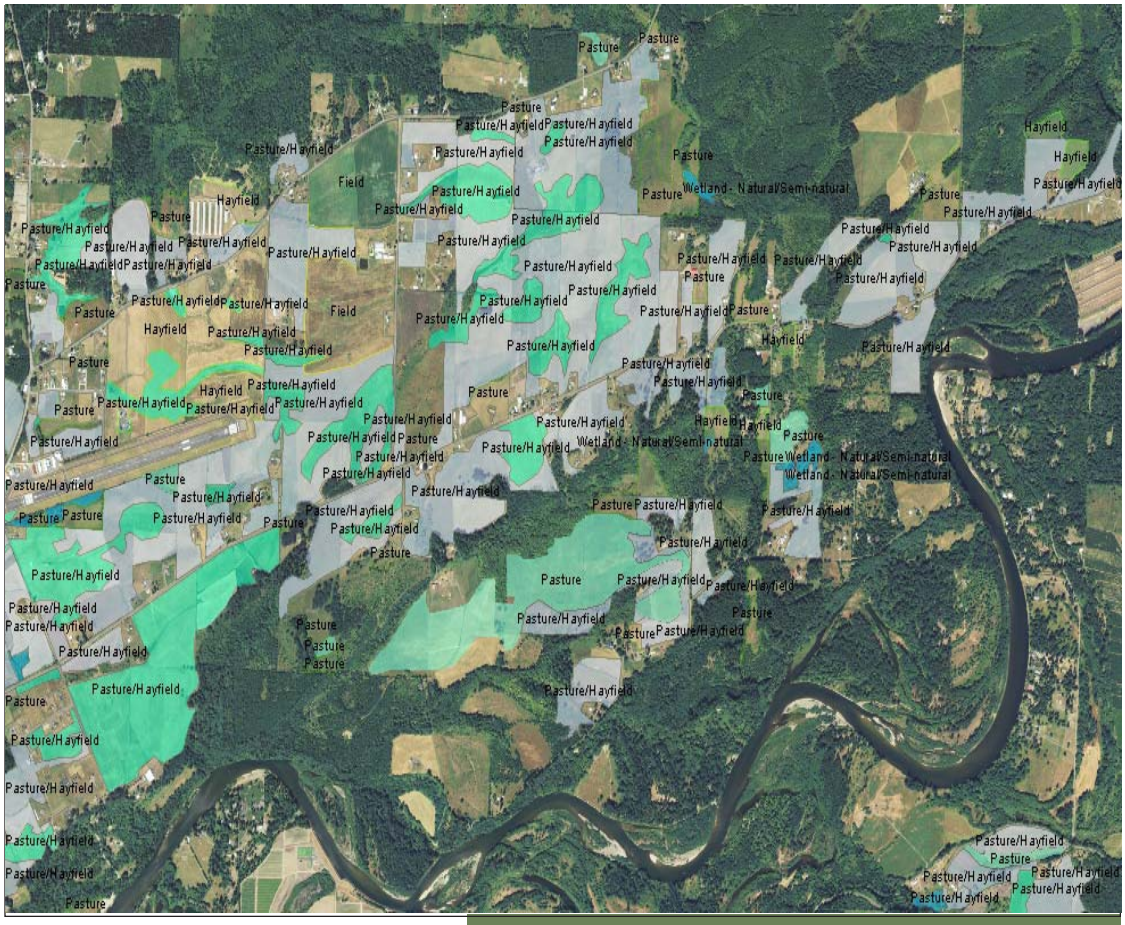
WASHINGTON NATURAL HERITAGE PROGRAM



Vegetation/Landuse Map of Potential Habitat of Southwest Washington Prairie Species

Prepared for
U.S. Fish and Wildlife Service
Region 1

Prepared by

Rex C. Crawford

March 29, 2013

Natural Heritage
Report 2013-06

WASHINGTON STATE DEPARTMENT OF
Natural Resources

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Report Prepared for:
U.S. Fish and Wildlife Service
Western Washington Fish and Wildlife Office
Region 1

ESA Section 6 Grant E-2-71

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Abstract

The objective of this project is to map the vegetation of selected historical prairie areas in Lewis County to provide a template to identify areas with conservation potential for southwest Washington prairies. Land-use/land cover classes were identified at Boistfort, Drews, Grand, Cowlitz, and Layton Prairies (Lewis County, Washington). Image interpretation of the apparent land-use/land cover of 2009 images was based on field reconnaissance (2010) and land use changes apparent on older imagery (1990s, 2006, and 2008). The resulting 1,306 polygons vary between 0.23 acre and 313 acres with an average of 16.6 acres. No systematic and quantitative accuracy assessment was performed following mapping within the project area. Errors associated with misclassification and/or inaccurate delineation of polygons have not been determined. Appropriate caution needs to be used in interpretation of data and conclusions from this report.

Fourteen land-use/land types are mapped with 29 modifiers yielding 51 unique Cover types. Each primary Cover type definition includes modifying descriptors (species, additional life forms, and hydrologic indicators). Cover type and modifier combinations were placed in Class, SubClass, Formation, Division, Macrogroup and Group within the National Vegetation Classification in hierarchical levels (review version of the 2010 Revised USNVC, version 1.0). Cover type reflects the likelihood of supporting habitat for species associated with southwest Washington prairies and with a site's potential for restoration. Land uses are assumed to represent deviation from a natural condition and have differing probabilities for the presence of native prairie species. Probability estimates of native prairie species presence were at the NVC Macrogroup level.

Image interpretation delineated 1,306 polygons representing 16,548 acres. Polygon sizes ranged between 0.23 and 313 acres with an average of 16.8 acres and a median of 7.9 acres. In terms of prairie areas, Boistfort Prairie and associated valley bottoms along Boistfort and Lake Creeks was the largest area mapped at 6,852 acres and Drews Prairie the smallest at 511 acres. The most common NVC Class mapped was Agricultural Vegetation (7,870 acres) consisting of mostly non-cultivated pasture/hayfields (3,895 acres) with some unimproved pastures (391 acres), primarily recently cleared forests and cultivated crops (3,584 acres), i.e. annual crops, cultivated hay, and Christmas trees. The Shrubland and Grassland and Forest and Woodland Classes covered 3,914 and 2,944 acres, respectively. In general, over half of the area associated with the Boistfort, Grand, Drews, Cowlitz and Layton historical prairies in Lewis County is in agricultural production.

Polygons with a high probability of supporting upland prairie species include those mapped as oak stands within Boistfort, Cowlitz, Drews, and Grand Prairies. Moderate probability polygons for upland prairie species included mostly ruderal vegetation types and total 2,186 acres. High probability polygons for wet prairie species are associated with natural wet meadows and wet prairies and total 894 acres. Non-cultivated pastures are moderate probability polygons for upland and for wet prairie species. Moderate probability wet prairie species polygons sum 2,438. These are considered overestimates because it is likely that we conservatively mapped many agricultural areas as non-cultivated pasture or hayfields and thus included cultivated hayfields.

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1.0 Introduction

1.1 Project Objective

The objective of this project is to map the vegetation of selected historical prairie areas in Lewis County to provide a template to identify areas with conservation potential for southwest Washington prairies. Conservation potential includes the following criteria:

- Support objectives outlined in the 2010 Recovery Plan for individual southwest Washington prairie species
- Soils associated with prairie ecosystems
- Current land use is conducive to maintaining native or semi-native grassland
- Large enough area or within a landscape that will allow management activities to maintain viability of targeted species

In addition, a protocol for developing a range of possible conservation, management or restoration targets is provided in Appendix 1. This protocol, referred to as Ecological Integrity Assessments (EIAs), was developed by NatureServe (Faber-Langendoen et al. 2006) and fine-tuned by the Washington Natural Heritage Program (Rocchio and Crawford 2009) as a method for assessing ecological integrity, setting management or restoration goals, and documenting attainment of those goals. The EIA method is briefly described and two EIAs specific to southwestern Washington prairies (e.g., upland and wet prairies) are included in the report.

2.0 Project Area and Methods

Land-use/land cover class mapping focused on Boistfort, Drews, Grand, Cowlitz, and Layton Prairies as delineated from GLO Cadastral Survey maps drawn in the late 1800s (Caplow and Miller 2004) (Figure 1). Figure 1 also displays the locations of areas documented as having prairie soils (Caplow and Miller 2004). For this project, mapping concentrated on GLO prairies that overlapped prairie soil. Parts of what is included in Cowlitz Prairie in Figure 1 are mapped as part of Lacamas Prairie on US. Geological Survey maps and is not included. Areas were occasionally delineated adjacent to either historical prairie or prairie soil areas that appeared to be grassland (pasture). Image interpretation of the apparent land-use/land cover of 2009 images was based on field reconnaissance (2010) and land use changes apparent on older imagery (1990s, 2006, and 2008). Polygons were determined by visual evaluation of images by Rex Crawford and Joe Rocchio. Polygons were typically digitized at the 1:10,000 scale or at finer resolution when habitat differences were not fully apparent or inconclusive at the 1:10,000 scale. The resulting 1,306 polygons vary between 0.23 acre and 313 acres with an average of 16.6 acres.

No systematic and quantitative accuracy assessment was performed following mapping within the project area. Errors associated with misclassification and/or

inaccurate delineation of polygons have not been determined. Appropriate caution needs to be used in interpretation of data and conclusions from this report.

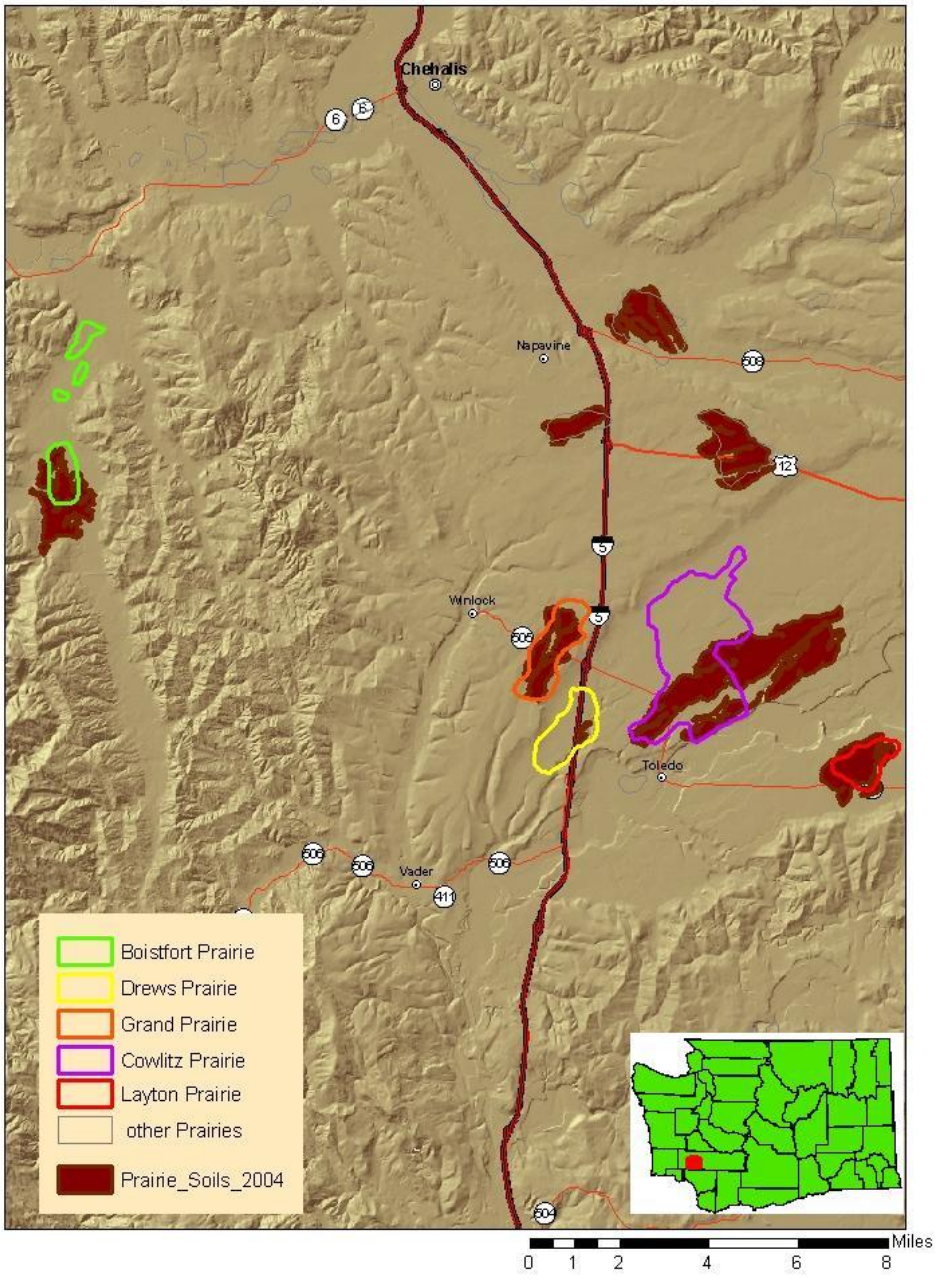

Figure 1. Location of prairies mapped focused on intersection of historical prairies from GLO and historical prairie indicated by prairie soils (Caplow and Miller (2004).

1.2.1 Image Interpretation and Cover types

Fourteen land-use/land Cover types are mapped with 29 modifiers yielding 51 unique polygon labels. Cover type definitions were derived in somewhat of an *ad hoc* manner reflecting what was confidently discernible, the scale of image evaluation, and what met the objective of the project. Each primary Cover type definition includes modifying descriptors (species, additional life forms, and hydrologic indicators) and the prairie areas (in parenthesis) where the class appears. Each Cover type reflects the likelihood of supporting habitat for species associated with southwest Washington prairies and with a site's potential for restoration. Land uses are assumed to represent deviation from a natural condition and differing probabilities of the presence of native prairie species. Polygon Cover type and modifier combinations were also placed within the National Vegetation Classification (see below).

