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 Broadleaf Landslide Forest and Shrubland

Ecological Summary

The North Pacific Broadleaf Landslide Forest and Shrubland ecological systemoccurs on steep slopes and bluffs that are subject to periodic mass movements. They are found in patches of differing age associated with different landslide events. It is a large and small patch system found throughout the northern Pacific mountains and lowlands, becoming less prominent in the northern half of this region. Occurring throughout western Washington, the North Pacific Broadleaf Landslide Forest and Woodland system typically appears within the matrix North Pacific Maritime Dry-Mesic and Wet-Mesic Douglas-fir Western Hemlock Forest systems landscape. It is associated with steep slopes (over 10%) and bluffs found in lowland areas and are characterized by slopes subjected to periodic landslides dominated by deciduous trees and shrubs (e.g. *Acer macrophyllum* and/or *Alnus rubra*). It also occurs on the shorelines of Puget Sound and adjacent marine waters (Chappell 2004). They can be associated with deep-seated landslides or ancient landslides and with mid-slope benches a common setting for slides for a variety of landslide types (http://www.ecy.wa.gov/programs/sea/landslides/about/about.html). Parent materials likely include glacial till, advance glacial outwash, and glacial lake and marine sediments. Seeps are frequent on these slopes, resulting in local wetter microsites. Conifers would be expected to increase in abundance without large slides and long-term substrate stability. Fire and wind also affect some of these forests.

In general, landslides increase the floristic and structural diversity of landscape and vegetation (Guariguata, M. 1990). Younger landslides have different vegetation on the slide than vegetation on the surrounding slopes. The vegetation consists of deciduous broadleaf forests, woodlands, or shrublands, sometimes with varying components of conifers that usually have less than 50% relative cover. *Alnus rubra* and *Acer macrophyllum* are the major tree species. *Rubus spectabilis, Rubus parviflorus, Ribes bracteosum,* and *Oplopanax horridus* are some of the major shrub species. Shrublands tend to be smaller in extent than woodlands or forests. Small patches of sparsely vegetated areas or herbaceous-dominated vegetation (especially *Petasites frigidus*) also often occur as part of this system. Vegetation on earthflows, once stable, may succeed to dominance by conifers. In coniferous forests, landslides typically are covered with deciduous trees for the first 100 years after the failure. (Early-successional patches dominated by *Alnus* or *Acer* that are **not** associated with landslide disturbance are part of the sere vegetation of the matrix forest type. More stable shrub patches generally belong to North Pacific Montane Shrubland.)

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).

Non-native English ivy (*Hedera helix*) and Himalayan blackberry (*Rubus armeniacus= discolor* are prolific invaders in this system. Many other non-native plants can occur. Development on land above the bluffs on which this system occurs can impact rates and types of mass movement processes. Deep-seated landslides have weak soils and are where the ground previously slid below the tree roots and when undercut by road-building and logging alter natural slide events. Other actions that trigger landslide movement include erosion, poor construction practices, clear cutting timber on unstable slopes particularly when combined with heavy rainfall event, freezing and thawing, and earthquakes. Efforts to stabilize slopes such as draining excess water from slopes, adding material to buttress base of a slope and building retaining walls influence natural processes.

