WASHINGTON STATE DEPARTMENT OF
Natural Resources
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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 Montane Riparian Woodland and Shrubland

Ecological Summary

The North Pacific Montane Riparian Woodland and Shrubland ecological system occurs throughout the coastal mountains of the Pacific Northwest and in Washington is most abundant as woodland and shrubland on steep streams and narrow floodplains between the *Tsuga heterophylla* zone and the alpine environments in the Cascades and Olympics. It is the primary riparian system in the *Abies amabilis* and *Tsuga mertensiana* zones on both sides of the Cascade crest. Winters are moderate with 3-10+ foot snowpack, infrequent drought and summer precipitation that can exceed 6 inches. This system commonly occurs in V-shaped, narrow valleys and canyons (where there is cold-air drainage). Occurrences are less frequently found in moderate-wide valley bottoms on floodplains along meandering rivers, and on pond or lake margins. It is also associated with drainages, stream terraces, semi-riparian flats and spring or seep fed slopes.

This system occurs on steep stream banks with narrow floodplains where the shrubby or deciduous vegetation is significantly different than surrounding conifer forests. Riparian woodland and shrubland development is driven by the magnitude and frequency of flooding, valley and substrate type, and rarely beaver activity. Infrequent, high-powered floods determine large geomorphic patterns that persist on the landscape for hundreds to thousands of years (Hubert 2004). Floods of intermediate frequency and power produce floodplain landforms which persist for tens to hundreds of years as well as reset succession to early seral vegetation types (LANDIRE 2007; Hubert 2004). Seasonal and episodic flooding erode and/or deposit sediment resulting in complex patterns of soil development which subsequently have a strong influence on the distribution of riparian vegetation (Gregory et al. 1991; Poff et al. 1997). Bare alluvium provides suitable substrate for the germination of willow seedlings and is thus a critical patch type for continued regeneration of some riparian shrublands (Poff et al. 1997; Hubert 2004). Other types of willows can propagate through rooting of broken stems or roots, branch layering, and in a few species sprouting from subsurface runners (Kovalchik and Clausnitzer 2004).

Valley type may be the most important variable, as riparian woodlands are mostly found in V-shaped, steep valleys with many large boulders and coarse soils. The forest vegetation in these environments is often very similar to the adjacent uplands (Baker 1987, Kovalchik and Clausnitzer 2004, LANDFIRE 2007). Narrow and steep (i.e. confined) occurrences have minimal to no floodplain development whereas less steep and wider valley bottoms (i.e., unconfined) occurrences are often associated with substantial floodplain development (Gregory et al. 1991). Floodplains associated with the latter are comprised of a complexity of geomorphic surfaces which support a diverse array of vegetation communities and are able to store and release water slowly throughout the growing season (Hubert 2004). Confined streams typically have shallow soils with minimal alluvium and transport water downstream rapidly through step-pool channels armored by boulders, bedrock, and large woody debris (LANDFIRE 2007; Hubert 2004).

Beaver can be important hydrogeomorphic driver of montane riparian systems, especially along unconfined reaches. The presence of beaver creates a heterogeneous complex of wet meadows, marshes and riparian shrublands and increases species richness on the landscape. Naiman et al. (1986) note that beaver-influenced streams are very different from those not impacted by beaver activity by having numerous zones of open water and vegetation, large accumulations of detritus and nutrients, more wetland areas, having more anaerobic biogeochemical cycles, and in general are more resistance to disturbance.

Confined occurrences of this system (mostly along Rosgen A and B channels) are conifer woodlands dominated by *Abies amabilis, Abies lasiocarpa, Tsuga mertensiana* or *Pinus contorta* var. *murrayana.* Lower elevation occurrences with less confined channels may contain deciduous trees, such as, *Populus balsamifera* ssp*. trichocarpa, Alnus incana* ssp. *tenuifolia* (= *Alnus tenuifolia)* and *Alnus rubra*. Major shrub species include *Alnus viridis* ssp. *sinuata, Acer circinatum, Salix sitchensis, Oplopanax horridus, Rubus spectabilis*, and *Ribes bracteosum* and herbaceous *Senecio triangularis, Saxifraga arguta*, and *Petasites frigidus* plants*. Vaccinium alaskense* and *Vaccinium ovalifolium* can be frequent above bankfull riparian zones (Diaz and Mellen 1996).

