Appendix B. Ecology

This appendix provides background on the analysis of forest ecological conditions.

In this appendix:

Structural Stage Classification

Conifer forests within the planning area are classified in this analysis by a four-stage structural classification:

Stand Establishment
Young
Mature
Structurally Complex.

These four structural classes are further sub-divided by additional structural divisions and by tree species composition groupings.

Vegetation Series (by plant series)

- **Western Hemlock and Tanoak**: Western Hemlock, Sitka Spruce, Pacific Silver Fir, Tanoak
- **Douglas-fir**: Douglas-fir, Grand Fir, White Fir, Shasta Red Fir, Mountain Hemlock, Ponderosa Pine
- **Non-forest**: Jeffrey Pine, Oregon White Oak, Juniper, Sagebrush, Grassland, Water

These vegetation series are groupings that have been made for this analysis based on plant series and do not exactly correspond to mapped plant series or plant association groupings. The data on plant series was modeled at a very fine scale and has been coarsened in scale for this analysis. Adjustments have been made to the geographic boundaries of these vegetation series grouping to provide explicit boundaries without interspersion.

Classification

Each class appended with Vegetation Series:

- Western Hemlock and Tanoak
- Douglas-fir

1) Stand Establishment
<200 years old in current Forest Operations Inventory
Average tree height <50 feet

1a.) Without Structural Legacies
<6 trees per acre ≥20 inches diameter breast height

1b.) With Structural Legacies
≥6 trees per acre ≥20 inches diameter breast height

The Stand Establishment stage extends from stand initiation until stands have reached canopy closure and density-dependent tree mortality begins. Average tree height reflects the influence of site productivity on tree growth. At an average tree height of 50 feet, stands have passed the point at which they are typically pre-commercial thinned. The minimum density of structural legacies is set at 6 trees per acre to maintain consistency with the minimum green tree requirements in the No Action alternative.

2) Young
<200 years old in current Forest Operations Inventory
Average tree height ≥50 feet

Western Hemlock and Tanoak
<24 trees per acre ≥20 inches diameter breast height

Douglas-fir
<12 trees per acre ≥20 inches diameter breast height

2a.) Young High Density
relative density ≥ 25

2a1.) Without Structural Legacies
Descended from Stand Establishment without Structural Legacies

2a2.) With Structural Legacies
Descended from Stand Establishment with Structural Legacies

2b.) Young Low Density
relative density < 25

2b1.) Without Structural Legacies
Descended from Stand Establishment without Structural Legacies

2b2.) With Structural Legacies
Descended from Stand Establishment with Structural Legacies

The Young stage is characterized by the predominance of density-dependent tree mortality, and, in high density stands, a small range of tree diameters. Young stands have not yet acquired the density of large diameter trees that characterize Mature stands. Young Low Density stands are those with a tree density sufficiently low to largely eliminate the influence of density-dependent tree mortality.

3) Mature
<200 years old in current Forest Operations Inventory

Western Hemlock and Tanoak
≥24 trees per acre ≥20 inches diameter breast height

Douglas-fir
≥12 trees per acre ≥20 inches diameter breast height

3a.) Single Canopy

Western Hemlock and Tanoak
Coefficient of Variation of tree diameters > 10 inches diameter breast

height (CVgt(10)) < 0.35

Douglas-fir
CVgt(10) < 0.34

3b.) Multiple Canopy

Western Hemlock and Tanoak
CVgt(10) ≥ 0.35
<4.7 trees per acre ≥40 inches diameter breast height

Douglas-fir
CVgt(10) ≥ 0.34
<2.1 trees per acre ≥40 inches diameter breast height

The Mature stage generally begins as tree growth rates stop increasing (after culmination of mean annual increment), as tree mortality shifts from density-dependent mortality to density-independent mortality. The threshold values for the Mature stage are derived from Poage (*unpublished*), which comprises BLM timber cruise data for timber sales in the late 1980s and early 1990s. This data presents a precise and accurate sample of the population of trees in timber sale areas. Because timber harvest during that period was predominately in Mature and Structurally Complex forest, this data set, described in Poage (2000), provides a characterization of Mature and Structurally Complex forest on BLM-administered lands.

The thresholds presented here for Mature forest are intended to establish a threshold that represents the structural conditions of most Mature forests, but not necessarily absolute minimum conditions found in all Mature forests. Therefore, the density of large trees (greater than 20 inches in diameter) was derived from the 66th percentile of sample values from the Poage dataset, separating the data for the Western Hemlock and Tanoak, and Douglas-fir vegetation series.

The threshold for canopy layering was derived from the coefficient of variation in tree diameters, inferring that variation in tree diameters is reflected by variation in tree heights. The threshold here was derived by the mean coefficient of variation of tree heights minus one standard deviation from the Poage dataset.

