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 Hypermaritime Western Redcedar-Western Hemlock Forest

Ecological Summary

The North Pacific Hypermaritime Western Redcedar-Western Hemlock Forest system is a matrix to large patch type restricted to the hypermaritime (hypermaritime continentality *sensu* Klinka et al. 1989) climatic areas near the Pacific Coast centered in the northern coast of British Columbia into the southern half of southeastern Alaska and south into Washington. This is usually inland of the coastal fog zone and down slope of the rain-on-snow zone. The system occurs on low, gentle relief appearing mostly below 600 m (1970 ft) elevation and usually within 25 km (15 miles) of the outer coast. The associated hypermaritime climate has cool summers, fog, and very wet winters without a major snowpack. Annual precipitation is 100 to 150 inches, with the majority falling as rain, which can be heavy. Soils are often leached and nutrient-poor with much of the soil nutrients in the surface organic matter layers (McKinnon 2003). Soils typically have a distinct humus layer overlying mineral horizons or bedrock and are often poorly drained. These forests are best developed in a mosaic with forested wetlands, bogs, and *Picea sitchensis* forests associated with valley bottoms on steep, more productive soils. The system is part of the coastal temperate rain forests of North America which contain the largest, most commercially valuable, fastest-growing trees, and the oldest, most fought-over forests (McKinnon 2003).

The forests are often open and scrubby but can be closed. *Thuja plicata* is always present and typically is dominant or codominant often with *Tsuga heterophylla* as codominant. *Pinus contorta* or *Abies amabilis* can be part of the canopy. In Washington, nearly pure stands of *Tsuga heterophylla* are common and seem to be associated with microsites most exposed to intense windstorms. *Pseudotsuga menziesii* is rare in Washington. *Picea sitchensis* can be present (less than 10% cover) put never common. The understory is rich with shade-tolerant species including shrubs *Gaultheria shallon*, and *Vaccinium ovalifolium*, forbs *Maianthemum dilatatum* and *Oxalis oregana*, and ferns *Polystichum munitum*, *Dryopteris* spp., and *Blechnum spicant* which can be abundant. A high diversity of mosses (commonly *Hylocomium splendens* and *Rhytidiadelphus loreus)* and lichens are abundant on logs, snags, trees, or the ground surface. *Rubus spectabilis* and *Acer circinatum* are common and persistent shrubs following disturbance. Plant species and community change is similar among old growth and earlier stand developmental stages although some species are more common on old growth (McKinnon 2003).

Pre-settlement forests were mostly old-growth (a British Columbia project found 98% of hypermaritime forest stand age classes were greater than 141 years, McKinnon 2003) with abundant large woody debris. Van Pelt (2007) maps the presettlement distribution of 1000 year and older *Thuja plicata* forest in Washington reflecting the extent of this system near the outer coast. These forests very rarely burn and are more influenced by gap disturbance processes and intense windstorms than by fire. Intense windstorms are occasional (average 20 years Henderson et al. 1989; 100-200 years Landfire 2007) and widespread. Wind disturbance in contrast to fire tends to topple taller trees and leave small trees, while the tallest trees are often the most wind-firm by surviving normal wind events and are left in major events (Van Pelt 2007). *Thuja plicata* often are over 1000 years old and with candelabra tops reflecting past wind breakage and other top kill events (Van Pelt 2007). Wind effects are in the range of 1-1000 of hectares (2.5-2500 acres); most are 10-100 ha (25-250 ac) (Landfire 2007). Natural blowdown patches in Alaska hypermaritime forests are small (less than 50 acres) and scattered (Nowacki and Kramer 1998). Patches are concentrated on ridgetops and upper slopes and some locations development beyond the stem exclusion stage is rare due to repeated blowdown. *Tsuga heterophylla* is the usual dominant in these blown down forests. Nowacki and Kramer (1998) cite that the 50 percent of the hypermaritime forest landscape on an Alaska Island was a mix of small- and large-scale disturbances.