Cover Type definitions:

Christmas trees – upland areas with rows of Christmas trees of various sizes. *Modifiers*: Closed Forest – old and riparian. (all)

Clear cut – area of closed forest cover on 1990-2000 images which are now "unimproved pasture dominated by herbaceous or shrub (not coniferous) cover. *Modifiers*: oak – areas mapped by Chappell et al (2001) as oak-dominated; Wetland. (Boistfort, Drews, Grand, and Cowlitz)

Closed Forest - area with approximately 60% or more cover of trees. *Modifiers*: ash, ash-willow, conifer, conifer-hardwood, cottonwood, cottonwood-ash, hardwood, oak, oak-conifer, riparian, second growth and willow. (all)

Developed - concentrations of buildings, impervious surfaces, landscaping and associated ruderal vegetation. *Modifiers*: air field grassland, ball field grassland, oak. (all)

Field – Areas apparently annually cultivated, cropped and very unlikely to support native plants. *Modifiers*: none. (Boistfort, Grand, and Cowlitz)

Hayfield – Areas with obvious haying lines/stacks that does not appear to be grazed or field reconnaissance indicated are only hayed. Areas are assumed to have been planted, cultivated and very unlikely to support native plants. *Modifiers*: none. (Boistfort, Grand, Cowlitz, and Layton)

Hedge row – Prominent shrub-dominated (native or non-native) strips along roads or cultivated areas. *Modifiers*: none. (Cowlitz)

Open forest - area with less than approximately 60% cover of trees. *Modifiers*: ash, conifer, conifer-hardwood, cottonwood, hardwood, logged, oak, oak-ash, oak-conifer, and willow. (Drews, Grand, and Cowlitz)

Pasture – Herbaceous-dominated areas that do not appear to be annually cropped fields, do not have apparent haying lines/stacks and are likely to be grazed by livestock. They have moderate to high likelihood of supporting native plants. *Modifiers*: riparian, shrubs, trees, wetland, wetlands/trees. (all)

Pasture/Hayfield - Herbaceous-dominated areas that do not appear to be annually cropped fields, do have some apparent haying/mowing lines and are likely to be grazed by livestock. They have a moderate likelihood of supporting native plants. *Modifiers*: trees, wetland. (all)

Riparian – Areas associated exclusively with a natural channel, ditch or other artificial channel (Lewis) with typically woody-dominated stream-side vegetation. *Modifiers*: ash, ash-oak, cottonwood, shrubs, and stream. (Boistfort, Drews, Grand, and Cowlitz)

Shrubfield – Areas dominated by non-coniferous shrubs. *Modifiers*: forest, old field, planted and wetland old field. (Boistfort, Drews, Grand, and Cowlitz)

Water – Permanently flooded areas without emergent or woody vegetation. *Modifiers*: pond (Cowlitz)

Wetland Natural/Semi-natural – Areas associated with wetland on NWI map or interpreted to be wetland area not associated with a stream or channel and apparently not grazed or hayed. *Modifiers*: herbaceous- dominated, often by reed canarygrass (*Phalaris arundinacea*), forested. (Boistfort, Cowlitz and Layton)

*Modifiers***:**

air field grassland – mowed grass-dominated area surrounding air strips.

ash – forested area dominated by *Fraxinus latifolia.*

ash-oak - forested area co-dominated by *Quercus garryana* and *Fraxinus latifolia* trees.

ball field grassland – mowed grass-dominated area surrounding athletic field.

christmas trees – wetland areas with rows of Christmas trees.

closed forest – old – see closed forest class; here applied to old Christmas tree plantation areas

closed forest oak – closed canopy of *Quercus garryana*.

conifer - forested area dominated by unknown conifers

conifer-hardwood - forested area co-dominated by unknown conifer and hardwood trees

forest(ed)- area dominated by trees

hardwood - forested area dominated by unknown hardwood trees

logged – area with portion of tree canopy removed

oak - forested area dominated by *Quercus garryana* trees

oak-conifer - forested area co-dominated by *Quercus garryana* and unknown conifer trees

oak-riparian – stream associated forested area co-dominated by *Quercus garryana* trees

old field – area appears to have been cultivated in older imagery and currently supporting ruderal vegetation

old lumberyard –unused log storage area currently supporting native and non-native ruderal vegetation

plantation – logged landed dominated by even-size, short conifers.

riparian – see riparian type

second growth – forested area dominated by dense stands of smallish conifer trees

shrubs – short woody plants with multi stems.

stream - see stream class

trees – tall woody plants assumed to be single stem.

wetland - areas associated with wetland on NWI or interpreted to be wetland area not associated with a stream or channel.

1.2.2 National Vegetation Classification

The International Vegetation Classification (IVC) covers all vegetation from around the world. In the United States, its national application is the U.S. National Vegetation Classification (NVC), supported by the Federal Geographic Data Committee (FGDC 2008), NatureServe (Faber-Langendoen et al. 2009), and the Ecological Society of America (Jennings et al. 2009), with other partners. The IVC and NVC were developed to classify natural, semi-natural and cultural vegetation, wetlands and uplands, and identify types based on vegetation composition and structure and associated ecological factors. The NVC meets several important needs for conservation and resource management. It provides:

- An 8-level, ecologically based framework that allows users to address conservation and management concerns at scales relevant to their work.
- A characterization of ecosystem patterns across the entire landscape or watershed, both upland and wetland.
- Information on the relative rarity of types. Each association has been assessed for conservation status (extinction risk).

- Relationships to other classification systems are explicitly linked to the NVC types a federal standard for all federal agencies, facilitating sharing of information on ecosystem types (FGDC 2008).

Polygon Cover type and modifier combinations were placed within the National Vegetation Classification in hierarchical levels Class through Group (review version of the 2010 Revised USNVC, version 1.0) (Table 1). The hierarchical nature of the NVC provides map labels at different scales to match different objectives. Table 2 lists all cover types and modifier labels and their relationship to NVC Group. The NVC classification levels are used to display general distribution of mapped areas in this report. All classification levels and cover types are available digitally as a spreadsheet and GIS layer.

Table 1. U.S. National Vegetation hierarchy of vegetation mapped at project sites. (from the Revised USNVC version 1.0 , NatureServe 2010). Figures 2 and 3 illustrate the distribution of NVC Class level polygons.

Class	Subclass	Formation	Division	Macrogroup	Group
1 Forest & Woodland	1.C Temperate Forest	1.C.2 Cool Temperate Forest	1.C.2.b Western North American Cool Temperate Forest	Californian-Vancouverian Foothill & Valley Forest & Woodland	Californian-Vancouverian Deciduous Oak Woodland Group;
				Vancouverian Lowland & Montane Rainforest	North Pacific Maritime Douglas-fir - Western Hemlock Forest Group;
					North Pacific Red Alder - Bigleaf Maple - Douglas-fir Forest Group
				Western North American Ruderal Forest & Plantation	Western North American Conifer & Hardwood Plantation Group [Placeholder]
		1.C.3 Temperate Flooded & Swamp Forest	1.C.3.c Western North American Flooded & Swamp Forest	Western North American Cool Temperate Ruderal Flooded & Swamp Forest (Provisional)	Northwest North American Ruderal Riparian Group [Placeholder]
				Vancouverian Flooded & Swamp Forest	North Pacific Lowland Riparian Forest & Woodland Group;
					North Pacific Maritime Lowland Hardwood-Conifer Swamp Group
2 Shrubland & Grassland	2.C Temperate & Boreal Shrubland & Grassland	2.C.1 Temperate Grassland, Meadow & Shrubland	2.C.1.a Vancouverian & Rocky Mountain Grassland & Shrubland	Southern Vancouverian Lowland Grassland & Shrubland	Southern Vancouverian Shrub & Herbaceous Bald & Bluff Group
				Southern Vancouverian Lowland Ruderal Grassland & Shrubland	Northwest Ruderal Meadow & Shrubland [Placeholder]

Class	Subclass	Formation	Division	Macrogroup	Group
2 Shrubland & Grassland	2.C Temperate & Boreal Shrubland & Grassland	2.C.5 Temperate & Boreal Freshwater Wet Meadow & Marsh	2.C.5.b Western North American Freshwater Wet Meadow & Marsh	Western North American Lowland Freshwater Wet Meadow, Marsh & Shrubland	Western North American Temperate Interior Freshwater Marsh Group
				Western North American Ruderal Wet Meadow & Marsh	Western North American Ruderal Wet Meadow & Marsh Group
7 Agricultural Vegetation	7.1 Woody Agricultural Vegetation	7.1.B. Other Woody Agricultural / Rural Vegetation	7.1.B.1 Other Woody Farmland/Rural Vegetation	Temperate and Tropical Other Woody Farmland/Rural Vegetation	Other land in farms (not associated with farmsteads)
	7.2 Herbaceous Agricultural Vegetation	7.2.A. Herbaceous Cultivated Crop	7.2.A.2. Close Grown Crop	Temperate and Tropical Close Grown Crop	Wheat
			7.2.A.3. Cultivated Pasture and Hayland	Temperate and Tropical Cultivated Hayland and Pasture	Grass and Legumes
		7.2.C. Other Herbaceous Agricultural and Rural Vegetation	7.2.C.2. Other Rural, Crop or Farmland	Temperate and Tropical Rural Vegetation	Other cropland not planted (180) [conversion of forest to unimproved pasture]
8 Developed Vegetation	8.1. Herbaceous & Woody Developed Vegetation	8.1.A. Developed (Close cropped)	8.1.A.1 Lawn	Temperate and Tropical Lawn	Cool season Lawn
			8.1.A.x provisional Verges	Temperate and Tropical verges [Placeholder]	Cool season Verges [placeholder]
		8.1.B. Other Developed Urban / Built Up Vegetation	Urban / Build Up Vegetation	Other Urban / Built Up Vegetation	Vacant Lot Vegetation (abandoned log yard)
				Other Urban / Built Up Vegetation	Urban / Built Up Vegetation;
				Other Urban / Built Up Wetland Vegetation	Vacant Lot Wetland Vegetation;(abandoned log yard)

Table 2. USNVC Macrogroup, Group and map Cover type – *modifier* relationships.

Class	Macrogroup	Group	Cover Type with Modifier
1 Forest & Woodland	Californian-Vancouverian Foothill & Valley Forest & Woodland	Californian-Vancouverian Deciduous Oak Woodland Group	Closed Forest oak Closed Forest oak – conifer Open Forest oak
	Vancouverian Lowland & Montane Rainforest	North Pacific Maritime Douglas-fir - Western Hemlock Forest Group	Closed Forest conifer Closed Forest conifer - hardwood Closed Forest second growth Open Forest conifer Open Forest conifer - hardwood Open Forest logged Shrubfield forest
		North Pacific Red Alder - Bigleaf Maple - Douglas-fir Forest Group	Closed Forest hardwood Open Forest hardwood Closed Forest mixed
	Vancouverian Flooded & Swamp Forest	North Pacific Lowland Riparian Forest & Woodland Group	Closed Forest riparian Riparian Riparian ash Riparian ash oak Riparian stream Closed Forest ash Closed Forest oak riparian
		North Pacific Maritime Lowland Hardwood-Conifer Swamp Group	Wetland - Natural/Semi-natural forested
	Western North American Ruderal Forest & Plantation	Western North American Conifer & Hardwood Plantation Group [Placeholder]	Clear cut plantation
2 Shrubland and Grassland	Southern Vancouverian Lowland Ruderal Grassland & Shrubland	Northwest Ruderal Meadow & Shrubland [Placeholder]	Pasture Pasture shrubs Pasture trees
	Western North American Ruderal Wet Meadow & Marsh	Western North American Ruderal Wet Meadow & Marsh Group	Pasture riparian Pasture wetland Pasture wetland trees Pasture/Hayfield wetland Shrubfield wetland old field Wetland - Natural/Semi-natural Christmas trees
	Western North American Lowland Freshwater Wet Meadow, Marsh & Shrubland	Western North American Temperate Interior Freshwater Marsh Group	Clear cut wetland Wetland - Natural/Semi-natural Wetland - Natural/Semi-natural flooded
7 Agricultural Vegetation	Temperate and Tropical Cultivated Hayland and Pasture	Grass and Legumes [Placeholder]	Hayfield Pasture/Hayfield
	Temperate and Tropical Rural Vegetation	Other cropland not planted (180) [conversion of forest to unimproved pasture]	Clear cut Clear cut oak

	Temperate and Tropical Other Woody Farmland/Rural Vegetation	Other land in farms (not associated with farmsteads)	Christmas trees Christmas trees Closed Forest - old Christmas trees riparian Hedge row Shrubfield old field
	Temperate and Tropical Close Grown Crop	Wheat [Placeholder]	Field
8 Developed Vegetation	Temperate and Tropical Lawn	Cool season Lawn	Developed air field grassland Developed ball field grassland
	Temperate and Tropical verges [Placeholder]	Cool season Verges [Placeholder]	Road and verge
	Other Urban / Built Up Vegetation	Other Urban / Built Up Vegetation	Developed
		Vacant Lot Vegetation (abandoned log yard)	Developed old lumber yard
		Vacant Lot Wetland Vegetation (abandoned log yard)	Developed wetland old lumber yard

3.0 Results and Discussion:

Image interpretation delineated 1,306 polygons representing 16,548 acres. Polygon sizes ranged between 0.23 and 313 acres with an average of 16.8 acres and a median value of 7.9 acres. In terms of prairie areas, Boistfort Prairie and associated valley bottoms along Boistfort and Lake Creeks was the largest area mapped at 6,852 acres and Drews Prairie the smallest at 511 acres (Table 3). The most common NVC Class mapped was Agricultural Vegetation (7,870 acres) consisting of mostly non-cultivated pasture/hayfields (3,895 acres) with some unimproved pastures, primarily recently cleared forests (391 acres), and cultivated crops, i.e. annual crops, cultivated hay, and Christmas trees (3,584 acres). The Shrubland and Grassland and Forest and Woodland Classes covered 3,914 and 2,944 acres, respectively (Table 3). In general, over half of the area associated with historical prairies at Boistfort, Grand, Drews, Cowlitz, and Layton prairies in Lewis County is currently in agricultural production or development (Table 3).

Table 3. Acres of USNVC Class and clustering of Upland, Ruderal and Wetland Macrogroups and agricultural intensity at each prairie location.

Prairie	Boistfort	Cowlitz	Drews	Grand	Layton	Total
Forest & Woodland Class	**1911**	**517**	**256**	**148**	**112**	**2944**
Upland Forest	946	447	251	76	106	1826
Upland Ruderal Forest	68			40		108
Wetland Forest	898	70	5	32	6	1010
Shrubland & Grassland Class	**1923**	**1370**	**138**	**157**	**327**	**3914**
Wetland Shrub and Grass	349	19	58		16	442
Ruderal Wetland	1573	1352	80	157	311	3473
Agricultural Vegetation Class	**2637**	**2680**	**64**	**1031**	**1458**	**7870**
Cultivated	1241	770	9	695	869	3584
Non-cultivated	1305	1811	20	174	586	3895
Unimproved	91	99	35	162	4	391
Developed Class	**381**	**1018**	**54**	**234**	**130**	**1818**
Total acres	**6852**	**55876**	**511**	**1570**	**2027**	**16547**

Table 3 subdivides each NVC Class into clusters of upland, ruderal, and wetland macrogroups. Ruderal/semi-natural is vegetation in which human activities (past or present) significantly influence its composition or structure, but does not eliminate or dominate spontaneous ecological processes (FGDC 2008). Most (89%) of the Shrubland and Grassland Class is mapped as a ruderal or semi-natural vegetation Macrogroup (Table 2; Table 3). All of the Vancouverian & Rocky Mountain Grassland & Shrubland Division is mapped as a ruderal Macrogroup and the majority (83%) of the Western North American Freshwater Wet Meadow & Marsh Division is mapped as a ruderal Macrogroup (Table 4). This suggests that excluding developed, agricultural land, and

forests, wet prairies may constitute the majority, albeit semi-natural, of southwestern Washington prairies sites remaining in the project area.

Table 4. Acres of USNVC Division and Macrogroup (MG) of the Shrub and Grassland Class at each prairie location.

