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 Massive Bedrock, Cliff and Talus

Ecological Summary

The North Pacific Montane Massive Bedrock, Cliff and Talus ecological system is large patch system which occurs from northern California to southeastern Alaska. The Rocky Mountain Cliff, Canyon and Massive Bedrock, a similar system, includes similar sites in including the isolated island ranges of central Montana, northeastern Cascade Range and northeastern Olympic Mountains. This ecological system is found from foothill to subalpine elevations and includes barren and sparsely vegetated landscapes (generally <10% plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various bedrock types. This includes unstable scree and talus that typically occurs below cliff faces (NatureServe 2007). Steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous (intrusives), sedimentary, and metamorphic bedrock types are common locations where this system occurs. Soil development is limited.

Any vegetation established in this system typically reflects species composition of adjacent ecosystems, unless the latter is associated with an extreme parent material (i.e. North Pacific Serpentine Barren ecological system). Vegetation typically includes scattered trees and/or shrubs occasionally with small dense patches of shrubs or herbaceous plants. Characteristic trees include *Chamaecyparis nootkatensis*, *Tsuga* spp., *Thuja plicata*, *Pseudotsuga menziesii*, or *Abies* spp. There may be scattered shrubs present, such as *Acer circinatum*, *Alnus* spp., and *Ribes* spp. Herbaceous cover is limited. Mosses or lichens may be very dense, well-developed and display cover well over 10%.

Cliffs are generally cited to support high endemism of plants and refugia for old trees (Larson et al. 2000) as well as habitat for roosting or nesting birds and bats (Johnson and O'Neil 2001). Cliffs act as refugia for many rare plants that currently occur on cliffs and were often more common prior to increased human disturbance (Larson et al 2000). Due to the sparse nature of vegetation on cliffs, fire rarely has a direct influence on cliff vegetation although this lack of fire influence creates an environment for fire refugia (Graham and Knight 2004; Camp and others 1997). In Colorado, species richness of cliff communities appears to be controlled by coarser scale variables affecting the species pool in the immediate area (Graham and Knight 2004). Aspect, microsite size, and cliff surface roughness explain most of the plant richness in cliffs in Colorado (Graham and Knight 2004). Diversity increases when cliff microhabitats are compressed into a small area. For example, unfractured cliffs with no rooting space for vascular plants is habitat for lichens often next to a ledge where accumulated organic matter, minerals and water support grasses, sedges or small trees (Larson et al. 2000).

Cliff and barren systems have relatively discrete boundaries, very specific ecological settings, and strong links to local landscape conditions (Decker 2007). Decker (2007) stated that such small patch communities are often dependent on ecological processes in the surrounding communities. Graham and Knight (2004) concluded that cliff size appears to less important than the cliff micro-topography and, therefore, larger cliff areas would not necessarily contain greater number of species. Total plant species lists were least similar between large and small cliff faces (Graham and Knight 2004).

Colorado Natural Heritage summarized environmental processes of cliff ecology as follows:

> "Larson et al. (2000) define three basic parts of a cliff habitat: 1) the relatively level plateau at the top, 2) the vertical or near-vertical cliff face, and 3) the pediment or talus at the bottom of the face. These three elements share some physical characteristics, are linked by similar ecological processes, and often support the same plants and animals (Larson et al. 2000). Within the larger cliff habitat, steep slopes, small terraces ledges, overhangs, cracks and crevices often form a mosaic of microhabitat types that appears to be the primary factor contributing to cliff biodiversity (Graham and Knight 2004). In addition, the cliff rim is often windier than the surrounding plateau, providing a distinct microhabitat that differs from the nearby flatter areas. At cliff faces there is less hydraulic pressure retaining water within the rock, so liquid water is more consistently found than in the surrounding habitat types (Larson et al. 2000).
>
> Cliff environments are shaped by the parent rock type and strength, climate, aspect, and the weathering patterns produced by physical and chemical processes. Physical weathering includes the downward movement of rock and soil under the influence of gravity (mass wasting), including larger slips, slides and rockfalls, shrinking/swelling in response to changes in water content (mostly in shales and mudstones), direct pressure effects from the formation of ice and mineral crystals, thermal stress, and frost action (Larson et al. 2000). Chemical weathering in cliff environments is directly controlled by precipitation amount and chemistry, rock temperature, and the chemical composition of the rock. Chemical weathering is most prevalent under conditions of higher temperature and high precipitation, whereas physical weathering is more important at lower temperatures (Larson et al. 2000). The rate of erosion and the size of eroded rock particles have a strong influence over which organisms occur on cliffs and talus (Larson et al. 2000)."

