Inventory for fens and associated rare plants on Mt. Baker-Snoqualmie National Forest

Looking west over cloud-enshrouded upper portion of the 9020-310 wetland/fen, Snoqualmie Ranger District. Elev. = 3140 ft.

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Berries of the fen-loving, bog huckleberry (*Vaccinium uliginosum*) at Government Meadow. Note the persistent sepals characteristic of this species. Government Meadow is the only project site at which *V. uliginosum* was detected.

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Summary

Sites on Mt. Baker-Snoqualmie NF that were reasonably suspected to include groundwater-fed wetlands (fens) were visited between 8/15-9/28 2006. The intent of these visits was to inventory for rare plants associated with these wetlands, and to record a coarse biophysical description of the setting. Twelve of the 18 sites visited were determined in include notable amounts of fen habitat. Five rare target species and two otherwise notable rare species accounting for eight distinct occurrences/populations at six wetlands were detected during site visits.

Looking SSW over the largest fen/meadow in the 1775 rd. complex. This topographic setting has the look and feel of a basin, but has a low volume, apparently perennial, surface drainage output. Elev. = 3720 ft.

Introduction

This project is part of a series of Forest-level inventories within USFS Region 6 that are focused on better understanding the regional distribution of rare and uncommon fen-loving plants, as well as of the fens/groundwater-fed wetlands which include them. These inventories typically involve several days of pre-field analysis followed by 3-4 weeks of fieldwork by 1-2 persons. To date, the project lead has conducted either focused or opportunistic surveys for fens and fen-loving rare plants on the Deschutes, Ochoco, Fremont-Winema, Malheur, Umatilla, Wallow-Whitman, and Mt. Hood National Forests, and

the Klamath Falls Resource Area of the Lakeview BLM District in Oregon, and Gifford Pinchot, Olympic, Okanogan-Wenatchee and Colville National Forests in Washington.

Fens have been noted to play important roles in water quality maintenance and carbon retention. Fen ecosystems in Oregon and Washington are particularly notable for at least two other reasons. First, these ecosystems are locally either rare or uncommon, tending to be quite small in their individual aerial extent, and are generally very sparsely distributed within the mountains of these two states. For instance, on Deschutes National Forest in central Oregon, which has the likely distinction of being the most thoroughly inventoried and fen-rich forest in Oregon or Washington, the collective acreage of currently known fens is only about 460 acres, a mere 0.03% of the total acreage of the 1.6 million acre forest. Second, and as noted by Bedford and Godwin (2003), in spite of being an extremely tiny spatial component of the regional landscape, fen ecosystems contribute disproportionately to local levels of plant biodiversity, particularly with regard to rare and uncommon plant species. For instance, taxa found in seasonally or persistently groundwater-fed wetlands account for over 20% of rare, threatened and endangered Oregon plant species documented on Deschutes National Forest (Oregon Biodiversity Information Center, 2016). It is likely that fen-loving plant species make similar contributions to local biodiversity on many of the other forests on and east of the Cascade crest in Oregon and Washington. This project was of particular interest to the project lead due to his relatively scant field experience regarding the distribution, character, and floras of groundwater-fed wetlands on west of the Cascade crest in Washington and Oregon.

Looking SE over the 1551 rd. fen/wetland on Mt. Baker District. Wetland occupies a bench along an otherwise steep slope between the 1551 rd. above and Irene Ck., below. Elev. = 3200 ft. *Carex magellanica* ssp. irrigua (CAMA12) and *Carex pauciflora* (CAPA19) were newly detected here.

Objectives

The geographic scope of this project was all four ranger districts of Mt. Baker-Snoqualmie (MBS) National Forest (NF). The intent of this study was to identify a group of sites on these forest lands that were reasonably likely to include fen habitats, and could be visited and examined with preferably no more than 1-2 hours hiking time, each way. Examination was to include development of a list of on-site bryophytes and vascular plants, including sensitive and other notable plant species, and a cursory description of vegetative structure, site wetness and soils, and site condition. It was hoped that this examination would allow at least a tentative recognition of sites as fens as opposed to some other type of wetland or meadow, and allow some type of comparison among fens. "Target species" are species that the project lead was hoping to find, if not reasonably expecting to find within the project area and that 1) have Forest Service Region 6 (R6) status as sensitive (SEN) or strategic (STR) species, or 2) are listed on the Washington Natural Heritage Program (WNHP) Rare Mosses list, or, 3) prior to project initiation, were identified by the project lead as possibly rare in Washington, even if not currently noted as such by WNHP. "Notable species" are essentially target species that the project lead neglected to include in the project proposal.

Carex pauciflora (CAPA19) in fruit at the 1551 rd. fen/wetland, Mt. Baker District.

Methods

During this project the project lead utilized a variety of data sources during the pre-field analysis process. Primary among these was wetland mapping provided by the USF&WS National Wetland Inventory (NWI). Other data sources included site information for selected fen indicator taxa (FIT) extracted from the Consortium of PNW Herbaria (CPNWH) website and Mt. Baker-Snoqualmie NF Natural Resource Manager (NRM) Threatened, Endangered, and Sensitive Plant species database (TESP). The NWI utilizes a very large set of wetland categories. Prior experience with the NWI has allowed the project lead to determine that the PEMB and PEMC categories are most strongly correlated with fens and fen-like ecosystems. A more detailed explanation of these codes is available at http://www.fws.gov/wetlands/data/wetland-codes.html, but briefly, "P" = palustrine, "EM" = emergent, and "B" = substrate saturated to surface for extended periods during the growing season. "C" = seasonally flooded, and "SS" = scrub-shrub. Ultimately, the list of candidate fen and fen-like ecosystems for this project was derived from an initial collection of NWI PEMB and PEMC sites screened for ease of access and promise as assessed by examining NAIP aerial imagery views. Field visits to fen candidate sites usually involved driving, parking, and some amount of trail and/or cross-country hiking. Upon arrival at a site, an effort was made to identify and walk through structurally differentiable plant communities within the site. Typically, the time spent at any site was directly related to the size of the site and the extent and pattern of biophysical diversity within that site. Types of information collected at a site included a plant species list, plant collections, a brief description of site character (vegetation structure, wetness and adjacent topography), soil probes, photographs and GPS coordinates of selected features. Plant species lists were never comprehensive. Known taxa were generally always recorded. Unknown taxa, after consideration of taxon's potential significance in interpreting site conditions, were either collected to provide an opportunity for later identification, simply noted in field notebook, or left for some other, less time-sensitive visit. Field visits to fen candidate sites are best done in late summer or fall, in order to better assess the relative contributions of seasonal surface water vs. persistent, diffusely-discharging groundwater in contributing to wetness at the site. Late summer visits, however, may mean that detection and identification of some plant species will be more difficult because flowering and even fruiting periods have already passed.

Carex flava at headwaters Cascade Ck. meadow (Elev. 2080 ft.), Darrington RD (l); in lab (r).

Results

Eighteen sites were visited during 16 field days within the period of 8/15/2016 to 9/28/2016. The large majority of sites were on Snoqualmie District (12) followed by Mt. Baker District (4), Darrington District (2) and Snohomish District (0). Number of sites visited per district is directly related to number of candidate sites per district identified during pre-field analysis. These sites are mapped in Appendix A. Site elevations ranged from 2080 – 4840 feet. A biophysical description of these sites is presented in Appendix B. Seventy-eight species, including 15 *Carex* species and 25 bryophyte species were noted among the sites visited. This group of plants is presented in Appendix C. Five target species and two otherwise notable species accounting for eight distinct occurrences/populations were detected during site visits. Detected occurrences of these species are presented in Table 1 below.

Table 1. Project target taxa and otherwise notable taxa newly detected on Mt. Baker-Snoqualmie NF. VP = Vascular Plant; B = Bryophyte.

Targets w/ newly detected sites	**District(s)**	**Site(s)**
Carex magellanica (VP)	Mt. Baker	1551 rd.
Carex magellanica (VP)	Snoqualmie	Government Meadow
Carex pauciflora (VP)	Mt. Baker	1551 rd.
Campylium stellatum (B)	Mt. Baker	1775 rd.
Harpanthus flotovianus (B)	Snoqualmie	Government Meadow
Elodium (*Helodium*) *blandowii* (B)	Snoqualmie	7160 rd.
Notables w/ newly detected sites		
Carex flava (VP)	Darrington	Hdws. Cascade Creek
Hypnum pratense (B)	Snoqualmie	Celery Meadow

East over lower portion of Pilchuck fen (Elev. 3225 ft.), Darrington RD (l) with long-style sedge (*Carex stylosa*) and few-flower sedge (*Carex pauciflora*) habitat in field of view; *C. stylosa* inflorescence with perigynia subtended by pistillate scale (r).

Selected descriptive information for all sites visited is presented in Table 2 below.

Table 2. Selected descriptive information for the 18 sites visited during this project. Asterisk denotes sites that include at least some habitat(s) clearly supported by persistent groundwater discharge. FIT = Fen Indicator Taxa; T/N = Target or otherwise Notable species. Values in Acres field = surveyed area mapped in NRM TES Survey layer. HGM = Hydrogeomorphological setting (applied only to sites with fen habitats). Sites appear in ranked order according to number of FIT detected at that site.

Site	**District**	**FIT**	**T/N**	**Acres**	**HGM setting(s)**
Government Meadow*	Snoqualmie	18	2	42.4	toe-slope, valley bottom
Celery Meadow*	Snoqualmie	16	1	10.8	headwaters, valley bottom, toe-slope, ~basin
1775 rd.*	Mt. Baker	16	1	4.8	toe-slope, side slope, headwaters, bench, ~basin
9020-310 rd.*	Snoqualmie	16	0	10.5	headwaters, valley bottom
Mt. Pilchuck*	Darrington	12	2	1.4	bench, side slope
Naches Pass Trail*	Snoqualmie	12	0	3.5	toe-slope
7080 rd.*	Snoqualmie	11	0	14.8	toe-slope, valley bottom
Basin Lake*	Mt. Baker	10	0	0.9	bench
Evans Ck.*	Snoqualmie	9	0	1.2	valley bottom
1551 rd.*	Mt. Baker	8	2	1.8	bench
lower 7160 rd.*	Snoqualmie	8	1	5.5	toe-slope
7068-211 rd. (e)*	Snoqualmie	3	0	1.8	toe-slope, valley bottom
Williams Hole	Snoqualmie	1	0	1.1	
Greenwater Trail (s)	Snoqualmie	1	0	1.3	
Illabot Ck.	Mt. Baker	0	0	0.1	
Headwaters Cascade Ck.	Darrington	0	1	9.1	
7068-211 rd. (w)	Snoqualmie	0	0	1.2	
Greenwater Trail (n)	Snoqualmie	0	0	6.2	

SSE over 7160 rd. wetland (Elev. = 2630 ft.), Snoqualmie RD (l); shoots of the moss *Elodium* (*Helodium*) *blandowii* which is sparsely present at this wetland.

Discussion

Notes on rare species with sites newly detected in the course of this project.

Data sources for these notes derived from:

1. USFS fen and associated rare plant inventories by the project lead (Dewey 2015, 2013 and 2011).
2. Consortium of Pacific Northwest Herbaria (CPNWH)
3. Colville National Forest Bryophyte List (Ahlenslager 2015)
4. Okanogan County collections lists of Erica Heinlen
5. Olympic National Forest wetland bryophyte list developed following participation in an OLY NF ISSSSP wetland/rare plant field project in 2013.
6. Mt. Baker-Snoqualmie NF NRM TES database.

Site descriptions of newly detected species briefly discussed below are included in Appendix B of this report. The first five species listed below are regarded as fen indicator taxa by the project lead. Plant codes are those listed by the USDA Natural Resources Conservation Service, Plants Database (https://plants.usda.gov).

1. *Campylium stellatum* (CAST51). This moss is included in the WNHP Rare Moss List; its State Rank is not yet determined. CAST51 is not included in the 2015 R6 TES list. This species appears to have 13 Washington records, distributed on both sides of the Cascades crest and dating back to 1919. The species is known from perhaps 11 sites in Oregon, dating back to 1996. This may be a second record of this species on Mt. Baker-Snoqualmie NF. The CPNWH lists a collection from Stevens Pass in 1936.