	Boistfort	Cowlitz	Drews	Grand	Layton	Total
Vancouverian & Rocky Mountain Grassland & Shrubland	**440**	**554**	**49**	**135**	**174**	**1352**
Southern Vancouverian Lowland Ruderal Grassland & Shrubland MG	440	554	49	135	174	1352
Western North American Freshwater Wet Meadow & Marsh	**1482**	**816**	**89**	**22**	**152**	**2562**
Western North American Lowland Freshwater Wet Meadow, Marsh & Shrubland MG	349	19	58		16	442
Western North American Ruderal Wet Meadow & Marsh MG	1133	798	31	22	137	2120
Total	**1923**	**1370**	**138**	**157**	**327**	**3914**

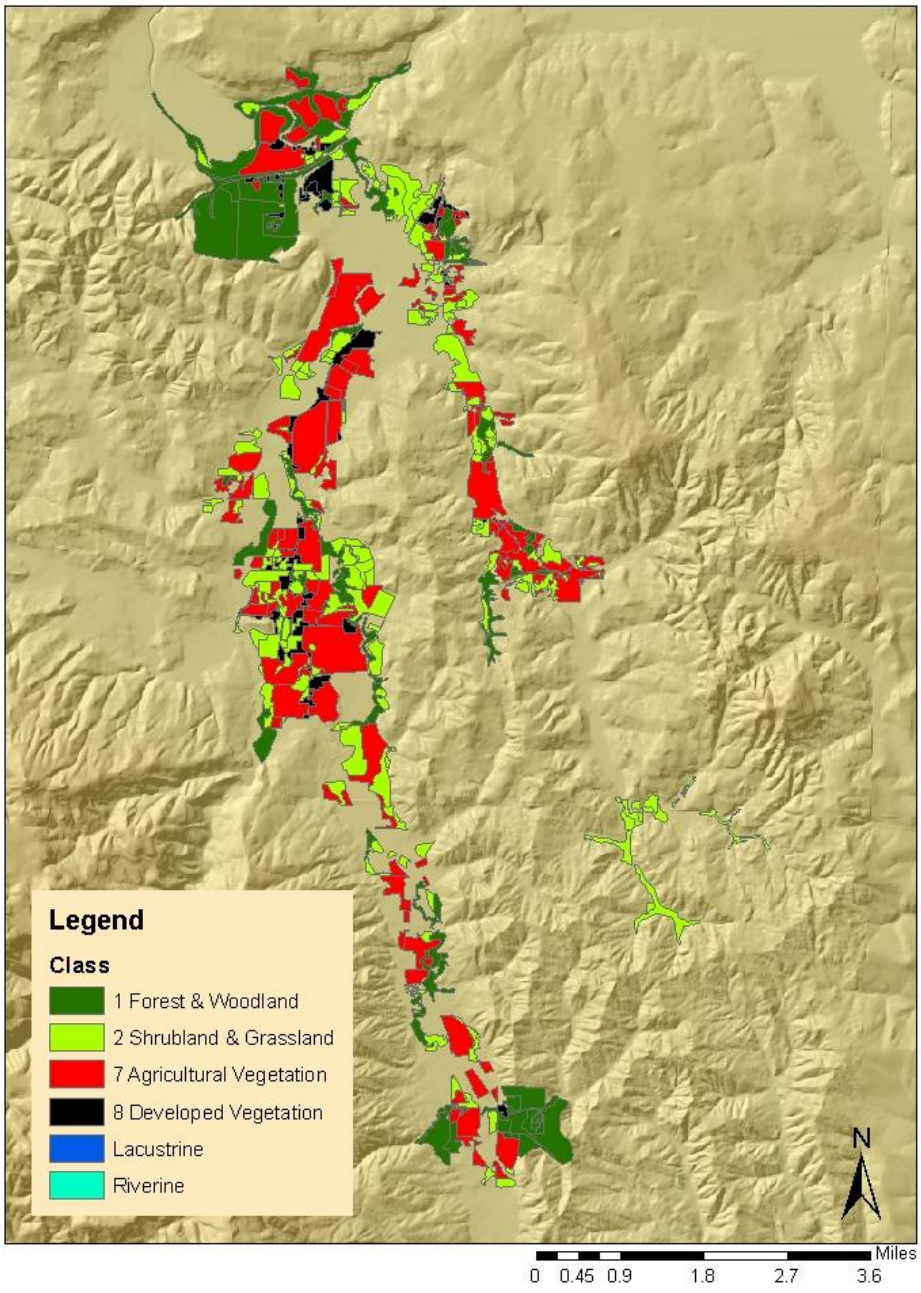

Figure 2 Distribution of NVC Classes mapped at Boistfort Prairie (near Township 12 North Range 4W); see Figure 1 for location. Lacustrine and Riverine are aquatic habitats not included in the NVC.

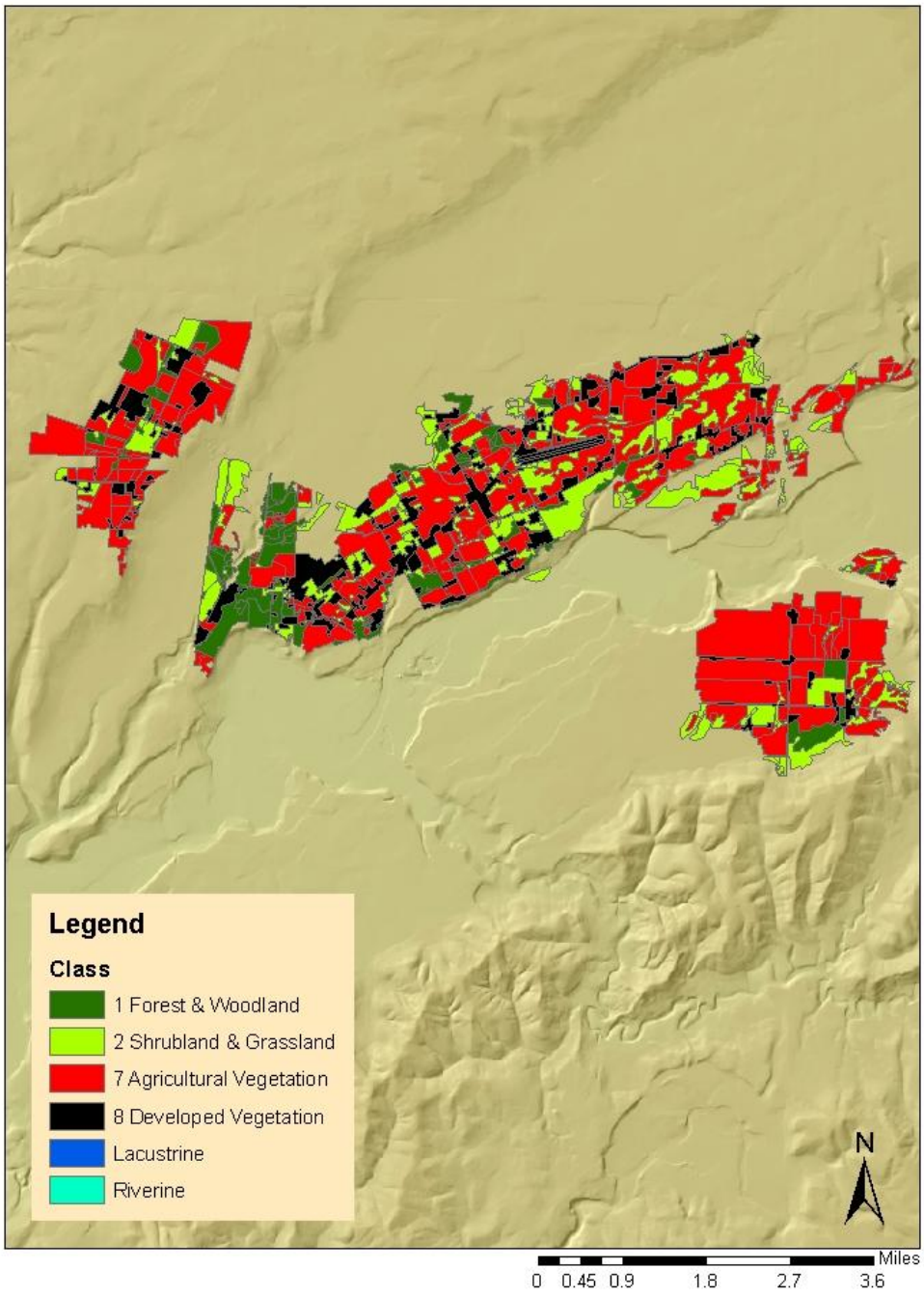

Figure 3 Distribution of NVC Classes mapped at Grand (left), Drews, Cowlitz and Layton (right) Prairies (near Township 11 North Range 1 W); see Figure 1 for location. Lacustrine and Riverine are aquatic habitats not included in the NVC.

Imprecision of knowledge of pre-settlement prairie locations does not allow for an exact accounting of prairie loss or conversion but our mapping does indicate the relative proportion of area converted to agricultural or urban development land uses. Land uses are assumed to represent deviation from a natural condition and differing probabilities of the presence of native prairie species. Presumably the NVC Class with the highest probability of supporting **native prairie species** is the Shrubland and Grassland Class followed by Forest and Woodland, Agriculture and finally Developed Classes, although as stated by Caplow and Miller (2004) fencerows and other transitions often support native species. A finer level of classification, Macrogroup or Group in the NVC, is a more appropriate level of landscape evaluation for focusing conservation planning efforts. For this project, all but two Macrogroups have more than one Group and those Groups have similar likelihoods of supporting prairie plants, therefore, no precision is gained at the Group level. Our probability estimates of native prairie species presence are then associated with mapped NVC Macrogroups and are summarized in Table 5.

Table 5. List of US NVC Macrogroups and the probability of the presence of native prairie species within each prairie. Upland and wet prairies defined in U.S. Fish and Wildlife Service (2010); H= a high likelihood of encountering species restricted to native prairies; M= Moderate or an equal likelihood of the presence or absence of species restricted to native prairies; L= Low or unlikely presence of species restricted to native prairies

Macrogroup	UPLAND Prairie Species	WET PRAIRIE Species
Californian-Vancouverian Foothill & Valley Forest & Woodland	H	
Southern Vancouverian Lowland Ruderal Grassland & Shrubland	M	
Temperate and Tropical Rural Vegetation (unimproved pasture)	M	
Temperate and Tropical Permanent Pasture & Hayland	M	M
Western North American Lowland Freshwater Wet Meadow, Marsh & Shrubland	M	H
Western North American Ruderal Wet Meadow & Marsh	L	M
Western North American Cool Temperate Ruderal Flooded & Swamp Forest [provisional]	L	L
Vancouverian Flooded & Swamp Forest	L	L
Other Urban / Built Up Wetland Vegetation	L	L
Vancouverian Lowland & Montane Rainforest	L	
Western North American Ruderal Forest & Plantation	L	
Other Urban / Built Up Vegetation	L	
Temperate and Tropical Close Grown Crop	L	
Temperate and Tropical Cultivated Hayland and Pasture	L	
Temperate and Tropical Lawn	L	
Temperate and Tropical Other Woody Farmland/Rural Vegetation	L	
Temperate and Tropical Verges [Placeholder]	L	

High probability polygons for the presence of upland prairie species includes oak stands on 1 acres at Boistfort, 119 acres at Cowlitz, 14 acres at Drews, and 5 acres at Grand Prairies. Moderate probability polygons for upland prairie species included mostly ruderal vegetation types and total 2186 acres at Boistfort, 2464 acres at Cowlitz, 141 acres at Drews, 471 acres at Grand, 780 acres and at Layton prairies. High probability polygons for wet prairie species are associated with (natural wet meadows and wet prairies) and total 349 acres at Boistfort, 58 acres at Drews, 471 acres at Grand, and 16 acres at Layton prairies. Non-cultivated pastures are moderate probability polygons for upland and for wet prairie species. Moderate probability wet prairie species polygons sum 2438 acres at Boistfort, 2627 acres at Cowlitz, 31 acres at Drews, 196 acres at Grand, 722 acres and at Layton prairies. These are considered overestimates because it is highly likely that we conservatively mapped many agricultural areas as non-cultivated pasture or hayfields and likely included cultivated hayfields. The probability of native species based on these putative relationships appears in Figures 4 and 5.

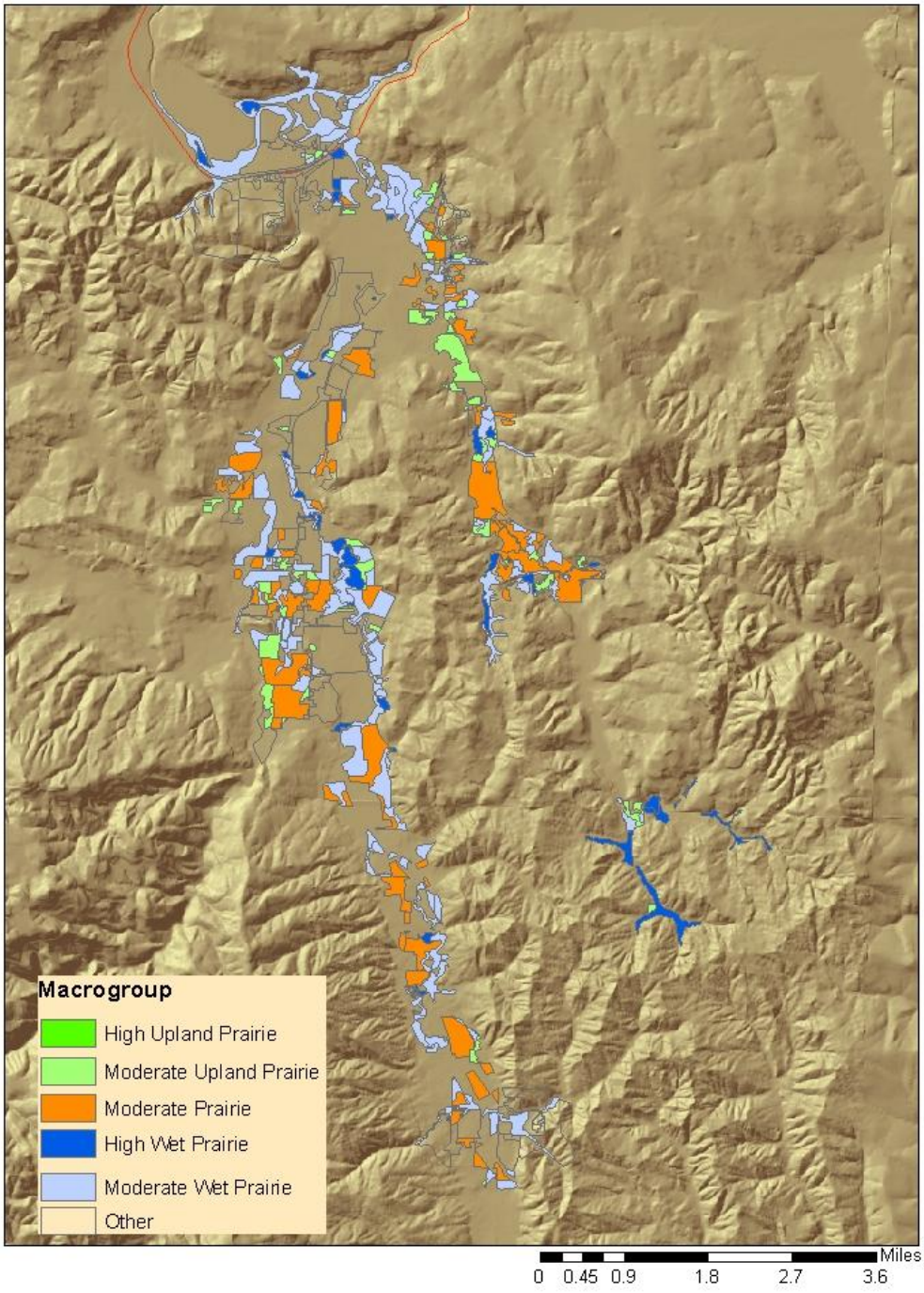

Figure 4 Distribution of polygons with estimated likelihood of containing southwest Washington prairie species based on NVC Macrogroup (see Table 3) at Boistfort Prairie and vicinity. High represents a likely presence of species restricted to native prairies; Moderate or an equal likelihood of the presence or absence of species restricted to native prairies.