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 riparian areas in Washington. Human land uses both within the riparian area as well as in adjacent and upland areas have fragmented many riparian reaches which has reduced connectivity between riparian patches and riparian and upland areas. Adjacent and upstream land uses also have the potential to contribute excess nutrients into riparian areas. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can have a substantial impact on the hydrologic and sediment regimes. Alterations to both processes can affect the establishment of new, and maintenance of existing, riparian vegetation. Management effects on woody riparian vegetation can be obvious, e.g., removal of vegetation by dam construction, roads, logging, or they can be subtle, e.g., removing beavers from a watershed, removing large woody debris, or construction of a weir dam for fish habitat. Logging activities tend to reduce the amounts of large woody debris in streams and remove future sources of that debris. Timber harvest can also alter hydrology, most often resulting in post-harvest increases in peak flows. Mass wasting and related disturbances (stream sedimentation, debris torrents) in steep topography increase in frequency with road building and timber harvest. Roads and other water diversion/retention structures change watershed hydrology with wide-ranging and diverse effects, including major vegetation changes.

Conceptual Ecological Model

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

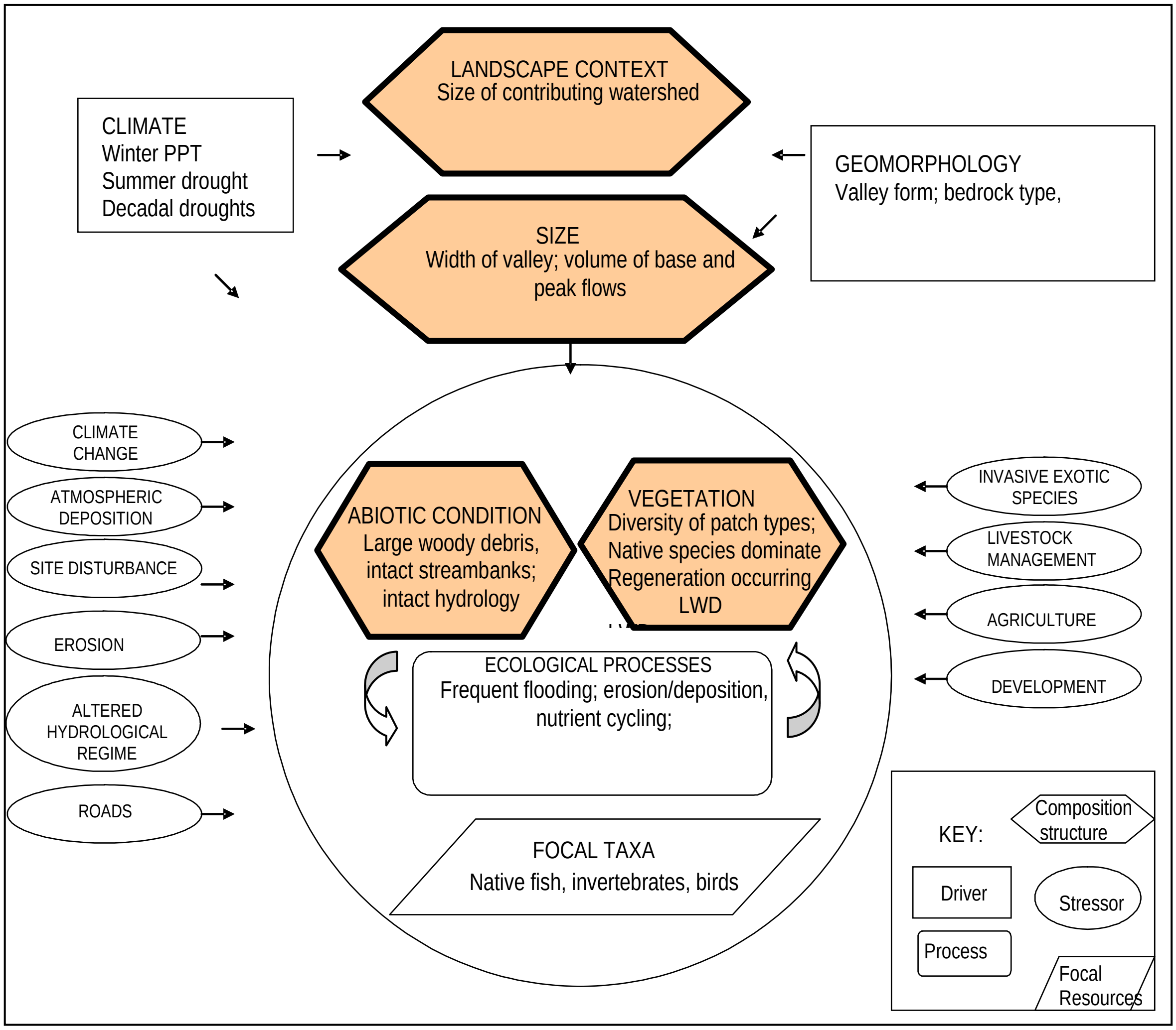

Figure 1. Conceptual Ecological Model for the North Pacific Lowland Riparian Forest and Shrubland.