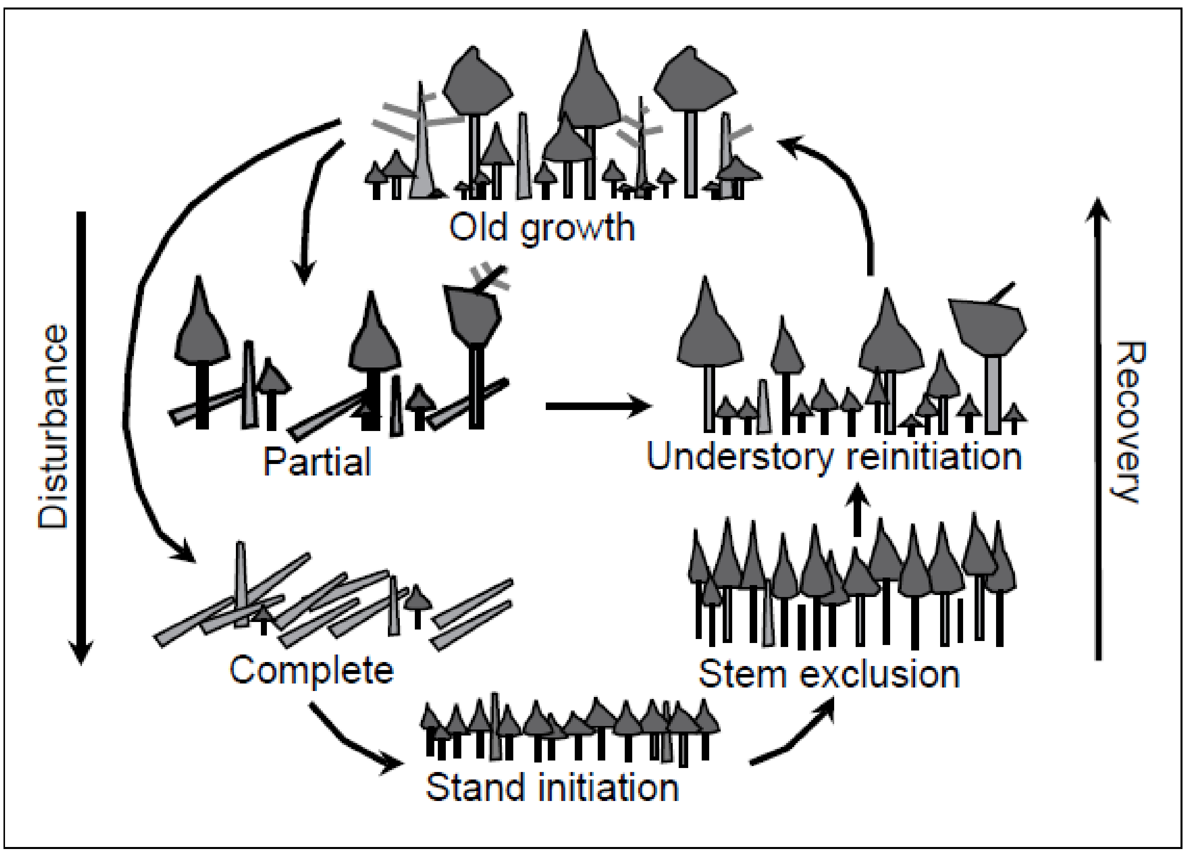

Figure 7—Disturbance and recovery cycles in temperate rain forests of southeast Alaska that occur on wind-protected landscapes where small-scale gap processes predominate.

Figure 1. Small gap-phase forest dynamics differ from fire replacement forest as illustrated above from Nowacki and Kramer (1998).

Daniels and Gray (2006) summarize that mean fire return intervals are typically over 1000 years in the hypermaritime forests in British Columbia and Landfire (2007) state that is no evidence of fire in these forests. In general, the flammability ratings of the wet coastal temperate rain forest are low. Coarse woody debris accounts for the majority of persistent surface fuels that stays moist under moss and herbs and in the shade of multiple layers of trees and shrubs.

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).

