs. Likewise, in sites with dense shrub cover, measures to reduce cover should be undertaken. This could be achieved by selective pruning to reduce woody cover, then running multiple light fires the site(s). This may release herbaceous vegetation that is currently suppressed by the shrubs, and subsequent restoration of those sites should be informed by adaptive management techniques. *F. latifolia* and the shrubs sprout vigorously from the root and crown, so herbicides or repeated cutting or burning will likely be needed.

Recommendations for Additional Work and Research

- Consult with Native Peoples (including Nisqually, Puyallup, Muckleshoot, Skokomish, Chehalis and Squaxin Island tribes), archeologists and anthropologists to assess the extent of management of wet sites before epidemics decreased First People's populations.
- Conduct additional field research in the spring to look at some of the fragments not accessed for this report, and further describe the vegetation at the Scatter Creek Wildlife Area.
- Soils work to relate wet prairie swale vegetation (native and non-native) to useful soil characters and dynamics.
- Develop local seed resources, gathered from wet prairie habitats, to begin restoration effort; model after methodology used in restoring prairies in Oregon.
- Additional interpretation of GLO Townships past 1855; i.e., compare the GIS map to Puget Sound Agricultural Company (1852) map. Read field notes to confirm that map-makers did not under-represent data gathered by surveyors.
- Digitize and incorporate Tolmie's 1852 map of the Nisqually Plains.
- Additional interpretation to extrapolating the prairie densities back to the much larger prairies of the 1830s, cited in Cooper (1860). Incorporate the apparent openness of the woodland/savanna settings and its potential of extending prairie habitat and resources using GLO field notes and anecdotal settler accounts.
- Some of the wet prairie ecotones have large rodent populations. Assess species composition and their role in shaping vegetation (seed dispersal, effect on germination of

native species, predation) and their potential effects on restoration attempts. Use results to inform composition of restoration flora.

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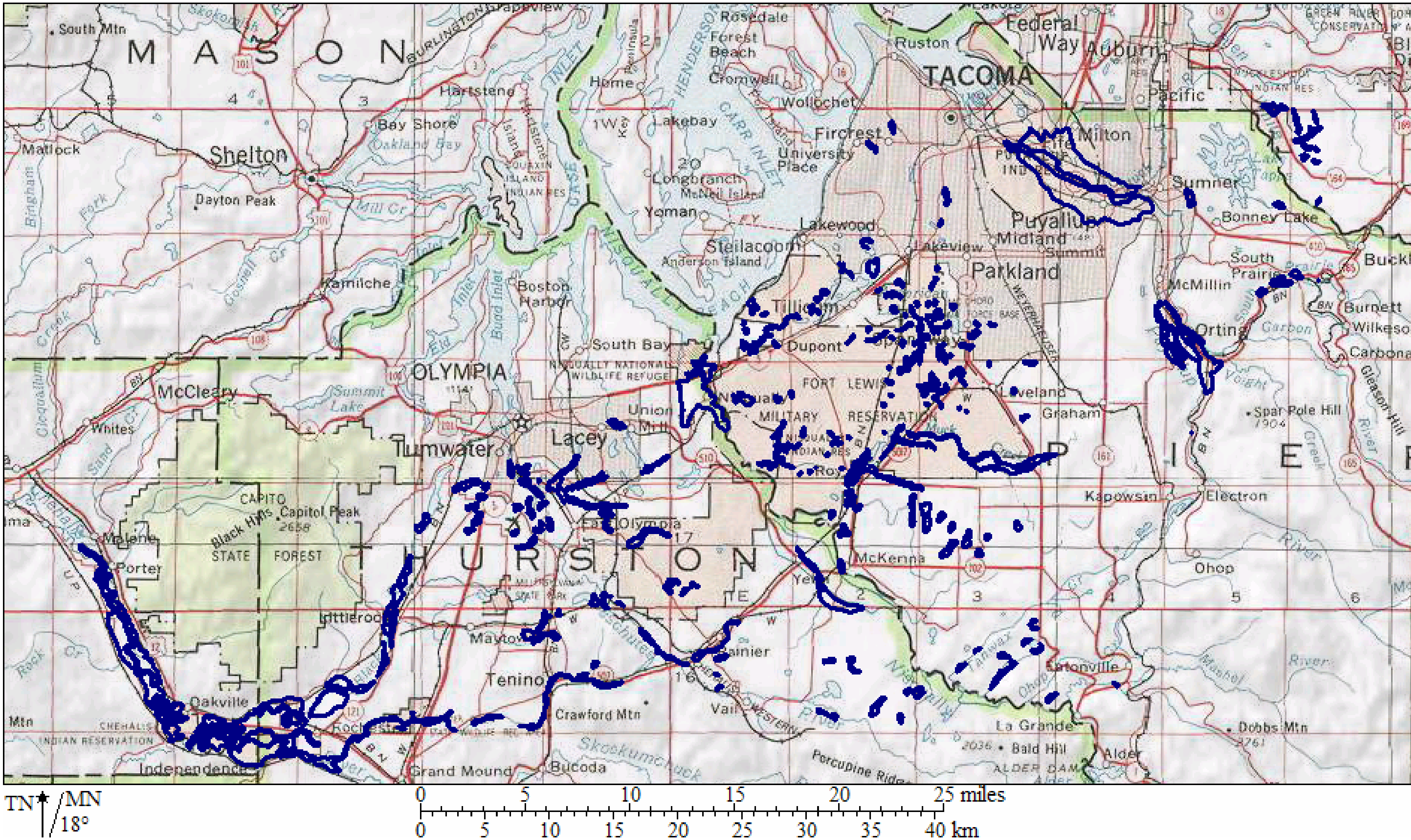