Looking NNW down the 9020-310 rd. fen/wetland (Elev. = 3140 ft.) on Snoqualmie RD.

2. *Harpanthus flotovianus* (HAFL9). Liverworts are not currently included in the WNHP species rarity ranking process. This species has perhaps 11 Washington records with the oldest dating back to 1931, but most being post-2000. Although often found in wetland complexes that include clearly expressed fens, this species is not unambiguously a fen associate. Numerous field observations indicate that it is consistently associated with microsites with at least thin organic soil crust that is primarily dampened by groundwater through most or all of the snow-free season. This may be a second record for this species on Mt. Baker-Snoqualmie NF. CPNWH lists a 1934 collection from Stevens Pass (as well as two 1931 collections from Mt. Rainier National Park).

3. *Elodium* (*Helodium*) *blandowii* (HEBL2). This moss is WNHP S1 and is on the 2015 R6 TES list as WA-STR. With at least 31 records detected, this species currently appears to be the most abundant of the presumed rare, fen-associated Washington bryophytes. These records represent both sides of the Cascades, excluding the Olympic Peninsula, and date to 1883. Because of its frequency of occurrence and fidelity to groundwater-fed habitats, HEBL2 is perhaps the most useful bryophyte fen-indicator species in Washington. This appears to be the first modern record of this species on Mt. Baker-Snoqualmie NF. CPNWH lists several Washington collections from 1888-1902, but has withheld locational information.

4. *Hypnum pratense* (HYPR70). This moss is listed in neither the WNHP Rare Moss List (2012) nor the 2015 R6 TES list for Washington. The species was added to the ORBIC rare plants list as S1, List 3 in April 2016. There appear to be 11 Washington records for this species, all east of the Cascades crest, and none dating back further that 2000. This appears to be the first record of this groundwater-loving species west of the Cascade crest in Washington.

Roundleaf sundew (*Drosera rotundifolia*) at the 2090-310 rd. fen/wetland. Central rosette of tightly curled new leaves prepared for overwintering (l); a few late-season mature leaves still conducting business (r).

5. *Carex magellanica* ssp. *irrigua* (CAMA12). This sedge is WNHP S2/S3 and is on the R6 TES list as WA-SEN. According to Wilson et al., (2008), CAMA12 is distributed across the breadth of northern Washington. This species was previously known on the Forest from two sites, one along the 17 road on Mt. Baker District in central Skagit Co., and the other at the "Mt. Pilchuck ski slope bog" on the Darrington District, in central Snohomish Co. During this project, two new sites of CAMA12 were detected on MBS NF. The first of these is shortly below the 1551 rd. on the Mt. Baker District in Skagit

Co., and the second is at Government Meadow on the Snoqualmie District, in extreme northeastern Pierce Co. The new Government Meadow site is a large southern extension of the known distribution of CAMA12 within the state. Curiously, a project-related re-examination of the project lead's bryophyte collections on Gifford Pinchot NF in 2010 resulted in discovery of a CAMA12 collection made at a time when the project lead regarded it as an odd, *Carex limosa*-like, but ultimately, unidentified sedge. This postponed detection has now extended the documented distribution of CAMA12 in Washington to Skamania Co., at the bottom of the state.

Boreal bog sedge (*Carex magellanica* ssp. *irrigua*) at Government Meadow (Elev. = 4840 ft.), Snoqualmie RD.

6. *Carex pauciflora* (CAPA19). This sedge is WNHP S2 and is on the R6 TES list as WA-SEN. The Washington distribution of this species is restricted to the Puget Sound/North Cascades area (Wilson et al., 2008). This species was previously known from the Forest from 6 sites: "Nooksack fen" on Mt. Baker District; Black Creek, Dorothy Lake and above end of 42 road (Pilchuck area) on Darrington District; and Snoqualmie Pass Ski Area and east Snoqualmie Pass pond on the Snoqualmie District. During this project, one new site of CAPA19 was detected at a fen shortly below the 1551 road on the Mt. Baker District.

7. Carex flava (CAFL4). CAFL4 is WNHP S3 and WNHP Sensitive, although not included in the R6 Forester's 2015 TES List. The CPNWH indicates that all but one Washington record is either from Stevens Co. or Pend Oreille Co., both in the upper NE corner of the state. One record is from Whatcom Co., and may be the same site included in the MBS NF NRM TES database as "upper Baker Lake" on the

Mt. Baker District. The new CAFL4 site detected during this project is at the large wetland/drainage impoundment at the headwaters of Cascade Creek on the Darrington District.

(l) Looking SE up Government Meadow (Elev. = 4740-4840 ft.), Snoqualmie RD, from its far NW corner; *Carex magellanica* ssp. *irrigua* site is just visible as abrupt rise at far end of Meadow. (r) Soppy-wet bench (top of slope) and toeslope (the visible meadow) supports the single population of *Carex magellanca* ssp. irrigua detected at Government Meadow.

GDEs

Groundwater-fed wetlands, seeps and springs are collectively referred to as groundwater-dependent ecosystems, or GDEs (USDA-USFS 2012). *Springs* are typically point sources of groundwater discharge. The behavior of the discharge, whether perennial or seasonal, and volume, can vary greatly among springs. *Groundwater-fed wetlands*, i.e., wetlands whose primary water source is groundwater, are generally associated with areas of diffuse groundwater discharge. Among groundwater-fed wetlands, groundwater discharge periods appear to represent a continuum, with periods ranging from early-season to persistent through the snow-free season. Depending on the character of the feeding aquifer, and annual precipitation variances, discharge periods can notably vary within individual groundwater-fed wetlands. *Seeps* can be challenging to characterize because depending on their size and location, they can resemble either springs or small groundwater-fed wetlands.

Wetlands

Wetlands are areas where generally hydric soils are at least seasonally inundated or saturated with water so as to support a predominantly hydrophytic flora, i.e., a set of plant species that are adapted to occupying soils that are at least periodically, very wet. Commonly reference types of wetlands include marshes, swamps, bogs and fens.

Groundwater, groundwater-fed wetlands (fens), bogs

Groundwater, at least with reference to GDEs, is water that, through infiltration of rain and melting snow, has moved underground to a site where as a point source, or diffusely, it discharges or saturates the soil at or near the soil surface. Groundwater is typically nutrient-poor, unless it has acquired nutrients in travelling along its subsoil journey. Groundwater-fed wetlands are generally best expressed at sites with some topographic gradient, although wetlands in basins or overtopping ponds and lake edges have been

described as groundwater-fed wetlands as well. Groundwater-fed wetlands are also referred to as fens, although this term can be ambiguous in its meaning, as differing definitions of "fen" are in common use. For purposes of managing and protecting rarity on public lands, both at the species and ecosystem scale, it seems appropriate to adopt a more inclusive fen definition such as offered by Bedford and Godwin (2003) who define fens as "wetlands that develop where a relatively constant supply of ground water to the plant rooting zone maintains saturated conditions most of the time and the water chemistry reflects the minerology of the surrounding and underlying soils and geological materials." Or more concisely, Hájek et al. (2006) have defined fens as "groundwater-fed wetlands that host low productive nutrient-limited vegetation dominated by Cyperaceae and bryophytes." Groundwater-fed wetlands typically have peaty, organic soils, but as noted in these definitions, soils neither need, nor should, be a defining criterion. It is commonplace to hear the term "bog" being applied to a wetland that is actually a fen. True bogs appear to be quite rare in montane settings in both Washington and Oregon. As is often the case with fens, bogs are perpetually wet peatlands. However, the primary water source for bogs is generally considered to be direct, on-site precipitation. Additionally, the water table associated with the saturated peat of bogs is consistently perched above the primary local water table. Bog vegetation is typically dominated by species of *Sphagnum* moss.

Groundwater-fed wetlands are particularly important biophysical features on USFS lands due to 1) the disproportionately large number of rare and uncommon plant species they support, 2) the susceptibility of their generally very wet, peaty soils to negative physical alteration due to certain management practices, thus degrading the habitat that these wetlands provide for rare and uncommon species, and 3) the general rarity of this type of wetland across the forest landscape.

Looking west from upper edge of south meadow at the Evans Creek fen/wetland (Elev. = 3740 ft.), Snoqualmie RD.

Rates of peat accumulation

Soil probes by the project lead at the Lava Lakes fen in the central Oregon Cascades indicated a rate of peat accumulation of about 0.8 inches per century. Dating utilized a layer of Mazama pumice and ash originally deposited about 7700 years before present (upon which the fen peat developed) as well as a layer of ash from more local eruptions about 2200 years ago. Notably, Cooper and Wolf (2006) give a rate of peat accumulation in Rocky Mountain fens of about 20 cm per thousand years (approximately 0.8 inches per century).

Recognizing fens in the field

Efforts at fen recognition in the field sometimes result in an uncertain assessment, and generally require considering multiple types of interrelated features including site wetness, topography, hydrology, soil character and plant community structure and composition.

Site wetness – It is understood from personal field observations that sites persistently and primarily wetted by groundwater are likely to exhibit the greatest diversity of fen indicator species and also likely to have developed the thickest layers of organic soil/peat. It is likely that many of these sites have been hydrologically stable for thousands of years. These sites are often saturated at or near the soil surface through all or most of the snow-free season. Because of the capillary properties of cellulose-rich peat, surfaces of peaty soil can be wet even while the water table is 10-15 cm or more beneath the surface. Groundwater-wetted sites in the field appear to exist on a continuum between persistently wetted and seasonally wetted. Seasonally wetted sites are evidently wetted primarily by groundwater, but their soils are only saturated early in the growing season, and range from damp, or even moist, as early as August. These sites have multiple fen-indicator taxa and have peaty soils. An unanswered question about these sites concerns the apparent potential for oxidative loss of peat during the period of non-saturation in the upper portion of the soil column. Site visits late in the growing season/snow-free season are hugely helpful in surmising primary water source for wetlands. Many meadows have wet soil in the spring or early summer due to direct, on-site wetting by rain or snow-melt and/or due to surface transport and delivery of rain and melt-waters by laminar or channeled flow, or even seasonal groundwater discharge. Wet soils, late in the season, in the absence of obvious, nearby surface water sources (e.g. water tables of perennial creeks and ponds), or recent heavy precipitation events, are strong circumstantial evidence that site wetness is primarily attributable to groundwater.

Fruits of the fen-loving sticky tofieldia (*Triantha glutinosa*) at the 1775 rd. fen system, Mt. Baker RD.

Topography and hydrology – Generally, topography appears to be a very important underlying determinant of hydrology at fen sites. Along with subsurface geology that can direct locations of aquifer discharge, the topographic and hydrologic features at a given fen site can be referred to as the hydrogeomorphological (HGM) setting of that fen. It is convenient to recognize two basic HGM settings, *slopes* and *basins*, although multiple sub-types of the former HGM setting are recognized.

Most fens in Oregon and Washington that have been visited by the project lead are in topographic settings that slope to some degree, ranging from steep to very slight. These settings include ridge shoulders, saddles, headwaters, side slopes, benches, toe-slopes and valley bottoms. In concept, sloping settings provide the least ambiguous evidence of the primary water source of wet soil. Surface water sources (snowmelt, rainwater) are unlikely to be persistent water sources on slopes unless they are moving within channels, which can be observed, and are typically either perennial or intermittent. If there are no perennial channels in the immediate vicinity of a wetland, or channels are present but are clearly intermittent, groundwater becomes a likely explanation for the wetness of local soil. Sloping fens appear to generally rely on settings where subsurface water, following a gravitational gradient, encounters a confining layer that redirects the aquifer to the soil surface. Fens can also form where the path of a shallow aquifer is excavated, as is often seen in roadside cut-bank fens. There may be an element of this interception phenomenon in the formation of the common toe-slope fen as well. Valley bottoms are perhaps the most difficult setting among sloping fens in which to surmise primary water source. This is due in part because valley bottoms may include active drainage channels carrying water into the fen from upland sources. Water in these active channels may wet adjacent soil through horizontal, subsurface movement. In such situations, it seems quite possible that surface water from an active channel that has secondarily become groundwater, may co-mingle with true groundwater making subsurface entry to the fen from aquifers on adjacent slopes. Hydrological interpretations can also be complicated in cases where valley bottom topographic gradient is very slight. This promotes longer retention and in turn, infiltration, of episodic, weakly channeled surface flow from adjacent uplands, as well as of meltwater from the annual winter snowpack sitting directly atop the wetland. In the course of this project, all fens identified by the project lead, are broadly regarded by him as various types of sloping fens.