Since European settlement, development, timber harvest, road building, tree plantations and introduced diseases have all impacted natural disturbance regimes, forest structure, composition, landscape patch diversity, and tree regeneration. Timber harvest operations change canopy structural complexity and abundance of large woody debris of individual stands and has altered whole landscape patch pattern, age and structural complexity (Van Pelt 2007). Many historical occurrences of this system have become conifer plantations and logging of remaining intact stands remains a threat. Clearcut logging and plantation forestry have resulted in less diverse tree canopies, with reductions in coarse woody debris, a shortened stand initiation phase, and succession truncated well before late-seral characteristics are expressed (Nowacki and Kramer 1998). In the past century, stand-initiating fires, most were human-ignitions, have burned coastal forests but under unusual conditions in which logging created large fuel loads and microclimatic conditions that allowed the fuels to dry, making these sites conducive to burning (Daniels and Gray 2006). Non-native species are also a potential threat to the persistence and ecological integrity of this ecological system.

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

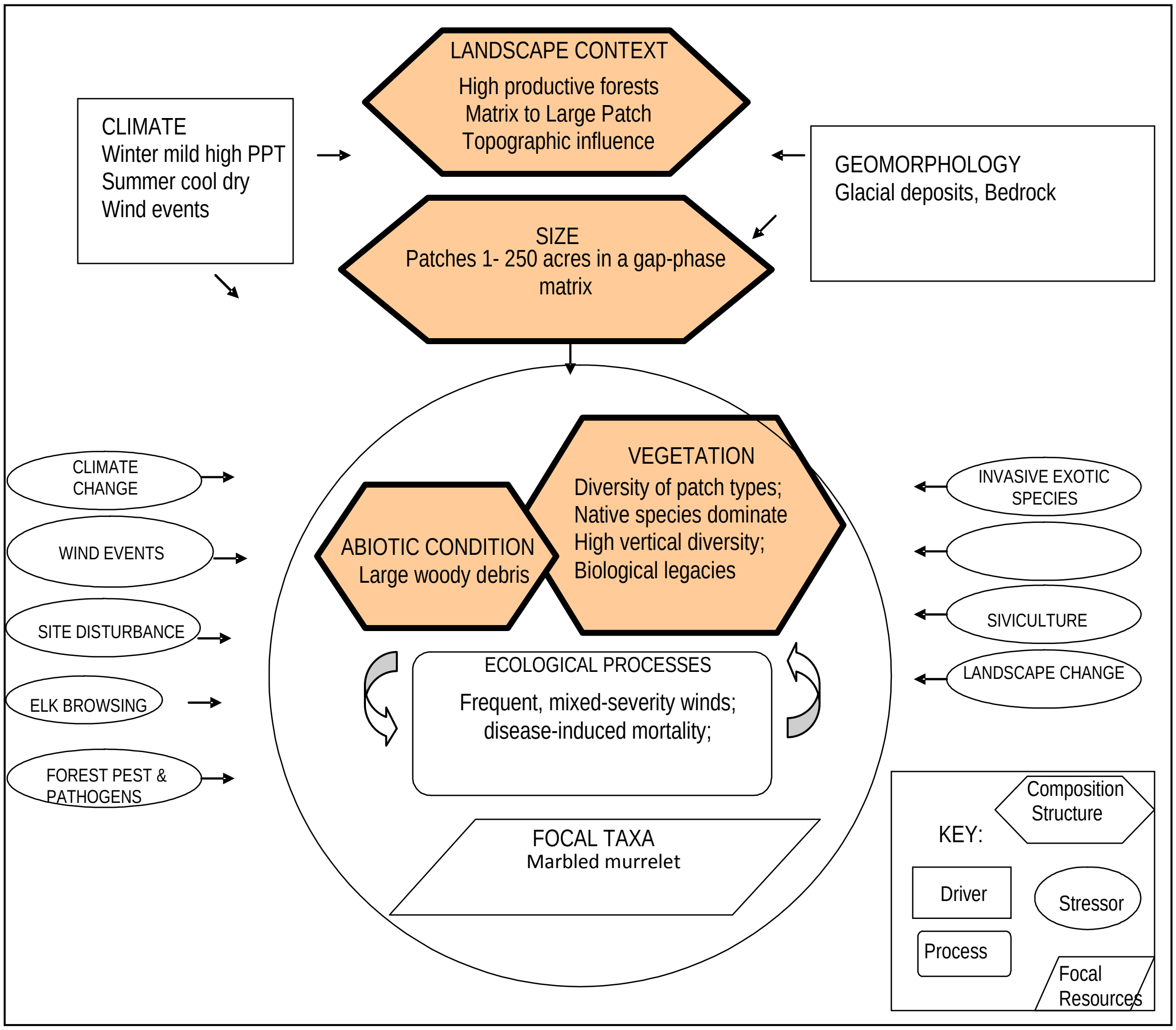

Figure 2. Conceptual Ecological Model for North Pacific Hypermaritime Western Redcedar-Western Hemlock Forest System.

Ecological Integrity Assessments
The assessment of ecological integrity can be done at three levels of intensity depending on the purpose and design of the data collection effort. The three-level approach is intended to provide increasing accuracy of ecological integrity assessment, recognizing that not all conservation and management decisions need equal levels of accuracy. The three-level approach also allows users to choose their assessment based in part on the level of classification that is available or targeted. If classification is limited to the level of forests vs. wetlands vs. grasslands, the use of remote sensing metrics may be sufficient. If very specific, fine-scale forest, wetland, and grassland types are the classification target then one has the flexibility to decide to use any of the three