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. Level 3 EIAs 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 table displays 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 Montane Riparian Forest and Shrubland Level 2 EIA.

<table>
<tr><th rowspan="2">Metric</th><th rowspan="2">Justification</th><th colspan="4">Rank</th></tr>
<tr><th>A (5 pts.)</th><th>B (4 pts.)</th><th>C (3 pts.)</th><th>D (1 pts.)</th></tr>
<tr><td colspan="6">Rank Factor: LANDSCAPE CONTEXT</td></tr>
<tr><td colspan="6">Key Ecological Attribute: Buffer</td></tr>
<tr><td>Buffer Length</td><td rowspan="3">The buffer can be important to biotic and abiotic aspects of the wetland.
Buffer Width Slope Multiplier
5-14% -->1.3; 15-40%-->1.4; >40%-->1.5</td><td>Buffer is > 75 – 100% of occurrence perimeter.</td><td>Buffer is > 50 – 74% of occurrence perimeter.</td><td>Buffer is 25 – 49% of occurrence perimeter</td><td>Buffer is < 25% of occurrence perimeter.</td></tr>
<tr><td>Buffer Width</td><td>Average buffer width of occurrence is > 200 m, adjusted for slope.</td><td>Average buffer width is 100 – 199 m, after adjusting for slope.</td><td>Average buffer width is 50 – 99 m, after adjusting for slope.</td><td>Average buffer width is < 49 m, after adjusting for slope.</td></tr>
<tr><td>Buffer Condition</td><td>Abundant (>95%) cover native vegetation, little or no (<5%) cover of non-native plants, intact soils, AND little or no trash or refuse.</td><td>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.</td><td>Moderate (25–50%) cover of non-native plants, moderate or extensive soil disruption; moderate intensity of human visitation or recreation.</td><td>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.</td></tr>
<tr><td colspan="6">Key Ecological Attribute: Landscape Structure</td></tr>
</table>

