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: Rocky Mountain Lodgepole Pine Forest

Ecological Summary

The Rocky Mountain Lodgepole Pine Forest ecological system is composed of subalpine and upper montane forests with *Pinus contorta* (primarily var. *latifolia*) dominance that is related to fire history, not to topo-edaphic conditions. This Rocky Mountain Lodgepole Pine Forest type is a widespread, large patch to matrix-forming system in upper montane to subalpine elevations of the Rocky Mountains, Intermountain West region, north into the Canadian Rockies, east into mountain "islands" of north-central Montana and into the northeast Cascades in Washington. *Pinus contorta* stands south in the Cascades in Oregon are either Rocky Mountain Poor-Site Lodgepole Pine Forest (pumice zone) or Sierra Nevada Subalpine Lodgepole Pine Forest and Woodland (*Pinus contorta* var. *murrayana*). As described here, the Rocky Mountain Lodgepole Pine Forest system includes fire-maintained *Pinus contorta* forests in the subalpine spruce-fir and Montane spruce zones in Washington (ESSF and MS zones Meidinger and Pojar 1991). The similar Rocky Mountain Poor-Site Lodgepole Pine Forest differs in that they are related to topo-edaphic conditions and nutrient-poor soils, such as excessively well-drained pumice deposits, glacial till and alluvium on valley floors where there is cold-air accumulation, warm and droughty shallow soils over fractured quartzite bedrock, and shallow moisture-deficient soils with a significant component of volcanic ash.

Rocky Mountain Lodgepole Pine Forest system is found mostly at mid- to higher elevations in typically cold and relatively dry areas, usually with a persistent winter snowpack. Most stands occur as early- to mid-successional forests which developed following fires associated with the Dry-Mesic Subalpine Spruce Fir and Mesic-Wet Subalpine Spruce Fir ecological systems. Soils supporting these forests are typically well-drained, gravelly, coarse-textured, acidic, and rarely formed from calcareous parent materials.

Pinus contorta possesses cone serotiny which is an important factor in its regeneration after fire. It typically is nonserotinous (open) cones until 20 to 30 years old and afterwards trees produce more serotinous (closed) cones (Smith and Fischer 1997). The serotinous cones on older trees open after exposure to heat during forest fire and allow it to regeneration quickly (Smith and Fischer 1997). Typically, *Pinus contorta* establishes within 10-20 years after fire and then declines after 100-200 years (Lilybridge et al. 1995). While these forests usually persistent for over 100 years, they may eventually succeed to mixed montane coniferous forests. Potential for high severity fires are in the dense regeneration phases and overmature late seral stage when fuels accumulate (Smith and Fischer 1997). Without fire and insects, stands become more

closed-canopy forest with sparse undergrowth and prone to stagnation, snow breakage, and windthrow. Because *Pinus contorta* rarely reproduces under a canopy, old unburned stands are replaced by shade-tolerant conifers. Vertical structure is typically a single tree layer; however, reproduction of other more shade-tolerant conifers can be abundant in the undergrowth. Several distinct undergrowth types develop under the tree layer: 1) evergreen or deciduous medium-tall shrubs, 2) evergreen low shrub, or 3) graminoids with few shrubs. The tree layer is dominated by *Pinus contorta* var. *latifolia* and may be associated with other montane conifers (*Abies grandis*, *Larix occidentalis*, *Pinus monticola*, *P. ponderosa*, *Pseudotsuga menziesii*). Tall deciduous shrubs include *Acer glabrum*, *Amelanchier alnifolia*, *Holodiscus discolor*, or *Salix scouleriana*. These tall shrubs often occur over a layer of mid-height deciduous shrubs such as *Rosa gymnocarpa*, *Shepherdia canadensis*, *Spiraea betulifolia*, and *Symphoricarpos albus*. At higher elevations, *Vaccinium membranaceum* can be locally important, particularly following fire. Mid-tall evergreen shrubs can be abundant in some stands, for example, *Mahonia repens*, *Ceanothus velutinus*, and *Paxistima myrsinites*. Colder and drier sites support low-growing evergreen shrubs, such as *Arctostaphylos uva-ursi* or *A. nevadensis*. *Vaccinium scoparium* and *Xerophyllum tenax* are consistent evergreen low shrub dominants in the subalpine part of this habitat. Some undergrowth is dominated by graminoids with few shrubs. *Calamagrostis rubescens* and/or *Carex geyeri* can appear with *Vaccinium scoparium* in the subalpine zone. The forb component of this habitat is diverse and varies with environmental conditions.