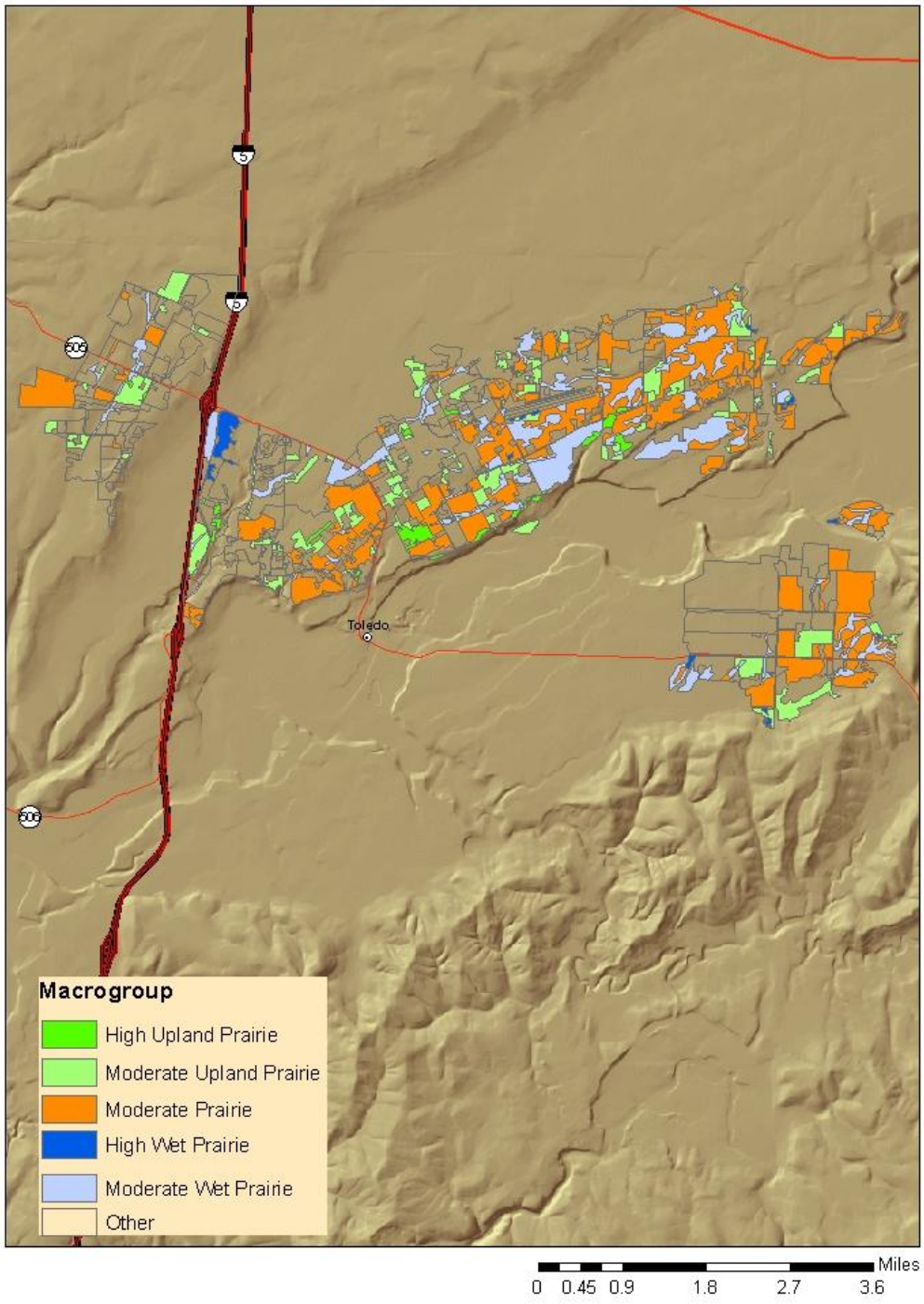

Figure 5 Distribution of polygons with estimated likelihood of containing southwest Washington prairie species based on NVC Macrogroup (see Table 3) at (left to right) Grand, Drews, Cowlitz, and Layton Prairies and vicinity.

4.0 References

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Appendix 1. Ecological Integrity Assessments

NatureServe and the Natural Heritage Network have developed an approach for assessing ecological condition that is scaled both in terms of the scale of ecosystem type that is being assessed and the level of information required to conduct the assessment. This method is called the Ecological Integrity Assessment (EIA) (Faber-Langendoen et al. 2006) and is now being implemented for a variety of small- and large-scale projects (Rocchio and Crawford 2009, Tierney et al. 2009). The EIA aims to measure the current ecological integrity of a site through a standardized and repeatable assessment of current ecological conditions associated with the structure, composition, and ecological processes of a particular ecological system. These conditions are then compared or ranked according to conditions expected in those sites operating within the bounds of their natural range of variation for that particular ecological system. The purpose of assigning an index of ecological integrity is to provide a succinct assessment of the current status of the composition, structure and function of occurrences of a particular ecosystem type and to give a general sense of conservation value, management effects, restoration success, etc. The EIA can be applied at a variety of spatial scales ranging from a remote-sensing, GIS-based approach to an on the ground, quantitative analysis these are referred to as Level 1 – remote assessments (GIS), Level 2 – rapid assessments (site) and Level 3 – intensive assessments (plot). A generalized Level 1 EIA is provided in Rocchio and Crawford (2009).

EIAs have been developed to assess units of Ecological Systems, a related but different classification than the NVC. Ecological systems provide a spatial-ecologic perspective on the relation of associations and alliances (fine-scale NVC types), integrating vegetation with natural dynamics, soils, hydrology, landscape setting, and other ecological processes. They can also provide a mapping application of the NVC, much as soil associations help portray the spatial-ecologic relations among soil series in a soil taxonomic hierarchy. Ecological systems types facilitate mapping at meso-scales (1:24,000 – 1:100,000; Comer and Schulz 2007) and a comprehensive ecological systems map exists for Washington State (www.landscope.org). Ecological systems meet several important needs for conservation, management and restoration, because they provide:

- an integrated biotic and abiotic approach that is effective at constraining both biotic and abiotic variability within one classification unit.
- comprehensive maps of all ecological system types are becoming available.
- explicit links to the USNVC, facilitating crosswalks of both mapping and classifications.

Ecological systems are somewhat comparable to the Group level of the NVC hierarchy, thus can be linked to other levels of the NVC hierarchy. For example, the Willamette Valley Wet Prairie Ecological System is equivalent to NVC's Western North American Temperate Wet Meadow & Seep Herbaceous Group. Level 2 EIAs have been developed for these ecological systems and, since they support the southwest Washington prairie species of concern, are included here as a guide for developing a range of possible

conservation, management or restoration targets. Both the NVC and Ecological Systems classifications can be used to define the ecological variability that may affect the ecological integrity of an area.

Willamette Valley Upland Prairie and Savanna

Ecological Summary

This is a grassland and savanna system endemic to the Puget Trough and Willamette Valley. Historically, this system occurred as large and small patches from portions of the Georgia Basin, Puget Trough, and Willamette Valley. In Washington, it is most expansive in the South Puget Sound region (e.g., Pierce and Thurston counties) but is also found in the San Juan Islands and in southwestern Washington. Most sites are topo-edaphically dry and experience extreme soil drought in the summer. In the South Puget Sound, this system occurs as large patches within more forested landscapes, usually associated with deep, gravelly/sandy glacial outwash that is excessively well drained. Historically, it also occurred as large patches on glacially associated soils of variable texture in localized portions of the Georgia Basin in both Washington and British Columbia, especially within the Olympic Mountain rainshadow. Landforms are usually flat, rolling, or gently sloping, and often part of extensive plains.

These upland prairies and savannas are thought to have developed during the relatively hot and dry Hypsithermal period about 10,000 to 7,000 b.p. (Whitlock 1992). Thereafter, a cooler and moister climate has prevailed creating suitable conditions for encroachment of woody vegetation into many prairies. Historically, frequent fires or extreme environmental conditions (e.g., drier climate and/or excessively drained soils) prevented the establishment of shrubs and trees. The high frequency of fires (< 10 years) was a result of occasional lightning strikes but more often from intentional ignition by indigenous inhabitants who set fires to encourage to the growth of food plants such as *Camassia quamash* and *Pteridium aquilinum* and to control the encroachment of woody vegetation. Fires are thought to have occurred every few years (Chappell and Kagan 2001). Annual soil drought during the summer made it difficult for woody species (especially trees) to establish in these grasslands. However, occasionally *Quercus garryana* and *Pseudotsuga menziesii* would establish and survive long enough to be resistant to frequent fires thereby creating savanna conditions (Chappell and Kagan 2001). Following European settlement of the region, anthropogenic fire became less frequent resulting in widespread encroachment of the prairies and savannas by woody vegetation, especially conifers.

Historically, these prairies and savannas are dominated by a native bunchgrass, *Festuca idahoensis* ssp. *roemeri* and, to a lesser degree, *Danthonia californica* and *Carex inops* ssp. *inops*, along with abundant and diverse perennial forbs such as *Achillea millefolium*, *Apocynum androsaemifolium*, *Brodiaea coronaria* ssp. *coronaria*, *Camassia quamash* ssp. *azurea* or ssp. *maxima*, *Campanula rotundifolia*, *Eriophyllum lanatum* var. *leucophyllum*, *Fragaria virginiana*, *Fritillaria affinis* var. *affinis*, *Hieracium cynoglossoides*, *Lomatium utriculatum*, *Lotus micranthus*, *Microseris laciniata*, *Prunella vulgaris* ssp. *lanceolata*, *Ranunculus occidentalis* var. *occidentalis*, *Sericocarpus rigidus*, *Viola adunca*, and *Zigadenus venenosus* var. *venenosus* (Dunwiddie et al.

2006). *Elymus trachycaulus*, *E. glaucus*, *Koeleria macrantha*, and *Stipa lemmonii* can be locally important. Savannas with scattered deciduous (*Quercus garryana*) and/or coniferous (*Pseudotsuga menziesii, Pinus ponderosa*) trees are rarely found now, but such savannas historically covered about one-third of the total acreage. Shrubs such as *Symphoricarpos albus*, *Rosa nutkana*, *Toxicodendron diversilobum*, *Amelanchier alnifolia*, and *Arctostaphylos uva-ursi* are common shrubs. Dunwiddie et al. (2006) recorded 278 plant taxa within the South Puget Sound prairies. Of these, 164 (59%) were native species, while 111 (40%) were non-native and four (~1%) were of uncertain origin. Forbs comprised a majority of the species (74%) while graminoids (17%), shrubs (8%), and trees (2%) were of less importance (Dunwiddie et al. 2006). Most of the native forbs were perennial (70%) while most of the nonnative forbs were annuals and biennials. The majority of graminoids were perennial, whether native (94%) or nonnative (67%) (Dunwiddie et al. 2006). In many extant prairies, moss (e.g., *Racomitrium canescens*) and lichen (*Cladina mitis*)cover is high between bunchgrasses, however some researchers postulate that more frequent fires would have resulted in less moss and lichen cover and a higher cover and diversity of native annual species (Dunwiddie et al. 2006).

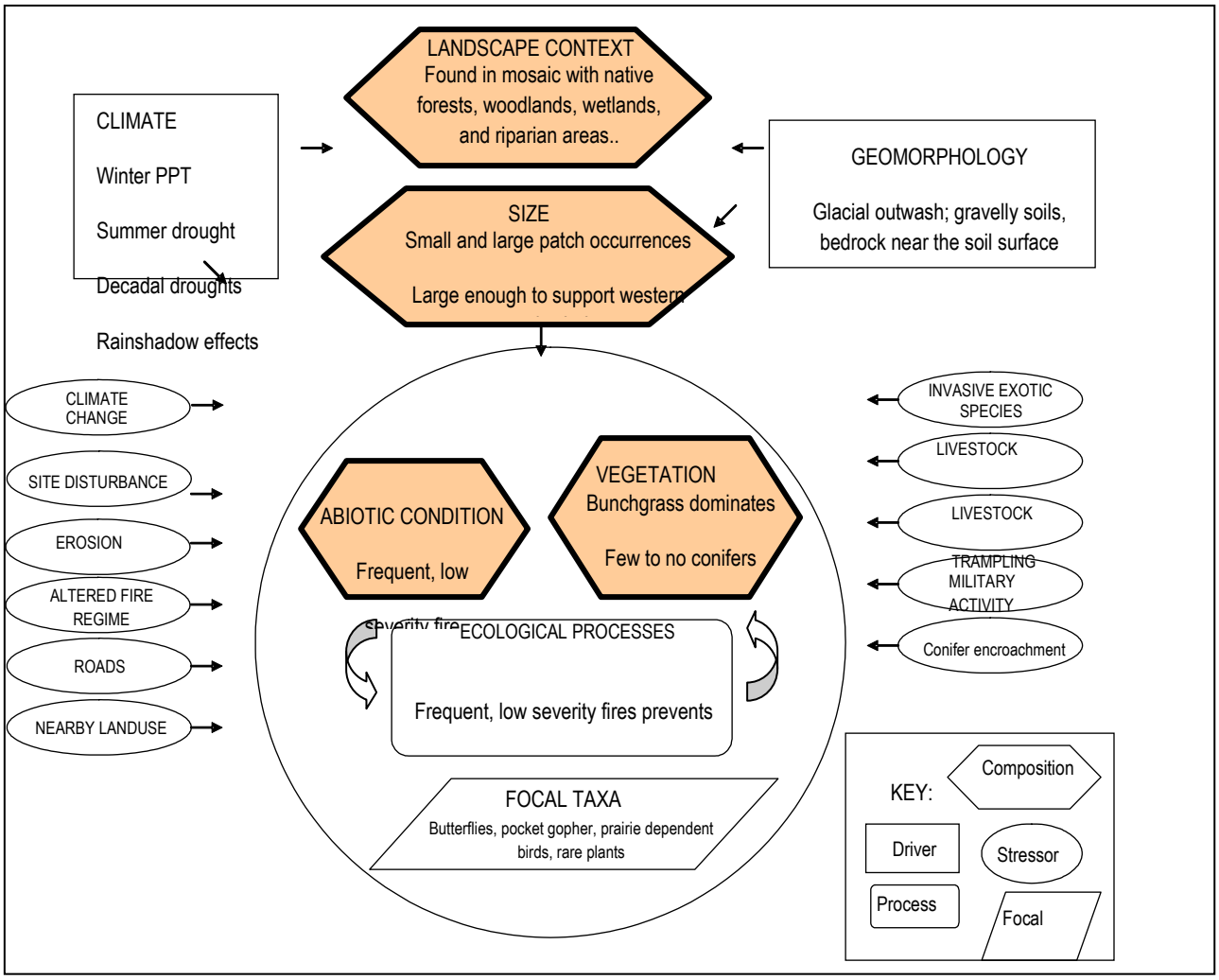
Stressors

The stressors described below are those primarily associated with the loss of extent and degradation of the ecological integrity of existing occurrences. The stressors are the cause of the system shifting away from its natural range of variability. In other words, type, intensity, and duration of these stressors is what moves a system's ecological integrity rank away from the expected, natural condition (e.g. A rank) toward degraded integrity ranks (i.e. B, C, or D).