Watershed Connectivity	The types of land cover/uses in the contributing watershed has a significant affect on ecological processes (May 2002)	Landscape of contributing watershed primarily natural land cover; no connectivity barriers and no regional flood control dams upstream; <5% of contributing watershed urban or agricultural land cover types; few to no recent (<20 years) clearcut (<10% of the landscape)	5-20% of contributing watershed urban or agricultural land cover types; connectivity mostly retained; heavily managed forest landscape with many tree plantations (<50% of watershed in recent clearcuts)	20-50% of contributing watershed urban or agricultural land cover types; limited connectivity; heavily managed forest landscape with many tree plantations (<50% of watershed in recent clearcuts)	>50% of contributing watershed urban or agricultural land cover types; limited connectivity largely disrupted; one or more regional flood control dams upstream.
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 0.75 – 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. *Phalaris arundinacea*, are examples.	None present.	Invasive species present, but sporadic (<3% cover).	Invasive species prevalent (3–10% absolute cover).	Invasive species abundant (>10% absolute cover).
Relative Cover of Native Increasers	Some stressors such as grazing can shift or homogenize native composition toward species tolerant of stressors.	Absent or incidental	<10% cover	10-20% cover	>20% cover
Species Composition Note: Once developed, the Floristic Quality Assessment index could be used here instead.	The overall composition of native species can shift when exposed to stressors.	Species diversity/abundance at or near reference standard conditions. Native species sensitive to anthropogenic degradation are present, functional groups indicative of anthropogenic disturbance (ruderal or "weedy" species) are absent to minor, and full range of diagnostic / indicator species are present.	Species diversity/abundance close to reference standard condition. Some native species reflective of past anthropogenic degradation present. Some indicator/ diagnostic species may be absent.	Species diversity/abundance is different from reference standard condition in, but still largely composed of native species characteristic of the type. This may include ruderal ("weedy") species. Many indicator/diagnostic species may be absent.	Vegetation severely altered from reference standard. Expected strata are absent or dominated by ruderal ("weedy") species, or comprised of planted stands of non-characteristic species, or unnaturally dominated by a single species. Most or all indicator/diagnostic species are absent.

Key Ecological Attribute: *Vegetation Structure*						
Canopy structure	Intact riparian areas should have a diversity of tree age classes.		Average tree cover generally > 50%; mixed age. Mature conifers and/or red alder present; Trees are of sufficient size to provide future LWD to stream or floodplain.		Somewhat homogeneous in density and age OR <50% canopy cover	Canopy extremely homogeneous, sparse, or absent (<10% cover).
Regeneration of Woody Species	Regeneration of woody species is expected in riparian areas with intact hydrology		Saplings/seedlings of native woody species present in expected amount; Obvious regeneration.	Saplings/seedlings of native woody species present but less than expected; Some seedling/saplings present.	Saplings/seedlings of native woody species present but in low abundance; Little regeneration by native species.	No reproduction of native woody species
Large Woody Debris (NMFS 1996, Fox 2001)	Large woody debris (LWD) in the stream channel is very important for channel formation, fish habitat, habitat heterogeneity, and sediment/ hydrological processes (NMFS 1996, Fox 2001)	Bank-full Width 0-6 m	(piece = >10cm diameter and > 2 m in length; key piece >38 pieces		26-38	<26
		>6-30 m	>63 pieces		29-63	<29
		>30-100 m	>208 pieces		57-208	<57
Patch Diversity and Connectivity	When hydrological processes are intact, a diversity of seral patch and habitat types are present within this system. The patches are well connected without interruption from anthropogenic land cover/use.		Confined reaches may have low patch diversity but connectivity within the riparian reach is unfragmented; Unconfined reaches have heterogeneous mix of well connected patch types. Mature conifer, mature deciduous (aspen or birch)/conifer mixed, or mature deciduous patches present along with early seral stands of trees, wetland shrub and emergent vegetation patches.	Connectivity of confined reaches is becoming fragmented; Unconfined reaches have expected patch diversity present but connectivity between patches is becoming fragmented. OR less diversity than expected, especially of mature stands of trees in unconfined reaches.	Confined reaches are moderately fragmented; Patch diversity in unconfined reaches is low and becoming homogeneous in unconfined reaches; few if any mature stands of trees present. Many patches isolated due to fragmentation within the riparian system.	Confined reaches are severely fragmented; Mostly dominated by one patch type (unconfined reaches). No mature conifer or deciduous tree patches present. Patch is isolated due to fragmentation within the riparian system.
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