Appendix 1. Areas identified as possible historic mesic prairie sites in the glacial outwash prairie landscape of the South Puget Sound, Washington.

Appendix 2.

Data points representing releves taken at Scatter Creek Wildlife Area and Muck Creek, 13th Division Prairie, June 2005 by SEE Botanical Consulting.

Mark	276	277	278	279	280	281	281	281	282	283	284	285	286
Easting	542858	542807	542890	542894	542956	543000	543000	543000	542982	543110	542836	543487	542513
Northing	5207123	5207083	5207027	5206951	5206951	5206884	5206884	5206884	5206831	5206807	5207050	5206995	5207673
Date	7/18/2005	7/18/2005	7/18/2005	7/18/2005	7/18/2005	7/18/2005	7/18/2005	7/18/2005	7/18/2005	7/18/2005	7/18/2005	7/18/2005	7/18/2005
Achillea millifolium	1											1	
Agropyron repens	80	1	30			20	10	10				90	60
Agrostis cf. scabra													
Agrostis sp.											1		
Agrostis capillaris	30								30	3		20	30
Aira caryophylla													
Alopecurus pratensis													
Anthoxanthum odoratum													
Arrhenatherum elatius													
Aster curtus								1					
Brodiaea coronaria	plus												
Bromus mollis	plus												
Bromus sp.													
Camassia sp.													
Carex obnupta													
Carex sp.													
cf. Coreopsis sp.							1						
Chrysanthemum leucanthemum								40	1				
Circaea alpina										1			
Cirsium arvense	1		10						1				10
Cirsium vulgare										1			
Cornus serica											1		
Crataegus douglasii			1						3		3		
Crataegus monogyna													
Cryptantha sp.													
Cytisus scoparius								3	2				
Dactylis glomerata	10								3			3	3
Deschampsia caespitosa													

Dianthus armeria						20								
Eleocharis palustris							20	20						
Elymus sp.											1			
Equisetum arvense														
Equisetum sp.														
Eriophylum lanatum														
Festuca arundinacea														
Festuca pratensis														
Festuca roemeri														
Festuca rubra		1												
Fragaria sp.									1					
Fraxinus latifolia			1							1	30			30
Galium cymosum														
Galium triflorum		3	3							1		3	20	30
Geranium dissectum														
Geranium spp.						10					1			
Gilia capitata						30								
Gnaphalium sp.						1								
Heracleum lanatum														
Holcus lanatus														
Hordeum brachyantherum														
Hypocharis radicata	plus					10			60	3				10
Juncus sp.							10						1	
Lactuca muralis														
Lapsana communis											1			
Linaria vulgaris														
Lotus corniculatus														
Lupinus polyphyllus														
Luzula campestris														
Marah oreganus		1	1								1		1	
Mentha arvensis														
Myosotis laxa												3		
Oemleria cerasiformis											3			
Parentuccellia viscosa														
Perideridia sp.											1			
Phalaris arundinacea			20	10	100		40	10				3	3	3