The exclusion of fire from most of this system over the last 100+ years has resulted in profound changes. Oak savanna has, for all practical purposes, disappeared from the landscape. *Pseudotsuga menziesii* encroachment, in the absence of fire, is a "natural" process that occurs eventually on the vast majority of upland prairie, except perhaps on the very driest sites. This encroachment leads to the conversion of prairies and savannas to forests. Fire exclusion has also resulted in increases in shrub cover and the conversion of some prairies to shrublands. Nonnative species such as *Cytisus scoparium*, *Hypericum perforatum*, *Hypochaeris radicata*, *Holcus lanatus*, *Chrysanthemum leucanthemum*, *Agrostis capillaris*, *Anthoxanthum odoratum*, *Poa pratensis*, *Arrhenatherum elatius*, *Taeniatherum caput-medusae*, *Festuca arundinacea*, *Hieracium pilosella*, *Potentilla recta*, *Centaurea* spp., and *Bromus mollis* are prominent in this habitat and generally increase after ground-disturbing activities like grazing or off-road vehicle use. The dominant native grass, *Festuca roemeri*, can be eliminated with heavy grazing. Prescribed fire and other management tools have been used recently to control *Cytisus scoparium*, *Pseudotsuga menziesii* encroachment, and to attempt to mimic historical conditions in some areas.

Conceptual Ecological Model

The general relationships among the key ecological attributes associated with natural range of variability of the Willamette Valley Upland Prairie and Savanna system are presented in **Error! eference source not found.**.



Generalized Conceptual Ecological Model for Willamette Valley Upland Prairie and Savanna Ecological System.

Ecological Integrity Assessments

The assessment of ecological integrity can be done at three levels of intensity depending on the purpose and design of the data collection effort. The three-level approach is intended to provide increasing accuracy of ecological integrity assessment, recognizing that not all conservation and management decisions need equal levels of accuracy. The three-level approach also allows users to choose their assessment based in part on the level of classification that is available or targeted. If classification is limited to the level of forests vs. wetlands vs. grasslands, the use of remote sensing metrics may be sufficient. If very specific, fine-scale forest, wetland, and grassland types are the classification target then one has the flexibility to decide to use any of the three levels, depending on the need of the assessment. In other words, there is no presumption that a fine-level of classification requires a fine-level of ecological integrity assessment.

Because the purpose is the same for all three levels of assessment (to measure the status of ecological integrity of a site) it is important that the Level 1 assessment use the same kinds of metrics and major attributes as used at Levels 2 and 3. Level 1 assessments rely almost entirely on Geographic Information Systems (GIS) and remote sensing data to obtain information about landscape integrity and the distribution and abundance of ecological types in the landscape or watershed. Level 2 assessments use relatively rapid field-based metrics that are a combination of qualitative and narrative-based rating with quantitative or semi-quantitative ratings. Field observations are required for many metrics, and observations will typically require professional expertise and judgment. Level 3 assessments require more rigorous, intensive field-based methods and metrics that provide higher-resolution information on the integrity of occurrences. They often use quantitative, plot-based protocols coupled with a sampling design to provide data for detailed metrics.

Although the three levels can be integrated into a monitoring framework, each level is developed as a stand-alone method for assessing ecological integrity. **When conducting an ecological integrity assessment, one need only complete a single level that is appropriate to the study at hand.** Typically only one level may be needed, desirable, or cost effective. But for this reason it is very important that each level provide a comparable approach to assessing integrity, else the ratings and ranks will not achieve comparable information if multiple levels are used.

Level 1 EIA

A generalized Level 1 EIA is provided in Rocchio and Crawford (2009). Please refer to that document for the list of metrics applicable to this ecological system. For the Level 1 Fire Condition Class metric, please use the metric ratings for that same metric found below in the Level 2 EIA.

Level 2 EIA

The following table displays the metrics chosen to measure most of the key ecological attributes in the conceptual ecological model above. The EIA is used to assess the ecological condition of an assessment area, which may be the same as the element occurrence or a subset of that occurrence based on abrupt changes in condition or on artificial boundaries such as management areas. **Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference between the two is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings.** To calculate ranks, each metric is ranked in the field according the ranking categories listed below. Then, the rank and point total for each metric is entered into the EIA Scorecard and multiplied by the weight factor associated with each metric resulting in a metric 'score'. Metric scores within a key ecological attribute are then summed to arrive at a score (or rank). These are then tallied in the same way to arrive at an overall ecological integrity score.

Willamette Valley Upland Prairie and Savanna Ecological Integrity Assessment Scorecard

Metric	Justification	Rank			
		A (5 pts.)	B (4 pts.)	C (3 pts.)	D (1 pts.)
Rank Factor: LANDSCAPE CONTEXT					
Key Ecological Attribute: *Edge Effects*					
Edge Length	The intactness of the edge can be important to biotic and abiotic aspects of the site.	75 – 100% of edge is bordered by natural communities	50 – 74% of edge is bordered by natural communities	25 – 49% of edge is bordered by natural communities	< 25% of edge is bordered by natural communities
Edge Width		Average width of edge is at least 100 m.	Average width of edge is at least 75-100 m.	Average width of edge is at least 25-75 m.	Average width of edge is at least <25 m.
Edge Condition		>95% cover native vegetation, <5% cover of non-native plants, intact soils	75–95% cover of native vegetation, 5–25% cover of non-native plants, intact or moderately disrupted soils	25–50% cover of non-native plants, moderate or extensive soil disruption	>50% cover of non-native plants, barren ground, highly compacted or otherwise disrupted soils

Key Ecological Attribute: ***Landscape Structure***					
Connectivity	Intact areas have a continuous corridor of natural or semi-natural vegetation between shrub steppe areas	Intact: Embedded in 90-100% natural habitat; connectivity is expected to be high.	Variegated: Embedded in 60-90% natural or semi-habitat; habitat connectivity is generally high, but lower for species sensitive to habitat modification;	Fragmented: Embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape.	Relictual: Embedded in < 20% natural or semi-natural habitat; connectivity is essentially absent
Landscape Condition Model Index	The intensity and types of land uses in the surrounding landscape can affect ecological integrity.	Landscape Condition Model Index >.8		Landscape Condition Model Index 0.75 – 0.5	Landscape Condition Model Index < 0.5
Rank Factor: CONDITION					
Key Ecological Attribute: ***Vegetation Composition***					
Cover Native Plant Species	Native species in shrub and herbaceous layers; non-natives increase with human impacts.	Native species total cover >95% and dominate all physiognomic layers;	Native species total cover > 90	Native species total cover 40 to 90%.	Native species total cover < 40%; nonnative species dominate.
Douglas-fir encroachment (Chappell 2000; Chappell 2004)	The amount of encroachment by *Pseudotsuga menziesii* is an indication of the integrity of the fire regime.	*Pseudotsuga menziesii,* if present, consists of widely scattered large, old trees.	Douglas-fir at densities of <4 individuals/acre regardless of size.	Douglas-fir numerous as seedlings/saplings/small trees.	Douglas-fir numerous as seedlings/saplings/small trees and >25% cover.

Cover of Ground Mosses and Lichens	Without frequent fire, moss (e.g., *Racomitrium canescens*) and especially lichen (e.g., *Cladina mitis*) increase and crowd out native species. *These are BPJ estimates*	Total cover <25%	Total cover 25-40%		Total cover >40-%
Cover of Native Increasers	Some stressors such as grazing can shift or homogenize native composition toward species tolerant of stressors. (i.e., *Carex inops*, *Lupinus* spp.,	<10% cover	10-20% cover	20-50%	>50% cover
Shrub Cover (DW-SPS CAP) Measured in area being managed for prairie	Shrub cover outside of NRV can indicate past disturbance such as grazing or fire suppression. *Symphoricarpos albus, Toxicodendron diversiloba, Rosa nutkana*	None or minimal cover (<1%).	Present and <10% cover.	<10-25%	>25%
Cover of Scotch broom (*Cytisus scoparius*)	This invasive shrub displaces native species and is very aggressive. Early detection is critical	None or minimal (<1%) present.	Present, but sporadic (<5% cover).	Prevalent (5–25% cover).	Abundant > 25% cover
Cover of Invasive Herbaceous Species	Invasive species can inflict a wide range of ecological impacts. Early detection is critical. Examples include *Arrhenatherum elatius*, *Holcus lanatus*, *Agrostis capillaris*, *Chrysanthemum leucanthemum*.	None or minimal (<1%) present.	Invasive species present, but sporadic (<5% cover).	Invasive species prevalent (5–30% absolute cover).	Invasive species abundant (>30% absolute cover).

Richness of Prairie Associated Plant Species (Alverson 2009a; Chappell 2000)	The overall composition of native species can shift when exposed to stressors. This metric measures the presence of those species with strong fidelity to prairies. Refer to fidelity list below.	>15 species with high fidelity of prairies	10-15 species with high fidelity of prairies	5-10 species with high fidelity of prairies	<5 species with high fidelity of prairies
Key Ecological Attribute: *Physicochemical*					
Soil Surface Condition	Soil disturbance can result in erosion thereby negatively affecting many ecological processes	Bare soil areas are limited to naturally caused disturbances such as flood deposition or game trails	Some bare soil due to human causes but the extent and impact is minimal. The depth of disturbance is limited to only a few inches and does not show evidence of ponding or channeling water.	Bare soil areas due to human causes are common. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts.	Bare soil areas substantially & contribute to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Water will be channeled or ponded.
Rank Factor: SIZE					
Key Ecological Attribute: *Size*					
Relative Size	Indicates the proportion lost due to stressors such as complete fire suppression (conversion to a new system), development, roads, etc.	Site is at or minimally reduced from natural extent (>95% remains)	Occurrence is only modestly reduced from its original natural extent (80-95% remains)	Occurrence is substantially reduced from its original natural extent (50-80% remains)	Occurrence is severely reduced from its original natural extent (<50% remains)

Absolute Size	Absolute size may be important for buffering impacts originating in the surrounding landscape.	Very large (>500 ac/200 ha) Large enough to support a population of western meadowlarks (Chappell 2000)	Large (100-500 ac/40-200 ha)	Moderate (20-100 ac/8-40 ha) Large enough to manage with a prescribed fire rotation. Size still large enough for many species (Chappell 2000)	Small (<20 ac/8 ha)

Level 3 EIA

Level 3 metrics would include more quantitative measures of the metrics listed above. In addition, further consideration might be given to:

- presence/absence of wildlife species of concern such as Western Meadowlarks, Streaked Horned Larks, pocket gophers, and prairie-associated invertebrates (e.g., Mardon Skipper, Puget Blue, Taylor's Checkerspot, Zerene fritillary, Obscure elfin, Oregon branded skipper, Puget Sound fritillary, Valley silverspot, Propertius duskywing)
- species composition of lichens and bryophytes.
- Alverson (2009a) has suggested metrics for 1 m^2 quadrats.

Triggers or Management Assessment Points

Ecological triggers or conditions under which management activities need to be reassessed are show in the table below. Since the Ecological Integrity rankings are based on hypothesized thresholds, they are used to indicate where triggers might occur. Specific details about how these triggers translate for each metric can be found by referencing the values or descriptions for the appropriate rank provided in the Tables above.

Triggers for Level 2 & 3 EIA

Key Ecological Attribute or Metric	Trigger	Action
Any metric (except Connectivity or LCM)	▪ C rank ▪ Shift from A to B rank ▪ negative trend within the B rating (Level 3)	Level 2 triggers: conduct Level 3 assessment; make appropriate short-term management changes to ensure no further degradation Level 3 triggers: make appropriate management adjustments to ensure no additional degradation occurs. Continue monitoring using Level 3.
Any Key Ecological Attribute	▪ any metric has a C rank ▪ > than ½ of all metrics are ranked B ▪ negative trend within the B rating (Level 3)	Level 2 triggers: conduct Level 3 assessment; make appropriate short-term management changes to ensure no further degradation Level 3 triggers: make appropriate management adjustments to ensure

		no additional degradation occurs. Continue monitoring using Level 3.

Protocol for Integrating Metric Ranks

If desired, the user may wish to integrate the ratings of the individual metrics and produce an overall score for the three rank factor categories: (1) Landscape Context; (2) Condition; and (3) Size. These rank factor rankings can then be combined into an Overall Ecological Integrity Rank. This enables one to report scores or ranks from the various hierarchical scales of the assessment depending on which best meets the user's objectives. Please see Table 5 in Rocchio and Crawford (2009) for specifics about the protocol for integrating or 'rolling-up' metric ratings.

