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 Douglas-fir Forest and Woodland

Ecological Summary

The North Pacific Dry Douglas-fir Forest and Woodland ecological system is a large and small patch system most common in the Puget Trough - Willamette Valley that occurs throughout western Washington and much of western Oregon. In Washington, it is most common in the Olympic rain shadow in the northern Puget Sound and on dry topo-edaphic locations across the lowland. In general, this system is associated with dry soils within relatively dry to mesic climates on sites up to about 1220 m (4000 feet) elevation. The vast majority of precipitation comes as rain during winter months and summer drought is the norm.
Historically, this system was either a part of larger forested landscapes (mostly with the North Pacific Maritime Dry-Mesic Douglas-fir Western Hemlock Forest system) or occupied sheltered topographic positions in prairie-dominated landscapes (with the North Pacific Oak Woodland or Willamette Valley Upland Prairie and Savanna system). The Dry Douglas-fir Forest and Woodland system now also occurs on some sites that formerly supported prairies or tall shrublands (*Corylus cornuta*) with scattered trees.

This is a forest or woodland system primarily dominated by the long-lived conifer *Pseudotsuga menziesii*. A discontinuous emergent layer of old *Pseudotsuga menziesii* often appears above a more continuous canopy layer of trees in moderately open stands that survived for several centuries in the presence of repeated fires (Arno 2000, Chappell and Giglio 1999). The evergreen broadleaf *Arbutus menziesii*, the short-lived conifer *Pinus contorta*, the broadleaf deciduous *Acer macrophyllum*, and the shade-tolerant conifer *Abies grandis* are local dominant or co-dominant species. *Abies grandis* can be an important subcanopy or sapling tree. The understory consists of one or more dry-site shrub species such as *Holodiscus discolor*, *Corylus cornuta* var. *californica*, *Symphoricarpos albus*, or *Mahonia nervosa*, and graminoid species *Festuca occidentalis* (Chappell 2004). Historically, moderately frequent low to mixed-severity fires characterized this system that resulted in multiple cohort stands, with both even-aged and uneven-aged stands and a diversity of biological legacies (Chappell and Giglio 1999; Van Pelt 2007). Landfire (2007) modeled this as a fire regime III system with 75% in late-seral structure (45% open), 20% mid-seral and 5% early seral in pre-settlement condition. In Puget Trough Douglas-fir—madrone forests, post-fire age classes are commonly 50–70, 110–140 and 250 or more years (Chappell and Giglio 1999). In Douglas-fir forests in the Elwha drainage of the Olympic Mountains the mean fire return intern is reported to be 99 years (Wendel and Zabowski 2010). Sites are too dry and warm or have been too frequently and extensively burned for anything more than small amounts of *Tsuga heterophylla* or *Thuja plicata* to be present. *Arbutus*

menziesii dominance is favored by high-severity fires, and *Pseudotsuga menziesii* can be locally eliminated by logging and hot fire or repeated high-severity fires. Catastrophic winds, laminated root rot, Douglas-fir bark beetle, and other pathogens create gaps in the canopy creating heterogeneous stand structure.

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, development, 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. Development has fragmented the landscape changing fire regime and connectivity of this small patch system particularly in lowlands. 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. Fire exclusion has likely increased tree density of stands, if seed source is available, and increased *Tsuga heterophylla* or *Thuja plicata* importance, and created environments favoring deciduous shrubs rather than grassy understory. Other effects include loss of early seral shrub 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). Moderate to heavy grazing or other significant ground disturbance leads to increases in non-native invasive species, many of which are now abundant in stands with grassy or formerly grassy understories. Exotic herbaceous invaders include *Agrostis capillaris*, *Holcus lanatus*, *Poa pratensis*, *Arrhenatherum elatius*, *Bromus rigidus*, *Dactylis glomerata*, *Cynosurus echinatus*, *Festuca arundinacea*, and *Hypericum perforatum*.

