This document is part of a collection of Ecological Integrity Assessments addressing 67 of Washington's 99 Ecological Systems. These documents were prepared by the Washington Natural Heritage Program with funding provided by the Washington Department of Fish and Wildlife.

Ecological Integrity Assessment: North Pacific Bog and Fen

Ecological Summary

The North Pacific Bog and Fen ecological system is composed of peatlands that occur as small patches along the Pacific coast from southeastern Alaska to northern California, in and west of the coastal mountain summits including the Puget Sound lowlands. Elevations are mostly under 457 m (1500 feet), and annual precipitation ranges from 890-3050 mm (35-120 inches). The system is found in river valleys, around lakes and marshes, behind coastal sand dunes, or on slopes. It generally forms in glacial scours, kettles, isolated oxbows, and old lake beds. Near the coast, organic soils typically have an abundance of sodium cations from oceanic precipitation. Topography is mostly flat with only localized hummock development. Initial development of most bogs and fens found in Washington occurred soon after the retreat of the last glacial phase.

Bogs and fen differ from other wetland in having a substrate composed of organic material, typically in the form of peat and muck. The origin of the peat can be *Sphagnum* moss, *Hypnum* ssp., 'brown' mosses, sedges, or woody species. The relative degree of decomposition of these histosol soils is distinguished as being either fibric (peat), hemic, and sapric (muck) in nature. Riggs (1956; 1958) noted that, in Washington, peat accumulates at an approximate rate of 1 inch/40 years and that peat depth in Washington's peatlands ranged from a few to over 50 feet.

Both fen and bogs are collectively called peatlands. Historically, many different criteria have been used to distinguish different types of peatlands such as fen and bog, including water chemistry, floristics, hydrology, and topography. Although there is some correspondence between these approaches, they are not always consistent which has resulted in much confusion about the precise definitions of a fen versus a bog. One of the common approaches is to classify peatlands according to pH and associated vegetation. For example, bog (very acidic) – poor fens – rich fens – extreme rich fens (very basic). Generally speaking, mineratrophic groundwater (discharges from bedrock or mineral substrates) occurs within the rooting zone of fens whereas in bogs peat has accumulated deep enough so that the rooting zone is above the influence of mineratrophic groundwater, limiting hydrological sources to precipitation. As such, "true" bogs are only found in areas of high precipitation. These hydrological differences result in chemical (pH and nutrient status) differences. Poor fens and bogs are often difficult to distinguish as they both have low pH (<5.5) and share many species such as *Sphagnum* moss and Ericaceous species. Fens are often dominated by "brown mosses", sedges, and graminoids and have circumneutral to basic pH (>5.5). In Washington, local researchers have suggested using the term "*Sphagnum*-dominated peatlands" to refer to 'bogs and poor fens' (Kulzer et al. 2001).

Often bogs and fens may be intermixed with each other in the same wetland because of development in similar topography. Often, other wetland type can surround or occur adjacent to bogs and fens. However, bogs and fens can also be hydrologically isolated from each other and other wetland types.

Within the North Pacific Bog and Fen system, vegetation is usually a mix of conifer-dominated overstory, shrubs, and open *Sphagnum* or sedge lawns, often with small ponds and pools interspersed. Graminoids, evergreen or deciduous broadleaf shrubs, or evergreen needleleaf trees are commonly dominate. Many plant species are confined to this system. Some of the bog and fen plant associations, especially those in fens, also occur in Temperate Pacific Freshwater Marsh and North Pacific Shrub Swamp Ecological Systems. Many species common to boreal continental bogs and fens, such as *Ledum groenlandicum, Vaccinium uliginosum, Myrica gale, Andromeda polifolia, Vaccinium oxycoccos, Equisetum fluviatile, Comarum palustre*, and *Drosera rotundifolia* are common. However, the presence of Pacific coastal species, including *Pinus contorta* var. *contorta, Picea sitchensis, Tsuga heterophylla, Ledum glandulosum, Thuja plicata, Gaultheria shallon, Spiraea douglasii, Carex aquatilis* var. *dives, Carex obnupta, Carex pluriflora, Sphagnum pacificum, Sphagnum henryense*, and *Sphagnum mendocinum*, provide a unique floristic character to this ecological system. Other common species include *Kalmia microphylla, Dulichium arundinaceum, Eriophorum* ssp., and a variety of sedges (*Carex* ssp.).