Soppy-wet toe-slope fen within the 1775 rd. fen system. The rare Washington groundwater-loving moss *Campylium stellatum* is abundant at this site. Soil probes here found organic soil layer 0-12” thick. Eleven FIT were detected at this specific site.

The project lead's understanding of the nature of basin fens is based on uncomfortably few observations. The concept seems well-exemplified by fen habitat situated around the perimeter of a basin pond with drainage largely limited to periods of episodic high water. It is likely that, dependent on the specific basin setting, groundwater, surface water and direct precipitation may all contribute in varying amounts to soil wetness. The concept may also apply to very low gradient, peaty meadows with no evident drainage output or input, and an inferred primary water source being the meltwater of the meadow's annual snowpack. This concept may also apply to peaty wetlands that form from the overtopping of ponds in basins or very low gradient meadows. Peatlands matching all the basin fen scenarios described above have been observed during the Oregon and Washington field visits of the project lead. A common feature of these "basin fens" is a lower count of fen indicator taxa.

Soil character – As noted above, in his field experience in Oregon and Washington, the project lead has found that organic soils of varied thicknesses are typically present at sites that, based on the HGM setting and vegetation, are regarded as fens. However, some sites that by HGM setting and vegetation clearly appear to be fens, may have soil organic layers that are thin or lacking. The history of these sites can be fairly evident, as in cases where human activity has removed "overburden" down to an aquifer surface (aggregate collection for topping local roads) or interrupting an aquifer's subsoil path (roadside cut-banks). Other instances of evident fens with little or no organic soil development are less readily understood. Some HGM settings favorable to fens may have only recently been created by local natural, geomorphological disturbances. At other wetland sites, thick organic soil layers may be present in the apparent absence of a primary groundwater influence. At the Greenwater Trail (s) site, soil probes identified apparent peat at thicknesses of 18"-51+". The primary water source here appears to the water table of the Greenwater River.

Vegetation - Whether HGM interpretations of primary water source(s) at a particular setting are seemingly simple or challenging, supporting evidence from the local vegetation can provide greatly important insight.

SE across Basin Lake fen (Elev. = 4160 ft.) from its NW corner; Mt. Baker RD.

Fen indicator taxa

These are taxa that the project lead has consistently detected within fens, especially sloping fens, during his visits to fen candidate sites across multiple national forests within the Pacific Northwest (Appendix D). This list, which is admittedly subjective and always open to edits, seems to be largely applicable across the montane Oregon and Washington fen sites visited to date, although the incidence of certain species can change geographically. For instance, *Eleocharis quinqueflora*, *Carex jonesii*, *Vaccinium uliginosum* and the mosses *Tomentypnum nitens* and *Meesia triquetra* are more frequently encountered in the Cascadian fens of Oregon than those of Washington. Conversely, *Salix pedicellaris*, *Vaccinium oxycoccos*, *Eriophorum* species and the mosses *Campylium stellatum* and *Calliergon* species appear to be better represented in fens of the Washington Cascades than those of Oregon. Notably, several taxa on this list (*Scheuchzeria palustris* ssp. *americana*, *Drosera rotundifolia*, *Triantha glutinosa*, *Vaccinium oxycoccos* and *Vaccinium uliginosum* appear to be scarcely present or lacking in fens in of the NE Oregon National Forests. The distributions of several boreal fen-loving taxa reach south to far northern Washington but apparently, not, or scarcely, beyond. Included in this set are the sedges *Carex tenuiflora* and *Carex magellanica* var. *irrigua* (although see discussion of this species earlier in the Discussion section), and the mosses *Paludella squarrosa*, *Scorpidium cossonii*, *Scorpidium scorpioides* and *Splachnum sphaericum* (although this species was recently detected on Wallowa-Whitman NF in Oregon). These appear to be good fen indicating taxa, but of limited geographic application in Washington and Oregon.

The widespread but useful fen indicator taxon, star sedge (*Carex echinata*), at 7160 rd. fen, Snoqualmie RD.

As a result of field observations during this project, the sedge *Carex luzulina* has been added to the project lead's OR/WA fen indicator taxon list. This species has long been a candidate for the FIT list, but its common occurrence at MBS project fen sites was sufficient evidence to push it over the threshold of acceptance. *Carex luzulina* was detected at 8 or the 12 project sites determined to include fens.

Numbers of FIT per fen site appear to correlate fairly strongly with amount/area of fen habitat per site, as well as with the number and type of fen plant communities within the fen. Generally, larger fens include more habitat heterogeneity and larger numbers of fen plant associations and/or types of fen vegetative structure. FIT count within fen sites visited during this project ranged from 3 to 18 (Table 2). FIT counts per site of 29 (Deschutes NF, Oregon) and 28 (Gifford Pinchot NF, Washington) are the highest yet observed by the project lead.

Vegetation and fen description

The project lead has found that a comprehensive plant species list with an emphasis on fen indicator taxa is the most economical means of gathering useful, vegetation-based descriptive information during a fen visit. These lists provide insight concerning biodiversity as well as the range of physical-chemical conditions within a site. However, multiple other uses of vegetation to describe fens exist.

Water chemistry and fen vegetation - Discussions of the relationship between pH and plant community composition appear to be very common in fen literature. It is in this context that "poor fen"-"rich fen" gradient is generally discussed.

Plant associations - Although likely sometimes undertaken without regard to wetland classification, per se, description of wetland plant associations has been undertaken over much of Oregon and Washington. Based on physical site descriptions, or more importantly, plant association names (e.g., *Eleocharis quinqueflora*/*Vaccinium uliginosum* plant association), it is evident that numerous plant associations have been recognized within the fens of Oregon and Washington. Fen plant association description has the potential to be particularly informative if associated physical data (e.g., HGM setting, wetness, soil character, nutrient availability, and pH) is simultaneously collected.

Aerial view of cloud-enveloped Pacific silver fir (*Abies amabilis*) cones high above Celery Meadow, Snoqalmie RD.

Vegetation structure - The project lead finds it convenient to use the categories of *short-statured*, *tall sedge*, *shrub*, and *forested* when describing plant communities encountered among, and often within, fens. Of course, these structural types can, and frequently do, intergrade.

Short-statured fen communities are characterized by persistently high water tables, high diversity of graminoids, forbs and bryophytes, and low stature of the vegetation. Height of vegetation in these communities is typically 12-16" or less, even while some included species are generally much taller outside of this community (e.g., *Carex aquatilis*, *Carex utriculata*, *Betula glandulosa*, *Kalmia microphylla*, and several *Vaccinium* and *Salix* species). This is the structural community type in which rare and uncommon vascular and nonvascular plant species, including sensitive species, are most likely to be found. Few-flowered spikerush (*Eleocharis quinqueflora*) is frequently either dominant or abundant among the vascular plants in this community. This is also the basic fen community type that includes the "brown mosses" which typify *rich* and *extremely rich* fens (Hájek et al., 2006; Bedford and Godwin, 2003); examples of brown mosses include species of *Tomentypnum*, *Hamatocaulis*, *Drepanocladus*, *Warnstorfia*, *Calliergon*, *Calliergonella*, *Campylium* and *Scorpidium*. The short-statured fen community appears to be the type of fen community to which Bedford and Godwin (2003) refer in noting that low nutrient availability may underlie "the low stature, distinctive flora, and high species diversity of some rich fen vegetation." This is also the basic fen community type from which most of the project lead's fen indicator species set is drawn. Plant communities approaching short-statured structure were the type of community structure most commonly observed at the 12 sites including fen habitats during this project. Strong expression of short-statured fen communities was observed at multiple sites within Government Meadow and at the Celery Meadow and 1775 rd. fen sites.

Squishy-wet to soppy-wet short-statured fen community (SSFC) at the very top of this otherwise sedgey meadow lobe at the 7080 rd. wetland complex (Elev. = 4500-4580 ft.), Snoqualmie RD. Organic soil layer in SSFC = 51+".

Tall sedge fen communities generally have low species diversity, little moss or forb ground cover, and are often dominated by 30-48" tall *Carex aquatilis* and/or *Carex utriculata*. It currently appears that the soil surface in tall-sedge fen communities is commonly saturated or inundated early in the growing season, but becomes damp, moist or even dry by late summer. It is most likely to be observed at very low-gradient or basin HGM settings. Patches of this structural type of plant community were observed at several sites, including Government Meadow and the 7080 rd. fen site, during this project.

Valley bottom fen at HGM setting with virtually no slope, within larger Celery Meadow wetland complex (Elev. ~4720 ft.), Snoqualmie RD. Organic soil layer near pool up to 51+" thick.

Shrub fen communities are often intermediate between short-statured and tall sedge fen communities with regard to species diversity, and likely include a patchy cover of graminoids, forbs and mosses. Water table behavior seems to be variable, dependent on setting. With a cover threshold of 20-25%, this structural type commonly intergrades with the short-statured community type in a complex mosaic. Shrub fen communities very commonly occur at the interface of the main body of an herbaceous fen and the adjacent wooded upland. In the Oregon Cascades, *Vaccinium uliginosum* (bog huckleberry) is perhaps the most frequent and abundant species within shrub communities, but is often accompanied by *Betula glandulosa*, *Kalmia microphylla* and various *Salix* species. In Washington, fen shrubs are likely to include *Vaccinium*, *Ledum*, *Betula*, *Salix*, *Alnus* and *Spiraea*. Shrub fen communities are often intermediate between short-statured and tall sedge fen communities with regard to species diversity, and likely include a patchy cover of graminoids, forbs and mosses. High early-season water tables commonly dip down towards the end of the growing season, but perhaps not so much as within tall sedge communities. In the Oregon Cascades, *Vaccinium uliginosum* (bog huckleberry) is perhaps the most frequent and abundant species within shrub communities, but is often accompanied by *Betula glandulosa*, *Kalmia microphylla* and various *Salix* species. In Washington, fen shrubs are likely to include

Vaccinium, *Ledum*, *Betul*a, *Sali*x, *Alnus* and *Spiraea*. Shrub fen communities are common within the fen sites visited during this project.

Forested fen communities appear to be uncommon within the forests visited to date by the project lead. These generally are areas that, in viewing aerial imagery, have more the character of forest than of meadow. On the ground, however, the wetland character of the site is evident. Persistent groundwater-fed wetness and a moderate level of species diversity (shrubs, graminoids, forbs and bryophytes) may be typical of forested fens. Lodgepole pine (*Pinus contorta*) and/or Engelmann spruce (*Picea engelmannii*) are most commonly present but a variety of other conifer species may be represented as well. A strong expression of a forested fen community was not observed among the fen sites visited during this project.

Biogeography of fen indicator taxa

The OR-WA fen indicator taxa recognized by the project lead are largely higher latitude, boreal taxa. North American distributions of 12 of these taxa that are generally representative of the group are illustrated in Appendix E (species maps from NRCS Plants Database). It's evident from Appendix E that the distributions of the fen indicator taxa have one or more southward extensions into decidedly non-boreal latitudes. For the most part, these southward distributional extensions are possible due to the presence of mountains (e.g., in the western US, the Cascades, Sierra Nevada, Ochoco, Blue and Wallowa Mountains, Kettle River Range, Selkirk Mountains and the Rockies). This seems to be simply another case of the long-standing observation that, at lower latitudes, sites at higher elevations can be climatically similar to sites at higher latitudes. Hence, while at higher latitudes these OR-WA fen indicator species are components of *boreal fen communities*, in Oregon and Washington, these same species are components of *montane fen communities*. But while the presence of mountains makes the presence of the OR-WA fen communities possible, it is the presence of particular, coincident topographic, geologic and hydrologic features that seem to dictate the distribution of suitable montane fen habitats. Along the Cascade crest and east, this coincidence of fen-enabling features among R6 forests is generally uncommon at best.