levels, depending on the need of the assessment. In other words, there is no presumption that a fine-level of classification requires a fine-level of ecological integrity assessment.

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

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

Level 1 EIA

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

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 Hypermaritime Western Redcedar-Western Hemlock Forest 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: *Edge Effects*					
Edge Length	The intactness of the edge can be important to biotic and abiotic aspects of the site.	75 – 100% of edge is bordered by natural communities	50 – 74% of edge is bordered by natural communities	25 – 49% of edge is bordered by natural communities	< 25% of edge is bordered by natural communities
Edge Width		Average width of edge is at least 100 m.	Average width of edge is at least 75-100 m.	Average width of edge is at least 25-75 m.	Average width of edge is <25 m.
Edge Condition		>95% cover native vegetation, <5% cover of non-native plants, intact soils	75–95% cover of native vegetation, 5–25% cover of non-native plants, intact or moderately disrupted soils	25–50% cover of non-native plants, moderate or extensive soil disruption	>50% cover of non-native plants, barren ground, highly compacted or otherwise disrupted soils
Key Ecological Attribute: *Landscape Structure*					
Connectivity **(within 1 km)**	Intact areas have a continuous corridor of natural or semi-natural vegetation between assessment 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
Patch Diversity Origin (within 1 km)	Patch diversity reflects natural dynamics of gap replacement processes	Over 90% of forest patches of natural origin or result of natural processes	75-90% of forest patches of natural origin or result of natural processes	50-74% of forest patches of natural origin or result of natural processes	Less than 50% of forest patches of natural origin or result of natural processes
Rank Factor: CONDITION					
Key Ecological Attribute: *Vegetation*					