The accumulation of undecomposed or slightly decomposed organic matter contributed by *Sphagnum* (poor fens and bogs) or sedges, shrubs, and/or brown mosses (fens) is the primary ecological driver distinguishing fens and bogs from other wetland types. Stable groundwater, surface water, or precipitation inputs are crucial for continual integrity of these organic soils.

Fire is relatively rare in these systems, although Native Americans were known to use fire in peatlands found on the coast of the Olympic peninsula to maintain and encourage growth of usable plants.

This system is distinguished and split from Rocky Mountain Subalpine-Montane Fen due to the overwhelming influence of oceanic inputs (e.g. higher sodium cations) which the latter lacks (thus, mostly a West-East Cascade distinction) as well as biogeographic differences in their respective floras.

Stressors

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

Historic and contemporary land use practices have impacted hydrologic, geomorphic, and biotic structure and function of peatlands in western Washington. Conversion of peatlands for agriculture has resulted in significant loss of peatland extent. These areas are often cultivated for blueberries, cranberries, etc.

Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed (fens) or surrounding landscape can also have a substantial impact on the hydrological regime. Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., roading or removing vegetation on adjacent slopes) results in changes in species composition and wetland extent. Water diversions and ditches can have a substantial impact on the hydrology as well as biotic integrity of peatland. For example, if the water table is lowered, peat oxidization and subsequent decomposition occurs thereby reducing peat depth, altering hydrological patterns, and resulting in a change of species composition. Conversely, increased surface flow into a bog or fen could result in the site being converted into a new wetland type that reflects the new hydrology, e.g., marsh. Since fens are reliant on groundwater any disturbances that impact water quality or quantity are a threat. These threats include groundwater pumping, mining, and improper placement of septic systems, water diversions, dams, roads, etc.

Human land uses in adjacent upland areas have reduced connectivity between wetland patches and upland areas. Land uses in contributing the watershed (e.g., logging, roads, development, etc.) have the potential to contribute excess nutrients into to the system which could lead to the establishment of non-native species and/or dominance of native increasing species. In general, excessive livestock or native ungulate use leads to a shift in plant species composition. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. Although most wetlands receive regulatory protection at the national, state, and county level, many wetlands have been and continued to be filled, drained, grazed, and farmed extensively.

Peat mining can have a substantial impact on bogs and fens. Given the slow accumulation rates of peat, once it is mined (i.e. removed) the fen or bog cannot be restored to historic conditions in a time frame relevant to management activities. The removal of peat alters the subsurface hydrological storage capacity of the peatland and tends to channelize surface flow which might result in further degradation. Peat mining can also decrease species diversity and alter species composition.

When upland forest areas adjacent to bogs and fens are logged, decreases in evaporation rates and increased surface flow from such areas can contribute excess water into the peatland. Such impacts could have negative consequences to hydrological regime of the peatland resulting in changes of decomposition and species composition.

Likewise, roads in a peatland’s watershed can have similar deleterious effects on the hydrological regime as well as increasing sediment, contaminant, and nutrient inputs into a peatland.

Increased nutrients (wherever the source) can alter species composition and, in *Sphagnum*-dominated peatlands, result in the loss of *Sphagnum*.

Conceptual Ecological Model
The general relationships among the key ecological attributes associated with this system are presented in Figure 1.

