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 Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest

Ecological Summary

The North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest ecological system forms the matrix forest in the mid-montane zones of western British Columbia, western Washington and much of western Oregon. In British Columbia and in the Olympic Mountains, it occurs only on the leeward side of the mountains. In the Washington Cascades, it occurs on both windward and leeward sides of the Cascades mountains. In Washington, this forested system dominates mid-montane zones of the Cascade and Olympic Mountains and very sporadically in the Willapa Hills. It generally occurs in an elevational band between *Pseudotsuga menziesii - Tsuga heterophylla* forests and *Tsuga mertensiana* forests. This system has a characteristically variable winter snowpack that typically lasts for 2 to 6 months and is sometimes referred to as the "rain-on-snow" zone because of the common occurrence of major winter rainfall on an established snowpack. Snowpack varies between 1 and 3.5 m (4-10 ft) and fog drip adds inches to yearly total precipitation (Henderson et al. 1989).

This system is characterized by having an overstory of *Abies amabilis* and/or *Abies procera* over 10% tree cover often with *Tsuga heterophylla* codominant and usually containing *Pseudotsuga menziesii*. *Tsuga heterophylla* and/or *Abies amabilis* dominate the canopy of late-seral stands, though *Pseudotsuga menziesii* and *Chamaecyparis nootkatensis* (especially at higher elevations) can be codominant. *Abies procera* forests (usually mixed with *Abies amabilis*) are included in this system and occur in the Cascades from central Washington to central Oregon. *Pseudotsuga menziesii* is a common species that regenerates after fires and therefore is frequent as a codominant, except at higher elevations. *Abies lasiocarpa* sometimes occurs as a codominant, along with other conifers such as *Abies grandis* and *Picea engelmannii* on the east side of the Cascades. Understory species that tend to be more common include *Achlys triphylla, Mahonia nervosa, Xerophyllum tenax, Vaccinium membranaceum, Rhododendron macrophyllum*, and *Rhododendron albiflorum*. *Vaccinium alaskense* is occasional and only dominates on more moist sites.

Overall, infrequent mixed severity fire regimes occurring at greater than 100 years characterize this system (Landfire 2007). A landscape variable sized patches results from that fire regime. Stand-replacement fires occur with mean return intervals of about 200-500 years, consequently where old-growth exist it is mostly "young old-growth" 200-500 years in age. Natural-origin stands less than 200 years old are also common. Fire frequency tends to decrease with increasing elevation and continentality but still remains within this typical range. Avalanches and wind

events are also common disturbances in this type. Landfire (2007) modeled this as a fire regime III system with 60% in late-seral structure (50% closed), 25% mid-seral (20% closed), and 15% early seral in pre-settlement condition.

The North Pacific Mesic Western Hemlock-Silver Fir Forest does not have stand replacing fires (Landfire 2007 fire regime V) whereas such fires are the dominant natural process in the Dry-Mesic silver fir system. The prevalence of *Pseudotsuga menziesii* is an important indicator if this system in relation to the related climatically wetter North Pacific Mesic Western Hemlock-Silver Fir Forest where *Pseudotsuga menziesii* is rare.

In a landscape analysis of the central Cascades in Washington, Thomson, Weller and Severtsen (2003) concluded that the pre-settlement mean forest patch sizes are 1-5 square miles (average of 4.3 square miles for the 25-square mile analysis windows and 6.9 square miles for the 100-square mile windows). Mixed-severity fires that are often stand-replacing events occur on the scale of 1000's of acres (Landfire 2007). Pre-settlement landscape patch structure as estimated by Landfire (2007) consisted of 15% early seral stage (cohort establishment of Franklin et al. 2002) dominated by shrubs and tree seedlings. That stage typically develops into closed canopy forest stands with poor understory development (biomass accumulation/ competitive exclusion of Franklin et al. 2002). Those patches occupied an estimated 20% of the landscape, typically with *Pseudotsuga menziesii* sometimes with *Abies amabilis* or *Abies procera* as the dominant trees. Trees are less than 20 inches diameter-at-breast height. Another 5% of the landscape consists of young, open canopy *Pseudotsuga menziesii* maybe with *Pinus monticola* stands developed from mix-severity fire. An estimate 10% of the forests is in the similar structural condition of larger trees following mix-severity fires but with *Abies amabilis*. An estimated 50% of forest patches would be closed canopy mature to old-growth stands with high vertical structural diversity (Maturation to Pioneer loss stage of Franklin et al. 2002).