Phleum pratensis			10									60	
Physocarpus capitatus											3		
Plagiobothrys scouleri					40	3	10						
Plantago lanceolata					3			3					
Plantago major							3						
Poa palustris													
Poa pratensis			50		10					10		10	
Poa spp.								3					
Polypodium glycyrrhiza										1			
Polystichum munitum													
Populus balsamifera ssp. trichocarpa									1				20
Potentilla gracilis													
Prunella vulgaris								3					
Pteridium aqulilnum													
Quercus garryanna										60			30
Ranunculus repens		1											
Ranunculus sp.													
Rhamnus purshiana													
Rosa sp.													90
Rubus discolor		80									10		
Rubus laciniatus											1		
Rubus ursinus													
Rumex crispus					10			3					
Rumex sp.													
Sambucus racemosa									1				
Senecio jacobaea													
Solanum dulcamara				3							10		
Spiranthes romanzoffiana					1								
Symphoricarpos albus		3								70	3		20
Taraxacum officianale													
Tragopogon dubius	plus											1	
Trifolium dubium					10								
Trifolium pratense								1					
Trifolium repens								1					
Urtica dioica		3									10		
Vancouveria hexandra													

Veronica scuttelata													
Vicia hirsuta	1		3									1	
Vicia sativa	plus		1									1	
Viola adunca													
COMMENTS		Creek margin, slight dip. SYAL in patches to 100% cover.			Surge zone of the creek.	Ponded sites with bare ground. PHAR (0-80%) along margin of flooded area.	Water 20, unknown herb 10		Above previous plot.	Oak overstory with smaller ash trees.	Ash along creek.	Also along creek: Salix sitchensis, cottonwood, FRLA, CIAR, PHAR Galium triflorum.	At authorized ford.

Appendix 3. From Chappell et al. (2004), sorted by Alverson (personal communication): Subsets of the list of prairie species known from the Willamette Valley/Puget Trough/Georgia Basin ecoregion. **(a)** Species known from seasonally wet prairies and/or vernal pools and vernal springs of the Puget Trough. **(b)** Species known from known from the Puget Sound in habitats other than prairies, but which occur in wet prairies, vernal pools or vernal seepages elsewhere in the ecoregion. GB: Georgia Basin; PT: Puget Trough; LC: Lower Columbia; WV: Willamette Valley. Definitions and other codes follow.

a.

SPECIES	Degree of fidelity to prairie habitats	GB	PT	LC	WV	Oak Wood-land & Savanna	Herbace-ous Balds & Rock Outcrops	Upland Prairies	Seasonal Wet Prairies	Vernal Pools & Vernal Seepage
Achillea millefolium L.	M	SJ	BH	EA	LC	1	1	1	1	
Agrostis exarata var. monolepis	M	1	BH							1
Agrostis microphylla Steud.	H	1	1		1				1	1
Agrostis scabra Willd.	M	VI	?	CO			1		1	
Allium amplectens Torr.	H	SJ	BH	CO	1	1	1	1	1	
Alopecurus saccatus	H		FNA		FNA					1
Apocynum androsaemifolium	M	SJ	1		LC		1	1	1	
Aster curtus Cronq.	H	VI	SC	1	1	1		1	1	
Aster hallii A. Gray	H		SC ?	1	1	1		1	1	
Aster subspicatus Nees	M	SJ	1	LM	1			1	1	
Barbarea orthoceras Ledeb.	M	?	?		1		1	1	1	
Brodiaea coronaria (Salisb.) Engl.	H	SJ	BH	EA	1	1		1	1	
Camassia leichtlinii (Baker) S. Watson var. suksdorfii (Greenm.) Gould	H	SJ	SC	EA	1	1	1	1	1	
Camassia quamash (Pursh) Greene ssp. maxima Gould	H	SJ	BH	EA	1	1			1	
Carex arcta	L		SC		1				1	
Carex athrostachya	M	SJ	SC	SE	OSC				1	
Carex pachystachya Cham. ex Steud.	M	SJ	1	LM	1	1		1	1	
Carex praticola	L	SJ	TH		1				1	
Carex tumulicola Mack.	H	SJ	BH	LM	1	1	1	1	1	
Carex unilateralis Mack.	M		SC	LM	1				1	
Carex vulpinoidea	L	1	1						1	
Centaurium muehlenbergii (Griseb.) W. Wight ex Piper	H	SJ	BH		1		1	1	1	1