Cottongrass (*Eriophorum* sp.) at Naches Pass wetland system (Elev. = 4680 ft.), Snoqualmie RD.

Fens and meadows

Meadows are generally described as being dominated by herbaceous vegetation, although some shrubs or trees may be included. As noted by Weixelman et al. (2011), meadow classification has been addressed by a large number or workers, and guided by a broad variety of key features such as plant communities, general topography, elevational range, site potential, and moisture gradients. A classification system developed by, and now commonly used by USFS (Hall, 1998) uses moisture gradient at its first order of grouping (dry, moist and wet), with classification within these major categories based on key indicator plant species (e.g., MW4911 = few-flowered spikerush wet meadow). A meadow nomenclature system that describes seasonality of soil wetness provides very useful management information, but it provides little information about the physical setting that is responsible for the presence of this type of community. In contrast, Weixelman et al. (2011), focus on physical setting, basing their highest order of meadow classification on hydrogeomorphological (HGM) setting. Working in the Sierra Nevada mountains of California, they recognize a total of 14 meadow types based on HGM settings. Four basic HGM settings are recognized, *slope*, *basin*/*depression*, *riparian* (well-defined drainage with defined throughput channel(s) and *subsurface* = well-defined drainage without defined channel(s). Differentiation among these basic groups is recognized based on presence or absence of peatland, and on percent of slope. Two additional HGM settings, *lacustrine fringe* and *mound peatland*, are recognized, as well as a meadow type seemingly without any strong HGM association, the *dry* meadow. The terms "moist" and "wet" are not included in the names of any meadow type. Basing a meadow classification system on physical properties of meadow setting, such as HGM, is very useful in that it creates categories that are explanatory and predictive, as well as descriptive. And although reducing the "peatland" criterion from 40cm of organic soil to 20cm allows a broader inclusion of peaty wetlands, application of the Hájek/Bedford-Godwin fen concept allows an even broader inclusion of primarily groundwater-fed meadows. Hence, the project lead would recommend recognizing a single *sloping* meadow type (not "discharge slope peatland" and "discharge slope" types) as well as a single *basin* meadow type (not "basin peatland" and "depressional perennial" meadow types).

Stand of snags at headwaters of Cascade Creek impoundment/wetland (Elev. = 2080), Darrington RD.

The experience of the project lead in visiting a large number of meadow types in Oregon and Washington has impressed him with the apparent high correlation between water source, in particular, groundwater, and the species composition of meadows. It has become the project lead's understanding that collectively, FIT indicate areas where the water source is predominantly groundwater, whether these areas be associated with slopes, where physical evidence for water source offers relatively confident interpretations, or basins and valleys, where physical evidence for primary water source tends to be equivocal. As noted above, description of a meadow's apparent wetness schedule is arguably very important in meadow management considerations. Likewise, further describing wetness as seasonal or persistent is coarse-scale, but also useful. Hence, where the site information is available, the project lead would argue for utilizing HGM, primary water source and wetness schedule in categorizing meadows. For example, suggested meadow names might include "persistently groundwater-fed sloping meadow", or "seasonally surface water-fed riparian meadow", or persistently groundwater-fed basin meadow" or "seasonally surface water-fed (snowfield) subsurface meadow." In this meadow classification system, any meadow describable as "persistently groundwater-fed" will qualify as a wetland and a fen. And again, it is very common to observe multiple meadow types comprising a meadow complexes in montane settings in Oregon and Washington.

Fens as unique ecosystems

Some familiarity with fens and fen-like ecosystems should cause hesitation in accepting their inclusion as "riparian" landscape features. The species composition of plant communities included within fen ecosystems is largely distinct among plant communities across the R6 forests visited to date by the project lead. With some notable exceptions (e.g., overtopped ponds and lakes) this distinctness appears to be very much tied to the community water source being primarily *nutrient-poor groundwater*, near the source of its initial, diffuse, surface/near surface discharge. The project lead's current concept is that fen ecosystems may or may not contribute surface water output to riparian systems, but they do not receive significant amounts of water or nutrients from these systems. A meadow that is regularly wetted by relatively *nutrient-enriched, surface-sourced* riparian water – often by means of seasonal or episodic channel flooding - will not support the plant communities associated with fens and fen-like ecosystems (Bedford and Godwin, 2003). With this view, the project lead would offer that fens are not just wet habitats that may support notable numbers of rare or uncommon plant species, but are themselves biophysically distinct, variously rare or uncommon *groundwater-supported ecosystems* that in their own right, merit recognition and appropriate restorative or protective management.

South over Greenwater Trail (s) peatland (Elev. = 3920 ft.) with Greenwater River as apparent primary water source.

Wetland condition assessments

Condition of fen habitats visited during this project appeared to be uniformly good, with little evidence of direct negative impacts from forest management actions or visitor impacts. Negative impacts seen elsewhere in Oregon and Washington fens include cattle grazing (major issue on many forests east of the Cascade crest), sediment and possible aquifer interference issues relating to nearby unpaved roads, and unauthorized recreational use, particularly off-road vehicle use. It is unfortunate that the Naches Pass "Trail" (apparently widened by four-wheel drive enthusiasts) passes upslope, closely adjacent to much of the northern edge of Government Meadow and the Naches Pass wetland. This route intersects apparent seasonal, groundwater-fed surface flow into these wetlands, and perhaps subsurface flow as well. On a lesser note, it is unfortunate that the Clearwater Trail (#1178) transects upper Celery Meadow, but this trail is presently transecting a less wet portion of the meadow system, and is cut relatively shallowly into the meadow peat.

Particularly notable sites

1. Government Meadow. Size begets diversity, and this meadow complex has both. Using a modified Weixelman et al. (2011) meadow classification, this complex appears to include both seasonal and persistently groundwater-fed sloping, riparian and subsurface meadows. Government Meadow had the largest count of FIT detected during this project, as well as two project target species. Peat thicknesses in excess of 4 feet were detected here. The Meadow's size and habitat diversity suggest that any number of other plant species went undetected. Botany surveys earlier in the flowering and fruiting season are recommended. Due to its headwaters setting, numerous points of groundwater input along its very large perimeter, and its biodiversity, the Meadow presents a great opportunity to monitor effects of regional climate change on the all-important water table level in this important MBS NF wetland ecosystem.

Kevin James, helping with surveys at Government Meadow.

2. 9020-310 rd. wetland. This is a robustly, persistently groundwater-fed wetland at the headwaters of a perennial creek. Although extensive and intensive logging has occurred above the 310 rd., which wraps around, well above this wetland in a horseshoe-shaped fashion, old growth forest appears to be providing an effective sediment buffer between the wetland and the lower edge of the 310 rd. Peat thicknesses in excess of 4 feet were detected here. This wetland is highly biodiverse, being second only to Government Meadow in FIT count. This biodiversity, along with the robustness of its groundwater feed, its large size and topographic continuity, cause this wetland to be essentially unique among the wetland sites visited during this project. Visiting this site required a 5+ mile walk-in beyond the current closure on the 9020 rd. Travel time significantly reduced available on-site time. Further exploration of this wetland, especially earlier in the growing season, is highly recommended.

3. 1775 rd. fen complex – roadside fen at 1775 saddle. This tiny, gently sloping roadside fen sandwiched between the 1775 rd. and upslope forest has a count of 9 FIT – notable diversity for such small area - and soppy wet peat up to 3.5 feet thick. Groundwater drainage through this fen is undoubtedly hastened by a ditch cut into its roadside edge. The thickness of peat suggests that this tiny wetland ecosystem likely has persisted at this site for 3500-4000 years.

Sonny Paz making his way through a tallish sedge and grass community at Government Meadow.

Follow-up recommendations

1. Return to the wetland at the headwaters of Cascade Creek, Darrington District, is highly recommended in order to confirm the identity of the *Carex flava* collected there, and better map its distribution. This appears to be only the second record of this species on MBS NF. Members of the Carex Working Group identified this collection based on digital photographs sent via e-mail. A bit of historical research on this wetland would be welcomed as well. The wetland appears to have an earthen dam at its lower, eastern

extent. Based on the presence of numerous large, white conifer snags present in mid-wetland, the impoundment may be only a few decades old. Primary water source in this wetland was apparently sufficient to warrant construction of the impoundment, but obvious groundwater or surface inputs to the wetland were not detected.

2. A revisit to the large, sprawling Celery Meadow wetland complex is highly recommended for at least two reasons. First, in what appears to be its first Washington record west of the Cascade crest, the rare moss *Hypum pratense* (HYPR70) was collected upslope at the eastern entrance to this wetland. This collection consists of just a few shoots intermixed with a collection of the moss *Sanionia uncinata* (SAUN8). A revisit to this wetland would provide an opportunity to better determine the distribution of HYPR70 at the wetland, as well as to confirm the presence of this species (HYPR70 is very similar in appearance to *H. lindbergii*, also rare in Washington, and ample good material is very helpful in making the distinction). Second, among project fen sites visited, Celery Meadow is very biodiverse (16 FIT detected) and a visit date earlier in the growing season (June or July) would offer a promising opportunity to detect additional plant species at this site.

3. Soil core analysis at selected sites within Government Meadow is recommended. Many soil probes within this meadow complex encountered stratified peat, with layers representing differing peat densities as well as thin depositions of fine-textured inorganic matter. Core analysis could potentially provide considerable insight concerning the developmental history of this large wetland complex.

4. With forest plan revision on the near horizon, the project lead recommends that MBS NF develop a Forest-wide groundwater wetland management program. This might involve the following steps:

a. develop a protocol for the identification and condition assessment of fens.
b. conduct a systematic analysis aimed at identifying potential fen sites across the Forest.
c. resulting candidate fen sites should then be prioritized for site visits on a schedule permitted by the availability of funding and qualified Forest staff.
d. site visits should include a description of the character and condition of fen habitats documented within the sites.
e. prepare a GIS layer with fen locations and selected attributes; place in Vegetation and Hydrology folders.
f. a protection/restoration prescription will need to be prepared for fens determined to be threatened or negatively impacted by past or present management activities or unauthorized recreational use.

5. Consider establishing long-term water table monitoring in one or more selected MBS NF fens as a means of tracking climate change effects on these very water table-dependent, high-value ecosystems. The project lead would recommend initiating this at Government Meadow. In a phone visit on 10/21/2016, Teresa Hollingsworth, a boreal ecologist with the PNW Research Station, indicated that submission of a research proposal to Station would be an appropriate means of exploring the opportunity for collaboration between a MBS NF and the Station, in initiating a forest-level climate change monitoring project.