In general, fire-free intervals less than the life span of *Pinus contorta* favor its dominance while greater intervals and the loss of standing dead trees with closed cones, favor dominance by other trees(Smith and Fischer 1997). Mean fire interval of replacement fires (80% of all fires) is 115 years and described as 35-100+ year frequency, replacement severity fires (Fire regime IV, Landfire 2007). Woody fuels accumulate on the forest floor from insect (*Dendroctonus ponderosae* mountain pine beetle) and disease outbreaks and residual wood from past fires. High-severity crown fires are likely in young stands, when the tree crowns are near deadwood on the ground. The historic range of variability of these systems is relatively straight forward. Because of fire sensitivity of both *Pinus contorta* and most invading conifers seedlings during stand development (*Abies lasiocarpa* and *Picea engelmannii*) the majority of trees are killed. Landfire (2007) modeled 25% of the Lodgepole Pine Forest system were early, closed canopy seedling stages, 45% in midseral closed canopy tree less than 10 inches dbh and the remaining 30% closed canopy *Pinus contorta* trees 10-21 inches dbh under natural fire regime. This system is model as stages A, B, C and D in the graphic below.

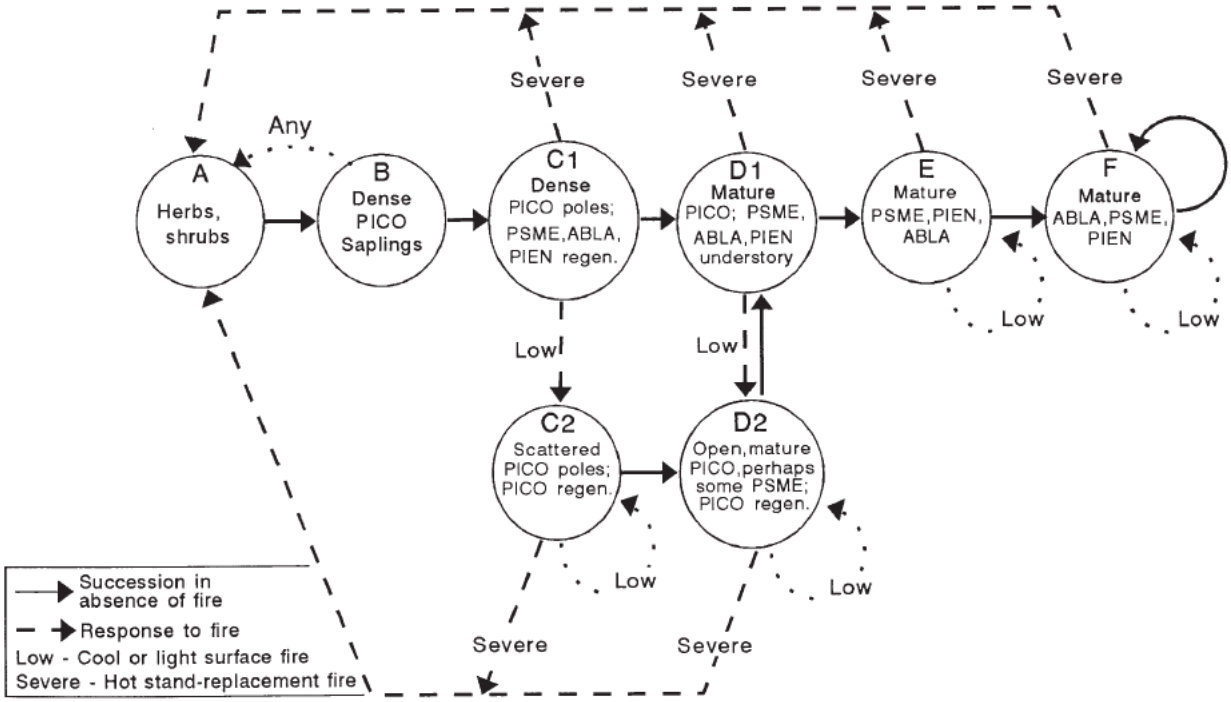

Figure 22—Pathway 4.2. Hypothetical fire-related succession for Fire Group Four stands where lodgepole pine is the major seral species. Succession is shown here for stands in the subalpine fir series.

From Smith and Fischer (1997)

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).

Fire suppression has left many single-canopy *Pinus contorta* sites unburned resulting in more multilayered stands. Mountain pine beetle can infest and kill *Pinus contorta* trees when they reach large trunk sizes and at low levels of infestation can create openings and *Pinus contorta* seed and reestablish with other conifers. As most tree reach large sizes with phloem thick enough to support large beetle populations pine beetle (over 10 inches dbh) epidemics can occur and kill many trees and fuel increasing future fire severity (Smith and Fischer 1997). These forests have been fragmented by roads, timber harvest, and influenced by periodic livestock grazing and altered fire regimes. Grasses compete with *Pinus contorta* seedlings, and use of non-native species causes long-term changes in community composition (Smith and Fischer 1997). *Poa pratensis* and *Elymus elymoides* can be locally abundant where livestock grazing has persisted. Increases in cattle use results in increases in trampling damage to regenerating *Pinus contorta* seedlings (Pitt et al. 1998).