Channel Stability	Alteration in hydrology or sediment loads or some onsite stressors can degrade channel stability	Natural channel; no evidence of severe aggradation or degradation;	Most of the channel has some aggradation or degradation, none of which is severe	Evidence of severe aggradation or degradation of most of the channel	Concrete, or artificially hardened, channels through most of the site
Streambank Stability	Stable streambanks are indicative of intact hydrological and sediment regimes (Henshaw and Booth 2000).	Stable Perennial vegetation ot waterline; no raw or undercut banks (some erosion on outside of banks normal); no recently exposed roots; no recent tree falls	Slightly Stable Perennial vegetation to waterline in most places; minor erosion and/or bank undercutting; recently exposed tree roots rare but present	Moderately Unstable Perennial vegetation to waterline sparse (mainly scoured or removed by lateral erosion); bank held in place by hard points (trees, boulders) and eroded back elsewhere; extensive erosion and bank undercutting; recently exposed tree roots and fine root hairs common	Completely Unstable No perennial vegetation to waterline; banks only held by hard points; severe erosion of both banks; recently exposed tree roots common; tree falls and/or severely undercut trees common
Hydrological Connectivity (Riverine)	Floodwater should have access to the floodplain. Stressors resulting in entrenchment affect hydrological connectivity	**LEVEL 2:** Completely connected to floodplain (backwater sloughs and channels)	Minimally disconnected from floodplain by dikes, tide gates, elevated culverts, etc	Moderately disconnected from floodplain by dikes, tide gates, elevated culverts, etc.	Extensively disconnected from floodplain by dikes, tide gates, elevated culverts, etc.
		LEVEL 3: Unconfined: Entrenchment ratio > 4.0; Confined: Entrenchment ratio > 1.4	Unconfined: Entrenchment ratio 1.4 – 2.2; Confined: Entrenchment ratio 1.0 – 1.4	Unconfined: Entrenchment ratio < 1.4; Confined: Entrenchment ratio < 1.0	
Key Ecological Attribute: *Physicochemical*					
Soil Surface Condition	Soil disturbance can result in erosion thereby negatively affecting many ecological processes	Bare soil areas are limited to naturally caused disturbances such as flood deposition or game trails	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.	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.	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.
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	Streams with limited floodplain development, primarily braided channels, or extremely sinuous stable channels (Rosgen A, B, D, E, or F types) > 5.0 linear miles (8 km)	3.0 to 5.0 linear miles (5-8 km)	1.0 to 3.0 miles linear miles (1.5 to 5 km)	< 1.0 linear miles (1.5 km)
		Meandering streams with well-developed floodplains and wide channels (mostly Rosgen C type) >25 meander wavelengths or 50 point bars	10-25 meander wavelengths or 20-50 point bars	4-10 meander wavelengths or 8-20 point bars	<4 meander wavelengths or <8 point bars

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:

- Benthic invertebrate Index of Biotic Integrity (BIBI; Kleindl 1995; Morley 200; WADOE 2003); see Morley (2000); May (2002); or WADOE (2003) for rating the BIBI scores. Statewide data are maintained by WADOE: http://www.ecy.wa.gov/apps/watersheds/streambio/regions/state.asp?symtype=1
- Index of Hydrological Alteration (Richter et al. 1997)
- Specific water quality measures (e.g., the temperature, dissolved oxygen, pH, conductivity, turbidity of stream water
- Specific nutrient levels of riparian vegetation (e.g., carbon to nitrogen (C:N) ratio in the aboveground biomass of plants)
- Pool Quality Index (May (2002)
- Riffle Quality Index (May (2002)

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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