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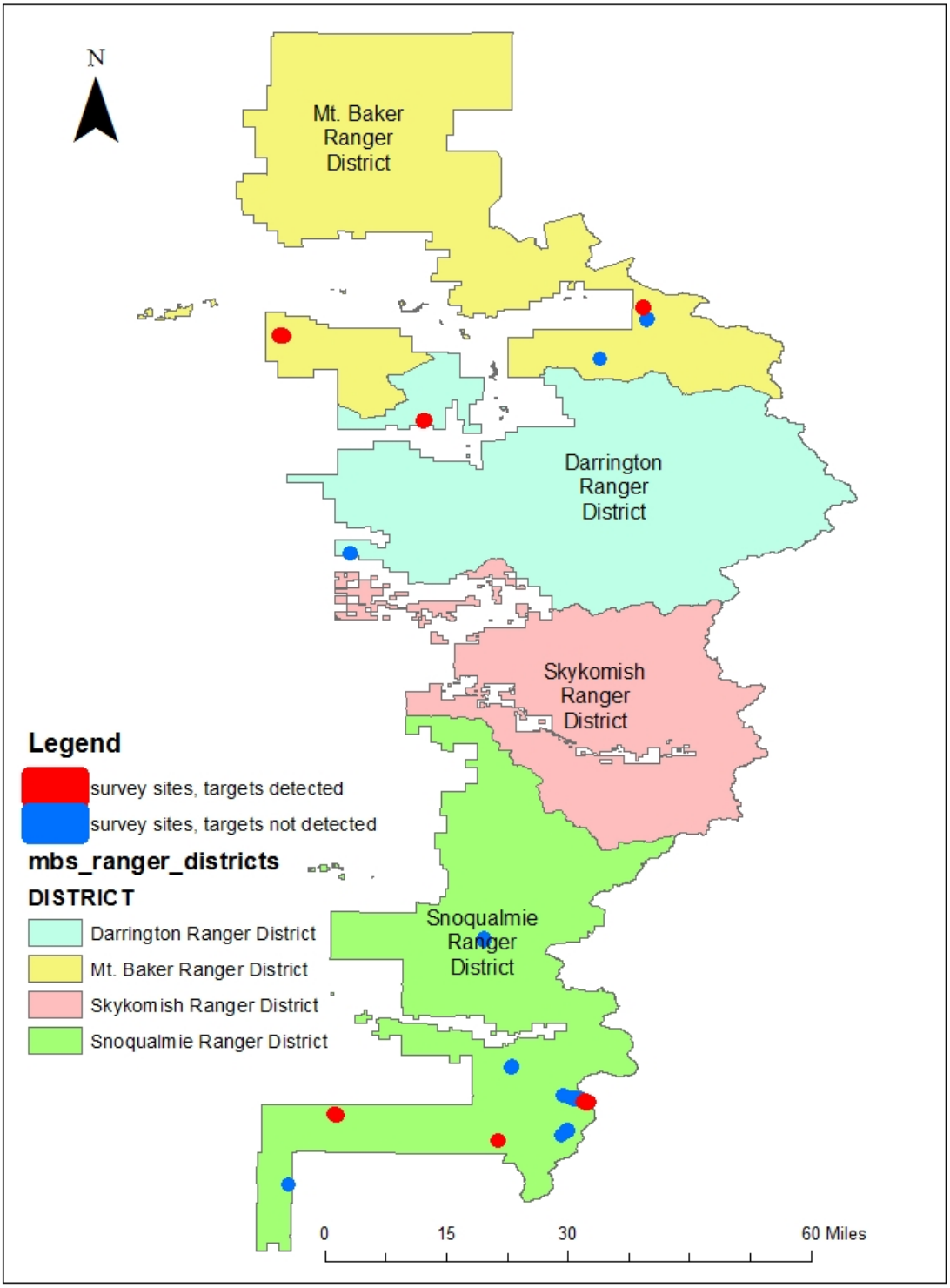
Appendix A – 2016 ISSSSP fen and rare plant survey sites on Mt. Baker-Snoqualmie NF.



Appendix B

Site descriptions for the 2016 Mt. Baker-Snoqualmie fen/rare plant ISSSSP project. Fen indicator taxa in bold, target taxa are underlined. Plant codes are those listed in Appendix C and by the USDA Natural Resources Conservation Service, Plants Database (https://plants.usda.gov).

Mt. Baker Ranger District

1. 1775 rd.
Elevation: 3720-3780 ft.
TRS: T34N, R7E, S5
Date: 8/15/2016
Rationale: Target meadow = NWI PEMC
Plants: Graminoids – **CAAQ**, **CAEC**, **CALU7**, **ERIOP**, DAIN, **JUEN**, CACA4, AGROS2
Forbs – CABI2, SAXIF, EQAR, **PEGR2**, **TRGL5**, **PLDI3**, ASTER, SAOF3, PAFI3, **SPRO**, ARNIC, **HYAN**2, LIGUS, SETR, **PLSA6**, EPILO, VERAT, EQFL
Shrubs - SALIX, PHYLL3, SPIRA, **KAMI**
Bryophytes – **SPHAG2**, **WAEX**, DIPA20, **CAST51**, BRPS70, PHFO6, RHIZO2, **CAST70**, AUPA70, SCPA24
Soil probes: Peat thickness across the 5 subunits chosen to represent this particular wetland complex ranged from 0”- 51+”. All three of the larger subunits had portions where peat thickness exceeded 51” (the useable length of the soil probe).
Notes: The focus of this site was a single, largish PEMC wetland, however, once on the ground near the site, other interesting, smallish sloping fens presented themselves. These smaller fens, which are all sloping fens with persistent groundwater-fed wetness, are not mapped in the NWI. The focus, PEMC wetland has northern, eastern and southern edges that slope toward the center of the wetland. The eastern sloping edge appears to be the most persistently wetted by groundwater and the most biodiverse. The central portion of this wetland approaches the hydrogeological character of a basin fen. The western edge of the wetland includes a route of low-volume surface water output from the wetland. Other local potential, smallish sloping fens were then identified using the hard copies of NAIP imagery brought into the field, but only the five polygons entered in NRIS were visited. Even the smaller of these polygons/sub-sites had significant numbers of detected fen indicator taxa. Because of the similarity of the flora noted in each of the polygons, and because of the likely similarity in the character of the local aquifers feeding these sub-sites, it was decided to consider the group of sub-sites as a single entity. A total of 16 fen indicator taxa were detected within this composite site. Sixteen fen indicator taxa were detected at this wetland composite (1775 rd.) as well as at the 9020-310 wetland. Among the MBS NF wetland sites visited during this project, a larger number of fen indicator taxa were detected only at Government Meadow (18) and Celery Meadow (17). This is the only site at which the target moss *Campylium stellatum* was detected. A return visit to this site earlier in the season (July?) is very much recommended.
Photos: #s 3126, 3127, 3129-3130, 3132, 3133, 3134-3135, 3136-3137.

2. Illabot Creek, 16 rd.
Elevation: 2360 ft.
TRS: T34N, R11E, S22
Date: 8/18/2016
Rationale: Target wetland = NWI PEMC
Plants: Graminoids – SCMI2, CACA4
Soil probes: None
Notes: Accessed the upper eastern edge of wetland by hiking down a very steep slope from 16 rd. Slope is a jumble of old growth with much down wood and thick duff. Passed over two very active, unmapped creeklets in driving from end of 16 rd. to parking site. There is a lot of channeled surface water entering this wetland from the steep eastern slope above it. Reach edge of wetland at a beaver dam which is holding back water, but most of the wetland that can be seen from this point on its edge, is inundated. From vantage point atop the beaver dam looking north, down the length of the wetland, it appears that this wetland in primarily a marsh, with little opportunity for the existence of fen habitat anywhere along its edges or within it. Soil within the beaver dam is a sticky, gray clay. And even though surface water is moving along an imperceptible gradient to the north, the air is heavy with an unpleasant odor, perhaps a mix of methane and sulfur.
Photos: 3153, 3154

3. 1551 rd., above Irene Creek
Elevation: 3200 ft.
TRS: T35N, R12E, S19
Date: 8/18/2016
Rationale: Target meadow = NWI PEMC
Plants: Graminoids – AGROS2, **CAEC,** CAPA19, **CAMA12**, CACA4
Forbs – LYAM3, **TRGL5**, **METR3**, NULU, ASTER, BLSP, EQAR, **SPRO**, **PLDI3**, SAXIF
Shrubs – VACCI, PHYLL3, **KAMI**
Bryophytes – **SPHAG2**, AUPA70, CALYP6
Soil probes: Two probes within wetland found peat thicknesses of 36” and 54+”.
Notes: Wetland occupies an essentially flat bench along a relatively steep slope between the 1551 rd. and Irene Creek. The NE half of the wetland consists largely of a system of irregularly-shaped, shallow pools interspersed with small islands and peninsulas covered in moss (lots of SPHAG2), small LYAM3, low shrubs and bonsai trees. The SW portion of the wetland lightly wooded and only very shallowly inundated or simply very wet. SPHAG2 is well-represented here as well. CAMA12 appears to be uncommon at this wetland, but CAPA19 is abundant, typically occurring on SPHAG2 anywhere within several meters of areas of inundation. More effectively than on the ground inspection, aerial imagery shows an apparent effort to somewhat buffer this wetland from the relatively recent clear-cutting of the steep, forested slope lying between the wetland and the 1551 road, 250+ meters above. The wetland itself has a green tree retention buffer of 35-55 m. Additionally, a column of uncut stand 80-100 m wide extends upslope from the wetland to the 1551 rd. It is not clear that this retention column was an

intentional attempt to protect the watershed thought likely to be supporting the wetland. If so, it is notable that this column is not as wide at the wetland (approx. 185 m wide). According to the 20' contour lines mapped across the slope above the wetland, the retention column would have needed to be approx. 200 m wide to more effectively conserve the watershed that is likely feeding the wetland.
Photos: #s 3155, 3156-3157.

4. Basin Lake
Elevation: 4160 ft.
TRS: T35N, R12E, S29
Date: 8/19/2016
Rationale: Target meadow = NWI PEMC
Plants: Graminoids – AGROS2, **JUEN**, **CAEC**, **ERIOP**, **CALU7**, CAIL, CALEL3
Forbs – SETR, ASTER, SAXIF, EQAR, **HYAN2**, **PEGR2**, EPILO, **TRGL5**, PAFI3
Shrubs – SPIRA, PHYLL3, SALIX, ALNUS, GAULT
Bryophytes – PHFO6, **CAST70**, **WAEX**, AUPA70, **SPHAG2**, DIPA20
Soil probes: Multiple probes found a range in peat thickness of 47"- 51+".
Notes: Site accessed by parking at end of 1550 rd. and hiking up Bear Lake Trail #746 to Bear Lake, then hiking cross-country to Basin Lake. The section of trail from La Rush Lake to Bear Lake is often obscure, especially its upper portions. Basin Lake appears to occupy a cirque basin, draining actively to the NE. The wetland lies on a terrace immediately NE of the lake. While the lake may contribute some groundwater flow to the wetland, primary flow appears to be contributed by tall, steep, talus slope with shrub patches, immediately above the wetland. Multiple active and intermittent creeklets flow across the meadow from the direction of this slope. These creeklets either arise at the edge of the meadow, or within it. Soil saturation with much of the meadow appears likely to be persistent. Vegetation of meadow is very much that of a short-statured fen community, with patches of bare peat dispersed amidst an otherwise solid carpet of moss. Dominant moss is WAEX, but SPHAG and PHFO6 are also abundant.
Photos: #s 3158, 3159.

<u>Darrington Ranger District</u>

1. Headwaters of Cascade Creek.
Elevation: 2080 ft.
TRS: T33N, R9E, S32
Date: 8/17/2016
Rationale: Target meadow = NWI PEMC
Plants: Graminoids – CAVE6, CAFL4
Forbs – LYAM3, NULU, SPARG
Shrubs – SPDO, VACCI, GASH
Soil probes: Two probes in SW portion (non-inundated) portion of wetland found peat thicknesses of 50" and 51+".

Notes: Accessed wetland by parking near junction of 1880 rd. and 013 spur, and walking along 1880 rd. until leaving the road to hike cross-country to wetland. Entered wetland at SW corner, where passed through a transition zone of THPL, SPDO, VACCI and GASH to reach main body of wetland that at point of entry is dominated by tall sedge (CAVE) over wet, largely bare peat. This SW end of wetland appears to be seasonally inundated. At time of visit, the eastern ½-2/3 of wetland is inundated, with tall sedge now emergent. Seasonal and persistent inundation appears to be the explanation for the very paucity of plant species seen here, including a nearly complete absence of bryophytes. What appears to be an overgrown, human-made earthen and pole dam crosses the full valley bottom and the eastern end of the wetland. It is not at all clear when, how, or why this dam was constructed. Beaver appear to be present in the lower SE corner of the wetland. It's notable that a stand of tall, but mixed age conifers, now dead and white, occurs in the center of the wetland. The source of water for this wetland is not apparent. Perennial creeks are mapped entering the wetland along it southern edge and at its NE corner, however, no evidence of these was seen when exploring these areas on the ground. As a headwaters site, it seems likely that at least seasonal groundwater discharge is occurring laterally or ever within this wetland, however none of this is obvious during a walkabout. A search for descriptions of the wetland's vegetation prior to the construction of the current dam is recommended. A sedge identified as CAFL4 is present at the SW end of the wetland. This was tentatively identified as either *C. retrorsa* or *C. flava*. Photographs were sent to the *Carex* Working Group, who identified the sedge as *C. flava*. As this appears to be only the second documented site of this species on MBS NF, a return to this site to more carefully examine this population is strongly recommended.
Photos: #s 3141-3144, 3145, 3146, 3148, 3149, 3150, 3152.