Chamaesyce serpyllifolia (Pers.) Small	H	VI	WTU		1					1
Crataegus douglasii	M	1	1	LM		1		1	1	
Crataegus suksdorfii (Sarg.) Kruschke	M	SJ	SC	EA	1	1		1	1	
Danthonia californica vars.	H	SJ	BH	EA	1		1	1	1	
Delphinium menziesii DC.	H	SJ	SC		1	1	1	1	1	
Deschampsia caespitosa (L.) P. Beauv.	M	1	SC	EA	1				1	1
Deschampsia danthonioides (Trin.) Munro	H	VI	JB		1				1	1
Deschampsia elongata (Hook.) Munro	L	VI	1	CO	1				1	
Dodecatheon pulchellum (Raf.) Merr. ssp. macrocarpum	H	SJ	BH	SH	1		1		1	
Downingia yina Applegate	H		TH	EA	1				1	1
Eleocharis acicularis (L.) Roem. & Schult.	M		1	1	1				1	1
Eleocharis palustris (L.) Roem. & Schult.	M	?	WTU	1	1				1	1
Epilobium densiflorum (Lindl.) P.C. Hoch & P.H. Raven	H	VI	1	CO	1				1	1
Epilobium torreyi (S. Watson) P.C. Hoch & P.H. Raven	H	VI	BH	1	1		1		1	1
Eriophyllum lanatum (Pursh) J. Forbes var. leucophyllum (DC) W.R. Carter)	H	SJ	BH	LM	1	1	1	1	1	
Fragaria virginiana Duchesne var. platypetala (Rydb.) H.M. Hall	H	SJ	BH	EA	1	1	1	1	1	
Fraxinus latifolia Benth.	M	VI	SC	CO	1	1		1	1	
Fritillaria affinis (Schult.) Sealy	H	SJ	BH	EA	1	1	1	1	1	
Galium cymosum	L	WTU	SC	LM	1			1	1	
Gnaphalium palustre Nutt.	M	SJ	1	EA	1				1	1
Gnaphalium purpureum L.	M	SJ	BH	CO	1		1		1	1
Gratiola ebracteata Benth.	M		TH	SH	1				1	1
Heracleum lanatum Michx.	L	SJ	JB	1	LC	1		1	1	
Heuchera chlorantha Piper	H	?	1	1	1	1			1	
Hordeum brachyantherum Nevski	M	?	SC	BI	1				1	
Isoetes nuttallii A. Br.	H	SJ	1	SH	1		1		1	1
Juncus bufonius L.	L	SJ	SC	CO	1				1	1
Juncus occidentalis	M	1	1	1	1				1	
Juncus tenuis Willd.	M	VI	BH	CP	1	1		1	1	
Koeleria macrantha (Ledeb.) Schult.	H	SJ	BH	CO	1		1	1	1	
Lepidium virginicum var. menziesii	M	SJ	WTU		1					1
Linanthus bicolor (Nutt.) Greene ssp. bicolor	H		BH	CO	1			1	1	1

Lomatium dissectum (Nutt.) Mathias & Constance var. dissectum	H	VI	BH	1	LC	1	1	1	1	
Lomatium nudicaule (Pursh) J.M. Coult. & Rose	H	SJ	BH	WN	LC			1	1	
Lotus formosissimus Greene	H	VI	1	CP	1				1	1
Lotus unifoliatus var. unifoliatus	M	SJ	BH	EA	1				1	1
Lupinus polyphyllus Lindl. Vars	M	VI	SC	EA	1				1	
Lupinus rivularis Douglas ex Lindl.	L	SE	1		1			1	1	
Luzula comosa E. Mey.	M	SJ	BH	EA	1	1		1	1	
Madia minima (A. Gray) D.D. Keck	H	SJ	WTU		1			1		1
Madia sativa Molina	M	SJ	BH	LM	1			1	1	
Mentha arvensis L. var. canadensis (L.) Kuntze	M	1	1	BI	1				1	
Microseris laciniata (Hook.) Sch. Bip.	H	SE	BH	1	1		1	1	1	
Mimulus guttatus DC.	M	SJ	BH	CP	1		1		1	1
Montia fontana L.	M	SJ	BH	CO	1				1	1
Montia howellii S. Watson	M	SJ	1	ONHP	1		1		1	
Montia linearis (Douglas ex Hook.) Greene	M	SJ	BH	EA	1				1	1
Navarretia intertexta (Benth.) Hook. ssp. intertexta	H	SJ	BH	EA	1					1
Panicum acuminatum Sw. ssp. fasciculatum (Torr.) Freckman & Lelong	H	1	TH	CP	1	1		1	1	1
Panicum capillare L.	M		WTU		1					1
Perideridia gairdneri (Hook. & Arn.) Mathias ssp. borealis Chuang & Const.	H	SJ	BH	LM	LC	1		1	1	
Phlox gracilis (Hook.) Greene	H	SJ	BH	CP	1		1	1	1	1
Pinus ponderosa Douglas ex Lawson & C. Lawson	H		1	CO	1	1		1	1	
Piperia elegans (Lindl.) Rydb. ssp. elegans	M	?	BH	CP	1	1		1	1	
Plagiobothrys figuratus (Piper) I.M. Johnst.	H	VI	SC	EA	1				1	1
Plagiobothrys scouleri (Hook. & Arn.) I.M. Johnst. var. scouleri	M	VI	TH		1					1
Plectritis congesta (Lindl.) DC. var congesta	H	SJ	1	CP	1	1	1	1	1	
Poa scabrella (Thurb.) Benth	H	SJ	BH	SH	1		1	1	1	1
Polygonum bistortoides Pursh	H		SC	EA	1				1	
Polygonum spergulariaeforme Meisn.	M	SJ	TH	CO	1		1	1	1	
Potentilla gracilis Douglas ex Hook. Var. gracilis	H	VI	SC	EA	1	1		1	1	
Prunella vulgaris L. var. lanceolata (W.P.C. Barton) Fernald	M	SJ	BH	EA	1	1		1	1	
Psilocarphus elatior (A. Gray) A. Gray	M	VI	WTU		1					1