Conceptual Ecological Model

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

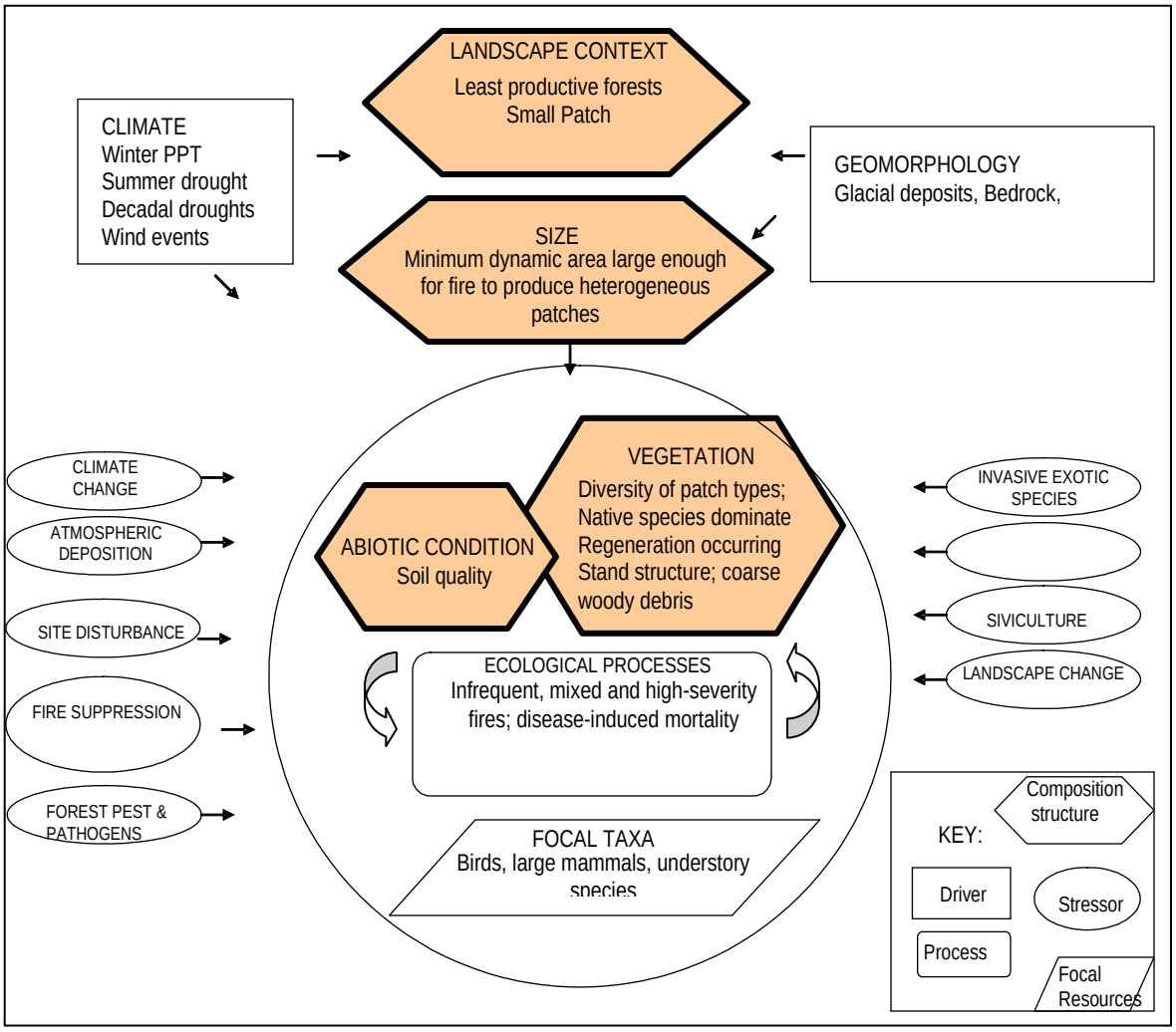

Figure 1. Conceptual Ecological Model for North Pacific Dry Douglas-fir Forest and Woodland.

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 Dry Douglas-fir 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 0.75 – 0.65	Landscape Condition Model Index < 0.65
Rank Factor: CONDITION					
Key Ecological Attribute: *Vegetation Composition*					
Relative Cover Native 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 > 90	Cover of Native species in shrub and herbaceous layers relative 50 to <90%. 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 Invasive Herbaceous 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: *Vegetation Structure*					
Patch Diversity	The diversity and interspersion of seral patches across the occurrence is indicative of intact mixed severity disturbance regimes (Landfire 2007).	Diverse assemblage of seral patches (clusters of similar-size trees) that are distributed in a complex mosaic 75% late seral, 25% mid-seral, 5% early seral (Landfire, 2007)	Diversity remains but late-seral patches are less than previous due to logging OR interspersion of seral patches is becoming simplified due to fire suppression.	Cohort diversity is low with most being early to mid-seral. Interspersion is simplified.	
Biological Legacies	Mixed severity/Moderate fire regimes leave large trees, snags, and large woody debris from previous stand	At least 1/2 of occurrence has stand age greater > 200 years or multi-cohort stand with significant component of >200 year old trees (>10/acre) (Franklin and Spies 1984); there are only a few if any cut stumps; Large trees >150 yr. old (old tree indicators Van Pelt (2007))	Some (10-30%) of the old trees have been harvested (old tree indicators Van Pelt (2007))	Many (over 50%) of the old trees have been harvested. (old tree indicators Van Pelt (2007))	Most, if not all, old trees have been harvested. None or rare old trees present (old tree indicators Van Pelt (2007))
Coarse Woody Debris	Accumulation of coarse woody debris is minimal in these forests due to recurring fire. Too much CWD can increase risk from fire.	Within old forest patches: Few large (> 6ft high and 12” dbh) snags and down logs.	Snags and down logs 4-12” or < 6 ft. high may be abundant.	Snags and down logs 4-12” or < 6 ft. are very abundant.	
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	Absolute size may be important for buffering impacts originating in the surrounding landscape	>400 ac/160 ha	100-400 ac/40-160 ha	20-100 ac/8-40 ha	< 20 ac/8 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)
- Macrolichens species composition and abundance are good indicators of air pollution and management (Peterson and McCune 2001; Geiser and Neitlich 2007).
- Weighted Old Growth Habitat Index (Franklin, Spies and Van Pelt 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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