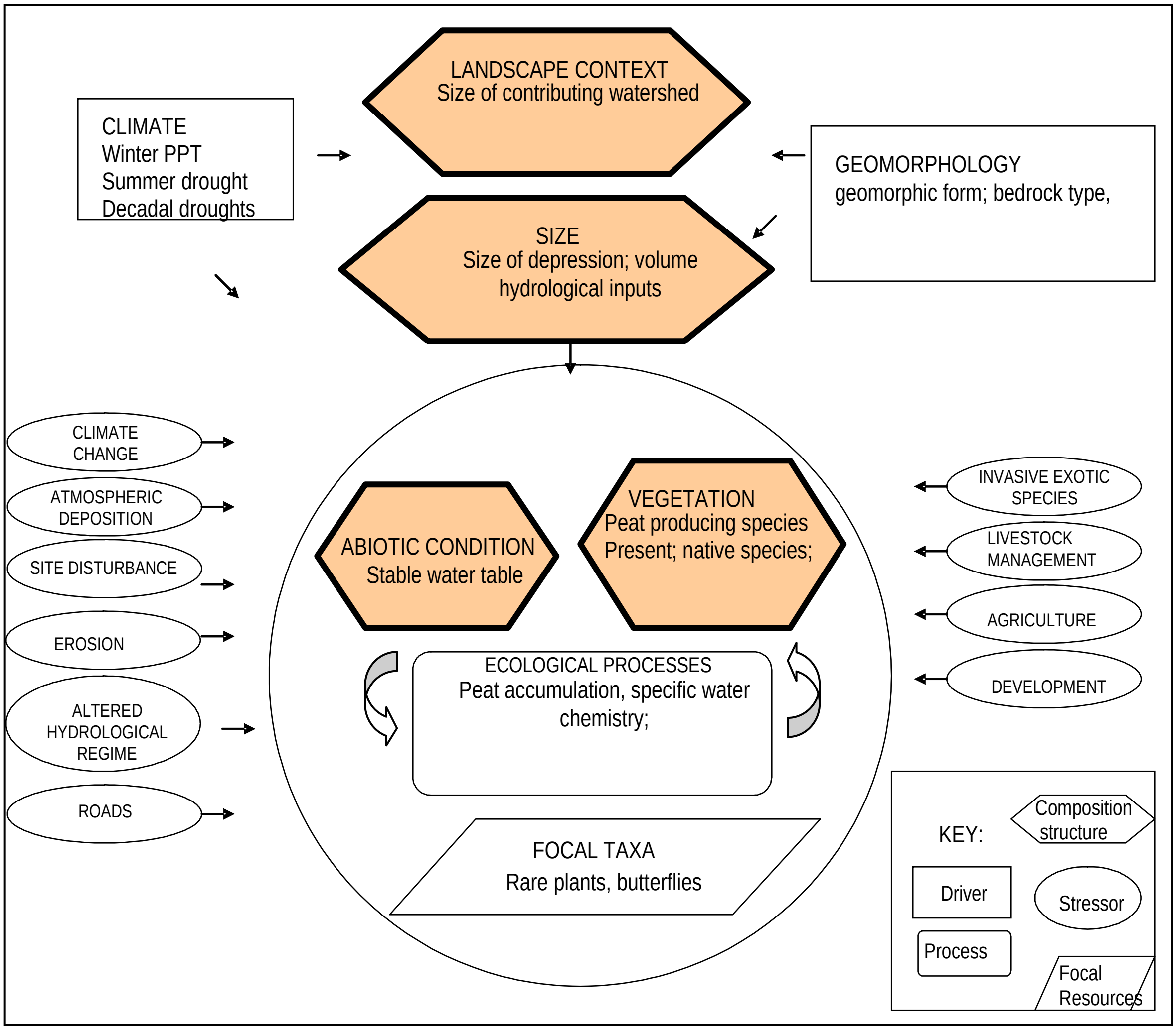

Figure 1. Conceptual Ecological Model for North Pacific Bog and Fen

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

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

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

Level 1 EIA

A generalized Level 1 EIA is provided in Rocchio and Crawford (2009). Please refer to that document for the list of metrics applicable to this ecological system.

Level 2 EIA

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

Table 1. North Pacific Bog and Fen Level 2 EIA.