Ranunculus alismifolius Geyer var. alismifolius	H	VI	JB	LM	1				1	
Ranunculus flammula L.	L	?	1	SE	1				1	1
Ranunculus occidentalis Nutt. var. occidentalis	H	SJ	BH	CO	1	1		1	1	
Ranunculus orthorhynchus Hook.	H	VI	SC	EA	1				1	
Rosa pisocarpa	L	SJ	SC	CM	1			1	1	
Sanguisorba annua (Nutt. ex Hook.) Torr. & A. Gray	M	?	BH	CO	1		1			1
Saxifraga oregana Howell	H	1	1	CP	1				1	
Sisyrinchium idahoense E.P. Bicknell var. idahoense	H	1	BH	LM	1	1		1	1	
Spiranthes romanzoffiana Cham.	H	SJ	BH	?	1		1		1	
Stellaria longipes	M	SJ	1						1	
Triodanis perfoliata	H	SJ	BH	CO	1		1	1	1	
Triphysaria pusilla (Benth.) Chuang & Heckard	M	SJ	BH	1	1		1	1	1	
Triteleia hyacinthina (Lindl.) Greene	H	SJ	BH	EA	1	1	1	1	1	1
Vaccinium cespitosum	M	H	PP	SE	1			1	1	
Veratrum californicum Durand var. caudatum (Heller) Hitchc.	L		TH						1	
Veronica peregrina L. var. xalapensis (Kunth) H. St. John & F.A. Warren	M	SJ	1		1				1	1
Vicia americana Muhl. ex Willd. Vars	M	SJ	SC	CO	1	1		1	1	
Wyethia angustifolia (DC.) Nutt.	H		SC		1	1		1	1	
Zigadenus venenosus S. Watson var. venenosus	H	SJ	BH	SH	1	1		1	1	

b.

SPECIES	Degree of fidelity to prairie habitats GB		PT	LC	WV	Oak Wood-land & Savanna	Herbace-ous Balds & Rock Outcrops	Upland Prairies	Seasonal Wet Prairies	Vernal Pools & Vernal Seepage
Agrostis exarata Trin. var. exarata	M	SJ	*	CO	1				1	1
Alopecurus geniculatus L.	M	WE	*	SE	1				1	1
Anaphalis margaritacea (L.) Benth. & Hook. f.	L		*	CO	LC		1			1