List of Native Species with High Fidelity to Willamette Valley Upland Prairie and Savanna (from Chappell et al. 2004 and Alverson 2009b)

SPECIES	FAMILY	COMMON NAME	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley
Achnatherum lemmonii (Vasey) Barkworth ssp. lemmonii	Poaceae	Lemmon's needlegrass	1	1		1
Agoseris elata (Nuttall) Greene	Asteraceae	Tall Agoseris	1	1	1	1
Agoseris grandiflora (Nuttall) Greene	Asteraceae	large flowered agoseris	1	1	1	1
Agoseris heterophylla (Nuttall) Greene ssp. heterophylla	Asteraceae	annual agoseris	1	1	1	1
Agrostis diegoensis Vasey	Poaceae		1	1	1	1
Agrostis microphylla Steud.	Poaceae	awned spike bentgrass	1	1	1	1
Allium acuminatum Hook.	Liliaceae	tapertip onion	1	1	1	1
Allium amplectens Torr.	Liliaceae	narrowleaf wild onion	1	1	1	1
Allium cernuum Roth var. obtusum Cockerell	Liliaceae		1	1	1	1
Amsinckia menziesii (Lehm.) A. Nels. & J.F. Macbr.	Boraginaceae	rancher's fiddleneck	1	1	1	?
Arabis hirsuta (L.) Scop. var. eschscholtziana (Andrz.) Rollins	Brassicaceae	hairy rockcress	1	1	1	1
Athysanus pusillus (Hook.) Greene	Brassicaceae	sandweed	1	1	1	1
Balsamorhiza deltoidea Nuttall	Asteraceae	deltoid balsamroot	1	1	1	1
Brodiaea coronaria (Salisb.) Engl. ssp. coronaria	Liliaceae	harvest brodiaea	1	1	1	1
Bromus carinatus Hook. & Arn.	Poaceae	California brome	1	1	1	1
Calochortus tolmiei Hook. & Arn.	Liliaceae	Tolmie's cat's ear	1	?	1	1

SPECIES	FAMILY	COMMON NAME	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley
Camassia leichtlinii (Baker) S. Watson ssp. suksdorfii (Greenm.) Gould	Liliaceae	large camas	1	1	1	1
Camassia quamash (Pursh) Greene ssp. maxima Gould	Liliaceae	small camas	1	1	1	1
Campanula rotundifolia L.	Campanulaceae	Scots harebell	1	1	1	1
Carex aurea Nuttall	Cyperaceae	golden fruited sedge	1	1		1
Carex densa (L.H. Bailey) L.H. Bailey	Cyperaceae	dense sedge	1	?	1	1
Carex inops L.H. Bailey ssp. inops	Cyperaceae	long stolon sedge	1	1	1	1
Carex rossii W. Boott	Cyperaceae	Ross' sedge	1	1	1	1
Carex tumulicola Mack.	Cyperaceae	foothill sedge	1	1	1	1
Castilleja attenuata (A. Gray) T.I. Chuang & Heckard	Scrophulariaceae	narrow leaved paintbrush	1	1	1	1
Castilleja hispida Benth. ssp. hispida	Scrophulariaceae	harsh paintbrush	1	1	1	1
Castilleja levisecta Greenm.	Scrophulariaceae	Golden Paintbrush	1	1	1	1
Centaurium muehlenbergii (Griseb.) W. Wight ex Piper	Gentianaceae	Muehlenberg's centaury	1	1	1	1
Cerastium arvense L. ssp. strictum (L.) Ugborogho	Caryophyllaceae	field chickweed	1	1	1	1
Cirsium remotifolium (Hook.) DC.	Asteraceae		1	?	1	1
Clarkia amoena (Lehm.) A. Nelson & J.F. Macbr. var. caurina (Abrams) C.L. Hitchc.	Onagraceae	farewell to spring	1	1		1
Clarkia amoena (Lehm.) A. Nelson & J.F. Macbr. var. lindleyi	Onagraceae	farewell to spring	1	1	1	1

SPECIES	FAMILY	COMMON NAME	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley
(Dougl.) C.L. Hitchc.						
Clarkia gracilis (Piper) A. Nelson & J.F. Macbr. ssp. gracilis	Onagraceae	slender godetia	1	?	1	1
Clarkia purpurea (Curtis) A. Nelson & J.F. Macbr. ssp. quadrivulnera (Douglas ex Hook.) F.H. Lewis & M.R. Lewis	Onagraceae	purple godetia	1	1	1	1
Clarkia viminea (Douglas ex Hook.) A. Nelson & J.F. Macbr.	Onagraceae	large godetia	1	1		1
Claytonia rubra (Howell) Tidestr. ssp. rubra	Portulacaceae	redstem miner's lettuce	1	1	1	1
Collinsia grandiflora Lindl.	Scrophulariaceae	large flowered blue-eyed Mary	1	1	1	1
Collinsia parviflora Lindl.	Scrophulariaceae	small flowered blue-eyed Mary	1	1	1	1
Comandra umbellata (L.) Nuttall var. californica (Eastw.) C.L. Hitchc.	Santalaceae	bastard toadflax	1	1	?	1
Crocidium multicaule Hook.	Asteraceae	spring gold	1	1	1	1
Cryptantha intermedia (A. Gray) Greene var. grandiflora (Rydb.) Cronq.	Boraginaceae	common cryptantha	1	1	1	1
Danthonia californica Bolander var. americana (Scribner) A.S. Hitchc.	Poaceae	Umbrella Plant	1	1	1	1
Danthonia spicata (L.) Beauv. var. pinetorum Piper	Poaceae	common wild oatgrass	1	1	1	1
Daucus pusillus Michaux	Apiaceae	rattlesnake weed	1	1	1	1
Delphinium menziesii DC.	Ranunculaceae	Menzies' larkspur	1	1	1	1

SPECIES	FAMILY	COMMON NAME	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley
Deschampsia danthonioides (Trin.) Munro	Poaceae	annual hairgrass	1	1	1	1
Dichelostemma congestum (Sm.) Kunth	Liliaceae	ookow	1	1	1	1
Dodecatheon hendersonii A. Gray ssp. hendersonii	Primulaceae	Henderson's shooting star	1	1	1	1
Dodecatheon pulchellum (Raf.) Merr. ssp. macrocarpum (A. Gray) Roy Taylor & MacBryde	Primulaceae		1	1	1	1
Downingia elegans (Douglas ex Lindl.) Torr. var. elegans	Campanulaceae	elegant downingia	1	?	1	1
Downingia yina Applegate	Campanulaceae	Willamette downingia	1	?	1	1
Dryopteris arguta (Kaulf.) Maxon	Dryopteridaceae	coastal shield fern	1	1	1	1
Elymus trachycaulus (Link) Gould ex Shinners ssp. trachycaulus	Poaceae	bearded wheatgrass	1	1	1	1
Epilobium densiflorum (Lindl.) P.C. Hoch & P.H. Raven	Onagraceae	close flowered boisduvalia	1	1	1	1
Epilobium torreyi (S. Watson) P.C. Hoch & P.H. Raven	Onagraceae	Torrey's willowherb	1	1	1	1
Erigeron speciosus (Lindl.) DC. var. speciosus	Asteraceae	showy daisy	1	1	1	1
Eriophyllum lanatum (Pursh) J. Forbes var. leucophyllum (DC) W.R. Carter)	Asteraceae	Oregon sunshine	1	1	1	1
Festuca roemeri Y.V. Alexeev	Poaceae	Roemer's fescue	1	1	1	1
Fragaria virginiana Duchesne var. platypetala (Rydb.) H.M. Hall	Rosaceae	prairie strawberry	1	1	1	1
Fritillaria affinis (Schult.) Sealy var. affinis	Liliaceae	chocolate lily	1	1	1	1
Gaillardia aristata Pursh	Asteraceae	Great Blanket-flower	1	1	1	1

SPECIES	FAMILY	COMMON NAME	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley
Galium boreale L.	Rubiaceae		1	1	1	1
Githopsis specularioides Nuttall	Campanulaceae	bluecup	1	1	1	1
Grindelia integrifolia DC var. integrifolia	Asteraceae	Willamette Valley gumweed	1	1		1
Heterocodon rariflorum Nuttall	Campanulaceae	western pearlflower	1	1	1	1
Hieracium cynoglossoides Arv.-Touv.	Asteraceae		1	1	1	
Hieracium scouleri Hook. var. scouleri	Asteraceae	Scouler's hawkweed	1	1	1	1
Idahoa scapigera (Hook.) A. Nels. & J.F. Macbr.	Brassicaceae	flatpod	1	1		1
Isoetes nuttallii A. Br.	Isoetaceae	Nuttall's quillwort	1	1	1	1
Koeleria macrantha (Ledeb.) Schult.	Poaceae	junegrass	1	1	1	1
Lasthenia glaberrima DC.	Asteraceae	smooth goldfields	1	1		1
Ligusticum apiifolium (Nuttall) A. Gray	Apiaceae	celery leaved lovage	1	?	1	1
Linanthus bicolor (Nuttall) Greene ssp. bicolor	Polemoniaceae	bicolored linanthus	1	?	1	1
Lithophragma parviflorum (Hook.) Nuttall var. parviflorum	Saxifragaceae	small flowered woodland star	1	1	1	1
Lomatium dissectum (Nuttall) Mathias & Constance var. dissectum	Apiaceae	fern leaved lomatium	1	1	1	1
Lomatium nudicaule (Pursh) J.M. Coult. & Rose	Apiaceae	barestem lomatium	1	1	1	1
Lomatium triternatum (Pursh) J.M. Coult. & Rose var. triternatum	Apiaceae	nineleaf lomatium	1	1	1	1

SPECIES	FAMILY	COMMON NAME	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley
Lomatium utriculatum (Nuttall) J.M. Coult. & Rose	Apiaceae	spring gold	1	1	1	1
Lotus formosissimus Greene	Fabaceae	bicolored lotus	1	1	?	1
Lotus pinnatus Hook.	Fabaceae	bog lotus	1	1	1	1
Lupinus arbustus Douglas ex Lindl. var. arbustus	Fabaceae	spurred lupine	1		1	1
Lupinus lepidus Douglas ex Lindl. var. lepidus	Fabaceae	prairie lupine	1	1	1	1
Lupinus sulphureus Douglas ex Hook. ssp. kincaidii (C.P. Sm.) C.L. Hitchc.	Fabaceae	Kincaid's lupine	1	1		1
Madia exigua (Sm.) A. Gray	Asteraceae	threadstem tarweed	1	1	1	1
Madia glomerata Hook.	Asteraceae	mountain tarweed	1	1	?	1
Madia gracilis (Sm.) D.D. Keck	Asteraceae	slender tarweed	1	1	1	1
Madia minima (A. Gray) D.D. Keck	Asteraceae		1	1	1	
Meconella oregana Nuttall	Papaveraceae	White Meconella	1	1	1	1
Microseris laciniata (Hook.) Sch. Bip. ssp. laciniata	Asteraceae	cutleaf microseris	1	1	1	1
Minuartia tenella (Nuttall) Mattf.	Caryophyllaceae	slender sandwort	1	1	1	1
Montia dichotoma (Nuttall) Howell	Portulacaceae	dwarf montia	1	1	1	1
Navarretia intertexta (Benth.) Hook. ssp. intertexta	Polemoniaceae	needle leaved navarretia	1	1	1	1
Nuttallanthus texanus (Scheele) D.A. Sutton	Scrophulariaceae	blue toadflax	1	1	1	1
Orobanche fasciculata Nuttall	Orobanchaceae	clustered broomrape	1	1	1	1

SPECIES	FAMILY	COMMON NAME	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley
Orobanche uniflora L. var. occidentalis (Greene) Taylor & MacBryde	Orobanchaceae	small flowered naked broomrape	1	1	1	1
Orthocarpus bracteosus Benth.	Scrophulariaceae	rosy owlclover	1	1	1	1
Panicum acuminatum Sw. ssp. fasciculatum (Torr.) Freckman & Lelong	Poaceae	western witchgrass	1	?	1	1
Panicum oligosanthes Schult. var. scribnerianum (Nash) Fern.	Poaceae	Scribner's rosette grass	1	1	1	1
Pentagramma triangularis (Kaulf.) Yatsk., Windham, E. Wollenw. ssp. triangularis	Pteridaceae	gold back fern	1	1	1	1
Perideridia montana (Blank.) Dorn	Apiaceae	mountain yampah	1	1	1	1
Phacelia linearis (Pursh) Holz.	Hydrophyllaceae	narrow leaved phacelia	1	1	1	1
Phlox gracilis (Hook.) Greene ssp. gracilis	Polemoniaceae	pink annual phlox	1	1	1	1
Pinus ponderosa Douglas ex C. Lawson var. ponderosa	Pinaceae	ponderosa pine	1	?	1	1
Piperia transversa Suksdorf	Orchidaceae	Suksdorf's rein orchid	1	1	1	
Plagiobothrys figuratus (Piper) I.M. Johnst. ssp. figuratus	Boraginaceae	fragrant popcorn flower	1	1	1	1
Plectritis congesta (Lindl.) DC. var. congesta	Valerianaceae	rosy plectritis	1	1	1	1
Poa scabrella (Thurb.) Benth	Poaceae	pine bluegrass	1	1	1	1
Polygonum bistortoides Pursh	Polygonaceae	western bistort	1	?	1	1
Polygonum douglasii Greene var. douglasii	Polygonaceae	Douglas' knotweed	1	1	1	1

SPECIES	FAMILY	COMMON NAME	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley
Polygonum spergulariaeforme Meisn.	Polygonaceae	fall knotweed	1	1	1	1
Potentilla glandulosa Lindl. var. glandulosa	Rosaceae	sticky cinquefoil	1	1	1	1

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February 22, 2010

Willamette Valley Wet Prairie

Ecological Summary

This is a small patch, wet meadow system largely restricted to the Willamette Valley of Oregon and parts of western Washington. In Washington, this system was historically mostly found in the South Puget Sound area where it occurred in areas with seasonally high water tables (e.g., local depressions, swales and low gradient riparian areas) within the matrix of a fire-maintained prairie landscape. Given their location within a fire-maintained, open grassland landscape, these

wet prairies experienced periodic fire, which is what distinguishes them from similar wetland types found elsewhere in western Washington and Oregon.

Within Washington, these wet prairies are found in two geographic areas: South Puget Sound and southwest Washington (i.e., Clark and Lewis County). The wet prairies of southwest Washington and the Willamette Valley of Oregon (hereafter referred to as 'Willamette Valley wet prairies') are often perched on clay-rich soils and historically covered large areas. The South Puget Sound wet prairies differ in that they are associated with permeable glacial outwash and thus are restricted to swales and riparian areas where surface topography intersects local groundwater tables and in other areas with local aquitards. The aquitards are likely the result of overflow deposition or temporary impoundment of glacial melt-water (Easterly et al. 2005). Aquitards may have also formed from lahars or volcanic ash (Easterly et al. 2005). In addition to having different soil characteristics, the South Puget Sound wet prairies were much more localized than Willamette Valley wet prairies.

The wet prairies in the South Puget Sound have been drastically reduced in extent and remaining wet prairies are so disturbed that the original composition, diversity and structure of the vegetation are largely unknown (Easterly et al. 2005). However, the South Puget Sound wet prairies are thought to be floristically similar to the Willamette Valley, of which more natural remnants remain. Based on the composition of the Willamette Valley wet prairies, it is thought that the South Puget Sound Prairie wet prairies were 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*). Chappell et al. (2004) compiled a list of species known from prairies in the Willamette Valley, Puget Trough and Georgia Basin ecoregion. This list has been maintained an updated by Alverson (2009b) and indicates 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.

This system was productive and likely dynamic due to frequency of fire. Vegetation composition may have changed rapidly between fires. Without frequent fires, woody species associated with riparian areas would likely have encroached into and dominated narrow wet prairie swales along riparian corridors (Easterly et al. 2005). Areas supporting larger and wider wet prairies, 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 (Easterly et al. 2005). The composition of woody species would likely have included many that are present today, but likely in different proportions. Relatively fire-tolerant trees like *Quercus garryana*, *Populus tremuloides* and probably *P. balsamifera* ssp. *trichocarpa,* would have likely been more abundant than the fire intolerant *Fraxinus latifolia*, which is presumed to have increased since European settlement (Easterly et al. 2005). Shrubby species likely included *Symphoricarpos albus*, *Crataegus douglasii*, *Rosa nutkana*, *R. pisocarpa*, *Oemleria cerasiformis*, *Amelanchier 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 and *Pteridium aquilinum* may have been aggressive and had significant cover in some sites (Easterly et al. 2005).