This analysis initially examined other measures of canopy layering, included a Canopy Height Diversity index (Spies and Cohen 1992), a Diameter Diversity Index (McComb et al. 2002), and a canopy classification technique in Baker and Wilson (2000).

The Canopy Height Diversity index uses data on tree heights directly, but classified most existing stands over 200 years old in this analysis as "single canopy," and therefore would be too restrictive.

The Diameter Diversity Index infers canopy height diversity from weighted values of tree diameters. The weighting values produce results that may be more effective at classifying existing stands than evaluating modeled stands. The Diameter Diversity Index results do not appear to accurately reflect future changes in canopy layering resulting from thinning or partial disturbance and would classify relatively young, even-aged stands as "multiple canopy."

The technique in Baker and Wilson (2000) uses tree height and canopy measurements, but would classify almost all stands in this analysis as "multiple canopy."

Coefficient of variation in tree diameters provides greater discrimination among the stands in this analysis than the other measures and appears to be sensitive to future changes in stand conditions. Coefficient of variation in tree diameters could provide misleading results in strongly bi-modal stands (i.e., very large trees and very small trees), which would be a concern if this analysis were attempting to provide continuous values of canopy layering. But this analysis is only attempting to classify stands as either single canopy layered or multiple canopies.

4) Structurally Complex

4a.) Existing Structurally Complex

4a1.) Existing Old Forest
200-399 years old in current Forest Operations Inventory

4a2.) Existing Very Old Forest
≥400 years old in current Forest Operations Inventory

4b.) Developed Structurally Complex
<200 years old in current Forest Operations Inventory

Western Hemlock and Tanoak
CVgt(10) ≥0.35
≥24 trees per acre ≥20 inches diameter breast height
≥4.7 trees per acre ≥40 inches diameter breast height

Douglas-fir
CVgt(10) ≥0.34
≥12 trees per acre ≥20 inches diameter breast height
≥2.1 trees per acre ≥40 inches diameter breast height

This analysis assumes that stands identified as 200 years old or older in the current stand inventory are Structurally Complex forest. In addition, stands that are not 200 years old or older but meet threshold values for Developed Structurally Complex described above are identified as Structurally Complex forest. Threshold values for Developed Structurally Complex include density of very large trees (greater than 40 inches in diameter) derived from the 66th percentile of sample values from the Poage dataset, separating data for the Western Hemlock and Tanoak and Douglas-fir vegetation series.

Structurally Complex stands approximate “old-growth” stands described in many analyses (see, e.g., District RMP/EISs), “Medium/large Conifer Multi-story” stands described in the FEMAT Report, and “Large, Multi-storied Older Forest” stands described in the LSOG Monitoring Report. In this analysis, “late-successional forest” encompasses both Mature and Structurally Complex stands, similar to how the Northwest Forest Plan FSEIS used “late-successional forest” to encompass mature and old-growth forests (p. Glossary-9). The LSOG Monitoring Report summarized the difficulties in describing and classifying older forest conditions (pp. 9-10).

Table 238. Comparison of different stand classification schemes and the structural stage classification used in this RMP/EIS. A more extensive comparison of classification schemes can be found in Franklin et al. 2002.

Typical stand age[1] (years)	Oliver (1981) stand development stages	Franklin et al. (2002) structural stage	1994 RMP/EIS Seral stage	Structural stages (This RMP/EIS)
0	Disturbance and legacy creation			
	Stand Initiation		Early seral	Stand Establishment
20		Cohort establishment		
			Mid seral	
30	Stem Exclusion	Canopy Closure		Young
50		Biomass accumulation/ competitive exclusion		
			Late seral	
80	Understory Reinitiation	Maturation		Mature
150		Vertical diversification	Mature seral	
300	Old Growth	Horizontal diversification		Structurally Complex
			Old-growth	
800-1200		Pioneer cohort loss		

[1] Stand ages are provided as references. However, stands can achieve structural classes at different stand ages, depending on disturbance and site conditions

Interagency Vegetation Mapping Project Data

Existing vegetation mapping for the planning area was based on the Interagency Vegetation Mapping Project (IVMP), which provides maps of existing vegetation, canopy cover, size, and cover type for the entire range of the Northern Spotted Owl using satellite imagery from Landsat Thematic Mapper (TM). The LSOG Monitoring Report contains detailed descriptions of the IVMP data and evaluations of IVMP map accuracy (Moeur et al. 2005, pp. 18-30, 108-109, 123-128). Those descriptions and evaluations are incorporated here by reference.