Stressors

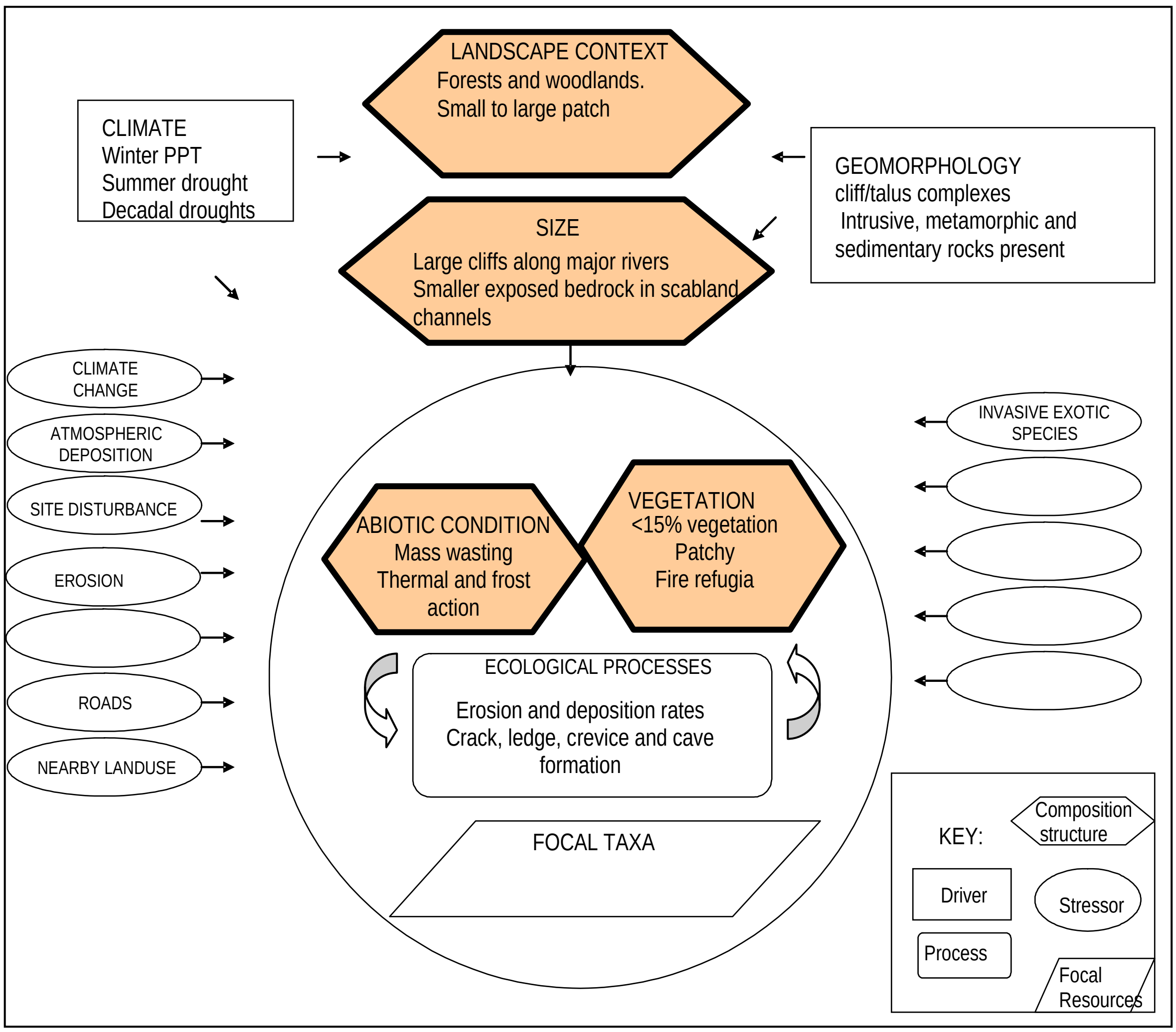
The stressors described below are those primarily associated with the loss of extent and degradation of the ecological integrity of existing occurrences. The stressors are the cause of the system shifting away from its natural range of variability. In other words, type, intensity, and duration of these 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).

This system usually occurs in inaccessible locations and thus is protected from much disturbance resulting from human activities. Direct human stressors to this system may include road construction and maintenance, recreation (climbing), and the effects of mining and quarrying. Wind and water erosion, chemical and physical effects of plant growth, and the force of gravity are the primary natural processes in the cliff environment. The rate of erosion and the size of eroded rock particles have a strong influence over which organisms occur on cliffs and talus (Larson et al. 2000).

Conceptual Ecological Model

The general relationships among the key ecological attributes associated with natural range of variability of the North Pacific Montane Massive Bedrock, Cliff and Talus Ecological System are presented in Figure 1.