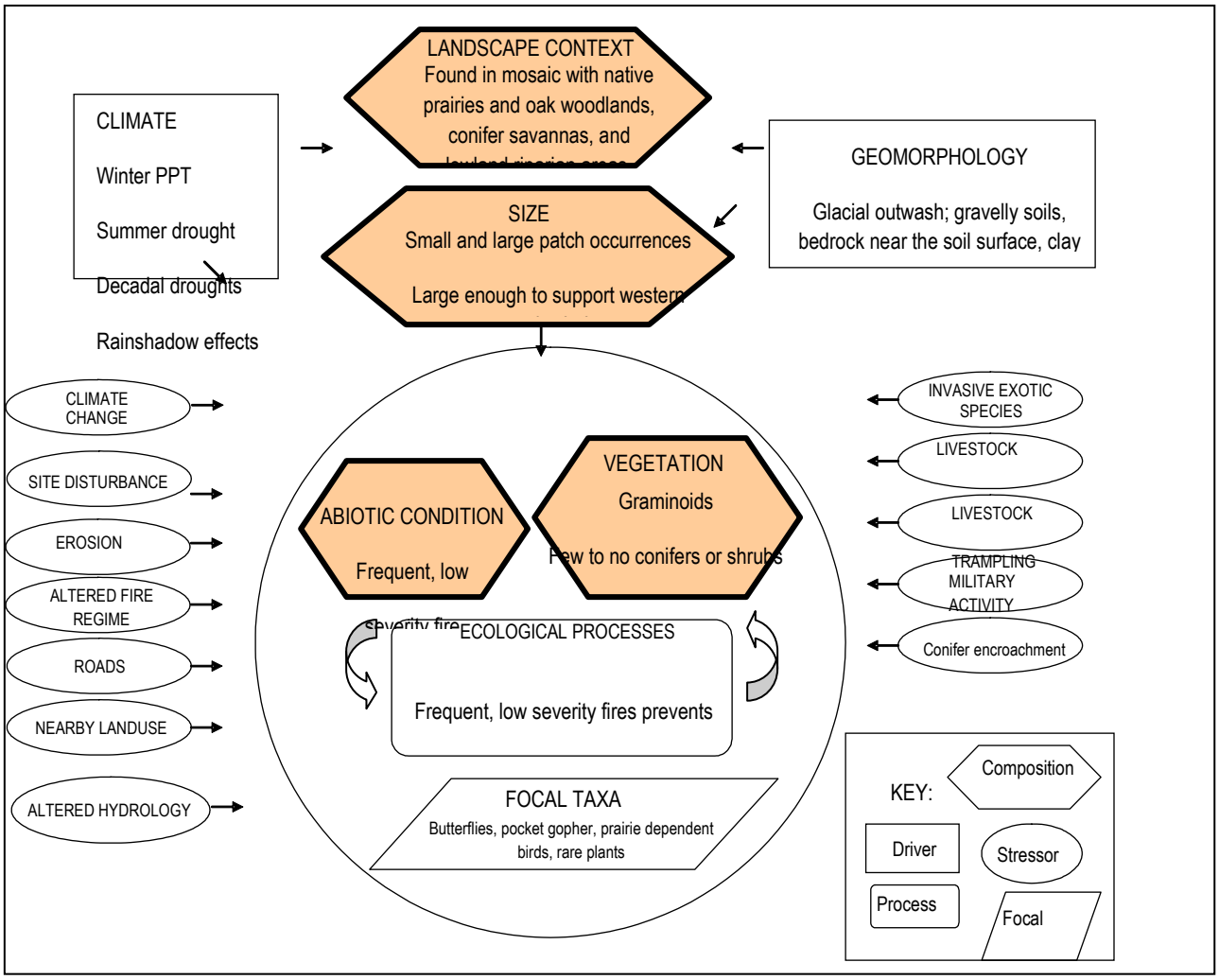
Stressors

The stressors described below are those primarily associated with the loss of extent and degradation of the ecological integrity of existing occurrences. The stressors are the cause of the system shifting away from its natural range of variability. In other words, type, intensity, and duration of these stressors is what moves a system's ecological integrity rank away from the expected, natural condition (e.g. A rank) toward degraded integrity ranks (i.e. B, C, or D).

Wet prairies have been lost and/or degraded due to numerous anthropogenic land uses and activities. Due to their productive nature, many wet prairies were converted to agriculture use, others were overgrazed, and others experienced invasion of woody vegetation due to fire suppression. Many other sites have been altered by draining, roads, and groundwater withdrawal. Due to these impacts, wet prairies have been nearly extirpated in the South Puget Sound region. The hydrologic regime of remaining wet prairie sites has likely been altered by draining and/or recession of the water table (Easterly et al. 2005). Fire suppression, attenuation of salmon runs, and altered hydrology of the current landscape has likely had a profound influence on the ecological processes and dynamics, such as nutrient cycling and successional status, of remaining wet prairie sites (Easterly et al. 2005).

Conceptual Ecological Model

The general relationships among the key ecological attributes associated with natural range of variability of the Willamette Valley Wet Prairie system are presented below.



Generalized Conceptual Ecological Model for Willamette Valley Wet Prairie Ecological System.

Ecological Integrity Assessments

The assessment of ecological integrity can be done at three levels of intensity depending on the purpose and design of the data collection effort. The three-level approach is intended to provide increasing accuracy of ecological integrity assessment, recognizing that not all conservation and management decisions need equal levels of accuracy. The three-level approach also allows users to choose their assessment based in part on the level of classification that is available or targeted. If classification is limited to the level of forests vs. wetlands vs. grasslands, the use of remote sensing metrics may be sufficient. If very specific, fine-scale forest, wetland, and grassland types are the classification target then one has the flexibility to decide to use any of the three levels, depending on the need of the assessment. In other words, there is no presumption that a fine-level of classification requires a fine-level of ecological integrity assessment.

Because the purpose is the same for all three levels of assessment (to measure the status of ecological integrity of a site) it is important that the Level 1 assessment use the same kinds of metrics and major attributes as used at Levels 2 and 3. Level 1 assessments rely almost entirely

on Geographic Information Systems (GIS) and remote sensing data to obtain information about landscape integrity and the distribution and abundance of ecological types in the landscape or watershed. Level 2 assessments use relatively rapid field-based metrics that are a combination of qualitative and narrative-based rating with quantitative or semi-quantitative ratings. Field observations are required for many metrics, and observations will typically require professional expertise and judgment. Level 3 assessments require more rigorous, intensive field-based methods and metrics that provide higher-resolution information on the integrity of occurrences. They often use quantitative, plot-based protocols coupled with a sampling design to provide data for detailed metrics.

Although the three levels can be integrated into a monitoring framework, each level is developed as a stand-alone method for assessing ecological integrity. **When conducting an ecological integrity assessment, one need only complete a single level that is appropriate to the study at hand.** Typically only one level may be needed, desirable, or cost effective. But for this reason it is very important that each level provide a comparable approach to assessing integrity, else the ratings and ranks will not achieve comparable information if multiple levels are used.

Level 1 EIA

A generalized Level 1 EIA is provided in Rocchio and Crawford (2009). Please refer to that document for the list of metrics applicable to this ecological system. For the Level 1 Fire Condition Class metric, please use the metric ratings for that same metric found below in the Level 2 EIA.

Level 2 EIA

The following table displays the metrics chosen to measure most of the key ecological attributes in the conceptual ecological model above. The EIA is used to assess the ecological condition of an assessment area, which may be the same as the element occurrence or a subset of that occurrence based on abrupt changes in condition or on artificial boundaries such as management areas. **Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference between the two is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings.** To calculate ranks, each metric is ranked in the field according the ranking categories listed below. Then, the rank and point total for each metric is entered into the EIA Scorecard and multiplied by the weight factor associated with each metric resulting in a metric 'score'. Metric scores within a key ecological attribute are then summed to arrive at a score (or rank). These are then tallied in the same way to arrive at an overall ecological integrity score.

Willamette Valley Wet Prairie Ecological Integrity Assessment Scorecard

Metric	Justification	Rank			
		A (5 pts.)	B (4 pts.)	C (3 pts.)	D (1 pts.)
Rank Factor: LANDSCAPE CONTEXT					
Key Ecological Attribute: *Buffer Effects*					
Buffer Length	The buffer can be important to biotic and abiotic aspects of the wetland as it provides connectivity and provides a 'filter' from exogenous	Buffer is > 75 – 100% of occurrence perimeter.	Buffer is > 50 – 74% of occurrence perimeter.	Buffer is 25 – 49% of occurrence perimeter	Buffer is < 25% of occurrence perimeter.
Buffer Width		Average buffer width of occurrence is > 200 m, adjusted for slope.	Average buffer width is 100 – 199 m, after adjusting for slope.	Average buffer width is 50 – 99 m, after adjusting for slope.	Average buffer width is < 49 m, after adjusting for slope.

Buffer Condition	threats.	Abundant (>95%) cover native vegetation, little or no (<5%) cover of non-native plants, intact soils, AND little or no trash or refuse.	Substantial (75–95%) cover of native vegetation, low (5–25%) cover of non-native plants, intact or moderately disrupted soils; minor intensity of human visitation or recreation.	Moderate (25–50%) cover of non-native plants, moderate or extensive soil disruption; moderate intensity of human visitation or recreation.	Dominant (>50%) cover of non-native plants, barren ground, highly compacted or otherwise disrupted soils, moderate or greater intensity of human visitation or recreation, no buffer at all.
Key Ecological Attribute: *Landscape Structure*					
Connectivity	Intact areas have a continuous corridor of natural or semi-natural vegetation between shrub steppe areas	Intact: Embedded in 90-100% natural habitat; connectivity is expected to be high.	Variegated: Embedded in 60-90% natural or semi-habitat; habitat connectivity is generally high, but lower for species sensitive to habitat modification;	Fragmented: Embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape.	Relictual: Embedded in < 20% natural or semi-natural habitat; connectivity is essentially absent
Landscape Condition Model Index	The intensity and types of land uses in the surrounding landscape can affect ecological integrity.	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.75 – 0.5	Landscape Condition Model Index < 0.5
Rank Factor: CONDITION					
Key Ecological Attribute: *Vegetation Composition*					
Cover Native Plant Species	Native species in shrub and herbaceous layers; non-natives increase with human impacts.	Native species total cover >95% and dominate all physiognomic layers;	Native species total cover > 90	Native species total cover 40 to 90%.	Native species total cover < 40%; nonnative species dominate.

Douglas-fir encroachment (Chappell 2000; Chappell 2004)	The amount of encroachment by *Pseudotsuga menziesii* is an indication of the integrity of the fire regime.	*Pseudotsuga menziesii,* if present, consists of widely scattered large, old trees.	Douglas-fir at densities of <4 individuals/acre regardless of size.	Douglas-fir numerous as seedlings/saplings/small trees.	Douglas-fir numerous as seedlings/saplings/small trees and >25% cover.
Cover of Native Increasers	Some stressors such as grazing can shift or homogenize native composition toward species tolerant of stressors. (i.e., Carex inops)	<10% cover	10-20% cover	20-50%	>50% cover
Shrub Cover	Shrub cover outside of NRV can indicate past disturbance such as grazing or fire suppression. *Symphoricarpos albus*, *Crataegus douglasii*, *Rosa nutkana*, *R. pisocarpa*, *Oemleria cerasiformis*, *Amelanchier alnifolia*, *Spiraea douglasii* and *Salix*	None or minimal cover (<1%).	Present and <10% cover.	<10-25%	>25%
Cover of Invasive Herbaceous Species	Invasive species can inflict a wide range of ecological impacts. Early detection is critical. Examples include *Phalaris arundinacea, Poa pratensis, Elymus repens*.	None or minimal (<1%) present.	Invasive species present, but sporadic (<5% cover).	Invasive species prevalent (5–30% absolute cover).	Invasive species abundant (>30% absolute cover).

Richness of Wet Prairie Associated Plant Species (Alverson 2009a; Chappell 2000)	The overall composition of native species can shift when exposed to stressors. This metric measures the presence of those species with strong fidelity to prairies. Refer to fidelity list below.	>15 species with moderate or high fidelity toward wet prairies	10-15 species with moderate or high fidelity toward wet prairies	5-10 species with moderate or high fidelity toward wet prairies	<5 species with moderate or high fidelity toward wet prairies
Key Ecological Attribute: *Hydrology*					
Water Source	Anthropogenic sources of water can have detrimental effects on the hydrological regime	Source is natural or naturally lacks water in the growing season. No indication of direct artificial water sources	Source is mostly natural, but site directly receives occasional or small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, artificially impounded water, or other artificial hydrology	Water flow has been substantially diminished by human activity
Hydroperiod **(partially from Alverson 2009a)**	Alteration in hydrology or sediment loads or some onsite stressors can degrade channel stability	Hydroperiod of the site is characterized by natural patterns of filling or inundation and drying or drawdown. Soils are generally saturated to the surface during the rainy season.	The filling or inundation patterns in the site are of greater magnitude (and greater or lesser duration than would be expected under natural conditions, but thereafter, the site is subject to natural drawdown or drying.	The filling or inundation patterns in the site are characterized by natural conditions, but thereafter are subject to more rapid or extreme drawdown or drying, as compared to more natural wetlands. OR filling or inundation patterns are of substantially lower magnitude or duration than expected under natural conditions, but thereafter, the site is subject to natural drawdown or drying.	Both the filling/inundation and drawdown/drying of the site deviate from natural conditions (either increased or decreased in magnitude and/or duration). Soils are either never saturated to the surface during the rainy season, or are completely inundated for more than 120 continuous hours (5 days) at least once in a five year period.

Hydrological Connectivity (non-riverine)	Floodwater should have access to the floodplain. Stressors resulting in entrenchment affect hydrological connectivity	Rising water in the site has unrestricted access to adjacent upland, without levees, excessively high banks, artificial barriers, or other obstructions to the lateral movement of flood flows.	Lateral excursion of rising waters is partially restricted by unnatural features, such as levees or excessively high banks, but < than 50% of the site is restricted by barriers to drainage. Restrictions may be intermittent along the site, or the restrictions may occur only along one bank or shore. Flood flows may exceed the obstructions, but drainage back to the wetland is incomplete due to impoundment.	Lateral excursion of rising waters is partially restricted by unnatural features, such as levees or excessively high banks, and 50-90% of the site is restricted by barriers to drainage. Flood flows may exceed the obstructions, but drainage back to the wetland is incomplete due to impoundment.	All water stages in the site are contained within artificial banks, levees, sea walls, or comparable features, or greater than 90% of wetland is restricted by barriers to drainage. There is essentially no hydrologic connection to adjacent uplands.
Key Ecological Attribute: *Physicochemical*					
Soil Surface Condition	Soil disturbance can result in erosion thereby negatively affecting many ecological processes	Bare soil areas are limited to naturally caused disturbances such as flood deposition or game trails	Some bare soil due to human causes but the extent and impact is minimal. The depth of disturbance is limited to only a few inches and does not show evidence of ponding or channeling water.	Bare soil areas due to human causes are common. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts.	Bare soil areas substantially & contribute to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Water will be channeled or ponded.
Water Quality	Excess nutrients, sediments, or other pollutant have an adverse affect on natural water quality	No evidence of degraded water quality. Water is clear; no strong green tint or sheen.	Some negative water quality indicators are present, but limited to small and localized areas. Water may have a minimal greenish tint or cloudiness, or sheen.	Negative indicators or wetland species that respond to high nutrient levels are common. Water may have a moderate greenish tint, sheen or other turbidity with common algae.	Widespread evidence of negative indicators. Algae mats may be extensive. Water may have a strong greenish tint, sheen or turbidity. Bottom difficult to see during due to surface algal mats and other vegetation blocking light to the bottom.
Rank Factor: SIZE					

Key Ecological Attribute: *Size*					
Relative Size	Indicates the proportion lost due to stressors such as complete fire suppression (conversion to a new system), development, roads, etc.	Site is at or minimally reduced from natural extent (>95% remains)	Occurrence is only modestly reduced from its original natural extent (80-95% remains)	Occurrence is substantially reduced from its original natural extent (50-80% remains)	Occurrence is severely reduced from its original natural extent (<50% remains)
Absolute Size	Absolute size may be important for buffering impacts originating in the surrounding landscape.	Very large (>300 ac/120 ha)	Large (100-300 ac/40-120 ha)	Moderate (10-100 ac/4-40 ha)	Small (<10 ac/4 ha)

Level 3 EIA

Level 3 metrics would include more quantitative measures of the metrics listed above. In addition, further consideration might be given to:

- Alverson (2009a) has suggested metrics for 1 m^2 quadrats.
- Nitrogen Enrichment (C:N)
- Phosphorous Enrichment (C:P)
- Soil Organic Carbon
- Soil Bulk Density
- Water Table Depth

Triggers or Management Assessment Points

Ecological triggers or conditions under which management activities need to be reassessed are show in the table below. Since the Ecological Integrity rankings are based on hypothesized thresholds, they are used to indicate where triggers might occur. Specific details about how these triggers translate for each metric can be found by referencing the values or descriptions for the appropriate rank provided in the Tables above.