2. Mt. Pilchuck
Elevation: 3200-3250 ft.
TRS: T30N, R8E, S20
Date: 9/28/2016
Rationale: Documented records of CAPA19 and CAMA12; no NWI mapped here.
Plants: Graminoids – **CAEC**, **ELQU2***, CAPA19, CACA4, DECE, **JUEN**, AGROS2, CAUT, CALEL3, CAST10, **ERIOP**
Forbs – BLSP, LYAM3, **TRGL5**, **SPRO**, EQUIS, EQAR, CABI2, **PEGR2**, **HYAN2**
Shrubs – SPDO, **KAMI**
Bryophytes – **SPHAG2**, AUPA70, RHSQ70, **CAST70**, **WAEX**
Soil probes: One dozen or so probes within the wetland system found peat thicknesses ranging from 19"- 48".
Notes: Very easy access by parking at end of 42 rd., hiking a few 10's of meters up the Mt. Pilchuck Trail (#700) and walking 10-15 m east into woods to reach W edge of wetland system. Wetland is a system of interconnected or immediately adjacent, irregularly-shaped meadows. Nearly all meadows in this wetland systems are, or include, sloping fens, with slope varying from moderate to very slight. Soils are mostly peaty throughout the systems, and mostly saturated and soppy-wet with groundwater at the time of visit. Shallow, mostly smallish pools are common within the wetland system. Moss cover within the wetland system is nearly

complete, with nearly all of it being SPHAG2. This is a very wet, complex fen system with lots of edge habitat and hard to comfortably examine in a single visit. *Carex pauciflora* was abundant over SPHAG2 in the lower, more gently sloped portion of the wetland system. *Carex magellanica*, although documented here, was not detected. *Carex stylosa*, detected upon entry at the western portion of the lower system, was previously detected at this site by Weinmann in 2002. This record occurs as an EO point (not poly) in MBS NF NRM TES.
Photos: #s 3274, 3281.

<u>Snoqualmie Ranger District</u>

1. Williams Hole
Elevation: 4260-4280 ft.
TRS: T19N, R10E, S10
Date: 8/30/2016
Rationale: Target meadow = NWI PEMC
Plants: Graminoids – **CALU7**, CACA4, DECE, CASCB
Forbs - LIGUS, CABI2, SETR, VERAT, TRIFO
Shrubs - SALIX
Bryophytes – AUPA70, PHFO6, FONTI
Soil probe: Single probe at dampest soil detected within meadow (at upper S end) found highly resistant organic layer that could not be penetrated more deeply than 4".
Notes: Meadow accessed via the Divide Trail (#1172) fortuitously picked up along the edge of the 7012-380 rd. on private land. Meadow appears to drain along its long axis from S to N, but is essentially flat. Meadow is dominated by the grasses CACA4 and DECE and appears to be only briefly, seasonally wet. Source of water probably a combination of snowmelt, surface input and groundwater discharge. No defined surface channels into meadow were detected. Meadow is mapped as a seasonal headwaters tributary to Rock Creek, but no obvious surface channels exit the N end of meadow. Evidence of seasonal groundwater discharge seen only a far S end of meadow, near meadow-woods interface. Meadow appears to be totally lacking in fen habitat, the presence of CALU7 not withstanding.
Photos: #s 3162, 3163.

2. 7160 rd., near Ranger Creek Campground
Elevation: 2630 ft.
TRS: T18N, R10E, S28
Date: 8/30/2016
Rationale: Target meadow = NWI PEMC
Plants: Graminoids – **JUEN**, AGROS2, HOLA, CALE10, CALEL3, SCVA, **CAEC**
Forbs – LOTUS, EQAR, LEVU, LYAM3, **HYAN2**, **PLSA6**, PRVU, BLSP, **SPRO**
Shrubs – SALIX, **KAMI**
Bryophytes – AUPA70, **CACU18**, PHFO6, MAPO16, **<u>HEBL2</u>**, RHSQ70
Soil probes: Multiple probes within the wetland found peat thicknesses of 20"– 51+".

Notes: This meadow is easily accessed by a short walk from an early hairpin turn in the 7160 rd., down a gentle slope through relatively open woods. This is a fairly curious and wonderful wetland that includes much fen habitat. Its peaty soils are often very wet, especially along the W half of the meadow where a groundwater discharge zone is evident all along the meadow's W edge. In spite of the meadow's general wetness, very old, highly lichenized, large diameter tree stumps are abundantly distributed within the meadow, as are weedy or otherwise misplaced-looking plants such as HOLA, LOTUS, LEVU and PRVU. Although many plant species are present here, it appears that many of these species are well-represented, and no species are clearly dominants. It is very likely that a shallow groundwater aquifer associated with the very tall and steep slope immediately adjacent to the meadow's W edge is the primary water source for this meadow. Surface water moves NE, gently downslope across the meadow. Flow appears to be mostly laminar, but numerous weakly defined channels are present as well. These channels all originate at the meadow/woods interface or no more than a few meters into to woods (TSHE, PSME, THPL). Evidence of robust seasonal groundwater discharge, such as cavitation about large tree roots, was not detected. The only project-related detection of the fen-loving target moss *Elodium* (*Helodium*) *blandowii*, occurred in this meadow.
Photos: #s 3164, 3165, 3166-3170, 3171, 3172, 3173, 3174.

3. Celery Meadow
Elevation: 4680-4760 ft.
TRS: T18, R8E, S7
Date: 8/31-9/1/2016
Rationale: Target meadow = NWI PEMC
Plants: Graminoids – CASCB, **ERIOP**, CALEL3, DECE, **CAEC**, **CALU7**, **ELQU2**, CANE6, **JUEN**, AGROS2
Forbs – EQAR, **DOJE**, **TRGL5**, ASTER, **HYAN2**, **PLSA6**, LIGUS, **METR3**, CABI2, SETR, SAXIF, COPA28, SAOF3, **SPRO**, NULU
Shrubs – SPIRA, **KAMI**, PHYLL3, LUPE, VACCI, SALIX
Bryophytes – BAHA3, PHFO6, **CACU18**, RHSQ70, **CAST70**, **SPHAG2**, AUPA70, SAUN8, **WAEX**, DIPA20, RHNU4, **HYPR70**
Soil probes: Probes were conducted in all four major portions of this wetland system. Peat thicknesses of 51+" were found in the S(outh), C(entral), and NW1 meadows. The single probe within the NW2 meadow found a peat thickness of 44".
Notes: Access is via the Clearwater Trail (#1178) whose trailhead is near the end of the 2270 rd. The trail is also accessible via the 7726 rd. but this is not recommended as the condition of this road is terrible. This is a large, sprawling, hydrologically complex meadow system comprised of four interconnected or closely adjacent meadows (S, C, NW1 and NW2). Primary water source for these meadows appears to groundwater, although evidence of seasonal or episodic surface flow may have been detected. The S(outh) and C(entral) meadows are broadly interconnected and are differentiated primarily by slope and apparent hydrology. The S meadow notably slopes down to the C meadow, which appears to be essentially flat/slopeless. There is evidence of seasonal groundwater discharge converts to surface flow along the NW and SW edges of this meadow. The central portion of the western edge of this meadow extends well upslope into the

woods as a very notable meadow lobe. Persistent and very active groundwater discharge is occurring in this lobe and appears to be the zone of most active groundwater discharge within the whole wetland system. Small channels with seasonal or low-volume persistent flow enter into the S meadow from this western edge. Most of these channels appear to continue weakly down to the C meadow. The main body of the S meadow is a mosaic of soil moisture conditions. Unexpectedly, the central portion of the eastern edge of the S meadow becomes squishy to soppy wet and gives rise to a low-volume creeklet that drains east and down into the woods where a louder, larger volume drainage through the woods can be heard. No obvious signs of groundwater discharge was detected along the edges of the C meadow, although there is a longer extent of squishy-wet peat along the meadow's SW edge than along its NE edge. In aerial imagery, this meadow is a distinctive straw color, contrasting with the mostly green color of the other three meadows in the system. A shallow pool, with METR3 and NULU occurs along centrally along the long axis (NW-SE) of this meadow. The relative contributions of episodic, unchanneled surface flow from the adjacent, tall, wooded slope, or from seasonal groundwater discharge, either from adjacent slope bases or from seasonal groundwater-fed channels in meadow S, is not clear. Very low volume drainage from this meadow occurs via a channel at the meadow's NW corner. This channel, up to one meter deep but with banks stabilized with bryophytes, extends through a narrow band of woods before entering the NW1 meadow and briefly travels across this meadow's NE corner. NW1 and NW2 are rather similar meadows, each sloping notably from SW downward to NE. Each of these meadows is primarily wetted by groundwater discharge along the meadow/woods interface along the meadows' upper, wedge-shaped edges. Meadows NW1 and NW2 appear to have relatively high cover values for tall sedges and grasses, but many of the same plant species found in meadows C and S are found here as well. The moss *Hypnum pratense*, suspected to be rare in Washington and Oregon, was detected only at Celery Meadow among the wetland sites visited during this project. Unfortunately, the specimen is merely a single shoot intermixed in a collection of SAUN at the original SW point of entry to meadow C. A return visit to better document the extent of this moss within the meadow is recommended. Among all wetland sites visited during this project, the count of detected fen indicator taxa at Celery Meadow (17) is second only to the number detected at Government Meadow (18).
Photos: #s 3175, 3176, 3177, 3178, 3179, 3180, 3181, 3182, 3183, 3184, 3185, 3186, 3187, 3188.

4. Evans Creek
Elevation: 3740 ft.
TRS: T17N, 7E, S21
Date: 9/2/2016
Rationale: Target meadow = NWI PEMC
Plants: Graminoids – AGROS2, DECE, **CAEC**, **CALU7**, **JUEN**
Forbs – LYAM3, SAOF3, **PEGR2**, ASTER, **HYAN2**, **PLDI3**, CABI2, **DODEC**
Shrubs - SALIX
Bryophytes – PHFO6, **DRAD2**, DIPA20, **CACU18**
Soil probes: Probes at two locations found a peat thickness of 51+".

Notes: Site accessed by parking at E end of Evans Creek Campground loop and hiking cross-country E through woods while generally keeping the creek within sight, until reaching target meadow. Raining hard during whole visit, nevertheless, meadow appears to be primarily and persistently, groundwater-wetted. Meadow is partitioned by tall SALIX and a small but active creeklet, into roughly S and N halves. The S half appears to have the more robust groundwater-feed. This half is also very notable in the high percentage of soil cover by the moss CACU18. The N half of meadow differs strikingly in having a very high percentage of cover by HYAN2 and little moss cover.
Photos: #s 3189, 3190, 3191-3193, 3194.

5. 7068-211 rd. (w)
Elevation: 4160-4220 ft.
TRS: T19N, R11E, S29
Date: 9/12/2016
Rationale: Target meadow = NWI PEMC
Plants: Forbs – TRIFO, CIAR4
Shrubs – SALIX
Soil probes: None attempted.
Notes: This site features a central stand of tall SALIX surrounded by a weedy herbaceous community occurring on moist, mineral soil. No evidence of even seasonal groundwater input was detected.
Photo: # 3197.

6. 7068-211 rd. (e)
Elevation: 4120-4220 ft.
TRS: T19N, R11E, S29
Date: 9/12/2016
Rationale: Target meadow = NWI PEMC
Plants: Graminoids – SCMI2, **JUEN**, CACA4
Forbs – EQAR, EPILO, **HYAN2**, GALIU, ASTER, CABI2, GEMA4, MIGU, PRVU, TRIFO, ATFI
Shrubs – ALNUS, SALIX
Bryophytes – **DRAD2**, BRPS70, PHFO6, MAPO16, BRWE70, BRFR70
Soil probes: Three probes spread across the extent of the meadow found a peat thickness of 51+".
Notes: This is a very curious wetland. It is persistently, abundantly and extensively wetted by groundwater discharge, thick peat has formed over much of its extent, and it occurs at the very suitable elevation of 4200 ft. It is therefore quite surprising that the wetland appears to lack so many of the fen indicator taxa detected elsewhere on MBS NF. These taxa include SPHAG2, CACU18, CAST70, WAEX, TRGL5, PEGR2, PLDI3, PLSA6, CAEC, and CALU7.
Photos: #s 3198, 3199, 3200, 3201.