The IVMP was initiated in 1998 under joint program management and funding by the Bureau of Land Management-Oregon and the Forest Service-Region 6. The project's goal was to provide consistent spatial data for monitoring older forests within the portions of the Plan area in Washington and Oregon. The IVMP mapped existing vegetation in the nine physiographic provinces in Washington (Eastern and Western Cascades, Olympic Peninsula, and Western Lowlands) and Oregon (Eastern and Western Cascades, Coast Range, Willamette Valley, and Klamath Mountains).

The IVMP modeling approach combined remotely sensed satellite imagery (25-m Landsat TM), digital elevation models, interpreted aerial photos, and inventory information collected on the ground to classify existing vegetation. Landsat scenes used in the IVMP project ranged from fall 1992 through summer 1996. Of the 17 scenes, 2 were acquired in 1992, 1 each in 1994 and 1995, and 13 in 1996. A regression modeling approach was used to predict vegetation characteristics from this Landsat data.

Inventory plot data were used as reference information for IVMP model building and accuracy assessment. Almost 10,000 plots were used for model building and testing, and another 2,800 plots were held out for an independent accuracy assessment. These data came primarily from Current Vegetation Survey (CVS) plots maintained by Forest Service-Region 6 and Bureau of Land Management-Oregon on Forest Service and Bureau of Land Management lands in Washington and Oregon, and from Forest Inventory and Analysis (FIA) plots administered by Pacific Northwest Research Station on nonfederal lands.

All IVMP map data and supporting documentation are available online at

http://www.or.blm.gov/gis/projects/ivmp.asp

Average Historical Conditions and the Historic Range of Variability

The description of the Affected Environment and the analysis of effects include a comparison of current and future conditions to the Historic Range of Variability. Characterization of historic landscape conditions can provide a reference point for comparison in the analysis of effects of different land management strategies. Historic landscape conditions were dynamic, which requires characterization of landscape conditions as a range, rather than a discrete point.

There are several challenges in describing the Historic Range of Variability:

1. Selecting metrics

Historic Range of Variability is often described by abundance of habitat types and frequency of disturbance, such as mean fire return interval. Some descriptions have included spatial pattern of habitats, such as patch size. Because the Historic Range of Variability is a range, it is not easily quantified, and at many spatial scales, the range is very broad (see, e.g., Wimberly et al. 2000). Simply describing an upper and lower bound of historic conditions may overemphasize the rare, extreme events that defined the bounds (Landres et al. 1999). However, more sophisticated descriptions may be difficult to communicate to decision-makers and the public, and may be difficult to compare to the effects of different land management strategies.

2. Selecting the portion of history

Historical conditions varied not only in a range of natural disturbance frequencies, but with patterns of pre-European anthropogenic disturbances and with climate changes. The selection of the portion of history to characterize can strongly influence the resulting "range" that is described (Millar and Woolfenden 1999, Long et al. 1998).

3. Incomplete and unavailable information

Our knowledge of historical landscape conditions is fragmentary at best. Descriptions of Historic Range of Variability have been built from pollen deposits in lake sediments, tree-ring data, fire-scar data, even animal deposits, such as pack-rat middens. These records are incomplete. Reconstructions from such data sources require inference and modeling to derive a description of Historic Range of Variability.

4. Change from historical conditions

> Some biological and physical characteristics have changed irreversibly from historic conditions and may distort any comparison to Historic Range of Variability. Climate conditions have changed and are continuing to change at a rapid rate. Species introductions and species extirpations have altered biological relationships.

These challenges should be considered in interpreting the Historic Range of Variability and caution against using it as an explicit target or management objective.

Several commentors have hypothesized that a landscape that reflects the abundance and arrangement of habitats within the Historic Range of Variability will support the species and processes that were historically present, and that the further the landscape lies outside the Historic Range of Variability, the less likely it will support those species and processes (see, e.g., Landres et al. 1999). These hypotheses remain largely untested, but several studies have characterized the historic range of variability in western Oregon and used it as a reference point to compare the effects of management strategies (Nonaka and Spies 2005, Wimberley 2002, Wimberley et al. 2000, Cissel et al. 1999, Rasmussen and Ripple 1998).

This analysis uses the description of habitat abundances and mean fire return intervals from the draft Rapid Assessment Reference Condition Models (USFS and BLM 2005). These models derived historic abundances by modeling disturbance probabilities generated from mean fire return intervals combined with the probabilities of other disturbances such as wind, insect and pathogens. These models described the average amount of the landscape that would be expected in each of the broad vegetation classes, which are roughly equivalent to the structural classes used in this analysis.