Triggers for Level 2 & 3 EIA

Key Ecological Attribute or Metric	Trigger	Action
Any metric (except Connectivity or LCM)	▪ C rank ▪ Shift from A to B rank ▪ negative trend within the B rating (Level 3)	Level 2 triggers: conduct Level 3 assessment; make appropriate short-term management changes to ensure no further degradation Level 3 triggers: make appropriate management adjustments to ensure no additional degradation occurs. Continue monitoring using Level 3.
Any Key Ecological Attribute	▪ any metric has a C rank ▪ > than ½ of all metrics are ranked B ▪ negative trend within the B rating (Level 3)	Level 2 triggers: conduct Level 3 assessment; make appropriate short-term management changes to ensure no further degradation Level 3 triggers: make appropriate

		management adjustments to ensure no additional degradation occurs. Continue monitoring using Level 3.

Protocol for Integrating Metric Ranks

If desired, the user may wish to integrate the ratings of the individual metrics and produce an overall score for the three rank factor categories: (1) Landscape Context; (2) Condition; and (3) Size. These rank factor rankings can then be combined into an Overall Ecological Integrity Rank. This enables one to report scores or ranks from the various hierarchical scales of the assessment depending on which best meets the user's objectives. Please see Table 5 in Rocchio and Crawford (2009) for specifics about the protocol for integrating or 'rolling-up' metric ratings.

List of Native Species with Moderate and High Fidelity to Willamette Valley Wet Prairies (from Chappell et al. 2004 and Alverson 2009b)

SPECIES	FAMILY	COMMON NAME	Degree of fidelity to prairie habitats	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley	Occurs in Wet Prairie	Occurs in Vernal Pools or Seeps
Agrostis exarata Trin. var. exarata	Poaceae	spike bentgrass	M	Y	?	Y	Y	Y	Y
Agrostis microphylla Steud.	Poaceae	awned spike bentgrass	H	Y	Y	Y	Y	Y	Y
Alopecurus carolinianus Walt.	Poaceae	Tufted Foxtail	H	Y	Y		Y		Y
Alopecurus geniculatus L. var. geniculatus	Poaceae	water foxtail	M	Y	Y	Y	Y	Y	Y
Alopecurus saccatus Vasey	Poaceae	Pacific foxtail	H	?	Y		Y		Y
Androsace filiformis Retz.	Primulaceae	slender rock-jasmine	H			Y	Y	Y	
Aristida oligantha Michaux	Poaceae	prairie threeawn	H				Y		Y
Asclepias fascicularis Duchesne	Asclepiadaceae	narrowleaf milkweed	H				Y	Y	Y
Beckmannia syzigachne (Steud.) Fernald	Poaceae	sloughgrass	H			Y	Y	Y	Y
Callitriche heterophylla Pursh ssp. bolanderi (Hegelm.) Calder & Taylor	Callitrichaceae	Bolander's water starwort	M	Y		Y	Y		Y
Callitriche marginata Torr.	Callitrichaceae	Winged Water-starwort	M	Y			Y		Y
Calochortus uniflorus Hook. & Arn.	Liliaceae	large flowered startulip	H				Y	Y	
Cardamine penduliflora O.E. Schulz	Brassicaceae	Willamette Valley bittercress	M			?	Y	Y	

SPECIES	FAMILY	COMMON NAME	Degree of fidelity to prairie habitats	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley	Occurs in Wet Prairie	Occurs in Vernal Pools or Seeps
Carex athrostachya Olney	Cyperaceae	slenderbeak sedge	M	Y	Y	Y	Y	Y	
Carex aurea Nuttall	Cyperaceae	golden fruited sedge	H	Y		Y	Y	Y	
Carex cusickii Mack. ex Piper & Beattie	Cyperaceae	Cusick's sedge	M	?	?	?	Y	Y	
Carex densa (L.H. Bailey) L.H. Bailey	Cyperaceae	dense sedge	H	?	Y	Y	Y	Y	Y
Carex feta L.H. Bailey	Cyperaceae	green sheathed sedge	M	Y	?	Y	Y	Y	
Carex scoparia Schkuhr ex Willd. var. scoparia	Cyperaceae	pointed broom sedge	M	Y		Y	Y	Y	
Carex unilateralis Mack.	Cyperaceae	one sided sedge	M	Y	Y	Y	Y	Y	Y
Centunculus minimus L.	Primulaceae	chaffweed	M	Y		Y	Y	Y	Y
Cicendia quadrangularis (Lam.) Griseb.	Gentianaceae	timwort	H				Y	Y	Y
Crassula aquatica (L.) P. Schoenl.	Crassulaceae	water pygmy weed	M	Y	Y	Y	Y		Y
Crassula connata (Ruiz & Pavón) Berger var. connata	Crassulaceae	Sand Pygmyweed	H	Y					Y
Cuscuta pentagona Engelm. var. pentagona	Cuscutaceae	field dodder	M	Y		?	Y	Y	Y
Deschampsia cespitosa (L.) P. Beauv. s.l.	Poaceae	tufted hairgrass	M	Y	Y	Y	Y	Y	Y
Deschampsia danthonioides (Trin.) Munro	Poaceae	annual hairgrass	H	Y	Y	Y	Y	Y	Y
Downingia elegans (Douglas ex Lindl.) Torr. var. elegans	Campanulaceae	elegant downingia	H	?	Y	Y	Y	Y	Y
Downingia yina Applegate	Campanulaceae	Willamette	H	?	Y	Y	Y	Y	Y

SPECIES	FAMILY	COMMON NAME	Degree of fidelity to prairie habitats	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley	Occurs in Wet Prairie	Occurs in Vernal Pools or Seeps
		downingia							
Eleocharis acicularis (L.) Roem. & Schult. var. acicularis	Cyperaceae	needle spikerush	M	?	Y	Y	Y	Y	Y
Eleocharis palustris (L.) Roem. & Schult. var. palustris	Cyperaceae	creeping spikerush	M	?	Y	Y	Y	Y	Y
Epilobium densiflorum (Lindl.) P.C. Hoch & P.H. Raven	Onagraceae	close flowered boisduvalia	H	Y	Y	Y	Y	Y	Y
Epilobium pygmaeum (Speg.) P.C. Hoch & P.H. Raven	Onagraceae	smooth willowherb	H			Y	Y		Y
Equisetum palustre L.	Equisetaceae	marsh horsetail	M				Y	Y	
Eryngium petiolatum Hook.	Apiaceae	coyotethistle	H			Y	Y	Y	Y
Gentiana sceptrum Griseb.	Gentianaceae	king's gentian	M	?		Y	Y	Y	
Glyceria occidentalis (Piper) J.C. Nelson	Poaceae	western mannagrass	M			Y	Y	Y	Y
Gnaphalium palustre Nuttall	Asteraceae	lowland cudweed	M	Y	Y	Y	Y	Y	Y
Gratiola ebracteata Benth.	Scrophulariaceae	bractless hedge hyssop	M	Y	Y	Y	Y	Y	Y
Helenium autumnale L. var. grandiflorum (Nutt). T.&G.	Asteraceae	autumn sneezeweed	M	Y	Y	Y	?	Y	
Juncus confusus Coville	Juncaceae	Colorado rush	H	?	?	?	Y	Y	
Juncus dudleyi Wieg.	Juncaceae	Dudley's rush	M				Y	Y	
Juncus hemiendytus F.J. Herm. var. hemiendytus	Juncaceae	dwarf rush	H			Y	Y		Y

SPECIES	FAMILY	COMMON NAME	Degree of fidelity to prairie habitats	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley	Occurs in Wet Prairie	Occurs in Vernal Pools or Seeps
Juncus nevadensis S. Watson var. nevadensis	Juncaceae	Sierra rush	H			Y	Y	Y	Y
Juncus occidentalis Wieg.	Juncaceae	prairie rush	M	Y	Y	Y	Y	Y	
Lepidium oxycarpum Torr. & Gray	Brassicaceae	Sharp-pod Pepper-grass	H	Y					Y
Limnanthes macounii Trel.	Limnanthaceae	Macoun's meadowfoam	H	Y					Y
Lotus formosissimus Greene	Fabaceae	bicolored lotus	H	Y	?	Y	Y	Y	Y
Lotus pinnatus Hook.	Fabaceae	bog lotus	H	Y	Y	Y	Y	Y	Y
Mentha canadensis L.	Lamiaceae	field mint	M	Y	?	Y	Y	Y	
Mimulus douglasii (Benth.) A. Gray	Scrophulariaceae	Dougla's Monkeyflower	H				Y	Y	Y
Mimulus tricolor Hartw.	Scrophulariaceae	Tricolor Monkeyflower	H				Y		Y
Montia fontana L. var. tenerrima (Gray) Fern. & Wieg.	Portulacaceae	water chickweed	M	Y	Y	Y	Y	Y	Y
Montia linearis (Douglas ex Hook.) Greene	Portulacaceae	narrowleaf montia	M	Y	Y	Y	Y	Y	Y
Myosurus minimus L.	Ranunculaceae	least mousetail	H	Y	Y	Y	Y		Y
Navarretia leucocephala Benth. ssp. leucocephala	Polemoniaceae	white flowered navarretia	H				Y		Y
Navarretia squarrosa (Eschsch.) Hook. & Arn.	Polemoniaceae	skunkweed	M	Y	Y	Y	Y		Y

SPECIES	FAMILY	COMMON NAME	Degree of fidelity to prairie habitats	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley	Occurs in Wet Prairie	Occurs in Vernal Pools or Seeps
Navarretia willamettensis S.C. Spencer	Polemoniaceae	Willamette navarretia	H				Y		Y
Penstemon hesperius Peck	Scrophulariaceae	western penstemon	H			Y		Y	
Physostegia parviflora	Lamiaceae	western false dragonhead	M			Y		Y	
Plagiobothrys figuratus (Piper) I.M. Johnst. ssp. figuratus	Boraginaceae	fragrant popcorn flower	H	Y	Y	Y	Y	Y	Y
Plagiobothrys scouleri (Hook. & Arn.) I.M. Johnst. var. hispidulus (Greene) Dorn	Boraginaceae	sleeping popcornflower	M	?		Y	Y	Y	
Plagiobothrys scouleri (Hook. & Arn.) I.M. Johnst. var. scouleri	Boraginaceae	Scouler's popcorn flower	M	Y	Y	Y	Y	Y	Y
Plantago bigelovii Gray ssp. bigelovii	Plantaginaceae	coastal plantain	H	Y		Y		Y	Y
Polygonum bistortoides Pursh	Polygonaceae	western bistort	H	?	Y	Y	Y	Y	
Polygonum polygaloides ssp. confertiflorum	Polygonaceae	close flowered knotweed	H			Y	Y		Y
Potentilla rivalis Nuttall	Rosaceae	Brook Cinquefoil	H	Y	Y	Y		Y	
Psilocarphus elatior (A. Gray) A. Gray	Asteraceae	tall woollyheads	M	Y	Y	Y	Y	Y	Y
Psilocarphus oregonus Nuttall	Asteraceae	Oregon Woollyheads	M			Y	Y	Y	Y
Pyrrocoma racemosa (Nuttall) Torr. & A. Gray var. racemosa	Asteraceae	racemed goldenweed	H				Y	Y	

SPECIES	FAMILY	COMMON NAME	Degree of fidelity to prairie habitats	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley	Occurs in Wet Prairie	Occurs in Vernal Pools or Seeps
Ranunculus alismifolius Geyer ex Bentham var. alismifolius	Ranunculaceae	plantain leaved buttercup	H	Y	Y	Y	Y	Y	Y
Ranunculus lobbii (Hiern) A. Gray	Ranunculaceae	Lobb's water buttercup	H	Y	?		Y		Y
Ranunculus orthorhynchus Hook. var. orthorhynchus	Ranunculaceae	straightbeak buttercup	H	Y	Y	Y	Y	Y	
Ranunculus orthorhynchus Hook. var. platyphyllus A. Gray	Ranunculaceae	broadleaved buttercup	H	Y		Y	Y	Y	
Rorippa curvisiliqua (Hook.) Bessey ex Britton	Brassicaceae	western yellowcress	M	Y	Y	Y	Y		Y
Rotala ramosior (L.) Koehne	Lythraceae	Toothcup	M		?	Y	Y		Y
Salix piperi Bebb	Salicaceae	Piper's willow	M	?	Y	Y	Y	Y	
Saxifraga oregana Howell var. oregana	Saxifragaceae	Oregon saxifrage	H	?	Y	Y	Y	Y	
Sclerolinon digynum (A. Gray) C.M. Rogers	Linaceae	northwestern yellowflax	H				Y	Y	Y
Sidalcea cusickii Piper	Malvaceae	Cusick's checkermallow	H				Y	Y	
Sidalcea nelsoniana Piper	Malvaceae	Nelson's Sidalcea	H			Y	Y	Y	
Stellaria longipes Goldie ssp. longipes	Caryophyllaceae	longstalk starwort	M	Y	Y	?		Y	
Thalictrum polycarpum (Torr.) S. Watson	Ranunculaceae	tall western meadowrue	M		?	?	Y	Y	

SPECIES	FAMILY	COMMON NAME	Degree of fidelity to prairie habitats	Present in Georgia Basin	Present in Puget Trough	Present in Lower Columbia River	Present in Willamette Valley	Occurs in Wet Prairie	Occurs in Vernal Pools or Seeps
Trichostema oblongum Benth.	Lamiaceae	downy blue curls	H			Y	Y	Y	Y
Veronica peregrina L. var. xalapensis (Kunth) H. St. John & F.A. Warren	Scrophulariaceae	hairy purslane speedwell	M	Y	Y	?	Y	Y	Y
Veronica scutellata L.	Scrophulariaceae	marsh speedwell	M	?	Y	Y	Y	Y	Y
Viola langsdorfii (Regel.) Fisch.	Violaceae	Alaska violet	M	Y				Y	
Viola nephrophylla Greene	Violaceae	northern bog violet	M	Y				Y	

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