Natural Tree regeneration	Natural forests are composed of largely spontaneously growing sets of native plants.	All trees originated from natural regeneration of native tree species	Evidence that at some of trees were planted but most trees are native originating from natural regeneration		Evidence that half to 10% of trees established as natural regeneration (partial or failed plantation with natural regeneration)
Relative Cover Native Understory Plant Species	Native species in shrub and herbaceous layers; non-natives increase with human impacts.	Native species in shrub and herbaceous layers; relative >95% and dominate all physiognomic layers;	Cover of native species in shrub and herbaceous layers; relative 80-95%	Cover of Native species in shrub and herbaceous layers relative 50 to 79%. Nonnative may be co-dominant with native species	Cover of Native species in shrub and herbaceous layers < relative 50%. Nonnative species dominate understory with minor native component.
Absolute Cover of Exotic Invasive Understory Species	Invasive species can inflict a wide range of ecological impacts. *Digitalis purpurea Geranium robertianum, Rubus armeniacus*	None or minimal (<1%) present.	Invasive species present, but sporadic (<5% cover).	Invasive species prevalent (5–30% absolute cover).	Invasive species abundant (>30% absolute cover).
Relative Cover of Native Increaser Species	Some stressors such as soil disturbance can shift or homogenize native composition toward species tolerant of stressors, such as *Rubus ursinus, Urtica dioeca*	Absent or incidental	<10% cover	10-20% cover	>20% cover
Key Ecological Attribute: *Structure*					
Coarse Woody Debris (upland)	Coarse woody debris (CWD), cubic meters/ha, is an important structural feature that provides necessary habitat for many forest taxa and is characteristic and vital part of the hypermaritime forest (Harcombe et al. 2005)	Considering the natural stand development stage, a wide size-class diversity of downed coarse woody debris (logs), with several or more logs exceeding 50 cm dbh / ha, and logs in various stages of decay.	Considering the natural stand development stage, a moderately wide size-class diversity of downed coarse woody debris (logs), with a few logs exceeding 50 cm dbh / ha, and logs in various stages of decay.		Considering the natural stand development stage, a low size-class diversity of downed coarse woody debris (logs) with logs and snags absent to rarely exceeding 50 cm dbh / ha, and logs in mostly early stages of decay (if present).

Large Snags	Large snags are a characteristic and vital part of the forest (Franklin and Spies 1984; Pabst 2005)	Considering the natural stand development stage, large snags common or frequently observed (unless in natural, late stem exclusion stage)	Considering the natural stand development stage, large snags occasionally observed to present		Considering the natural stand development stage, large snags absent.
Large Live Trees	Large trees are a characteristic and vital part of the forest (Franklin and Spies 1984; Pabst 2005) arbitrary thresholds	Considering the natural stand development stage, there are only a few if any cut stumps	Considering the natural stand development stage, there are many more large trees than large cut stumps; Some (10-30%) of the old trees have been harvested		Considering the natural stand development stage, there are around as many large trees as large cut stumps; Many (over 50%) of the old trees have been harvested.
Key Ecological Attribute: *Physicochemical*					
Soil Surface Condition	Soil disturbance can result in compaction, erosion thereby negatively affecting many ecological processes (Napper et al 2009)	**Soil-disturbance Class 0** – Undisturbed • No evidence of past equipment. • No depressions or wheel tracks. • Forest-floor layers are present and intact. • No soil displacement evident. • No management-generated soil erosion. • No management-created soil compaction. • No management-created platy soils.	**Soil-Disturbance Class 1** • Wheel tracks or depressions evident, but faint and shallow. • Forest-floor layers are present and intact. • Surface soil has not been displaced. • Soil burn severity from prescribed fires is low (slight charring of vegetation, discontinuous). • Soil compaction is shallow (0 to 4 inches). • Soil structure is changed from undisturbed conditions to platy or massive albeit discontinuous.	**Soil Disturbance Class 2** • Wheel tracks or depressions are evident and moderately deep. • Forest-floor layers are partially missing. • Surface soil partially intact and maybe mixed with subsoil. • Soil burn severity from prescribed fires is moderate (black ash evident and water repellency may be increased compared to preburn condition). • Soil compaction is moderately deep (up to 12 inches). • Soil structure is changed from undisturbed conditions and may be platy or massive.	**Soil Disturbance Class 3** • Wheel tracks or depressions are evident and deep. • Forest-floor layers are missing. • Surface soil is removed through gouging or piling. • Surface soil is displaced. • Soil burn severity from prescribed fires is high (white orreddish ash, all litter completely consumed, and soil structureless). • Soil compaction is persistent and deep (greater than 12 inches). • Soil structure is changed from undisturbed and is platy or massive throughout.
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	Average wind blowdown event are less 50 acres (Nowacki and Kramer 1998)	Over 5000 acres	500-5000 acres	50-500 acres	<50 acres

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

- Stand structure and composition measurements (Franklin et al. 2002)
- Macrolichens species composition and abundance indicator of air pollution and management (Peterson and McCune 2001; Geiser and Neitlich 2007).
- Weighted Old Growth Habitat Index (Pabst 2005)

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

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