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:
East Cascades Mesic Montane Mixed-Conifer Forest and Woodland

Ecological Summary

The East Cascades Mesic Montane Mixed-Conifer Forest and Woodland ecological system is composed of highly variable montane coniferous forests in Chelan, Kittitas, Yakima, and Klickitat counties in Washington and in adjacent Oregon. This large patch to matrix system lies between and interfingers with the higher elevation North Pacific Mountain Hemlock Forest, North Pacific Mesic Western Hemlock-Silver Fir Forest or Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland and the lower elevation Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest. Westward in the Columbia River Gorge, this system merges with North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest. Elevations range from 610 to 1520 m (2000-5000 feet).The system is associated with a mesic climate regime with annual precipitation ranging from 100 to 200 cm (40-80 inches) and winter snowpack that typically melts off in early spring at lower elevations.

Dominant canopy trees include a mix of *Pseudotsuga menziesii* var. *menziesii* with *Abies grandis, Thuja plicata* and/or *Tsuga heterophylla.* The latter trees have at least 10% cover. Several other conifers can dominate or codominate, including *Pinus contorta, Pinus monticola, Pinus ponderosa* and *Larix occidentalis*. Common shrubs include *Mahonia nervosa, Linnaea borealis, Paxistima myrsinites, Acer circinatum, Spiraea betulifolia, Symphoricarpos hesperius, Cornus nuttallii, Rubus parviflorus*, and *Vaccinium membranaceum*. This system is similar to the Northern Rocky Mountain Mesic Montane Mixed Conifer Forest system except with distinct Cascadian floristic elements, such as *Acer circinatum*, *Acer macrophyllum* and *Mahonia nervosa*. Herbaceous species the reflects local climate and degree of canopy closure and include species restricted to the Cascades, for example, *Achlys triphylla, Anemone deltoidea*, and *Vancouveria hexandra*.

Stand-replacement, fire-return intervals are typically 150-500 years, with moderate-severity fire intervals of 50-100 years (Fire Regime Group III or IV, Landfire 2007). Wright and Agee (2004) calculated a mean fire return interval of 23.9 years for the "wet grand fir" plant association group in the Teanaway Drainage. Hessburg and others (2007) found that mixed severity fires occurred on 53% of the cool/moist forest landscape of the east Cascades and the rest were low (21%) and high severity (26%) fires. Timing of mixed severity fires is irregular and fires are often overlapping (Brown et al. 2000). These mixed fire regimes and varied topography results in a varied landscape of stand development and composition. Noss and others (2006) concluded that knowledge of the mixed-severity fire regime is lacking on its influence on stand structure and development and that assuming fire exclusion results in high tree density or shade-tolerant trees abundance may be incorrect. This complexity results in five general seral or developmental types recognizable in the similar Northern Rocky Mountain Mesic Mixed Conifer system (Shiplett and Neuenschwander 1994):

1) *Tsuga heterophylla – Thuja plicata* stands that initiate following disturbance
2) Mixed conifer stands that initiate from various disturbances
3) Shrubfields that develop from multiple burns
4) Scattered large *Larix occidentalis* surviving fires, and
5) *Pinus contorta* on less productive sites and relatively frequent burns.