Conceptual Ecological Model

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

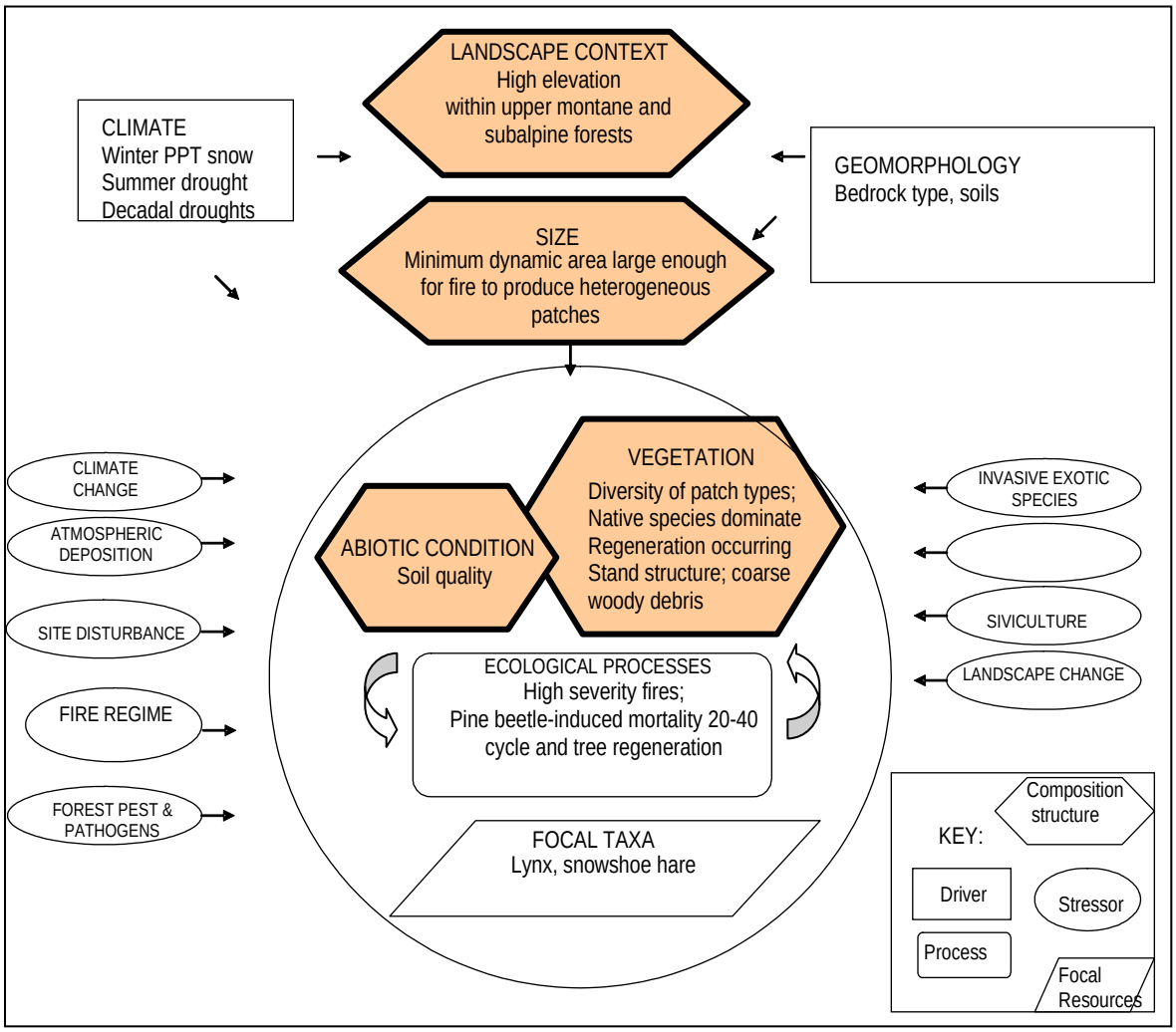

Figure 1. Conceptual Ecological Model for Rocky Mountain Lodgepole Pine Forest System.

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. Rocky Mountain Lodgepole Pine Forest System 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 at least <25 m.
Edge Condition		>95% cover native vegetation, <5% cover of non-native plants, intact soils	75–95% cover of native vegetation, 5–25% cover of non-native plants, intact or moderately disrupted soils	25–50% cover of non-native plants, moderate or extensive soil disruption	>50% cover of non-native plants, barren ground, highly compacted or otherwise disrupted soils
Key Ecological Attribute: *Landscape Structure*					
Connectivity	Intact areas have a continuous corridor of natural or semi-natural vegetation 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
Landscape Fire Regime Condition	High severity fire is vital to maintaining ecological integrity (Fire Regime Condition Class) 2008).	FRCC1	FRCC2		FRCC3
Patch Diversity Origin (within 1 km)	Patch diversity reflects natural dynamics high severity fire regime	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 Composition*					
Relative Cover Native 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%.	