Metric	Justification	Rank			
		A (5 pts.)	B (4 pts.)	C (3 pts.)	D (1 pts.)
Rank Factor: LANDSCAPE CONTEXT					
Key Ecological Attribute: *Buffer Effects*					
Buffer Length	The buffer can be important to biotic and abiotic aspects of the wetland as it provides connectivity and provides a 'filter' from exogenous threats.	Buffer is > 75 – 100% of occurrence perimeter.	Buffer is > 50 – 74% of occurrence perimeter.	Buffer is 25 – 49% of occurrence perimeter	Buffer is < 25% of occurrence perimeter.
Buffer Width		Average buffer width of occurrence is > 200 m, adjusted for slope.	Average buffer width is 100 – 199 m, after adjusting for slope.	Average buffer width is 50 – 99 m, after adjusting for slope.	Average buffer width is < 49 m, after adjusting for slope.
Buffer Condition		Abundant (>95%) cover native vegetation, little or no (<5%) cover of non-native plants, intact soils, AND little or no trash or refuse.	Substantial (75–95%) cover of native vegetation, low (5–25%) cover of non-native plants, intact or moderately disrupted soils; minor intensity of human visitation or recreation.	Moderate (25–50%) cover of non-native plants, moderate or extensive soil disruption; moderate intensity of human visitation or recreation.	Dominant (>50%) cover of non-native plants, barren ground, highly compacted or otherwise disrupted soils, moderate or greater intensity of human visitation or recreation, no buffer at all.
Key Ecological Attribute: *Landscape Structure*					
Connectivity	Intact areas have a continuous corridor of natural or semi-natural vegetation between areas	Intact: Embedded in 90-100% natural habitat; connectivity is expected to be high.	Variegated: Embedded in 60-90% natural or semi-habitat; habitat connectivity is generally high, but lower for species sensitive to habitat modification;	Fragmented: Embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape.	Relictual: Embedded in < 20% natural or semi-natural habitat; connectivity is essentially absent

Landscape Condition Model Index	The intensity and types of land uses in the surrounding landscape can affect ecological integrity.	Landscape Condition Model Index >0.8		Landscape Condition Model Index 0.79 – 0.65	Landscape Condition Model Index < 0.65

Rank Factor: CONDITION

Key Ecological Attribute: *Vegetation Composition*

Relative Cover Native Plant Species	Native species dominate this system; non-natives increase with human impacts.	Cover of native plants 95-100%.	Cover of native plants 80-95%.	Cover of native plants 50 to <79%.	Cover of native plants <50%.
Absolute Cover of Invasive Species	Invasive species can inflict a wide range of ecological impacts. Early detection is critical.	None present.	Invasive species (e.g., *Typha*, *Phalaris*, *Phragmites*) present, but sporadic (<3% cover).	Invasive species (e.g., *Typha*, *Phalaris*, *Phragmites*) prevalent (3–10% absolute cover).	Invasive species (e.g., *Typha*, *Phalaris*, *Phragmites*) abundant (>10% absolute cover).
Relative Cover of Native Increasers	Some stressors such as grazing or water quality changes can shift or homogenize native composition toward species tolerant of stressors. (Christy and Chappell 2000)	Absent or incidental. Native species that increase with disturbance or changes in hydrology/nutrients (e.g *Juncus effusus*, *Spirea douglasii*, *Carex obnupta*) are absent or confined to nutrient-medium to rich communities (fens).	<10% cover; Native species that increase with disturbance or changes in hydrology/nutrients are low in abundance.	10-20% cover; Native species that increase with disturbance or changes in hydrology/nutrients may be very prominent, even in communities adapted to nutrient poor conditions (*Sphagnum* bogs).	>20% cover; Native species that increase with disturbance or changes in hydrology/nutrients are prominent to dominant.
Mean Coefficient of Conservatism	The proportion of conservative, native plants in the peatland. (ratings are based on Rocky Mtn. Fen values)	Mean C: > 6.9	Mean C: 6.0 – 6.9	Mean C: 5.5 – 5.9	Mean C: < 5.5
Cover of Shrubs	Shrub density/cover can increase as water tables decline resulting in detrimental shading of *Sphagnum* (only use in non-forested *Sphagnum*-dominated peatlands) (Kulzer et al. 2001)	*Ledum*, *Kalmia*, *Vaccinium* cover is < 90 cm/3 feet high		*Ledum*, *Kalmia*, *Vaccinium* cover is > 90 cm/3 feet high and starting to shade out *Sphagnum* moss and allowing other moss species to establish.	