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, timber harvest, road building, fire suppression, tree plantations and introduced diseases have all impacted natural disturbance regimes, forest structure, composition, landscape patch diversity, and tree regeneration. Timber harvest operations change canopy structural complexity and abundance of large woody debris of individual stands and has altered whole landscape patch pattern, age and structural complexity (Van Pelt 2007). Plantation forestry has changed local tree gene pools, horizontal arrangement of trees and homogenized the diversity of tree sizes. *Abies procera* and *Pseudotsuga menziesii* are planted at higher densities than under natural regimes. Other effects include loss of early seral species, advanced stand development, increased stand density, and increased tree mortality. Older logged areas can support dense, stagnating second growth with root rot (Arno 2000). Ohlman and Waddel (2002) speculated that snag abundance more likely reflect recent disturbance and forest succession, whereas down wood amounts more are strongly reflect long-term stand history and site productivity.

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

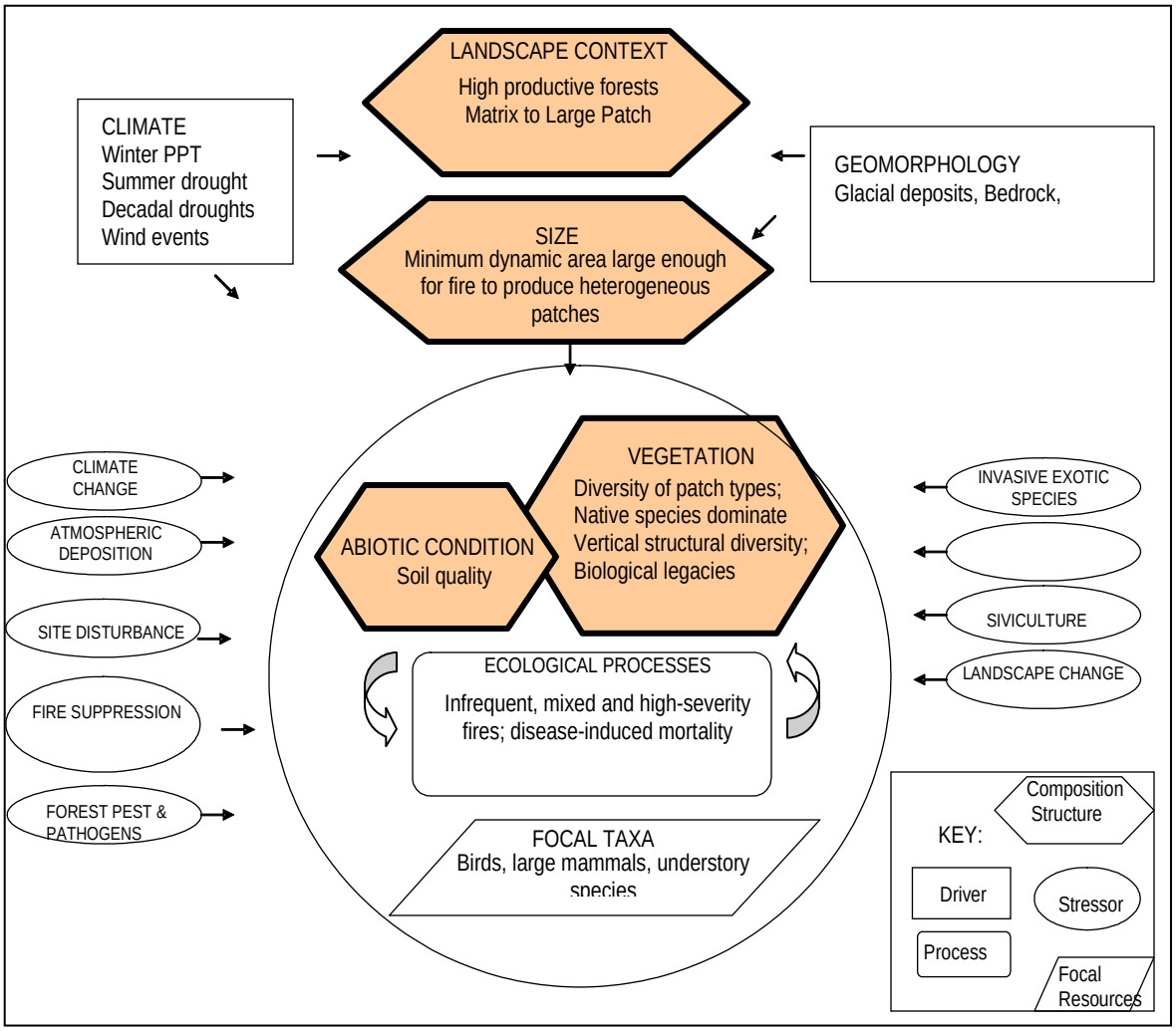

Figure 1. Conceptual Ecological Model for North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest Systems.