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

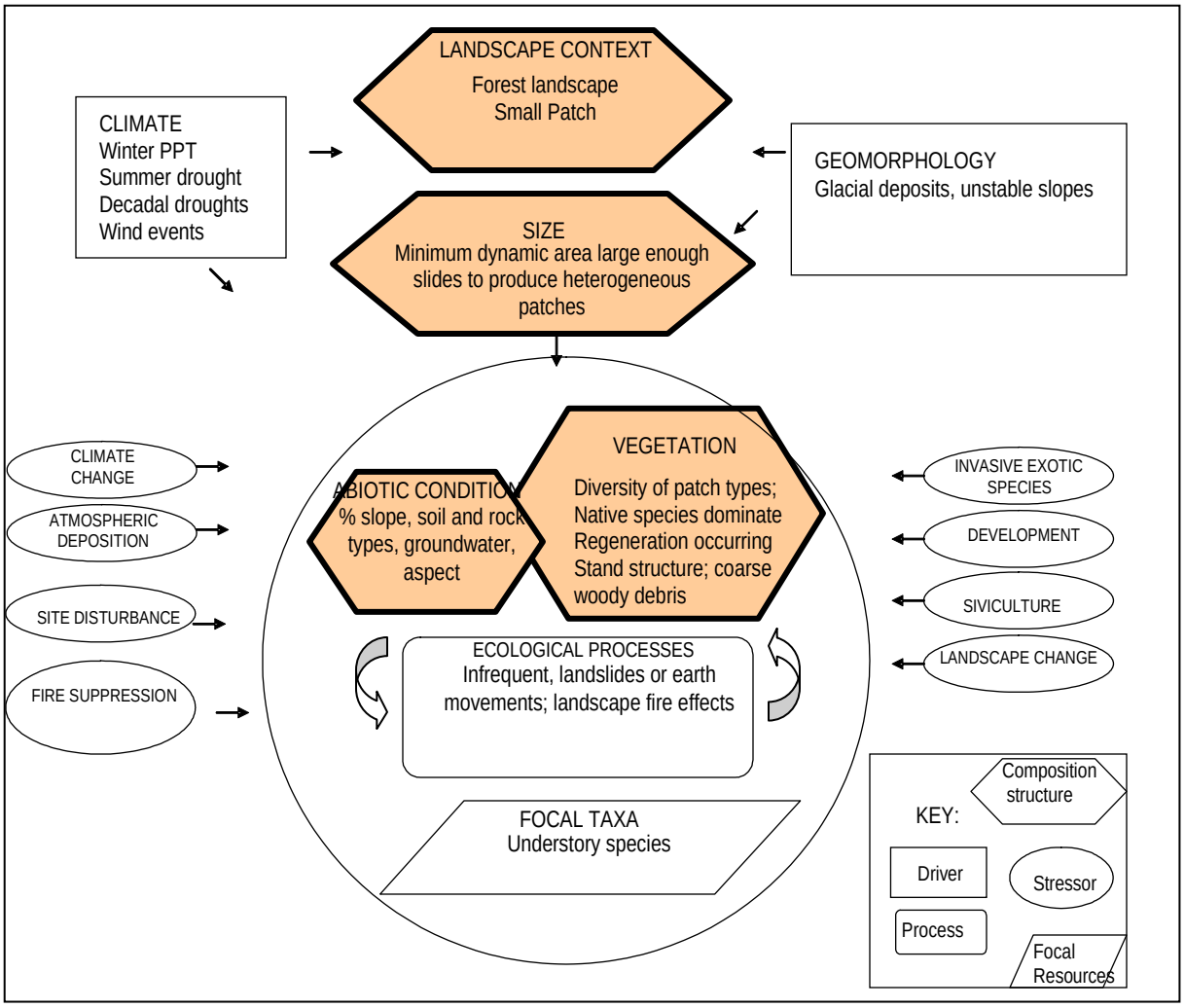

Figure 1. Conceptual Ecological Model for North Pacific Broadleaf Landslide Forest and Woodland.

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 Broadleaf Landslide Forest and Woodland 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.	Intact: Embedded in 90-100% natural habitat; connectivity is expected to be high.	Variegated: Embedded in 60-90% natural or semi-habitat; habitat connectivity is generally high, but lower for species sensitive to habitat modification;	Fragmented: Embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape.	Relictual: Embedded in < 20% natural or semi-natural habitat; connectivity is essentially absent

Landscape Condition Model Index	The intensity and types of land uses in the surrounding landscape can affect ecological integrity.	Landscape Condition Model Index > 0.8		Landscape Condition Model Index 0.79 – 0.65	Landscape Condition Model Index < 0.65
Patch Diversity	Patch diversity reflects natural dynamics of mixed slide movements and gap replacement processes	Less than 5% of spatial distribution of patches and/or vertical diversity of stands altered by timber harvesting or development	5-25% of spatial distribution of patches and/or vertical diversity of stands altered by timber harvesting or development	25-50% of spatial distribution of patches and/or vertical diversity of stands altered by timber harvesting or development	Over 50% of spatial distribution of patches and/or vertical diversity of stands altered by timber harvesting or development
Rank Factor: CONDITION					
Key Ecological Attribute: *Vegetation*					
Relative Cover Native Understory Plant Species	Native species in shrub and herbaceous layers; non-natives increase with human impacts.	Native species in shrub and herbaceous layers; relative >95% and dominate all physiognomic layers;	Cover of native species in shrub and herbaceous layers; relative 80-95%	Cover of Native species in shrub and herbaceous layers relative 50 to 79%. Nonnative may be codominant with native species	Cover of Native species in shrub and herbaceous layers < relative 50%. Nonnative species dominate understory with minor native component.
Absolute Cover of Exotic Invasive Understory Species	Invasive species can inflict a wide range of ecological impacts. Early detection is critical.	None or minimal (<1%) present.	Invasive species present, but sporadic (<5% cover).	Invasive species prevalent (5–30% absolute cover).	Invasive species abundant (>30% absolute cover).
Key Ecological Attribute: *Structure*					
Coarse Woody Debris (upland)	Snags and fallen coarse woody debris (CWD) are important structural features that provide necessary habitat for many forest taxa. Silviculture and land management often reduce the quantity and quality of dead wood.	A wide size-class diversity of downed coarse woody debris (logs) and standing snags, with several or more logs and snags logs in various stages of decay.	A moderately wide size-class diversity of downed coarse woody debris (logs) and standing snags and logs in various stages of decay.		A low size-class diversity of downed coarse woody debris (logs) and standing snags, with logs and snags absent, and logs in mostly early stages of decay (if present).
Key Ecological Attribute: *Physicochemical*					
Slope Alteration	Poor construction practices, roads, heavy timber harvests on unstable slopes and efforts to stabilize slopes influence natural processes.	Slope movements not altered directly by human activities.	Less than 10% of area directly manipulated.	10-25% of area directly manipulated.	Over 25% of area directly manipulated.

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 iscontinuous.	**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	>300 ac/120 ha	100-300 ac/40-120 ha	40-100 ac/15-40 ha	< 40 ac/15 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:

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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