Key Ecological Attribute: *Vegetation Structure*

Organic Matter Accumulation	Estimates the thickness and integrity of the surface organic soil horizons (e.g., peat; Oi, Oe, and Oa horizons) in the bog/fen.	Surface organic horizons are present and undisturbed. Von Post index is within natural range of variability		Surface organic horizons are present. The thickness of the organic horizon has been reduced by > 25 %. The moss layer (when present) has been partially removed. Von Post index is lower (2 categories) than natural range of variability	Surface organic horizons are present. The thickness of the organic horizon has been reduced by > 50 %. The moss layer (when present) has been mostly removed removed. Von Post index is lower (>2 categories) than natural range of variability
Key Ecological Attribute: *Hydrology*					
Water Source	Anthropogenic sources of water can have detrimental effects on the hydrological regime	Source is natural or naturally lacks water in the growing season. No indication of direct artificial water sources	Source is mostly natural, but site directly receives occasional or small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, artificially impounded water, or other artificial hydrology	Water flow has been substantially diminished by human activity
Hydroperiod	Alteration in hydrology or sediment loads or some onsite stressors can degrade channel stability	Site is characterized by stable, saturated hydrology, or by naturally damped cycles of saturation and partial drying.	Site experiences minor altered inflows or drawdown/drying, as compared to more natural wetlands (e.g., ditching).	Site is somewhat altered by greater increased inflow from runoff, or experiences moderate drawdown or drying, as compared to more natural wetlands (e.g., ditching).	Site is greatly altered by greater increased inflow from runoff, or experiences large drawdown or drying, as compared to more natural wetlands (e.g., ditching).
Key Ecological Attribute: *Physicochemical*					
Physical Patch Diversity	Intact sites have a diversity of physical environments	Full range of physical patch types expected at any given bog/fen such as *Sphagnum* hummocks, *Sphagnum* carpets, hollows, water tracks, pools, laggs, sedge lawns, etc. are present. Human-induced impacts have not eliminated the presence of any patch types.		Most physical patch types typical of bogs/fens are present but some may have been lost or eliminated due to human-induced impacts.	Many physical patch types typical of bogs/fens are missing from the site due to human-induced impacts. Patch diversity has been homogenized.
Soil Surface Condition	Soil disturbance can result in erosion thereby negatively affecting many ecological processes	Bare soil areas or degradation of surface peat are limited to naturally caused disturbances such as game trails, fallen logs, natural fires, etc.	Some bare soil due to human causes but the extent and impact is minimal. The depth of disturbance is limited to only a few inches and does not show evidence of ponding or channeling water or degradation of the peat profile.	Bare soil areas due to human causes are common. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts. Peat profile is degrading.	Bare soil areas substantially & contribute to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Water will be channeled or ponded. Peat profile is degraded.
Water Quality	Excess nutrients, sediments, or other pollutant have an adverse affect on natural water quality	No evidence of degraded water quality. Water is clear; no strong green tint or sheen.	Some negative water quality indicators are present, but limited to small and localized areas. Water may have a minimal greenish tint or cloudiness, or sheen.	Negative indicators or wetland species that respond to high nutrient levels are common. Water may have a moderate greenish tint, sheen or other turbidity with common algae.	Widespread evidence of negative indicators. Algae mats may be extensive. Water may have a strong greenish tint, sheen or turbidity. Bottom difficult to see during due to surface algal mats and other vegetation blocking light to the bottom.