Figure 1. Conceptual Ecological Model for North Pacific Montane Massive Bedrock, Cliff and Talus 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 Montane Massive Bedrock, Cliff and Talus Ecological Integrity Assessment Scorecard

Metric	**Justification**	**Rank**			
		A (5 pts.)	**B (4 pts.)**	**C (3 pts.)**	**D (1 pts.)**
Rank Factor: LANDSCAPE CONTEXT					
Key Ecological Attribute: *Buffer Effects*					
Buffer Length	The buffer can be important to biotic and abiotic aspects of the ecosystem as it provides connectivity and a 'filter' from exogeneous threats.	Buffer is > 75 – 100% of occurrence perimeter.	Buffer is > 50 – 74% of occurrence perimeter.	Buffer is 25 – 49% of occurrence perimeter	Buffer is < 25% of occurrence perimeter.
Buffer Width		Average buffer width of occurrence is > 200 m, adjusted for slope.	Average buffer width is 100 – 199 m, after adjusting for slope.	Average buffer width is 50 – 99 m, after adjusting for slope.	Average buffer width is < 49 m, after adjusting for slope.
Buffer Condition		Abundant (>95%) cover native vegetation, little or no (<5%) cover of non-native plants, intact soils, AND little or no trash or refuse.	Substantial (75–95%) cover of native vegetation, low (5–25%) cover of non-native plants, intact or moderately disrupted soils; minor intensity of human visitation or recreation.	Moderate (25–50%) cover of non-native plants, moderate or extensive soil disruption; moderate intensity of human visitation or recreation.	Dominant (>50%) cover of non-native plants, barren ground, highly compacted or otherwise disrupted soils, moderate or greater intensity of human visitation or recreation, no buffer at all.
Key Ecological Attribute: *Landscape Structure*					

Connectivity	Intact areas have a continuous corridor of natural or semi-natural vegetation between cliff and rock 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 0.75 – 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 = relative 95-100%.	Cover of native plants relative 80-95%.	Cover of native plants relative 50 to 79%.	Cover of native plants < relative 50%.
Absolute Cover of Invasive Species	Invasive species (e.g. *Cytisus scoparius*) can inflict a wide range of ecological impacts. Early detection is critical.	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 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*					

Patch diversity	Spatial heterogeneity of microhabitats strongly influence the abundance and distribution of species that use a particular habitat (Pulliam et al. 1992). Human-induced stress can decrease the range of biotic/abiotic patches from an un-impacted site.	No or little change in patch types* due to human stressors	Less than 50% change in expected patch types* due to human stressors	Over 50% change in expected patch types due to human stressors	All or most patch types changed due to human stressors
Key Ecological Attribute: *Physicochemical*					
Soil Surface Condition	Site disturbance can result in erosion thereby negatively affecting many ecological processes; the amount of bare ground or newly exposed rock varies naturally with site type.	Bare \areas are limited to naturally caused disturbances such as frost-cracking or animal trails	Some bare soil due to human causes but the extent and impact is minimal.		Bare soil areas due to human causes are common.
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	Plant species lists were least similar between large and small cliff faces (Graham and Knight 2004).	Large cliffs (>20 m high)	Medium cliffs (10 - 20 m high)	Small cliffs (5 and 10 m high)	>5 m high

*Patch types: Tree- Shrub-, Perennial herbaceous-, Annual-, Non-vascular-dominated, Cliff bedrock, Plateau bedrock, Cavities or cracks in bedrock, Unconsolidated rocks (i.e. talus) and Bare ground.

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

- Lichen and moss species composition and abundance (Eldridge and Rosentreter 1999).

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

Table 2. Triggers for Level 2 & 3 EIA

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

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

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

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

References

Anderson, R.C., J.S. Fralish, and J.M. Baskin. 1999. Savannas, Barrens, and Rock Outcrop Plant Communities of North America. Cambridge University Press, Cambridge, UK.

Camp, A., C. Oliver, P. Hessburg, and R. Everett. 1997. Predicting late-successional fire refugia pre-dating European settlement in the Wenatchee Mountains. For. Ecol. Mangemt. 95:63-77.

Colorado Natural Heritage Program. 2005. Rocky Mountain Cliff, Canyon and Massive Bedrock. Ecological System Description. Colorado Natural Heritage Program. Colo. State Univ. Ft. Collins. CO.
http://www.cnhp.colostate.edu/download/projects/eco_systems/pdf/RM_Cliff_and_Canyon.pdf

Graham, L. and R.L. Knight. 2004. Multi-scale comparison of cliff vegetation in Colorado. Plant Ecology 170:223-234.

Johnson, D.H. and T.A. O'Neil. 2001. Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis, OR.

Larson, D.W., U. Matthes, and P.E.Kelly. 2000. Cliff Ecology: Pattern and Process in Cliff Ecosystems. Cambridge University Press. 340pp.

NatureServe Explorer. 2007. Descriptions of Ecological Systems for the State of Washington. Data current as of October 06, 2007. NatureServe, Arlington, VA. [http://www.natureserve.org/explorer/index.htm]

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

Authorship: Rex Crawford and Joe Rocchio, Washington Natural Heritage Program
February 23, 2011