7. Naches Pass Trail

Elevation: 4680 ft.
TRS: T19N, R11E, S34
Date: 9/12/2016
Rationale: Target meadow = NWI PEMC
Plants: Graminoids – SCMI2, **CALU7**, CANE6, **CAAQ**, **JUEN**, AGROS2, **CAEC**, DECE, CACA4
Forbs – CABI2, ATFI, GEMA4, **ERIOP**, **PLSA6**, EPILO, TRIFO, SETR, SAXIF, **HYAN2**, VERAT
Shrubs – VACCI, **KAMI**
Bryophytes – RHSQ70, CAFI12, **WAEX**, **DRAD2**, PHFO6, MAPO16, **SPHAG2**, BRFR70
Soil probes: Three probes in the W-most of these two small, adjacent meadows found peat thicknesses ranging from 36”- 42”.
Notes: Two small, closely adjacent meadows are here regarded as a single site. Each of these meadows is closely adjacent to the Naches Pass Trail and slope notably from north downward to south. The W-most of these two meadows is the larger, more strongly groundwater-fed, and botanically diverse. Eleven fen indicator taxa were detected at the W-most meadow while only three were detected at the E-most meadow. At least 25% of soil in the W-most meadow was no more than moist at the time of visit; most of the soil in the E-most meadow was no more than moist at the time of visit.
Photos: #s 3203, 3204.

8. 7080 rd.
Elevation: 4500-4580 ft.
TRS: T19N, R11E, S33
Date: 9/13/2016
Rationale: Target meadow = NWI PEMC
Plants: Graminoids – SCMI2, DECE, **CAEC**, **JUEN**, **CALU7**, CACA4, CANE6, DAIN, AGROS2, **CAAQ**, PHLEU, **CAJO**
Forbs – CABI2, **HYAN2**, GEMA4, **DODEC**, EPILO, EQAR, LIGUS, **ERIOP**, **PLDI3**
Shrubs – SALIX
Bryophytes – AUPA70, PHFO6, BRWE70, RHSQ70, **DRAD2**, BRPS70, CHPO14, SAUN8, **CACO70**
Soil probes: Probes in all three major lobes of the portion of this large wetland-meadow complex that is mapped as NWI PEMC, found peat thicknesses of 51+”.
Notes: This is a very large, variously partitioned by SALIX and conifer, wetland/meadow complex of which the W 35-40% is mapped as NWI PEMC. A small strip of upper meadow slope in the far NE corner of the complex is also mapped as PEMC. The W portion of the complex that is mapped as PEMC is comprised of three major lobes, which are here referred to as the W(est), C(entral) and E(ast) lobes. The W and C lobes are roughly the same size and combined, occupy about half the area of the much larger E lobe. All these lobes are situated on notable, south-aspect slopes. The W and C lobes are the only portion of the whole complex that appear to be persistently and primarily wetted by groundwater. Soils within these lobes are

extensively squishy- and sometimes soppy-wet. In lobe W, botanical diversity is highest along its northern edge. The main body of the lobe is dominated by 24”-30” tall CAAQ, CANE6 and taller yet CACA4. Much CABI occurs on the peat surface beneath these graminoids but virtually no mosses were detected here. Lobe W and lobe C are separated from one another by a north-south partition of tall SALIX. The lower, southern portion of lobe features much SCMI2 and heavily browsed SALIX. The upper portion of the lobe C is the strongest representation of short-statured fen community that was detected within the whole wetland/meadow complex. Interestingly, all plant species detected here were also represented elsewhere in lobes W and C. Soil in lobe E is mostly damp or moist. Broad, seasonal surface flow tracks/channels are present, but only damp or moist-soiled as well. The lobe is dominated by grasses, with a lesser cover of intermixed, vegetative sedges. It is notable that many of species seen in lobes W and C are present here as well, they are more sparsely distributed. HYAN2 is the dominant soil-covering plant species. Also notably, after overcoming initial high resistance, a soil probe in the upper portion of this lobe indicates presence of organic soil 51+” thick. Such thick accumulation of organic soil suggest that either this slope is typically very wet in spring through mid-summer and then loses moisture very rapidly, or that historically, this site was much more persistently groundwater-fed that it is today. The latter would appear to be the more likely scenario. A brief walk-through of the remaining eastern portion of the complex found low-relief topography and many areas of soppy-wet or shallowly inundated soil occupied by much tall SALIX. It seems likely that this wetness is due to gravity-fed accumulation of groundwater-fed surface flow, along with perhaps a lesser amount of seasonal surface flow originating from both rains and snowmelt. The small strip of mapped PEMC at the upper NE edge of the wetland/meadow complex is located where at least seasonal groundwater discharge would be anticipated, but a walkthrough found dry soil and little evidence of any significant groundwater influence. It should be noted that the entry point to this system, from the 7080 rd. immediately south of its junction with the 210 spur, allowed passage through a squishy-wet, groundwater fed, lightly wooded, lightly shrubby fen community that is largely separated from lobe W by a partition of conifers. It appears that the western edge of the groundwater aquifer feeding this community coincides with the 7080 roadbed. The eastern edge of the aquifer, as least as it is manifested by wet peat surfaces, probably coincides with eastern edge of lobe C.
Photos: #s 3208, 3209, 3210.

9. Government Meadow
Elevation: 4740-4840 ft.
TRS: T19N, R11E, S34
Date: 9/12, 9/13, 9/14, 9/15/2016
Rationale: Target meadow = NWI PEMC
Plants: Graminoids – DECE, CASCB, **CAJO**, **CAAQ**, CACA4, **<u>CAMA12</u>**, DAIN, PHLEU, **ELQU2**, **CAEC**, **CALU7, ERIOP**
Forbs – **HYAN2**, TRIFO, ASTER, CABI2, **SPRO**, EQAR, **DODEC**, COPA28, NULU, SPARG, EPILO, **PLDI3**, LIGUS
Shrubs – **KAM**I, SALIX, **VAUL,** SPIRA
Bryophytes – **CAST70**, **WAEX**, **SPHAG**2, RHSQ70**, CACO70**, CHPO14, **<u>HAFL9</u>**,

PHFO6, AUPA70

Soil probes: More than two dozen probes were conducted at widely ranging sites within this large wetland. No peat thicknesses less than 36" were detected. Probes in the southwestern, southern, southeastern and central portions of the wetland detected peat thicknesses greater than 51". Soil probes in this meadow typically encountered dense resistant peat with one or more thin, even more resistant layers, en route to the eventual firm base. These thin, interspersed layers scratch the fiberglass rod, suggesting presence of sand-sized inorganic material.

Notes: This headwaters wetland is essentially a broad, low-relief valley whose primary axis descends from east to west. Its maximum dimensions are approximately 0.5 x 0.25 miles. The primary source of water for this wetland appears to be both seasonal and persistent groundwater discharge.

Zones of squishy to soppy-wet peat along the wetland margins are interpreted as areas of persistent groundwater discharge. Such zones occur at unpredictable points along the entire perimeter of the whole wetland except for along the far western edge. Squishy or soppy-wet interior sites are occasionally found within the many, variously defined channels within the wetland. Wetness within these channels may be intermittent, suggesting that while these channels may carry low-volume continuous flow fed by early season groundwater discharge, they may also intermittently intercept flow of local subsurface groundwater flow later in the snow-free season. The single channel within the wetland that appears carry continuous, if low-volume flow, flows along essentially the full southern edge of the wetland. Flow in the channel originates as groundwater discharge at the forest/wetland interface at the wetland's SE corner. Several pools/ponds of varying sizes occur within the very low-relief, southern portion of the wetland. Wetland vegetation is predominantly herbaceous although inclusions of conifer and SALIX patches are common. The only project-related detection of the target liverwort *Harpanthus flotovianus* was made on a soppy-wet slope at the SE corner of this wetland. One of the two project-related detections of the target sedge *Carex magellanica* is at this same soppy slope. This is now the southern-most record of CAMA12 on MBS NF. Also, this is the only project wetland at which the fen-loving shrub *Vaccinium uliginosum* was detected. The 18 fen indicator taxa detected within this wetland is the largest number detected among the wetlands visited during this project.

Photos: #s 3205, 3206, 3207, 3211-3212, 3213, 3214, 3215, 3216, 3217, 3218, 3219, 3220-3227, 3228-3230, 3231, 3232, 3233, 3234, 3235.

10. Greenwater Trail (s)

Elevation: 3920 ft.

TRS: T18N, R11E, S20

Date: 9/16/2016

Rationale: Target wetland = NWI PEMC

Plants: Graminoids – CAUT, **CAAQ**, DECE, CACA4, SCMI2

Forbs – GALIU, EPILO, CIAR4, ASTER

Shrubs – SALIX

Soil probes: 18"- 51+" organic soil in nearly pure stand of CAUT at mid-wetland.

Notes: Site is accessed by hiking down Greenwater Trial (#1176) after parking at Corral Pass. This is a virtually flat, valley bottom/creek terrace wetland situated along a braided, active creek (Greenwater River). Dominant vegetation is tall CAUT away from active channels and SALIX along those channels. Soil under CAUT is bare peat. There is no evidence of significant groundwater influence on composition of vegetation. Primary water source appears to be seasonal/episodic flooding of terrace, and subsurface connection of terrace water table and water level in the creek channels.
Photos: # 3237.

11. Greenwater Trail (n) – Echo Lake
Elevation: 3840 ft.
TRS: T18N, R11E, S21
Date: 9/16/2016
Rationale: Worth a visit because already in the proximity.
Plants: Graminoids – SCMI2, CACA4, CAUT
Forbs – COPA28, EPILO, GALIU, ASTER
Shrubs – SALIX
Soil probe: None conducted.
Notes: Accessed by hiking about 0.5 mile north along Greenwater Trail beyond site #10 above. No evidence of significant groundwater influence on composition of local wetland/meadow flora. This wetland/meadow is something of a creek terrace/delta at the point of Greenwater River entry to Echo Lake. Primary water source of wetland/meadow appears to seasonal/episodic flooding of this very low-relief, broad valley bottom by Greenwater River. Soil in terrace, not immediately adjacent to any water-bearing channel, tends to be firm and relatively dry.
Photos: # 3242.

12. 9020-310 rd./Harris Lake Trail
Elevation: 3140 ft.
TRS: T22N, R10E, S19
Date: 9/27/2016
Rationale: Target wetland = NWI PEMC
Plants: Graminoids – **CALU7**, **JUEN**, **CAEC**, **ELQU2***, **ERIOP**, DECE, CACA4, CAUT, CASCB
Forbs – CABI2, LYAM3, EQAR, **HYAN2**, **PLSA6**, **PEGR2**, **DODEC**, **TRGL5**, SAXIF, EPILO, SAOF3, BOTRY, **DRRO**, NULU, ASTER, **PLDI3**
Shrubs – **KAMI**, SPIRA
Bryophytes – **SPHAG2**, DIPA20, SCPA24, CELU, CEBI4, RICCA, **CACU18**, **CAST70,** BRPS70
Soil probes: Probes at the upper (southern) eastern edge, center, and northern end of this wetland found peat thicknesses of 28”, 51+” and 51+”, respectively.
Notes: Site is accessed by parking at the 9020 rd. closure and walking 5.5 miles up road (including following the 310 spur toward end of travel) and then hiking down a steep, heavily

wooded slope to SE edge of wetland. This is a largely squishy or soppy-wet, gently sloping (nearly flat) headwaters wetland that very evidently is primarily wetted by groundwater discharge from shallowly subsurface aquifers on the adjacent eastern, southern and western slopes. Several small, irregularly-shaped pools occur in the southern half of the wetland meadow. The northern end of the wetland is lightly wooded. The upper portion of the adjacent slopes, above the 9020-310 rd., have been logged, but the portions of the slopes between the wetland and road appear to be uncut. While not a target species, but apparently rare on MBS NF, the only project-related detection of the insectivorous plant *Drosera rotundifolia*, occurred at this wetland. Sixteen fen indicator taxa were detected at this wetland, as well as at the 9020-310 wetland. Among the MBS NF wetland sites visited during this project, a larger number of fen indicator taxa were detected only at Government Meadow (18) and Celery Meadow (17).
Photos: #s 3253, 3256, 3257, 3260-3261, 3263-3267, 3269-3270, 3272.