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 Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forests 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 <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 (within 1 km)	Intact areas have a continuous corridor of natural or semi-natural vegetation between assessment 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
Patch Diversity Origin (within 1 km)	Patch diversity reflects natural dynamics of mixed or high severity fire and gap replacement processes	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
Old Growth Proportion (within 1 km)	Patch diversity reflects natural dynamics of mixed or high severity fire and gap replacement processes (Landfire 2007)	Mature & Old Growth over 60% (Landfire 2007)	Early seral and/or Stem exclusion and/or mid seral open 25-70%; Mature & Old Growth 20-60%		Mature & Old Growth <20% (Raphael 1995)

Rank Factor: CONDITION					
Key Ecological Attribute: *Vegetation*					
Natural Tree regeneration	Natural forests are composed of largely spontaneously growing sets of native plants.	All trees originated from natural regeneration of native tree species	Evidence that at some of trees were planted but most trees are native originating from natural regeneration		Evidence that half to 10% of trees established as natural regeneration (partial or failed plantation with natural regeneration)
Large tree Age	Age is not a structural feature but is included because some of the biological diversity of old growth requires a long time to colonize and accumulate after stand-replacement disturbance (Pabst 2005).	Large trees >140 yr. old (Van Pelt 2007)	Large trees 60-100 yr. old (Van Pelt 2007)		Large trees <60 yr. old (Van Pelt 2007)
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 co-dominant 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. *Digitalis purpurea Geranium robertianum, Ilex* sp., *Rubus armeniacus*	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).
Relative Cover of Native Increaser Species	Some stressors such as soil disturbance can shift or homogenize native composition toward species tolerant of stressors, such as *Rubus ursinus, Urtica dioeca*	Absent or incidental	<10% cover	10-20% cover	>20% cover

Key Ecological Attribute: *Structure*					
Coarse Woody Debris (upland)	Coarse woody debris (CWD), cubic meters/ha, is an important structural feature that provides necessary habitat for many forest taxa and is characteristic and vital part of the forest (Franklin and Spies 1984; Pabst 2005; Faber-Langendoen 2007)	Considering the natural stand development stage, a wide size-class diversity of downed coarse woody debris (logs), with several or more logs exceeding 50 cm dbh / ha, 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 logs exceeding 50 cm dbh / ha, 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 logs and snags absent to rarely exceeding 50 cm dbh / ha, and logs in mostly early stages of decay (if present).
Large Snags	Large snags, >50 cm (19 in) & >15 m (49 ft) tall, are a characteristic and vital part of the forest (Franklin and Spies 1984; Pabst 2005)	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.
Large Live Trees	Large trees, >80 cm (33 in) dbh, are a characteristic and vital part of the forest (Franklin and Spies 1984; Pabst 2005) arbitrary thresholds	Considering the natural stand development stage, there are only a few if any cut stumps.	Considering the natural stand development stage, there are many more large trees than large cut stumps; Some (10-30%) of the old trees have been harvested.	Considering the natural stand development stage, there are around as many large trees as large cut stumps; Many (over 50%) of the old trees have been harvested.	Considering the natural stand development stage, most, if not all, old trees have been harvested. None or rare old trees present.
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	In a landscape analysis of the central Cascades in Washington, Thomson, Weller and Severtsen (2003) concluded that the pre-settlement mean forest patch sizes are 1-5 square miles. Agee (1998) list over 10,000 ha as fire patch size.	24,7000+ ac/10,000+ ha (matrix Agee 1998)	24,700-3200 ac/10,000-1300 ha	3200-640 ac/1300-260 ha	< 640 ac/260 ha (Thomson et al 2003)

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)
- Macrolichens species composition and abundance indicator of air pollution and management (Peterson and McCune 2001; Geiser and Neitlich 2007).
- Weighted Old Growth Habitat Index (Pabst 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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February 24, 2011