Bidens cernua L.	L	1	*		1					1
Bidens frondosa L.	L		*		1				1	1
Callitriche heterophylla Pursh	M	?	*	SH	1					1
Carex aperta	L		*	PG					1	
Carex cusickii Mack. Ex Piper & Beattie	M		*		1				1	
Carex densa (L.H. Bailey) L.H. Bailey	H		*	LM	1				1	
Carex feta L.H. Bailey	M		*	SE	1				1	
Carex obnupta L.H. Bailey	L		*	SE	1				1	
Carex pellita Muhl.	L		*	LM	1				1	
Carex scoparia Schkuhr ex Willd.	M		*	OSC	1				1	
Cirsium edule	M	VI	*	CO	1			1	1	
Epilobium brachycarpum	M	SJ	*	CO	1			1	1	1
Epilobium ciliatum Raf.	L	?	*	CP	1	1			1	
Gentiana sceptrum Griseb.	M		*		1				1	
Geum macrophyllum Willd. var. macrophyllum	L	SE	*	CP	1	1	1	1	1	
Hypericum anagalloides Cham. & Schltdl.	M	?	*	EA	1				1	
Hypericum formosum Kunth var. scouleri (Hook.) Coult.	M	?	*	EA	1				1	
Lotus pinnatus Hook.	H	VI	*	SH	1				1	1
Madia glomerata Hook.	H	SJ	*		1			1	1	1
Myosotis laxa	L		*	OSC	OSC				1	1
Psilocarphus tentllus var. tenellus	H	SJ	*		1			1		1
Ranunculus aquatilis L.	L		*		1					1
Rorippa curvisiliqua (Hook.) Bessey ex Britton	M	SJ	*	?	1					1
Rumex salicifolius Weinm. var. salicifolius	M	1	*		1			1	1	1
Veronica scutellata	M		*	SE	1				1	1

Definitions:

Degree of fidelity to prairie habitats:

This is a generalization for the species across the ecoregion.

H = high fidelity to native prairie and related habitats; usually when this species is observed it is in a prairie remnant or fragment of historic native prairie.

Note: this category may include native weeds that historically occurred primarily in prairies but have spread into other disturbed areas.

M = moderate fidelity to native prairie habitats; may occur occasionally in conifer forest, wetland, riparian forest, or other habitats.

L = low fidelity to native prairie habitats, typically found in other non-prairie habitats and occasionally present in prairie remnants.

Sections of the WPG ecoregion:

GB = Georgia Basin section. Includes SE Vancouver Island and adj. Gulf Islands, San Juan Islands, and rain shadow portions of Island, Clallam, and Jefferson Counties.

SJ = Wild Plants of the San Juan Islands, Atkinson & Sharpe, 2nd. Ed, 1993

VI = Flora of the Saanich Peninsula, Szczawinski & Harrison 1972

PT = Puget Trough section. Includes mainland BC portions of the ecoregion, plus Puget Trough outside of the Olympic Rain shadow, south through Thurston County WA.

SC = Scatter Creek wildlife area, Thurston Co. WA, Jim Barrett 1979

TH = list of vascular Plants of Thurston Co. WA, Jim Barrett et al.

BH = Bald Hill NAP, Thurston Co. WA, Ed Alverson 1988

PP = Glacial Outwash Prairies, Thurston and Pierce Cos., WA

LC = Lower Columbia section. Includes immediate vicinity of the Columbia River from about Cape Horn downstream to below Longview, and From Lewis County WA south to Washington County OR and most of Clackamas County

EA = Plants of the Lewis County prairies, Ed Alverson, 1986

BI = Blackwater Island RNA, Clark Co. WA

LM = Lacamas Meadows/Green Mtn. Resort easement, Clark Co. WA

CP = TNC Camassia Preserve, Clackamas Co. OR

WN = Willamette Narrows, Clackamas Co. OR

CO = Cooper Mountain Metro Greenspace, Washington Co., OR

WV = Willamette Valley section. From the Molalla River and Chehalem Mountains south to Lane County, OR.

LC = Vascular Plants of Lane County Oregon, 2002

OSU = Oregon State University Herbarium data base

unless otherwise noted, data taken mostly from WV flora focus list, Native Seed Network.

Ecological Systems:

Oak woodland and savanna:

Habitats with oak as a dominant or co-dominant in the overstory and low shrubs and herbs in the understory.

Herbaceous balds and rock outcrops:

Areas of bedrock exposure that are relatively open and herbaceus dominated, plus rock crevices and open talus sopes.

Upland Prairies:

Prairies on deep, well drained, soils dominated by grasses and forbs. Includes coastal meadows above the immediate wave-influenced zone.

Seasonal Wet Prairies:

Prairies on poorly drained soils or otherwise with a seasonally high water table.

Vernal Pools and vernal seepage:

Localized depressions within a prairie landscape that are seasonally inundated, plus depressions or flats on bedrock outcrops that are seasonally inundated or constantly saturated.