This analysis used the description of spatial patterns of habitat types from Nonaka and Spies (2005), which modeled historic spatial pattern in the Coast Range. Although this research applies to only a portion of the planning area, it presents an available description of historic spatial pattern. The historic spatial pattern in the other provinces in the planning area likely differed from the Coast Range, and therefore the comparative value of this description of Historic Range of Variability is limited and must be used with caution.

FRAGSTATS

FRAGSTATS is a computer software program designed to compute a wide variety of landscape metrics for categorical map patterns. The original software (version 2) was released in the public domain during 1995 in association with the publication of a USDA Forest Service General Technical Report (McGarigal and Marks 1995).

The following discussion is summarized from the FRAGSTATS website (http://www.umass.edu/landeco/research/fragstats/fragstats.html), which describes FRAGSTATS in detail, those descriptions incorporated here by reference.

FRAGSTATS is a spatial pattern analysis program for categorical maps. The landscape subject to analysis is user-defined and can represent any spatial phenomenon. FRAGSTATS simply quantifies the areal extent and spatial configuration of patches within a landscape; it is incumbent upon the user to establish a sound basis for defining and scaling the landscape (including the extent and grain of the landscape) and the scheme upon which patches are classified and delineated. The output from FRAGSTATS is meaningful only if the landscape mosaic is meaningful relative to the phenomenon under consideration.

FRAGSTATS computes 3 groups of metrics. For a given landscape mosaic, it computes several metrics for: (1) each patch in the mosaic; (2) each patch type (class) in the mosaic; and (3) the landscape mosaic as a whole. The FRAGSTATS website contains a detailed description of the metrics.

The FRAGSTATS website includes a discussion on the conceptual background of FRAGSTATS analysis, including advice and caveats about use of the software. Key points from that discussion are summarized here.

A landscape is not necessarily defined by its size; rather, it is defined by an interacting mosaic of patches relevant to the phenomenon under consideration (at any scale). It is incumbent upon the investigator or manager to define landscape in an appropriate manner. The essential first step in any landscape-level research or management endeavor is to define the landscape, and this is of course prerequisite to quantifying landscape patterns.

Classes of Landscape Pattern

Real landscapes, at any scale, contain complex spatial patterns in the distribution of resources that vary over time. Quantifying these patterns and their dynamics is the purview of landscape pattern analysis. Landscape patterns can be quantified in a variety of ways depending on the type of data collected, the manner in which it is collected, and the objectives of the investigation. Broadly considered, landscape pattern analysis involves four basic types of spatial data corresponding to different representations of landscape pattern. These look rather different numerically, but they share a concern with the relative concentration of spatial variability:

(1) Spatial point patterns represent collections of entities where the geographic locations of the entities are of primary interest, rather than any quantitative or qualitative attribute of the entity itself.

(2) Linear network patterns represent collections of linear landscape elements that intersect to form a network.

(3) Surface patterns represent quantitative measurements that vary continuously across the landscape; there are no explicit boundaries (i.e., patches are not delineated). Here, the data can be conceptualized as representing a three-dimensional surface, where the measured value at each geographic location is represented by the height of the surface.

(4) Categorical (or thematic; choropleth) map patterns represent data in which the system property of interest is represented as a mosaic of discrete patches. From an ecological perspective, patches represent relatively discrete areas of relatively homogeneous environmental conditions at a particular scale. The patch boundaries are distinguished from their surroundings by abrupt discontinuities (boundaries) in environmental character states of magnitudes that are relevant to the ecological phenomenon under consideration

Patch-Corridor-Matrix Model

Patch must be defined relative to the phenomenon under investigation or management; regardless of the phenomenon under consideration (e.g., a species, geomorphological disturbances, etc), patches are dynamic and occur at multiple scales; and patch boundaries are only meaningful when referenced to a particular scale.

It is incumbent upon the investigator or manager to establish the basis for delineating among patches and at a scale appropriate to the phenomenon under consideration.

Corridors are distinguished from patches by their linear nature and can be defined on the basis of either structure or function or both. If a corridor is specified, it is incumbent upon the investigator or manager to define the structure and implied function relative to the phenomena (e.g., species) under consideration.

It is incumbent upon the investigator or manager to determine whether a matrix element exists and should be designated given the scale and phenomenon under consideration.

The Importance of Scale

One of the most important considerations in any landscape ecological investigation or landscape structural analysis is (1) to explicitly define the scale of the investigation or analysis, (2) to describe any observed patterns or relationships relative to the scale of the investigation, and (3) to be especially cautious when attempting to compare landscapes measured at different scales.

Landscape Context

A landscape should be defined relative to both the patch mosaic within the landscape as well as the landscape context. Moreover, consideration should always be given to the landscape context and the openness of the landscape relative to the phenomenon under consideration when choosing and interpreting landscape metrics.