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 Stand Characteristics	Late seral patches (>80 yr) are closed, typically single layered of lodgepole pine	Lodgepole pine dominates canopy with serotinous cones; shade tolerant species subcanopy only if present; there are only a few if any stumps;	Lodgepole dominates canopy with serotinous cones; there are some stumps; 10-30% shade tolerant species in canopy.	Lodgepole co-dominates canopy with serotinous cones; there are some stumps; 30-50% shade tolerant species in canopy.	Lodgepole in canopy with serotinous cones; there are some stumps; over 50% shade tolerant species in canopy.
Early Stand Characteristics	Down woody debris is most abundant in early (<20 yr) and late stand development stages	*Pinus contorta* seedling and saplings (<6" dbh) with abundant snags and DWD	*Pinus contorta* seedling and saplings dense with snags and DWD reduced by harvesting		*Pinus contorta* seedling and saplings dense with few snags and little DWD due to harvesting

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 or reddish ash, all litter completely consumed, and soil structureless). • Soil compaction is persistent and deep (greater than 12inches). • 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 (Agee 1998)	>10,000 ha	1000-10,000 ha	100-1000 ha	<100 ha

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

- Stand structure and composition measurements (Franklin et al. 2002)
- Impact of introduced forest pathogens, particularly white pine blister rust on *Pinus albicaulis* and adelgid aphid on forest structure
- 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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