Appendix C

Plant taxa noted at project field sites. Fen indicator taxa in bold.

Taxon Group	Taxon Code	Scientific Name
Graminoids	AGROS2	*Agrostis* sp.
	CAAQ	*Carex aquatilis*
	CACA4	*Calamagrostis canadensis*
	CAEC	*Carex echinatqa*
	CAFL4	*Carex flava*
	CAIL	*Carex illota*
	CAJO	*Carex jonesii*
	CALE10	*Carex leptalea*
	CALEL	*Carex lenticularis* var. *lipocarpa*
	CALU7	*Carex luzulina*
	CAMA12	*Carex magellanica*
	CANE6	*Carex neurophora*
	CAPA19	*Carex pauciflora*
	CASCB	*Carex scopulorum* var. *bracteosa*
	CAST10	*Carex stylosa*
	CAUT	*Carex utriculata*
	CAVE6	*Carex vesicaria*
	DAIN	*Danthonia intermedia*
	DECE	*Deschampsia cespitosa*
	ELQU2	*Eleocharis quinqueflora*
	ELQU2*	*Eleocharis quinqueflora*
	ERIOP	*Eriophorum* sp. (either *E. polystachion* or *E. gracile*)
	HOLA	*Holcus lanatus*
	JUEN	*Juncus ensifolius*
	PHLEU	*Phleum* sp.
	SCMI2	*Scirpus microcarpus*
	SCVA	*Scirpus validus*
Forbs	ARNIC	*Arnica* sp.
	ASTER	*Aster* sp.
	ATFI	*Athyrium filix-femina*
	BLSP	*Blechnum spicant*
	BOTRY	*Botrychium* sp.
	CABI2	*Caltha biflora*
	CIAR4	*Cirsium arvense*
	COPA28	*Comarum palustre*
	DODEC	*Dodecatheon* sp.
	DOJE	*Dodecatheon jeffreyi*
	DRRO	*Drosera rotundifolia*
	EPILO	*Epilobium* sp.
	EQAR	*Equisetum arvense*
	EQFL	*Equisetum fluviatile*

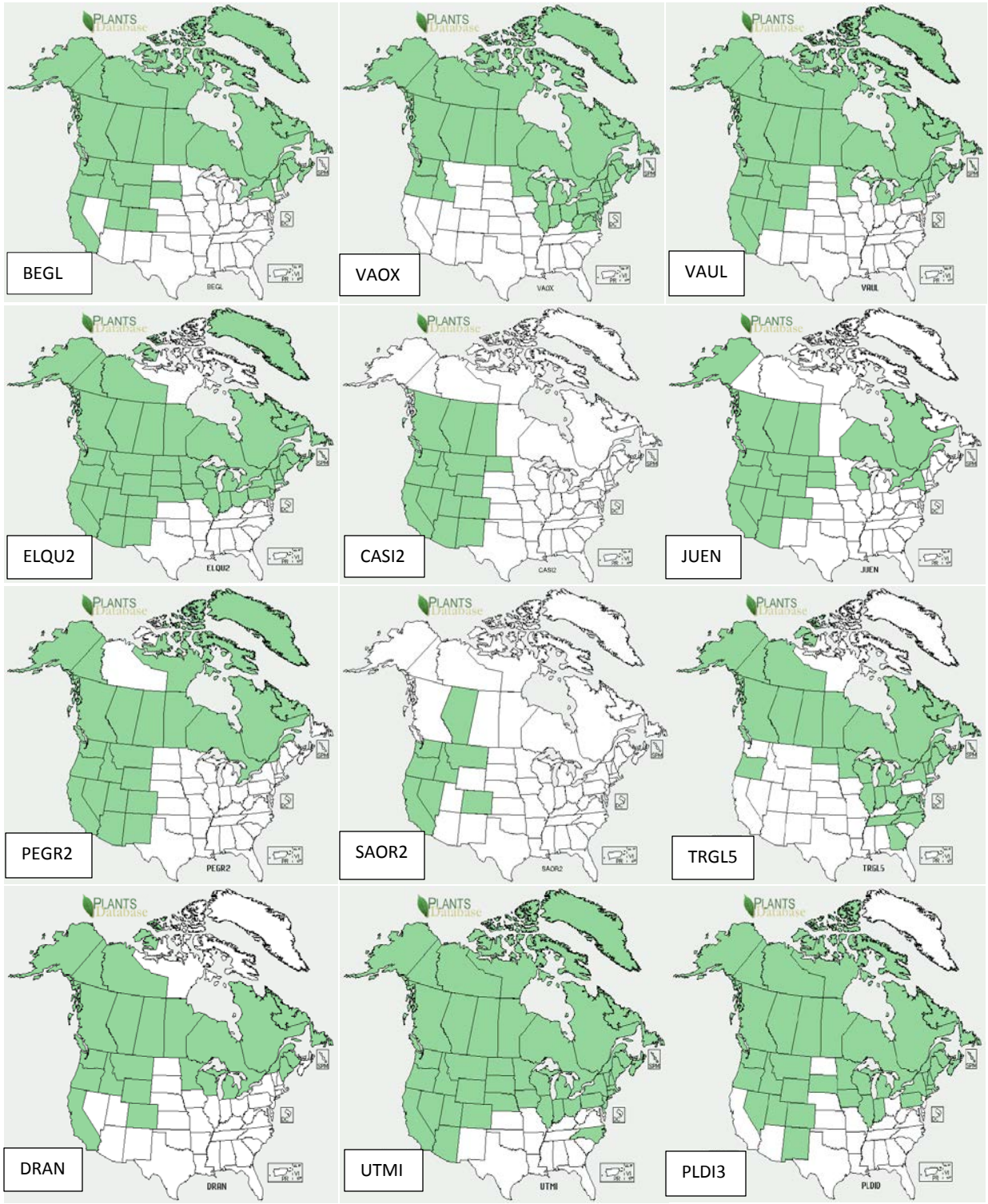
Taxon Group	Taxon Code	Scientific Name
	GALIU	*Galium* sp.
	GEMA4	*Geum macrophyllum*
	HYAN2	*Hypericum anagalloides*
	LEVU	*Leucanthemum vulgare*
	LIGUS	*Ligusticum* sp.
	LOTUS	*Lotus* sp.
	LYAM3	*Lysichiton americanus*
	METR3	*Menyanthes trifoliata*
	MIGU	*Mimulus guttatus*
	NULU	*Nuphar lutea*
	PAFI3	*Parnassia fimbriata*
	PEGR2	*Pedicularis groenlandica*
	PLDI3	*Platanthera dilitata*
	PLSA6	*Platanthera saccata* (= *P. stricta*)
	PRVU	*Prunella vulgaris*
	SAOF3	*Sanguisorba officinalis*
	SAXIF	*Saxifraga* sp.
	SETR	*Senecio triangularis*
	SPARG	*Sparganium* sp.
	SPRO	*Spiranthes romanzoffiana*
	TRGL5	*Triantha glutinosa*
	TRIFO	*Trifolium* sp.
	VERAT	*Veratrum* sp.
Shrubs	ALNUS	*Alnus* sp.
	GASH	*Gaultheria shallon*
	GAULT	*Gaultheria* sp.
	KAMI	*Kalmia microphylla*
	LUPE	*Leutkea pectinata*
	PHYLL3	*Phyllodoce* sp.
	SALIX	*Salix* sp.
	SPDO	*Spiraea douglasii*
	SPIRA	*Spiraea* sp.
	VACCI	*Vaccinium* sp.
	VAUL	*Vaccinium uliginosum*
Bryophytes	AUPA70	*Aulacomnium palustre*
	BAHA3	*Barbilophozia hatcheri*
	BRFR70	*Brachythecium frigidum*
	BRPS70	*Bryum pseudotriquetrum*
	BRWE70	*Bryum weigelii*
	CACO70	*Calliergon cordifolium*
	CACU18	*Calliergonella cuspidata*
	CAFI12	*Calypogeia fissa*
	CALYP6	*Calypogeia* sp.
	CAST51	*Campylium stellatum*
	CAST70	*Calliergon stramineum*
	CEBI4	*Cephalozia bicuspidata*

Taxon Group	Taxon Code	Scientific Name
	CELU	*Cephalozia lunulifolia*
	CHPO14	*Chiloschypus polyanthos*
	DIPA20	*Dicranella palustris*
	DRAD2	*Drepanocladus aduncus*
	FONTI	*Fontinalis* sp.
	HAFL9	*Harpanthus flotovianus*
	HEBL2	*Helodium blandowii*
	HYPR70	*Hypnum pratense*
	MAPO16	*Marchantia polymorpha*
	PHFO6	*Philonotis fontana*
	RHIZO2	*Rhizomnium* sp.
	RHNU4	*Rhizomnium nudum*
	RHSQ70	*Rhytidiadelphus squarrosus*
	RICCA	*Riccardia* sp.
	SAUN8	*Sanionia uncinata*
	SCPA24	*Scapania paludosa*
	SPHAG2	*Sphagnum* sp.
	WAEX	*Warnstorfia exannulata*

Appendix D

Current list of fen indicator taxa for Oregon and Washington developed by project lead. See Discussion section of report for more information about this group of species.

Taxon Group	Taxon Code	Scientific Name
Graminoids	CAAQ	*Carex aquatilis*
	CAEC	*Carex echinata*
	CAGY2	*Carex gynocrates*
	CAJO	*Carex jonesii*
	CALI7	*Carex limosa*
	CALU7	*Carex luzulina*
	CAMA12	*Carex magellanica ssp. irrigua*
	CASI2	*Carex simulata*
	CATE5	*Carex tenuiflora*
	ELQU2	*Eleocharis quinqueflora*
	ERIOP	*Eriophorum* spp.(*E. gracile* or *E. polystachion*)
	JUEN	*Juncus ensifolius*
	JUNE	*Juncus nevadensis*
Forbs	DODEC	*Dodecatheon* spp. (especially *D. jeffreyi*)
	DROSE	*Drosera* spp. (*D. anglica* or *D. rotundifolia*)
	HYAN2	*Hypericum anagalloides*
	METR3	*Menyanthes trifoliata*
	MIPR	*Mimulus primuloides*
	PEGR2	*Pedicularis groenlandica*
	PLATA2	*Platanthera* spp. (*P. dilatata* or *P. saccata*)
	SAOR2	*Saxifraga oregana*
	SCPAA3	*Scheuchzeria palustris* ssp. *americana*
	SPRO	*Spiranthes romanzoffiana*
	TRGL5	*Triantha glutinosa*
	UTRIC	*Utricularia* spp. (*U. minor* or *U. intermedia*)
Shrubs	BEGL	*Betula glandulosa*
	KAMI	*Kalmia microphylla*
	SAPE	*Salix pedicellaris*
	VAOX	*Vaccinium oxycoccos*
	VAUL	*Vaccinium uliginosum*
Bryophytes	CACO70	*Calliergon cordifolium*
	CAGI70	*Calliergon giganteum*
	CARI70	*Calliergon richardsonii*
	CAST70	*Calliergon stramineum*
	CACU18	*Calliergonella cuspidata*

	CAST51	*Campylium stellatum*
	DRAD2	*Drepanocladus aduncus*
	HAVE70	*Hamatocaulis vernicosus*
	HAFL9	*Harpanthus flotovianus*
	HEBL2	*Helodium blandowii*
	HYPR70	*Hypnum pratense*
	METR70	*Meesia triquetra*
	PASQ70	*Paludella squarrosa*
	PLEL2	*Plagiomnium ellipticum*
	SCCO18	*Scorpidium cossonii*
	SCSC70	*Scorpidium scorpioides*
	SPAM5	*Splachum ampullaceum*
	SPSP70	*Splachnum sphaericum*
	SPHAG2	*Sphagnum* spp.
	TONI70	*Tomentypnum nitens*
	WAEX	*Warnstorfia exannulata*

Appendix E – Biogeography of selected fen indicator taxa.