The East Cascades Mesic Montane Mixed-Conifer Forest system is primarily composed of the first two types. Shrubfields (type 3 above) composed of *Acer circinatum* and *A. glabrum, Amelanchier alnifolia, Ceanothus* spp., *Salix scouleriana, Ribes* spp., and/or *Vaccinium membranaceum* typically develop following stand-replacing fire. Tree regeneration usually accompanies shrubs and the shrubfields become young forests within a few decades and are included in this system. (Shrubfields where trees are persistently absent to rare are better included in the Northern Rocky Mountain Lower Montane and Foothill Deciduous Shrubland system.) Most stands following fire retain some trees and other biological legacies from the previous forest stand. Tree individuals or whole sites that escape a fire or two allow trees to reach sizes more resistant to fire and results in the clustering of old trees and stands across the landscape. Thus, old growth forests (type 1 above) develop in fire refugia such as headwalls and in riparian stringers and along benches (Camp et al. 1997). The less fire resistant and shade tolerant *Abies grandis*, *Taxus brevifolia*, *Thuja plicata*, and *Tsuga heterophylla* are more common in older forests. The mid-seral, mixed conifer (100-200 year old) stands (type 2 above) are usually canopies composed of *Pseudotsuga menziesii* var. *menziesii*, *Picea engelmannii, Pinus monticola,* and *Larix occidentalis* with *Abies grandis* and maybe *Thuja plicata* on moist, cool sites (Lillybridge et al 1995). Type 4 (above) is recognized as a separate small to large patch within the Western Larch Savanna and Woodland ecological system and type 5 is the Rocky Mountain Lodgepole Pine ecological system. Less productive sites may be susceptible to insects or disease. Douglas-fir bark beetle will affect *Pseudotsuga menziesii* var. *menziesii* and *Abies grandis*. Root rots, butt rots, and stem decay can affect *Abies grandis, Thuja plicata,* whereas *Tsuga heterophylla* is less susceptible. *Pinus monticola* has been impacted by white pine blister rust and its abundance reduced in affected stands. Park and others (2005) concluded that due to climate, limited settlement history, low seed source and closed canopy forest the mountain ecoregions of the Northwest have fewer non-native invasive plants than other regions of the United States. Quigley and others (1997) estimate that late-seral forest structure (stands with upper canopy of primarily shade-intolerant trees) historically occupied about one-third of the landscape, mid-seral forest occupied 40% of the landscape, and early-seral forest occupied 20% of the landscape. Landfire (2007) modeled 65% of this system (BpS) as late seral (50% open), 25% mid-seral (20% closed) and 10% early seral.

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, fire suppression, timber harvest, introduced diseases, road building, development, and plantation establishments have all impacted natural disturbance regimes, forest structure, composition, landscape patch diversity, and tree regeneration (Franklin et al. 2008). Timber harvesting has focused on the large shade-intolerant, fire-resistant species in mid- and late-seral forests thereby eliminating many old forest attributes from stands (Franklin et al. 2008). Fire suppression has allowed less fire-resistant, shade-tolerant trees to become established in the understory (and sometimes dominate the canopy) creating more dense and multi-layered forests than what historically occurred on the landscape. Road development has fragmented many forests creating fire breaks. Under present conditions the fire regime is mixed severity and more variable, with stand-replacing fires more common, and the forests are more homogeneous. With vigorous fire suppression, fire-return intervals are longer, and multi-layered stands provide fuel "ladders," making these forests more susceptible to high-intensity, stand-replacing fires. Quigley and others (1997) estimate that mid-seral forest structure is currently over 40% more abundant than historically, late-seral forests are diminished by 90% and early-seral forest abundance is 20% less than historically lacking snags and other legacy features.