Rank Factor: SIZE					
Key Ecological Attribute: *Size*					
Relative Size	Indicates the proportion lost due to stressors.	Site is at or minimally reduced from natural extent (>95% remains)	Occurrence is only modestly reduced from its original natural extent (80-95% remains)	Occurrence is substantially reduced from its original natural extent (50-80% remains)	Occurrence is severely reduced from its original natural extent (<50% remains)
Absolute Size	Absolute size may be important for buffering impacts originating in the surrounding landscape	Very large (> 150 ac/60 ha)	Large (50-150 ac/20-60 ha)	Moderate (5-50 ac/2-20 ha)	Small (< 5 ac/2 ha)

Level 3 EIA
Level 3 metrics would include more quantitative measures of the metrics listed above. In addition, the following metrics should be considered in a Level 3 EIA:

- Water Table Depth
- pH
- Nitrogen Enrichment (C:N)
- Phosphorous Enrichment (C:P)
- Metal contaminants

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

Table 2. Triggers for Level 2 & 3 EIA

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

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

Supporting documents for the EIAs can be found at:
http://www1.dnr.wa.gov/nhp/refdesk/communities/eia.html

Documentation about Ecological Systems can be found at:
http://www1.dnr.wa.gov/nhp/refdesk/communities/ecol_systems.html

References

Anderson, M.K. 2009. The Ozette Prairies of Olympic National Park: Their Former Indigenous Uses and Management. Final Report to Olympic National Park, Port Angeles, Washington.

Christy, J. 2001. Low-elevation *Sphagnum* Wetlands in Western Oregon. Report Submitted to the U.S. Environmental Protection Agency, Region 10 Oregon Operations Office, Portland, OR. Oregon Natural Heritage Program. Portland, Oregon.

Christy, J. and C. Chappell. 2001. *Sphagnum* Bogs and Fens. Appendix 11 Willamette Valley – Puget Trough – Georgia Basin Ecoregion Terrestrial Ecological System EO Specs and EO Rank Specs. *In* Floberg, J., M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Iachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, D. Rolph. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report. Prepared by The Nature Conservancy with support from the Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.

Collins, J.N., E. Stein, and M. Sutula. 2008. California rapid assessment method (CRAM) for wetlands. Version 5.0.2. San Francisco Estuary Institute. San Francisco, California. Available online at: http://www.cramwetlands.org/

Kulzer, L., S. Luchessa, S. Cooke, R. Errington, and F. Weinmann. 2001. Characteristics of the Low-elevation *Sphagnum*-dominated Peatlands of Western Washington: A Community Profile. Report Prepared for U.S. Environmental Protection Agency, Region 10. Online: http://www.kingcounty.gov/environment/waterandland/stormwater/documents/sphagnum-bogs.aspx

MacKenzie, W.H. and J.R. Moran. 2004. Wetlands of British Columbia. A Guide to Identification. Research Branch, B.C. Ministry of Forestry, Victoria, British Columbia.

Rigg, George B. 1925. Some *Sphagnum* Bogs of the North Pacific Coast of America. Ecology, Vol. 6, No. 3 (July, 1925), pp. 260-275

Rigg, George B. 1958. Peat Resources of Washington. Washington Department of Conservation, Division of Mines and Geology. Bulletin No. 44. Olympia, Washington.

Rigg, G.B. and S.P. Gessel. 1956. Peat Deposits of the State of Washington. Soil Science Society Proceedings, 1956.

Rocchio, F.J. and R.C. Crawford. 2009. Monitoring Desired Ecological Conditions on Washington State Wildlife Areas Using an Ecological Integrity Assessment Framework. Washington Natural Heritage Program, Washington Department of Natural Resources, Olympia, WA.

Rocchio, J. 2006. Rocky Mountain Subalpine-Montane Fen Ecological Integrity Assessment. Report Prepared for NatureServe, Arlington, VA. Colorado Natural Heritage Program, Colorado State University. Fort Collins, CO. Online: http://www.cnhp.colostate.edu/download/documents/2005/ecological_integrity/Rocky%20Mountain%20Subalpine-Montane%20Fen_EIA_Dec09_05.pdf

Sheldon, D., T. Hruby, P. Johnson, K. Harper, A. McMillan, T. Granger, S. Stanley, and E. Stockdale. 2005. Wetlands in Washington State. Volume 1: A Synthesis of the Science. Ecology Publication #05-06-006, Washington Department of Ecology, Olympia, Washington.

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