Conceptual Ecological Model

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

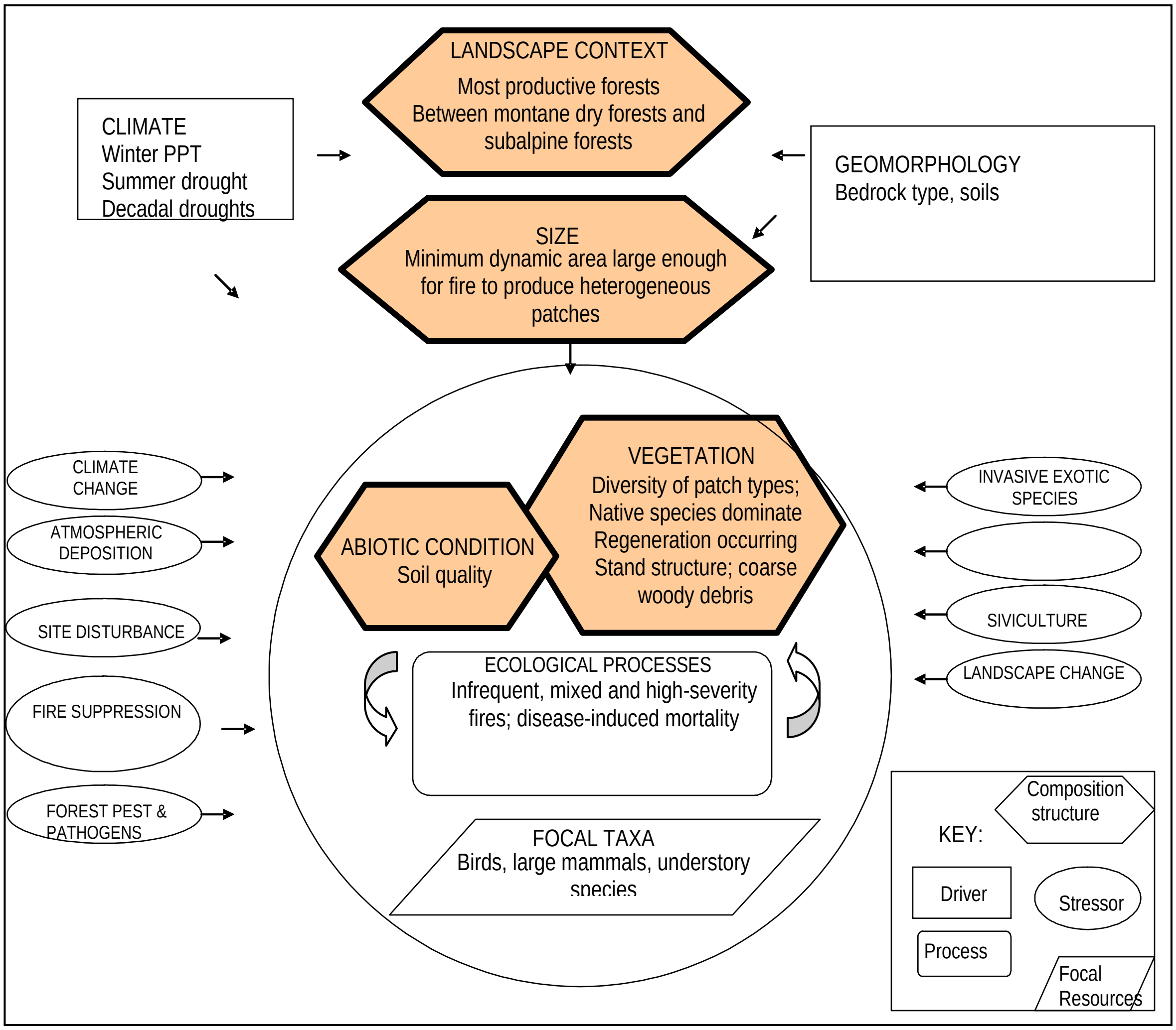

Figure 1. Conceptual Ecological Model for East Cascades Mesic Montane Mixed Conifer Forest.

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. East Cascades Mesic Montane Mixed Conifer 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: *Buffer*					
Edge Length	The intactness of the edge can be important to biotic and abiotic aspects of the site.	75 – 100% of edge is bordered by natural communities	50 – 74% of edge is bordered by natural communities	25 – 49% of edge is bordered by natural communities	< 25% of edge is bordered by natural communities
Edge Width		Average width of edge is at least 100 m.	Average width of edge is at least 75-100 m.	Average width of edge is at least 25-75 m.	Average width of edge is at least <25 m.
Edge Condition		Abundant (>95%) cover native vegetation, little or no (<5%) cover of non-native plants, intact soils	Substantial (75–95%) cover of native vegetation, low (5–25%) cover of non-native plants, intact or moderately disrupted soils	Moderate (25–50%) cover of non-native plants, moderate or extensive soil disruption	Dominant (>50%) cover of non-native plants, barren ground, highly compacted or otherwise disrupted soils
Key Ecological Attribute: *Landscape Structure*					
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 0.65 – 0.79	Landscape Condition Model Index < 0.65

Landscape Fire Regime Condition	Mixed to high severity fire is vital to maintaining ecological integrity. (Fire Regime Condition Class) 2008)	FRCC 1 No departure from historic fire regime.	FRCC 2 Slight-moderate departure from historic fire regime.		FRCC 3 Severe departure from historic fire regime. Fire suppression is evident; Fuel laddering is severe and throughout much of stand.
Connectivity	The percentage of anthropogenic (altered) patches provides an estimate of connectivity among natural ecological systems.	Intact: Embedded in 90-100% natural habitat; connectivity is expected to be high. (Remaining natural habitat is in good condition (low modification); and a mosaic with gradients).	Variegated: Embedded in 60-90% natural habitat; habitat connectivity is generally high, but lower for species sensitive to habitat modification; (Remaining natural habitat with low to high modification and a mosaic that may have both gradients and abrupt boundaries).	Fragmented: Embedded in 10-60% natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape. (Remaining natural habitat with low to high modifications and gradients shortened).	Relictual: Embedded in < 10% natural habitat; connectivity is essentially absent. Remaining natural habitat generally highly modified and generally uniform).
Rank Factor: CONDITION					
Key Ecological Attribute: *Vegetation Composition*					
Relative Cover Native of Understory Plant Species	Native species dominate the understory; non-natives increase with human impacts.	Relative cover of native plants = 95-100%.	Relative cover of native plants 80-95%.	Relative cover of native plants 50 to 79%.	Relative cover of native plants <50%.
Species Composition Once developed the Floristic Quality Assessment Index can replace this metric (FQA measures percentage of conservative native species)	The overall composition of native species can shift when exposed to stressors.	Composed of appropriate species and proportions. Native species sensitive to degradation are present, functional groups indicative of degradation (e.g., pioneer or early successional trees) are absent to minor, full range of diagnostic/indicator species are present.	Functional groups indicative of degradation are present but low in abundance. Some indicator/diagnostic species may be absent.	Native species characteristic of the type remain present but weedy (pioneer, early successional) native species that develop after clearcutting or clearing are dominant. Many indicator/diagnostic species may be absent.	Severely altered from reference condition. Most or all indicator/diagnostic species are absent. Native species consist mostly of weedy species.
Key Ecological Attribute: *Vegetation Structure*					

Late Seral Patches	Late seral patches are closed to open, typically multilayered of shade tolerant trees or single-layered shade intolerant trees.	Vast majority of the old trees have not been harvested, i.e. there are only a few if any large stumps; Large trees >150 yr. old; >10 old trees/ac (>21"dbh or using Van Pelt (2008) old tree indicators)	Some (10-30%) of the old trees may have been harvested. 4-10 old trees/ac (10-20/ha) (>21"dbh or using Van Pelt (2008) old tree indicators)	Many (over 50%) of the old trees may have been harvested. 2-4 old trees/ac (5-10/ha) (>21"dbh or using Van Pelt (2008) old tree indicators)	Most, if not all, old trees have been harvested. <2 old trees/ac (<5/ha) (>21"dbh or using Van Pelt (2008) old tree indicators)
Mid-Seral Patches	Mid-seral patches are typically closed canopy, single-layer or multilayered of mostly shade intolerant trees	Vast majority of trees have not been harvested, i.e. there are only a few if any large stumps	Some (10-30%) of the trees have been harvested.	Many (over 50%) of the trees have been harvested.	Most, if not all, trees have been harvested.
Coarse Woody Debris	With a disturbance regime of relatively infrequent, mixed to high severity fire there should be considerable CWD both resulting from infrequent fire events and accumulation between fire events.	Considering the natural stand development stage, a wide size-class diversity of downed coarse woody debris (logs), with several large logs 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 large logs 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 large logs and logs in mostly early stages of decay (if present).
Large Snags	Large snags (average number of snags >=9 in. dbh 12 – 14 per acre) are a characteristic and vital part of the forest (Green et al, 1994)	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.
Patch Diversity	The diversity and interspersion of seral patches across the occurrence is indicative of intact mixed severity disturbance regimes (Landfire 2007).	Diverse assemblage of seral patches (clusters of similar-size trees) that are distributed in a complex mosaic 65% late seral, 25% mid-seral, 10% early seral (Landfire, 2007)	Diversity remains but late-seral patches are less than previous due to logging OR interspersion of seral patches is becoming simplified due to fire suppression.	Cohort diversity is low with most being early to mid-seral. Interspersion is simplified.	
Key Ecological Attribute: *Natural Disturbance Regimes*					
Forest Pathogens	Forest pathogens are sources of natural tree mortality that influence fire effects and forest structure	Pathogens are all native species and are within the natural range of variability (NRV).	Native pathogen are significantly effecting forest structure beyond NRV	Exotic and native pathogen are significantly effecting forest structure beyond NRV	Exotic and native pathogen are significantly effecting forest structure beyond NRV
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	Absolute size may be important for buffering impacts originating in the surrounding landscape. Landscape is relatively contiguous and big enough to exhibit natural variation in fire regimes and associated vegetation (FRCC 2008).	>8,000 ha (20000 ac)	4000-8,000 ha	2000-4000 ha	<2000 ha (5000ac)

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)
- Impact of introduced forest pathogens, particularly white pine blister rust and adelgid aphid on forest structure
- Weighted Old Growth Habitat Index (Franklin, Spies and Van Pelt 2005)
- Fire Regime Condition Class standard landscape worksheet method (FRCC 2010)

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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Authorship: Rex Crawford, Washington Natural Heritage Program
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